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APPLES
AND PEARS
IN THE
MIDWEST
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Publication prepared by Dwight Powell, University of Illinois; Blair Janson, Ohio State University; and Eric G. Sharvelle, Purdue University

Other Extension plant pathologists of the North Central Region

E. E. Burns, University of Illinois, Urbana
Malcolm C. Shurtleff, University of Illinois, Urbana
D. H. Scott, Purdue University, Lafayette, Indiana
A. H. Epstein, Iowa State University, Ames
Claude L. King, Kansas State University, Manhattan
William Willis, Kansas State University, Manhattan
Alan L. Jones, Michigan State University, East Lansing
N. A. Smith, Michigan State University, East Lansing
H. L. Bissonette, University of Minnesota, St. Paul
Herbert G. Johnson, University of Minnesota, St. Paul
C. H. Baldwin, Jr., University of Missouri, Columbia
E. W. Palm, University of Missouri, Columbia

E. D. Kerr, University of Nebraska, Lincoln
D. S. Wysong, University of Nebraska, Lincoln
John L. Weihing, University of Nebraska, Lincoln
E. H. Lloyd, Jr., North Dakota State University, Fargo
Robert E. Partyka, Ohio State University, Columbus
Leon Wood, South Dakota State University, Brookings
Gayle Worf, University of Wisconsin, Madison
Earl K. Wade, University of Wisconsin, Madison

Federal Extension Service

Harlan E. Smith, Washington, D.C.

Industry representative


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JOHN B. CLAAR, Director, Cooperative Extension Service, University of Illinois at Urbana-Champaign.
Both the home fruit gardener and the commercial fruit grower have occasion to consult a reference on diseases. It is hoped that this circular will serve that purpose for growers of apples and pears. Included are aids to identification, descriptions of the disease cycles, and control measures.

Most of the diseases included in this circular are illustrated. (Those not illustrated are apple scald, Armillaria root rot, brown rot, hairy root, hawthorn rust, pear leaf spot, and some of the storage rots and virus diseases.) The illustrations are grouped on pages 10 to 16 and on the front and back inside covers. This grouping should make it easier to find the picture that most resembles the disease you want to identify. The symptoms given in each disease writeup are further aids to identification.

Descriptions of the disease cycles explain the relationship of the seasons to different stages of a disease. For example, where does the disease pathogen overwinter? When and where will the disease first appear in the spring? How often do secondary infections occur during the spring and summer? These questions need to be answered if a suitable control program is to be followed.

In disease control one should consider three main points. First, when a choice exists, select varieties which are known to have some resistance to the more important fruit diseases. Second, use every possible measure of sanitation in a fruit planting. Third, if necessary, use chemical sprays. Never depend entirely on a chemical spray program if some other measure will lessen the problem.

Recommended chemicals, as well as other control measures, are included in this circular. Required concentrations are omitted, however, since these are given on the containers. A definite spray schedule is also omitted because of the large number of available fungicides.

In general, to control pear diseases apply the first fungicide at the cluster bud stage. Switch to streptomycin during the bloom period and then start the fungicides again during the calyx (petal fall) period. Usually not more than two cover sprays of fungicides are needed on pears, one 14 days after petal fall and the second 14 days after the first cover.

Apple trees generally require a fungicide at frequent intervals throughout the spring and summer. The first application should start with the half-inch green stage of bud development (see back cover). A second spray is needed at the pink stage. If streptomycin is used at the start of the early bloom period a fungicide may be included. After the calyx (petal fall) spray, fungicides can be included in all the cover sprays up to harvest.

For more detailed information on disease control, consult your county agent or farm adviser.

DISEASES AFFECTING APPLES

Alternaria Cork Rot

Although alternaria cork rot is usually a minor disease of apples, it damaged 35 percent of the fruit in one Illinois block of Jonathan in 1957. The organism, Alternaria mali, attacks leaves and fruits through punctures or wounds. On leaves, apple scab lesions are the most usual points of invasion. When fully developed in late summer or fall, alternaria lesions are commonly confused with secondary scab infections because of their dark olive color.

Symptoms. Fruit infections develop as black corky spots about \( \frac{1}{4} \) inch in diameter and \( \frac{1}{4} \) inch deep. Close examination reveals a minute hole, probably caused by an insect, in the center of the spot. A fruit seldom has more than three spots (Fig. 1).

Disease cycle. A. mali winters over on dead apple leaves on the ground. Spring rains and warm weather cause a discharge of spores from these leaves. Wind carries the spores to infect new leaves. First signs of infection appear on these leaves in June. By late fall A. mali may be the predominant organism on the underside of apple leaves.

Fruit infections make their first appearance in July, reaching a peak in August. As fruits mature, they become more susceptible to infection. Fortunately, cool weather in September retards the organism’s development. As long as the temperature is about 85° F., which is optimum for the organism’s growth, the incubation period is 5 to 7 days during August and September.

In the orchard, varieties differ in susceptibility. Immature fruits of Jonathan and Golden Delicious are very susceptible, those of Grimes Golden are moderately susceptible, while those of Delicious, Rome Beauty, Winesap, and Stayman Winesap are resistant. After fruits have been in cold storage and have ripened, all varieties become susceptible.

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Control. No present-day fungicide has had marked effect on alternaria cork rot, and no definite control measure has been developed. It is important to follow a good fungicide program that will control apple scab since A. mali thrives in scab lesions.

Apple Anthracnose

Other names for apple anthracnose are “northwestern anthracnose,” “bullseye rot,” “Pacific coast canker,” and “black spot canker.” The disease is not common in the Midwest, and does not occur at all south of the forty-second parallel. It is caused by the fungus Neofabraea malicorticis.

Symptoms. Anthracnose appears as limb cankers and as a fruit rot. Limb cankers form on the younger branches, first appearing in late fall as small, reddish-brown spots with discolored bark extending inward to the cambium. By the following spring, the cankers are full size (1 to 10 inches long), with an elliptical shape. The surface of the canker is smooth until mid-summer, when dark pustules appear which later break through to the surface, exposing cream-colored spore masses. After this, slits may appear across the surface of the canker. Mature cankers are sunken in the center and have a definite crack at the outer margin.

Fruit infections (Fig. 2) most commonly develop in storage, seldom appearing in the orchard. They take the form of concave brownish lesions which at first glance resemble bitter rot. As the lesions mature, definite spore masses develop.

Disease cycle. Infection occurs during the fall on small limbs. The following summer conidial pustules or acervuli (asexual fruiting bodies) appear, which produce pinkish to cream-colored conidia (asexual spores). These may infect fruit and limbs. During the second summer, apothecia (sexual fruiting structures) develop in the old acervuli and discharge ascospores. Thus, it requires two years to complete the life cycle of this fungus.

Control. A judicious pruning program will remove the cankered limbs. New infections of the limbs and fruit can be prevented by spraying with captan in the late season. Usually three or four sprays at weekly intervals, with the last spray just before harvest, will control the disease adequately.

Apple Bark Necrosis (Measles)

This physiological disease has been related to manganese toxicity and boron deficiency, alone or in combination. In the Midwest, a more appropriate common name would be “Delicious measles,” since only this variety and its sports appear to be affected.

Symptoms. Four different manifestations are evident on infected trees: (1) Small elevations covering the surface of 1- to 2-year-old wood. (2) Brown dead areas in the outer bark beneath these elevations (Fig. 3). (3) A roughening of the older wood sometimes similar to injuries caused by the buffalo tree hopper when laying eggs. (4) Stunted terminal growth and in extreme cases death of small terminal branches.

Control. Since there is some question as to whether boron deficiency or manganese toxicity causes this disease, most workers try to correct both conditions. Boron deficiency can be corrected by adding 1/4 to 1/2 pound of Borax per year of tree growth. One such application should last several years. To correct manganese toxicity, add lime to adjust the soil to a pH of at least 5.7. In extremely acid soils manganese becomes soluble and is taken up by the roots to cause injury. Increasing the soil alkalinity makes the soil manganese insoluble so that it cannot be absorbed by the roots.

Apple Blotch

This disease is caused by the fungus Phyllosticta solitaria. Blotch is most important in home orchards where susceptible varieties are grown and a minimum fungicide schedule is being used.

Symptoms. P. solitaria infects leaves, twigs, and fruits. There are two types of leaf lesions. One appears on the tissues between the veins of the leaf blade. At first this type of lesion is difficult to see because it is only about the size of a pinhead. As the lesions mature, they show up as light gray spots, each with a dark dot in the center. The other leaf lesion, which is more common, occurs on the veins, midribs, and petioles. These infections are elongated, sunken, and light-colored, with several black dots (fruiting structures called pycnidia). During a severe infection these lesions may girdle the petiole and cause leaves to fall.

Twig infections resemble the elongated type of leaf lesion but are larger and more evident. They may develop either on or between the nodes. It is through these infections that the organism becomes established in the tree. Once a lesion is established, it may continue to grow and develop for three or four years (Fig. 4). Each year it enlarges and oozes spores until it becomes a prominent branch canker, which may eventually be twice the diameter of a normal limb.

Fruit may be infected any time from petal fall until
harvest. The lesions are shiny black blotches varying from small spots to a large part of the fruit surface (Fig. 5). The larger areas usually represent the coalescing of several lesions. Edges of the lesions are irregularly lobed with many radiating outgrowths or projections. Fruiting structures develop in the central portion of these lesions. Large lesions may cause fruit cracking, thus exposing the flesh to insects and the rot fungi.

**Disease cycle.** The organism winters over in limb cankers. As spring approaches, structures called pycnosclerotia ooze pycnospores. The first infections of leaves, twigs, and fruits may occur about the petal fall period. The normal incubation period is 14 days. As infections develop, pycnidia form from which spores ooze, causing secondary infections. These may occur until late summer, after which no more pycnidia are formed. Instead, as fall approaches, pycnosclerotia develop. These go through the winter and start the spring infection.

**Control.** Blotch is called a “warm, wet weather disease.” Heavy rain and warm temperatures (75° F. and above) encourage its spread.

Fortunately the popular apple varieties are not susceptible to blotch. Duchess and Rhode Island Greening are very susceptible, and Transparent develops blotch in some years. The dithiocarbamate fungicides such as ferbam, zineb, and thiram will all give good blotch control. Use any one of them starting at the petal fall application and continuing through the summer at 10- to 14-day intervals. By preventing new twig lesions from developing, this treatment will eventually eradicate blotch from the orchard.

**Apple Powdery Mildew**

A fungus, *Podosphaera leucotricha*, is the cause of powdery mildew. Although this disease is not normally serious in the Midwest, it is important enough that it cannot be ignored. When sulfur was the main fungicide, powdery mildew was only a very minor disease in this region. It has become more prevalent, however, with the increased use of organic fungicides and the gradual elimination of sulfur from spray programs.

**Symptoms.** All live tissue of the apple tree, including buds, blossoms, leaves, twigs, and fruits, are susceptible to powdery mildew infections. Infected leaves have the light gray powdery coating of spores which is typical of this disease. The leaves become crinkled, curled, and stunted, and often die. The fungus spreads rapidly from leaves to the succulent terminal twigs, which become stunted and shortened while the lateral buds tend to be bunched together. After the buds develop, the terminal growth has a witches'-broom appearance, with the powdery spores covering all the leaf and twig tissue. The witches'-broom manifestation is a very common symptom when the disease is severe and is easily seen since a high percentage of the terminal growth may be affected. (A color plate of terminal infection is on inside front cover.)

Fruit infection is most interesting. It results in a fine network of russetting, which is occasionally so closely woven that it looks like solid russet (Fig. 6). In a severe infection all of the fruit on a tree will be russeted in this fashion.

**Disease cycle.** The pathogen winters over as mycelium, mostly in terminal buds. With warm spring weather, the mycelium begins to grow, and conidial spores and mycelium cover the outer part of the new leaf. As the season progresses, the conidia are spread by wind and rain to infect new leaves, twigs, and fruits. With temperatures of 66° to 72° F., the incubation period is about 10 days. During the period from 2 weeks after petal fall until about August 1, mycelium invades the buds for the following year. Occasionally cleistothecia (the sexual fruiting structures) develop on the surface of the leaves, but these are not considered an important part of the disease cycle.

**Control.** The disease can be adequately controlled with either sulfur, Dikar, or dinocap (Karathane) when applied in successive sprays from the half-inch green stage until the second cover. None of the other organic fungicides are effective.

Weather is an important factor in powdery mildew development. Even if fungicide protection is inadequate, the disease will not develop during a normal Midwestern season with frequent rains. But it will develop rapidly when weather is dry and morning dews are heavy. Accurate predictions can therefore be made as to the probable occurrence of this disease.

**Apple Scab**

Apple scab is caused by a fungus known as *Venturia inaequalis*. Although some other diseases are harder to control, scab is still the number one apple disease. It is always present in apple orchards. While an adequate spray program will give almost complete control, improper spraying may have no effect and scab may destroy the crop.

**Symptoms.** Scab mainly infects the leaves, petioles, and fruit, although twig lesions have also been re-
ported in other countries. Infection starts as soon as the first leaves come out in the spring. Light brown or olive-colored spots appear either on the leaf or the leaf petiole. The infection will cause the foliage to drop off, thus greatly weakening the tree. Later on fruit is infected. Early fruit infections will give the fruits a scabby, knotty, misshapen appearance (Fig. 7). Such fruits usually drop before maturity. (A colored plate of fruit and leaf infection is on inside front cover.)

**Disease cycle.** Scab overwinters in the dead leaves under the tree. During warm days after January 1, the fungus starts to enter the sexual stage and produces perithecia. Each perithecium contains a large number of sac-like organs called asci. Each ascus contains eight ascospores.

As spring appears, a microscopic examination of the dead leaves will show many black, pimple-like structures, called perithecia, imbedded in the leaf. The mature perithecia are filled with ascospores. Spring rains cause the perithecia to discharge ascospores into the air, and the wind carries them to the new green leaves and opening fruit buds of the apple tree.

Perithecia do not all mature at the same time. Some may mature as early as February, and others may produce spores as late as June. With each spring rain new spores discharge to produce infections on the green leaves.

Once an ascospore is established, it sends a germ tube into the epidermis or external portion of the plant tissue. This tube branches out as the infection spreads. The first visible sign of infection is a light brown or olive-colored spot. Depending on the temperature, it shows up about 10 days after infection begins. Microscopic examination of this spot shows hundreds of new spores which are called conidia, or summer spores. Rains wash the summer spores from the infected spots to other green leaves and to the young fruit, where they start secondary infections.

Once the primary infection gets started, an apple scab epidemic is almost impossible to stop. New infections develop with each rain all summer long and into the early fall.

**Control.** Either captan or dodine will control scab satisfactorily. Whichever you use, it is important to spray at least every 7 to 10 days. Make the first application when the new leaves appear, and continue until you are sure you have the infection under control. Except in the north, you will not normally need to spray for scab control after July 1. You can combine the captan or dodine with the proper insecticides when you want to control insects too.

### Apple Scald

A physiological or noninfectious disease, apple scald develops in fruit which has been picked when immature and stored under unfavorable conditions.

**Symptoms.** Scald may develop in either common or cold storage. The degrees of scald have been classified as common scald, soft scald, and soggy breakdown.

Common scald first appears as a slight darkening of the skin color, which is most pronounced on light-colored varieties. Usually a sharp line of demarcation exists between the affected area and normal unaffected fruit tissue. As the condition develops it changes from a superficial discoloration to a deep brown flesh rot. Often the rot extends over a large area — sometimes affecting three-quarters of the fruit; but it may appear as small, numerous lesions. Sometimes the affected area remains firm. Other times, however, it becomes quite soft and watery, the condition being known as “soft rot” and eventually “soggy breakdown.”

Varieties differ markedly as to which of these symptoms they show. Immature Grimes Golden will develop a deep, soft scald at 33°F. if the storage is not properly aerated. Out of 10 years of successive fruit production. When it does appear it may be prevalent in many different orchards throughout a fruit-growing area. Bitter pit is most likely to occur when the crop is light and the apples are larger than normal. If serious, it lowers fruit quality and may cause heavy crop loss.

**Control.** Chemical control of scald is now possible. "No Scald DPA" (diphenylamine) may be applied just before picking or used as a post-harvest dip before storage.

### Bitter Pit

Bitter pit is one of several apple diseases that are physiological and are not infectious. The cause has not been determined. The disease has never been known to occur consistently in any block of apple trees year after year, and it may be a problem in only one out of 10 years of successive fruit production. When it does appear it may be prevalent in many different orchards throughout a fruit-growing area. Bitter pit is most likely to occur when the crop is light and the apples are larger than normal. If serious, it lowers fruit quality and may cause heavy crop loss.

**Symptoms.** Bitter pit occurs only on the fruit. Usually it first appears in the orchard in early summer. First symptoms are slightly sunken, water-soaked circular spots which, regardless of fruit color, are dark green with a small amount of internal browning (Fig. 8). A fruit may have from one to ten such spots. They are commonly located toward the calyx end but may
appear anywhere on the fruit. As the fruits mature, the spots or lesions become more sunken with a definite brown, dry corkiness beneath the surface. This internal browning may extend $\frac{1}{4}$ inch into the fruit and is usually associated with the vascular tissue.

**Control.** This disease is very difficult to control. Recent studies have shown a possible correlation with calcium deficiency. Calcium nitrate, 5 pounds in 100 gallons of water, has shown promise experimentally when applied to the trees four times at 3-week intervals, starting 7 days after petal-fall. Varieties vary in susceptibility, with Red Delicious and Grimes Golden being very susceptible.

### Black Pox

Although black pox is not common, it will occasionally break out in an isolated orchard or part of an orchard, seriously degrading the fruit. It is caused by the fungus *Helminthosporium papulosum*.

**Symptoms.** Well-defined, conical, shining, blackish pustules are produced on twigs and limbs. Some of the heaviest infestations have been on water sprouts. Over a period of years the bark assumes a fine, flaky appearance, very similar to the bark scaling that follows severe infestations of scale insects. The condition is also easily confused with apple measles, a physiological disease. Infected fruits have small, black, circular, slightly sunken spots usually less than $\frac{1}{4}$ inch in diameter. A single fruit may have 100 or more spots (Fig. 9).

**Disease cycle.** The organism winters over on twigs. The disease is very difficult to diagnose because symptoms vary between twigs of different ages and even between twigs of the same age. In spring, conidia are produced which invade the current season's growth. Pustules caused by new infections appear on the bark in August. Smooth bark remains susceptible for a long time, so the number of pustules on a given area of bark surface increases over a period of years.

Very little work has been done on the fruit-infection phase of the disease. Infection is first noticed on apples during August, as they approach maturity. Nothing is known about the incubation period or the temperature and moisture requirements of the fungus.

**Control.** The normal apple fungicide program has apparently kept black pox under control. Grimes Golden is the variety on which the disease is most commonly reported here in the Midwest. Other varieties which have developed infection are Maiden Blush, Rome Beauty, Duchess, Red Delicious, and Golden Delicious. Transparent, York Imperial, and Gano are thought to be resistant.

### Blister Spot

This disease is caused by the bacterium *Pseudomonas syringae papulans*. Although it is common in orchards, it is seldom serious.

**Symptoms.** Blister spot appears on the fruit in early summer as very superficial, darkened, water-soaked areas around the lenticels. These spots never enlarge but become darker upon maturity, when they appear as light brown, slightly raised pimples (Fig. 10). One fruit may have one to 100 or more such infections. Normally the spots are not abundant enough to lower fruit quality.

**Disease cycle.** Not enough is known of the disease cycle of this pathogen. Artificial inoculations have produced twig cankers, so it is assumed that the pathogen winters over on the twigs. The cankers are not strongly pronounced, however, and very few natural ones have been found. Rain apparently washes the bacteria from the cankers to the fruit. The organism becomes established in the lenticels during periods of continuous moisture. The incubation period may vary from 14 to 24 days, probably depending on variety and temperature. The first symptoms appear in June.

**Control.** Blister spot has not caused enough damage to warrant a study of control measures. It is assumed that the normal apple fungicide program helps to keep the disease at a minimum. Some varieties are apparently more susceptible than others. Golden Delicious, Red Delicious, Rome Beauty, and Duchess are the commercial varieties most commonly infected in the Midwest.

### Cedar Apple Rust

Cedar apple rust is one of our most common and destructive apple diseases, although it is one of the easiest to identify and control. It is caused by a fungus known as *Gymnosporangium juniperi-virginianae*.

**Symptoms.** Rust occurs on apple leaves and fruits and occasionally infects twigs. Leaf infections usually show up during May, appearing as small, pale yellow spots on the upper surface. One leaf may have anywhere from one to 100 spots. As these spots enlarge to about $\frac{1}{8}$ inch in diameter, an orange exudate appears in the center, and somewhat later black dots or fruiting bodies called pycnia are seen.

With development of the pycnia, the disease becomes evident on the underside of the leaf. Diseased tissue on the undersurface later thickens, and usually a number of orange-yellow, tube-like protuberances called aecia appear in each spot. As the infected areas
Jonathan Spot

This physiological disease occurs on fruits as they reach maturity. It is thought to result from toxins which accumulate in the lenticels of the skin. The name is derived from the fact that Jonathan, a very popular variety, is highly susceptible to the disease. King David is also very susceptible, and Wealthy and Rome Beauty are moderately so.

**Symptoms.** Jonathan spot is easily distinguished from other fruit diseases. The lesions are typically deep brown to black, superficial, slightly depressed, circular with a very definite border, and 1/16 to 1/8 inch in diameter (Fig. 11). One fruit may have as many as 50 spore-horns, it looks something like a blossom at this stage. (A cedar gall, along with diseased apple leaves and fruit, is shown in color on the inside front cover.)

**Disease cycle.** It is estimated that a single spore-horn will discharge as many as 8 billion spores, which are carried by wind and rain to apple leaves and fruits. The discharge of spores begins in early spring, usually when the apple buds are in the pink to early bloom stage, and continues until about June 10. If apples are not affected by then, they won't be affected during that season.

Within 5 or 6 hours after the spores reach an apple leaf, they attach themselves to the leaf and send a root-like germ tube into the leaf tissue. Here they develop, and after about 10 days of warm temperature, the first symptoms are visible. Several weeks later, after the infection tends to "mature," aecia develop on the underside of the leaf.

Spores called aeciospores are released from the aecia and are carried by the wind back to the red cedar. After becoming lodged in leaf axils and in cracks or crevices of the cedar twigs, they germinate, infect the twig, and produce galls. There is some question about exactly when the spores germinate and become firmly attached to the cedar twigs. It is spring when the first newly formed galls, about the size of a pea, appear. The galls do not produce spores until the second spring. The complete life history therefore requires two years.

**Control.** Cedar apple rust pathogens attack some varieties more than others. Most ornamental crabs are highly susceptible, as are Jonathan, Rome Beauty, Wealthy, and York Imperial. Golden Delicious, Grimes Golden, Delicious, Winesap, Stayman, Transparent, and Duchess are immune or only slightly susceptible.

This rust is fairly easy to control. Either ferbam, zineb, thiram, Dikar, Polyram, or formulations containing these chemicals are very effective on apples. Four sprays should be applied 7 to 10 days apart, starting at the pink stage to early bloom period. These chemicals will also prevent infection on cedar trees if applied in July and August.

Usually red cedar is quite common in wooded areas. Also, many species of *Juniperus* that are susceptible to cedar apple rust are commonly used as ornamentals. Eradication of cedar trees within two miles of apple orchards has been considered as a possible control measure, but is not very practical.

**Similar rusts.** Quince rust (described on page 22) and hawthorn rust (page 22) are very similar to cedar apple rust.
ever, if fruit is harvested at the proper stage of maturity and is stored properly, this disease is not serious.

**Virus Diseases**

While a large number of virus diseases may damage apples and pears, a comparatively small number are known in the midwestern states. Only the most prevalent will be discussed. There is no control for virus diseases in fruit trees except to rogue infected plants.

**Russet ring**

In some years this disease is fairly common on Golden Delicious apples, first appearing in midsummer. Fruit symptoms vary from a very narrow, irregular closed ring to a solid circle of russet 1 to 2 inches in diameter (Fig. 12). The leaves on spurs bearing russet-ring fruit are usually dwarfed and puckered, and sometimes they show chlorotic (yellowish) flecking. In general, the fruit attains normal size. The infection does not seem to harm tree growth in any way.

Russet ring has been observed for three or four years in Illinois. In 1962 it was widespread, appearing in seven different orchards. In one 30-acre block of Golden Delicious every tree had a few (less than 1 percent) russet-ring apples. Since then typical symptoms have been hard to find. Thus russet ring apparently follows some type of pattern based on the weather. In some years it could be of potential commercial importance.

**Stem pitting**

Apparently this virus is latent in most apple varieties but it manifests symptoms only in certain ones. It first became a serious problem when Virginia crab was top-worked with standard apple scions and as an interstock in sectional-type dwarf trees. Since then, a large number of crab apple varieties have been shown to be susceptible to this virus.

The symptoms appear only as deep longitudinal pits or furrows in the developing wood underneath the bark. The pitting develops in one-year-old wood and becomes more severe with age. There is no external evidence of these symptoms and they cannot be seen without removing the bark. The end result of a stem-pitting virus infection is a gradual tree decline and earlier than normal tree death.

**Apple mosaic**

Probably one of the most common apple viruses, apple mosaic has seriously reduced yields in some areas though not in the Midwest. The virus spreads very slowly from tree to tree. In one Illinois orchard it took 15 years to spread from one tree to two others. Symptoms appear as chlorotic leaves with the veins yellow and the interveinal area a light to medium yellow-green. Occasionally the veins are light green instead of yellow. Mosaic symptoms do not seem to encompass the entire tree; usually they appear on the leaves of only certain twigs. There are no symptoms on the fruit.

**Scar skin**

This virus has been reported in Missouri and has probably been overlooked in other midwestern states. In Missouri, the first symptoms appear in early June as light green water-soaked areas on the calyx end of the young fruit. As the fruit grows, scar tissue develops in the calyx end and later spreads to other areas. In severe cases, up to 50 percent of the fruit surface may be affected. With this potential, scar skin could be commercially serious when prevalent. It has been reported on Delicious, Jonathan, and Turley, while Golden Delicious is apparently tolerant to the disease.

**False sting**

Symptoms typical of the false sting virus first appeared in southern Illinois in 1962 on a sport of Duchess of Oldenburg, although the virus was never positively identified. During the next two years the symptoms spread through the block with a speed that is typical of false sting. One tree showed symptoms in 1962; by 1964, 15 trees were infected. All infected trees were then removed and the symptoms have not recurred.

When the fruit of infected trees are \( \frac{1}{2} \) to \( \frac{3}{4} \) inch in diameter, small depressions appear over the entire fruit. As the fruit enlarges, the depressions deepen and would easily be confused with apple maggot injury. The entire crop on an infected tree will show these symptoms. Wood growth is greatly retarded and by the third year the tree dies; once a tree develops symptoms it does not recover.

**Trunk twisting and flattening**

This condition was first observed in 1962 on five-year-old Golden Delicious on Malling VII rootstocks (Fig. 13). It since has been found on Delicious and Wine-sap but not on Jonathan. It has also been observed in these same varieties with Malling II and IX rootstocks. Affected trees are generally weak and enter into decline by the sixth year. That this is a virus infection still has not been confirmed. Some workers believe that it may be a physiological condition.
As an aid in identifying unknown diseases, all black and white illustrations have been grouped on this and the following pages. With each illustration is given the number of the page where the disease is described.

Alternaria cork rot, page 3. (Fig. 1)

Apple anthracnose, page 4. (Fig. 2)

Apple bark necrosis (measles), page 4. At right, outside surface has been sliced away to show underlying dark areas. These two pictures are used through the courtesy of A. B. Groves, Virginia Agricultural Experiment Station. (Fig. 3)
Apple blotch limb canker, page 4. (Fig. 4)

Apple blotch, page 4. (Fig. 5)

Apple powdery mildew, page 5. (Fig. 6)

Apple scab, page 5. (Fig. 7)
Bitter pit, page 6.  (Fig. 8)

Blister spot, page 7.  (Fig. 10)

Jonathan spot, page 8.  (Fig. 11)

Block pox, page 7.  (Fig. 9)

Russet ring, page 9.  (Fig. 12)
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Trunk twisting, page 9. (Fig. 13)

Black rot, page 18. (Fig. 15)

Black rot (frogeye leaf spot), page 18. (Fig. 16)
DISEASES AFFECTING APPLES AND PEARS

Armillaria Root Rot

This disease is caused by a mushroom-producing fungus, *Armillaria mellea*. It does not normally infect an entire orchard but it does cause the loss of a few trees, creating a production problem. It also complicates the replanting program because trees are seldom affected until they are old enough to bear fruit.

**Symptoms.** Armillaria is virtually impossible to diagnose in its early stages, for almost any condition which interferes with the normal nutrition of a tree will produce similar symptoms on the parts of the plant above the ground. The trunk may be girdled by mice, for example, or the tree may have suffered frost damage or collar rot infection, as well as Armillaria infection. A tree weakened in any of these ways will develop normally in early spring but will gradually decline as summer approaches and the water supply decreases. The only visible symptoms will be a weakness of foliage and twig growth. The tree may die by late summer or may survive for two or three years.

After an Armillaria infection is well advanced, one should expect to see groups of honey-colored toadstools around the base of the tree, but they are not present in the early stages of the disease when one wants to make a diagnosis.

An examination of the roots is sometimes helpful. This disease produces structures called rhizomorphs (or “shoestrings”) on the surface of dead root tissue as well as on dead wood of the above-ground parts. Rhizomorphs are dark brown or black threads, about the size of the lead in a pencil. Unfortunately, rhizomorphs are seldom seen in the Midwest until after the tree is dead.

One characteristic which may be useful is that root infections usually start on the outer extremities. This is because the infection mostly comes from old roots which have been left in the ground after a piece of timber, especially oak, has been cleared or an old orchard removed. After starting at the root ends, the infection works in toward the main root system. In other types of root infection, collar rot for example, the infection starts in the main root or crown area and spreads outward toward the root extremities. The terminal portion of the roots may be alive and undamaged while the main root is dead or dying.

**Disease cycle.** There is little to say about the disease cycle. The pathogen can survive on dead root tissue in a timber-cleared area. As fruit trees grow, the roots extend deeper and deeper in the soil until they reach the infected roots from the previous tree crop. In many parts of the country Armillaria spreads mainly by rhizomorphs, which grow rapidly over the root surface and other infected areas. The fungus also spreads by means of mycelial strands. It invades the root system, eventually girdling the tree at the crown area.

**Control.** No effort has been made in the Midwest to control this disease. When practical, new orchards should not be planted in old timber sites or in land which has had more than one orchard. In Illinois, a third orchard planting on the same land has brought Armillaria infections.

The soil can be disinfected with 2 ounces of carbon tetrachloride or carbon bisulphide injected 8 to 10 inches deep in spots centered 18 inches apart. This treatment has been effective on porous soil but it is very expensive and is of doubtful value in nonporous soil.

It is hoped that resistant rootstocks will be developed eventually. Two plum stocks, Myrobolan 29 and Marian 2624, have shown some resistance.

Bitter Rot

The fungus causing this disease is known as *Glomerella cingulata*. It has a very wide host range including privet, grape, peaches, apples, pears, and blueberry. On privet it causes a limb canker called anthracnose. On blueberry it may infect both twigs and leaves. On peaches, pears, grapes, and apples it infects the fruit. In the United States it is considered a warm weather disease, doing most of its damage in the apple belt south of 40° latitude, from the Atlantic coast to mid-Kansas. The optimum conditions for growth are a temperature of 85° F. and a relative humidity of 80 to 100 percent.

**Symptoms.** On apples and pears, only the fruits are infected (Fig. 14). Bitter rot is one of the few rots that infect the uninjured surface of the fruit. It is a fairly firm rot that starts as a small circular light brown area. One or many such areas may appear on a fruit. The spots enlarge rapidly, becoming darkened and almost black. A saucer-shaped depression in the center is a distinctive characteristic. When a spot has reached about 1/2 inch in diameter, fruiting structures appear in the center. Later they form concentric rings to the outside periphery. Soon they produce spores which ooze in a gelatinous, salmon-pink mass. These are washed by rain to other fruits.

**Disease cycle.** The bitter rot organism survives the winter mainly in mummified fruit and cracks or crevices in apple and pear wood. It overwinters in the mummified fruit and in the crevices of trees which have been injured by frost. In the spring, the hyphae grow inward to the heartwood of the tree and produce masses of spores which are then blown to other trees. The disease is spread by wind and rain. The fungus can also be spread by infected nursery stock and by equipment used in planting orchards.

**Control.** There is no effective control for bitter rot. The best control measures are to remove all infected fruit and to keep the trees free of injuries which may provide entry points for the fungus. In areas where bitter rot is a problem, it is advisable to plant trees which are resistant to the disease. Some resistant stocks include Myrobolan 29 and Marian 2624. In addition, it is important to keep the trees healthy by providing adequate water and fertilizer, and by controlling other diseases and pests. Regular pruning and thinning of the trees will also help to reduce the amount of infected tissue that is available for the fungus to attack.

It is also important to keep the orchard clean by removing all infected fruit and other debris from the orchard floor. This will help to reduce the amount of spores that are available for the fungus to infect the trees. Additionally, it is important to avoid planting trees in areas where bitter rot has been a problem in the past. This will help to prevent the disease from spreading to new areas.

Overall, the best approach to controlling bitter rot is to use a combination of cultural practices and resistant rootstocks. By following these strategies, it is possible to reduce the incidence of bitter rot and to keep the orchard healthy and productive.
ices in bark (such as the jagged, broken end of a limb). Infection can be traced to the end of a broken limb 99 percent of the time. Definite cankers are very rare.

As spring appears, the fungus grows and produces spores. Close observation will usually reveal that the source of spores is above the infected fruits. No one knows for sure when fruits are first infected although it is known that very immature fruits are resistant. The first symptoms may show up during July. Thereafter the disease develops rapidly as the fruit matures and the temperature remains high.

Under ideal conditions the incubation of this disease is about 4 days. Infection is well established by direct penetration of the cuticle in about 5 hours. With a temperature of 85°F and several light rains, one inoculum source can infect 70 percent of a 40-acre orchard within 14 days. The disease continues to develop in common storage but not, normally, in cold storage (33°F).

**Control.** All varieties grown in the Midwest are equally susceptible to bitter rot. If not controlled, the disease is devastating. It becomes progressively more difficult to control as one moves southward, but control is possible.

Usually infection arises from one or two trees in a block. A weekly inspection of the orchard will locate these trees. Since infection normally spreads tent-like from the source, search above the first few infected apples for the source of infection. If you find a broken limb, cut off the jagged end. Then spray with either captan or folpet at 7-day intervals until the spread of the disease is halted. As infected fruits appear, remove them from the orchard. Close vigilance will be rewarding; carelessness may cause a complete crop loss.

**Black Rot (Frogeye Leaf Spot)**

The black rot pathogen is *Physalospora obtusa.* It infects the leaves, fruits, and limbs of apple and quite commonly causes fruit rot on pear.

**Symptoms.** In the Midwest, black rot on the fruit always appears around an injury or open calyx end. (Fig. 15). Farther south, it may infect a fruit directly through the uninjured cuticle. Black rot is a firm-textured rot. Normally there is only one spot per fruit. The spot is first light brown, darkening with age. As the rotted area enlarges, a series of concentric dark bands are formed. These usually contain pycnidia, which develop as the spot matures. While spreading, the rotted area retains the convex contour of the apple. Eventually it may cover the entire fruit, which gradually becomes shrunk and mummified. (A color plate of an infected fruit is on inside front cover.)

On the leaf, many small purple specks are the first evidence of infection. As these slowly enlarge, they are seen to be irregularly shaped (Fig. 16). The margins retain their purple cast while the centers become brown or yellowish-brown. The entire effect has resulted in the popular name, “frogeye leaf spot.” Black pycnidia form in the center of the spots on the upper surface of the leaf. In some varieties such as Jonathan a few spots per leaf may cause defoliation early in the season.

Twig or limb cankers are apparently less important in the Midwest than in the South and East. They start as small, slightly sunken, reddish-brown areas. Some remain quite small and these usually die. Others, however, may expand a little each year until they cover several feet. These areas remain somewhat sunken except for the margins, which are slightly raised. The margins are also lobed, making identification easy.

**Disease cycle.** The black rot organism winters over in cankers, in mummied apples, and on dead wood. In the Midwest dead wood is the main source of infection.

In the spring many small black pycnidia and perithecia develop to produce conidia and ascospores that spread the infection. Leaf infection usually develops at the petal fall period. The incubation period is 2 to 4 days. With wet weather and a temperature of about 80°F, leaf infection can be very serious.

Fruit infection is not apparent before midsummer, but it is always worst when a severe leaf infection has occurred after petal fall. The calyx of the fruit may be infected early even though symptoms do not develop until later. Sugar content of the fruit has to be at a certain level for symptoms to appear.

All varieties are equally susceptible to fruit rot, but Jonathan appears to be most susceptible to leaf infection. The Twenty Ounce variety is very susceptible to limb canker symptoms. As a pathogen, the black rot organism is mostly confined to the pome fruits—apple, pear, and quince. As a saprophyte it will invade many different hosts and has been found on 75 or more.

**Control.** None of the present-day fungicides appear very effective against black rot. Sanitation is the primary control measure. In fact, 99 percent control can be assured if a special effort is made to remove all mummied fruit and dead twigs so that none are around during the growing season. The potential inoculum from just one dead twig, 1/4 inch in diameter, is tremendous. One inch of this twig can have 10 or more pycnidia, and each pycnidium will produce at least 1,500 spores. Trees should be kept in a good state of vigor, as weak trees will develop more limb cankers than trees with good healthy wood.
example, during the era of lead arsenate and lime sulphur, frog eye leaf spot may develop after chemical injury. For example, during the era of lead arsenate and lime sulphur, frog eye leaf spot was more common than today, when less phytotoxic chemicals are being used. Occasionally, however, two chemicals may be incompatible, causing leaf injury that is only microscopic but still enough to allow frogeye leaf spot to develop.

**Botryosphaeria Ribis (Bot Rot)**

This fungus disease has caused heavy crop losses in the Midwest. Some orchards have been so extensively damaged that they have had to be removed. *Botryosphaeria ribis* has a very wide host range of woody plants. It has been reported on currant, blueberry, blackberry, all stone fruits, grape, rose, quince, sumac, willow, chestnut, mountain ash, citrus, and gooseberry, as well as on apples and pears.

**Symptoms.** The Botryosphaeria fungus infects woody tissues and fruits, but not the leaves. On limbs and twigs, most new infections become visible in July, appearing as blisters filled with liquid. When a blister ruptures, the liquid spreads over the surface of the wood. The organism usually grows rapidly through the wet area, forming a sunken, dark-colored lesion (Fig. 17). This lesion may extend to the cambium on especially susceptible varieties such as Transparent and Rome Beauty. The lesion stops spreading in the fall, and the canker may split along the edges. Spore-producing structures (stromata) are formed on the surface of the lesion. The following spring, the lesion may cork off and become inactive, or it may start growing again, producing spores at periodic intervals throughout the summer. These spores then serve as a source of primary inoculum.

Fruit infections usually start as small, reddish-brown spots surrounding the lenticels (Fig. 18). As the fungus advances through the fruit, it forms a series of egg-shaped, rotted spots. The long axis of each spot is parallel to the axis of the core. These spots run together and ultimately involve the entire fruit, causing a “soft rot.” As the rot progresses, the skin color fades to a light brown, then turns a deeper brown (see color plate, inside back cover). Syrupy beads of exudate form on the surface of completely rotted fruit. Under favorable conditions, small black fruiting bodies filled with spores also develop. Golden Delicious and Grimes Golden appear to be the varieties most susceptible to fruit rot.

This type of rot does not necessarily show up in the orchard. Many times fruit becomes infected during the summer without showing symptoms. After it is removed from cold storage (33° F.), the rot starts to develop.

**Disease cycle.** The organism survives the winter in fruiting structures on both live and dead limbs. During spring rains these fruiting structures ooze spores which are washed to other parts of the tree. This oozing and dissemination of spores may continue all summer. Fruits may become infected early in the season but rotting does not develop until the fruit is near maturity. Mature and ripened fruits are very susceptible. At temperatures of 75° F. or above, rotting will develop on mature fruit within a few days after inoculation.

**Control.** Botryosphaeria infection is favored by any condition which reduces tree vigor, such as drought, winter injury, and low nutrition. When moisture is high and trees are vigorous, the lesions on limbs and twigs may be sloughed off, exposing healthy tissue underneath.

The disease can be controlled by judicious pruning and the normal fungicide program. Probably the most important means of control is to prune out all dead wood and remove it from the orchard. No fungicide is effective enough to depend on alone for control of this disease. However, fruit rot can be reduced by folpet, captan, or combinations of either material with zineb, if used all summer until harvest.

**Brown Rot**

Two species of fungi, *Monilinia fructicola* and *M. laxa*, cause brown rot on pome fruits. The disease is a very minor one in the Midwest, although in Europe and some other areas it causes problems similar to those of brown rot on stone fruits in this country. Here the *Monilinia* fungi will infect only those fruits which have been injured by insects, hail, or other mechanical means. Thus brown rot does not occur on apples or pears if insects are controlled and the fruits are not damaged.

**Collar Rot**

The fungus *Phytophthora cactorum* causes collar rot, for many years known as “Grimes collar rot disease.” This organism has a very wide host range of almost 200 species. It is a serious disease on peach seedlings in the nursery and will infect other stone fruits. On strawberries, it causes a root disease and also a fruit condition called leather rot. In some seasons it seriously damages apple and pear orchards, and is a particular problem on dwarf apple trees.

**Symptoms.** Normally collar rot appears at the ground line or not more than 30 inches above it.
Of the Malling-Merton stocks, MMI03, MMI04, MMI07, MMll0, MM1l3, and MM1l5 have shown resistant than MaIling II. The remainder (MMI06, MMI09, and MM1l1) are more little resistance. MM1l2 is intermediate, and the remainder, because of the many variables, the length of the winter application of copper oxychloride (1 pound for a mature tree; ½ pound for a young tree) gives effective control. Collar rot is difficult to distinguish from similar cankers caused by secondary invaders. For example, if a tree is injured by chemical fertilizers in the crown area, a canker may develop from many fungi and bacteria which ordinarily would not cause such an infection.

While collar rot infection normally occurs at the ground line, the canker may spread through the tissue up into the trunk or down into the root system. Root invasion usually begins in the crown area or at ground level. Infection migrates downward toward the tip, but normally it doesn't get that far. In a root disease such as Armillaria, infection usually starts at the tips of the roots and extends upward into the crown area.

Although *P. cactorum* does most of its damage on the main limbs and tree trunk of apples, it can also infect fruits of susceptible varieties such as Grimes Golden. Apples on the lower limbs, which may be a few inches from the ground, commonly develop a soft, brownish rot from zoospore infections.

**Disease cycle.** Not much is known about the organism's mode of infection. When the disease was first reported on the Grimes Golden variety, it was shown that infection did not occur until a tree was about eight years old. Thereafter the tree's susceptibility increased until it was about 15 years old. This was thought to be associated with the development of rough bark on the tree trunk. The theory was that the bark catches and holds the zoospores as they are splashed upward from the ground, and gives them a place to germinate. Since the early reports, it has been found that collar rot is not confined to mature trees. In fact, it is one of the main diseases in nurseries, where young trees are often severely infected.

Like most Phytophthora pathogens, *P. cactorum* is a cool weather fungus, being most active in the plant tissue at a temperature of 56° F. The apple tree is a cool weather fungus, being most active in the plant tissue at a temperature of 56° F. The apple tree is most susceptible while leaves and flowers are developing. In summer the pathogen becomes relatively inactive, but it may resume activity in the fall and cause new infections both then and early in the following spring. It is more difficult to culture the fungus from infected tissue in midsummer than in early spring or late fall. Secondary infection from cankers has little significance.

The pathogen survives the winter as mycelium in a trunk canker or in soil, or as oospores in the soil. All new infections arise from the soil. In early spring the oospores may germinate or the mycelium may start to grow. In either case, sporangia develop from which zoospores arise. While the mycelium may infect the bark at the ground line, it is quite certain that the zoospores are splashed and disseminated by rain drops. Artificial inoculations have been successful both when a zoospore suspension has been sprayed on apple twigs and when a piece of infected bark containing only mycelium has been inserted into apple tissue. Because of the many variables, the length of the incubation period has not been exactly determined. Generally, under Midwestern field conditions, symptoms appear about 30 days after infection.

**Control.** Collar rot is very difficult to control on susceptible varieties, partly because it is very erratic. It may not appear for several years, then after one season of cool, wet weather during the prebloom period, an entire orchard can be destroyed. Often the infection is not discovered until the damage is done.

Work in New Zealand indicates that a winter application of copper oxychloride (1 pound for a mature tree; ½ pound for a young tree) gives effective control. The chemical is mixed with enough water to cover the tree trunk and the soil for a radius of 3 feet around the base of the tree. Other workers have used Bordeaux mixture, at various concentrations, in a similar manner. If infections are seen before they have advanced too far, a trunk spray of copper may prevent further development.

Resistant varieties and rootstocks offer the most effective means of controlling collar rot. Of the standard midwestern varieties, Delicious, Winesap, and Wealthy are highly resistant. Jonathan, Golden Delicious, McIntosh, and Rome Beauty have a moderate amount of resistance. Lodi, Grimes Golden, and Duchess are extremely susceptible. The disease has been successfully controlled by "double-working" susceptible varieties on a resistant variety. Grimes Golden on a Delicious trunk is a standard practice. The susceptible stock should be at least 30 inches above the ground level so that it can't be reached by zoospores splashing from the ground.

Of the Malling rootstocks, Malling IX and VII are considered quite resistant, but all others are thought to be susceptible.

Of the Malling-Merton stocks, MM103, MM104, MM107, MM110, MM113, and MM115 have shown little resistance. MM112 is intermediate, and the remainder (MM106, MM109, and MM111) are more resistant than Malling II.
Crown Gall and Hairy Root

Both crown gall and hairy root are bacterial root diseases. Crown gall, the more common of the two, is caused by Agrobacterium tumefaciens. It has a very wide host range of at least 63 different plant genera including apples and pears. Hairy root, caused by Agrobacterium rhizogenes, has been reported only on apple. Although these diseases have different symptoms, they are otherwise very similar.

Symptoms. Crown gall causes a gall, or tumorlike malformation, on the roots (Fig. 20). Galls will vary from ¼ inch to 3 or 4 inches in diameter. The surface of the gall is very rough and irregular and becomes somewhat darker than the normal root. Occasionally galls are soft and fleshy, but usually they become firm to hard.

Hairy root appears as the name implies. It starts with a protuberance similar to crown gall. Soon fairly thick, fleshy-type roots develop from the protuberances. Eventually secondary roots appear. Excessive fibrous root growth gives the hairy or wooly appearance which characterizes this disease.

Disease cycle. The bacteria enter the roots through wounds. The deeper the wound, the more susceptible the root is to infection. New grafts are ideal infection sites. Root insects cause enough damage to allow bacterial infection. If bacteria are in the soil, root-feeding insects may actually inoculate the root.

Infection may occur at any time during the growing season if bacteria are in the soil and the roots become injured. Once a gall is begun, it may continue to enlarge for several years.

As the galls form, many bacteria are produced on the surface. These are washed off into the soil with rains. Bacteria will survive in soil for many years independent of plant tissue.

Control. Nurseries are required to destroy plants infected with these diseases. However, some infected plants may slip by unnoticed. Do not plant trees having abnormal root overgrowths or enlargements. Be extremely careful not to injure the roots by hoeing or in any other way. Before planting, treat the soil with an insecticide to prevent injury from root-feeding insects.

If soil is infested with the crown gall or hairy root organisms, it should be cropped with nonsusceptible grains for several years before susceptible crops are planted. There is no good method of sterilizing infested soil. However, one suggestion is to drench soil with a solution containing 1 pint of 40-percent formaldehyde in 6 gallons of water. Apply ½ gallon of this solution to 1 square foot of soil surface, making certain the solution penetrates to at least 4 inches. There is some evidence that the bacteria are more prevalent in alkaline than in acid soils.

Thus far there is no evidence that any variety is resistant to crown gall or hairy root.

Fire Blight

Fire blight is caused by the bacterium Erwinia amylovora. It is one of the most serious diseases of apple and pear, and attacks as many as 75 other hosts, including quince, pyracantha, spiraea, hawthorn, and mountain ash.

Symptoms. Blossoms, twigs, leaves, and fruits can all be infected. Common symptoms are a blighting of the blossoms and terminal growth or twigs. Terminal or twig blight is especially prevalent, occurring almost every year on susceptible varieties of both apples and pears. (Terminal blight on pear is shown in color on inside back cover.) Blossom blight is very common on pears but may not occur each year on apples in the Midwest.

Infected blossoms suddenly wilt and soon turn a light to dark brown. As the disease progresses down the pedicel, the tissue becomes water-soaked and dark green. Droplets of a clear, milky ooze appear on the surface of the infected tissue. These contain bacteria which can cause new infections.

Most of the time blossom infection does not travel beyond the pedicel, so that the leaves of the spur do not become infected. Sometimes, however, the bacteria do continue the invasion down into the spur and out into leaves, following the midrib and main veins, which are soon darkened. The leaves wilt, and the entire spur growth turns brown and dies. These leaves remain attached throughout the summer.

Twig blight starts with an infection of the young, succulent, growing tip of the terminal growth. After symptoms first appear, infection travels very rapidly down this terminal shoot, at the rate of 6 to 12 inches daily. Newly infected tissue becomes watery, dark green, and somewhat oily. Under ideal conditions droplets of ooze will appear on the fifth day after infection. As in spur blight, the leaves on the invaded terminal turn a light to dark brown and remain attached throughout the summer. The end of the terminal bends, resembling a shepherd’s crook (Fig. 21).

On a severely infected tree, a high percentage of terminals will be blighted back 12 to 36 inches, depending on terminal length. In young trees, the bacteria may continue infection down the limb to girdle the tree trunk and kill the tree.

Disease cycle. The bacteria winter over in limb and twig cankers, and start to multiply as spring ap-
proaches. By the time trees are in the full-pink to early-bloom stage, the bacteria start oozing to the surface of the canker, and may continue oozing until midsummer. Rains, wind, and insects all help to spread bacteria from the oozing cankers to the blossoms and new leaves. With optimum temperatures of 76° F., the incubation period on newly formed blossoms and tender succulent leaves is about 4 days. Shortly after new infections appear they produce droplets of ooze which contain bacteria for secondary infections.

Most of the twig blight infection is caused by bacteria which are blown through the air in bacterial strands. These strands become lodged in various portions of the tree. Rain or other moisture dissolves the gelatinous matrix of the strand and the bacteria enter the stomata of the leaf tissue. Water-soaked leaves are extremely susceptible to bacterial invasion. The more tender or succulent the leaf, the more subject it is to water soaking. Thus the tender leaves of the terminal growths are the ones to become infected. In a normal season, twig blight starts the first part of June, reaches a peak by June 25, and tapers off until August 1, after which no infection normally occurs.

Control. Some varieties of apples and pears are more susceptible to fire blight than others. Jonathan, Rome Beauty, Wealthy, Willow Twig, and Transparent apples and Transcendent crabapple are very susceptible. During warm, rainy weather Golden Delicious, Delicious, and Stayman Winesap have developed twig infections. Bartlett, a high-quality pear, cannot be successfully grown in the Midwest because of this disease.

Like most plant bacterial diseases, fire blight is very difficult to control, but it can be reduced with chemical spraying and sanitation.

The most effective material is streptomycin, an antibiotic. The first spray should be just before the blossoms open (full pink stage). Since the material loses its effectiveness 4 days after application, the sprays should be repeated at 4-day intervals during the blossoming season.

Bearing trees may be sprayed with streptomycin up to 50 days of harvest for control of twig blight. A 7-day schedule is suggested during the main infection period. Streptomycin is most effective when applied at night. Nonbearing trees may be sprayed with streptomycin as often as considered necessary.

A 1-2-100 Bordeaux spray, made by mixing 1 ounce of copper sulfate (Bluestone or bluevitriol and 2 ounces of hydrated lime in 6 gallons of water, may be used. However, it is not as effective as streptomycin.

Good sanitation is advisable. When infection first appears in the spring, prune out infected branches. Be sure to cut 6 inches below the last point of visible infection. After each branch is pruned, sterilize the knife in a 5-percent solution of clorox.

If necessary, continue pruning through the winter. Pruning is less likely to spread the disease in winter than in spring, but to be safe make cuts 2 to 4 inches below the last point of visible infection. Cut into the large trunk cankers, removing all discolored tissue, and paint them with a mixture of 1 quart of distilled or rain water, 3 quarts of commercial glycerine, and 1/4 ounce (16 tablets) of cyanide of mercury. (CAUTION: Cyanide of mercury is a deadly poison.)

Heavy applications of nitrogen fertilizers will promote tree vigor but will increase susceptibility to blight infections. For blight-susceptible varieties, it is best to use either manure or complete fertilizers with fairly low nitrogen content.

**Hawthorn Rust**

A very common disease in the Midwest, hawthorn rust may infect apple and pear foliage and fruit. Symptoms are very similar to those of cedar apple rust (page 7). The spray program recommended for cedar apple rust will also control hawthorn rust.

**Quince Rust**

This rust may infect quince leaves and fruit and apple fruit, but not apple leaves. It has also been reported on pear fruit.

Fruit lesions are somewhat similar to the ones caused by cedar apple rust (page 7), except that they are larger, are dark green, and may greatly retard apple growth at the point of infection, causing deep, crater-like depressions (Fig. 22). No aecia are produced. Apple varieties which are resistant to cedar apple rust are usually susceptible to quince rust. Among the highly susceptible varieties are Golden Delicious, Delicious (Red), and Winesap.

The spray program recommended for cedar apple rust will also control quince rust.

**Sooty Blotch and Flyspeck**

Normally sooty blotch and flyspeck appear together on the same fruit (Fig. 23 and color plate, inside back cover). Rarely is one disease seen without the other. For that reason they are being considered together even though they are two separate diseases caused by two different fungi. Sooty blotch is caused by *Gloeodes pomigena*; flyspeck, by *Microthyriella rubi*. Both fungi infect leaves and stems of many different hosts such
as sumac and Rubus spp., as well as the fruits of apple and pear.

**Symptoms.** Sooty blotch is also called "sooty smudge" because hundreds of dark, minute pycnidia give a smudged appearance to the affected fruit. A closer examination will show that the pycnidia are all connected with rather loose, profusely branched thread-like fungal growths (hyphal threads). The fungus is superficial but can only be removed by vigorous rubbing.

Flyspeck consists of definite, circular, black, often glistening spots resembling true flyspecks. These occur in groups, with 10 to 50 specks in each group, but are more widely scattered and larger than sooty blotch pycnidia. The flyspeck structures are asccarps or thyriotheca (morphological base of ascocarp is inverted). While they appear to be isolated, all asccarps in an infection site are connected by a hyphal strand.

**Disease cycle.** Both fungi winter over on twigs of many wild hosts. Sooty blotch conidia are disseminated by wind into orchards from late May or June until fall. Here they infect fruit, twigs, and other parts of the tree. The fungus is active only in humid, cool weather. In late spring, with the approach of warm weather, growth is inhibited and symptoms seldom appear. As the temperatures cool in late summer, the fungus starts growing again. The optimum conditions for its development are a temperature of 65° F. and a relative humidity of 80 to 95 percent. Under ideal conditions, the incubation period may be as short as 5 days. In the field, however, it is usually 20 to 28 days on fruits 42 to 45 days old.

The life cycle of the fungus is little affected by the apple infections, since they do not produce conidia. However, conidia on the wild hosts cause new infections so that the pathogen is always present.

The flyspeck fungus also comes from wild hosts. Both ascospores and conidia are disseminated into the orchard, starting in the late spring. This fungus has an incubation period of about 15 days with cool temperatures. It requires the same moisture and temperature conditions as sooty blotch. This is undoubtedly why they are always seen together.

**Control.** With ideal weather these two fungi can infect a very high percentage of the fruit. Normally, however, such infections are confined to the lower, shaded areas of the orchard. The normal apple fungiicides such as captan, zineb, and glyodin will control these diseases satisfactorily. Should spring infections occur, the fungiicides will stop them. The most crucial period is late summer, after fungicide sprays have been discontinued. Captan sprays after infections first appear will halt the spread of the diseases.

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**Storage Rots**

Several fungi cause fruit rot even when apples are stored at 33° F.

*Penicillium expansum* causes a soft rot (Fig. 24) which is sometimes called "blue mold" because of the bluish spores that develop on the infected fruit surface. These spores are easily disseminated by air currents and are generally present in storage and other areas. *Penicillium* is especially prevalent on fruit with bruised or broken skin. Apples which are handled roughly during harvest are extremely susceptible to soft rot in storage. Sanitation and careful handling are suggested for control. Disinfecting the storage and grading equipment with clorox or a similar disinfectant before harvest usually helps in controlling this disease.

Species of *Alternaria* sometimes infect open calyx varieties such as Red Delicious during late spring. These pathogens enter the calyx and invade the core or carpel area, causing a disease called core rot. The disease is most likely to appear in apples which have been damaged by late spring frosts so that seeds do not develop normally. Sometimes the infection continues to the outside flesh and appears externally as a brown rot. When this happens, the entire central portion is rotted, as can be seen by cutting the fruit in half. External symptoms may not develop until after the fruit has been stored for several weeks and the disease may remain undiscovered until that time. In the orchard infected fruits may mature and color faster than normal fruits.

*Alternaria* species are very commonly isolated from fruits showing storage breakdown. This may be due to the fact that spores of this fungus are very common in the air during late summer and are more usually secondary invaders rather than being highly pathogenic. Thus far, no control measure has been developed for this disease.

A third fungus, *Corticium centrifugum*, may also invade apples in cold storage, causing a disease commonly called fisheye rot. This rot does not often occur, but it was reported recently in Illinois in Golden Delicious which were stored in pliofilm bags. Infected apples show one to three light brown, slightly depressed lesions ½ to 1½ inches in diameter, usually in the calyx area. The lesions are somewhat soft and watery and may extend into the core.

The disease develops at 33° F. on fruit maintained at a very high relative humidity. This may explain its development on apples that were stored in pliofilm bags to prevent dehydration. Apples which were artificially inoculated developed symptoms in about 5 days, with the depressed lesions showing in about 3 weeks.
DISEASES AFFECTING PEARS

Leaf Blight and Fruit Spot of Pear

The fungus *F. fabraea maculatum* causes leaf blight and fruit spot of pear (and quince), and also affects the twigs. Leaf infections are called leaf blight to distinguish them from another leaf spot disease. *F. maculatum* is the most common cause of fruit spot on pears in the Midwest.

**Symptoms.** Leaf spots first appear as small purple lesions (Fig. 25), about \(\frac{1}{4}\) inch in diameter, which later become deeper purple or dark brown. A fruiting structure (acervulus) appears in the center of the lesion and exudes a gelatinous mass containing conidia. Each leaf may have 100 or more such lesions. As a result, many leaves will fall early in the summer.

Fruit spots, which also reach about \(\frac{1}{4}\) inch in diameter, are black and slightly depressed (Fig. 26). Many times they coalesce to cover one-fourth to one-third of the fruit surface.

Twig lesions occur on the current season's growth as small, indefinite, purplish to black lesions which may coalesce and form a canker.

**Disease cycle.** Apothecia develop on infected fallen leaves during the winter, but these are apparently rare and play little part in the disease cycle. Spring infections mainly arise from conidia which develop on twig cankers. These are washed to the leaves by early spring rains. The incubation period is about 1 week, but acervuli are not developed in the new lesions until 2 weeks after infection occurs. Secondary infections occur throughout the summer with an optimum temperature of 75°F and adequate rainfall.

**Control.** Varietal differences in susceptibility exist but are insignificant. Kieffer, a popular Midwest variety, is considered to be only moderately susceptible, but in some years it may be seriously defoliated.

Fungicides will control the disease very effectively. Starting with the first full leaf development, apply four sprays at 2-week intervals. Wettable sulfur, captan, ferbam, and insoluble copper can be used at normal strength. Bordeaux mixture 4-6-100 is also satisfactory.

Pear Scab

This disease is caused by *Venturia pirina*, a fungus which is closely related to the one causing apple scab. Symptoms of the two diseases are very similar (Fig. 27), the main difference being that twig infections are common with pear scab. From them conidia are produced for early spring infections. The fungicide program recommended for pear leaf blight will give adequate control. Thus far, varietal differences in susceptibility are not important. Scab is considered a very minor pear disease in the Midwest.

Stony Pit of Pear

This virus disease is one of the most common on pears. The Bosc pear is considered very susceptible and most of the work on stony pit has been done with this variety. Occasionally, however, a Kieffer or Bartlett fruit will be seen which, to all appearances, has stony pit symptoms. The symptoms appear early after petal fall and consist of dark green areas under the epidermis of the fruit. At maturity the fruit is pitted, gnarled, and deformed. The flesh of infected fruits becomes woody, or stony, as the name implies (see color plate, inside back cover). Twigs commonly show symptoms similar to those of apple bark necrosis (page 4). Leaves may show veinlet chlorosis or yellowing. Once a tree becomes infected, it continues to show typical symptoms every year.

The only effective control measure is to destroy infected plants.

Pear Leaf Spot

Pear leaf spot is of minor importance except possibly in nursery plantings. It is caused by the fungus *Mycosphaerella sentina*, which has the asexual Septoria spores.

**Symptoms.** The fungus infects only the leaves. It causes typical Septoria symptoms which are easily distinguished by their grayish-white centers and well-defined margins. The lesions are mostly \(\frac{1}{8}\) inch in diameter. Usually in a normal infection each leaf will have 25 to 30 spots. In the grayish center of each spot are formed numerous small, black pycnidia from which conidia come to cause secondary infection. When leaf spot is serious, leaves fall in late summer.

**Disease cycle.** The fungus winters over on the dead leaves under the trees. Perithecia develop in the lesions during the winter and discharge ascospores in the spring. These spores cause the primary infections. The lesions develop slowly and after a month form pycnidia which produce conidia for secondary infections. Although secondary infections may occur all summer long, the peak infection usually develops during late summer and fall.

**Control.** Leaf spot is easily controlled with the same fungicide schedule recommended for the leaf blight and fruit spot disease previously described.
APPLE BUD STAGES

1. DORMANT
2. SILVER TIP
3. GREEN TIP
4. HALF-INCH GREEN
5. TIGHT CLUSTER (PRE-PINK)
6. PINK