An Introduction to Plant Diseases

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Learning Objectives

1. Gain a general understanding of disease concepts.
2. Become familiar with the major pathogens that cause disease in plants.
3. Gain an understanding of how pathogens cause disease and their interactions with plants.
4. Be able to distinguish disease symptoms from other plant injuries.
5. Understand the basic control strategies for plant diseases.
Introduction to Plant Diseases

The study of plant disease is covered under the science of Phytopathology, which is more commonly called Plant Pathology. Plant pathologists study plant diseases caused by fungi, bacteria, viruses and similar very small microbes (mlos. viroids, etc.), parasitic plants and nematodes. They also study plant disorders caused by abiotic problems, or non-living causes, associated with growing conditions. These include drought and freezing damage, nutrient imbalances, and air pollution damage.

A Brief History of Plant Diseases

Plant diseases have had profound effects on mankind through the centuries as evidenced by Biblical references to blasting and mildew of plants. The Greek philosopher Theophrastus (370-286 BC) was the first to describe maladies of trees, cereals and legumes that we today classify as leaf scorch, rots, scab, and cereal rust. The Romans were also aware of rust diseases of their grain crops. They celebrated the holiday of Robigalia that involved sacrifices of reddish colored dogs and cattle in an attempt to appease the rust god Robigo.

With the invention of the microscope in the seventeenth century fungi and bacteria associated with plants were investigated. In 1665, Robert Hooke published the first illustration of rust on a rose leaf. Advances in the study of disease life cycles were hampered by the widely held beliefs of "spontaneous generation". This theory, held by most people in the mid 18th century, considered pathogenic microorganisms as products of disease rather than causal agents of disease.

The devastating epidemics of Late Blight of Potato in Ireland in 1845 and 1846 dramatized the effect of plant diseases on mankind. Tragically these epidemics caused famine and death for over a million people and resulted in a loss of nearly a third of Ireland's population between 1845 and 1860. In 1861, a German botanist Anton De Bary proved that a fungus, Phytophthora infestans, was the causal agent of late blight of potato. This was a milestone in the study of plant disease since it showed that a fungal pathogen was indeed the cause of late blight of potato rather than an organism simply associated with the disease. Two years later in 1863, Louis Pasteur proposed his germ theory of disease that finally disproved the theory of spontaneous generation. This milestone essentially changed the way modern science investigated the diseases of all living creatures.

Late blight of potato has recently become a major problem for potato growers and home gardeners alike as new forms of Phytophthora infestans have migrated to the United States.
Significance of Plant Diseases in the United States

A few examples of plant disease epidemics that have resulted in devastating plant losses in the United States include: Chestnut Blight, introduced in 1904, this disease has virtually eliminated Chestnut trees from North America, Citrus Canker, introduced in 1910 and a closely related bacterium called Citrus Bacterial Spot discovered in 1984, have resulted in the destruction of millions of citrus trees, White Pine Blister Rust, introduced in 1912, has caused large economic losses in the timber industry, and Dutch Elm Disease, introduced in 1930, continues to destroy large numbers of elm trees from the east coast to the Midwest. As a direct result of severe disease losses from imported diseased plant material plant quarantine laws were passed by congress in 1912 to intercept diseased plant products before they could threaten our agriculture. The Agricultural Plant Health Inspection Service (APHIS) has quarantine inspectors stationed at points of entry into the country as well as certain interstate points to intercept produce likely to introduce new plant pathogens. Individual states also have inspection programs that help prevent new diseases from entering their areas.

The Concept of Disease

There are many ways to describe or define what a plant disease is, however simply put, a plant disease is a condition of a plant of abnormal growth or function.

A sampling of disease definitions include "a profound physiological and morphological change within the host that causes a disruption of normal plant function", "a harmful alteration of the normal physiological and biological development of a plant", "a condition involving abnormal changes in the form, physiology, integrity, or behavior of a plant", or "an injurious physiological process, caused by chronic irritation from a primary causal factor, exhibited through abnormal cellular activity and expressed in characteristic symptoms".

Symptoms are the visible reactions of a plant to a disease and may suggest a causal agent. A sampling of disease symptoms might include wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth or stunting of the infected plant. However it is important to remember and frustrating at times to realize that different disease agents can cause similar symptoms on the same host. An equally important point to remember is that insect feeding can also cause "disease like" symptoms on plants.

Signs are the visible parts of the pathogen or its products seen on the host that can be used to identify the pathogen. Examples of common disease signs would include the white coating of mycelium visible on powdery mildew infected leaves, mushroom growth on a tree limb, droplets of bacterial ooze running down a fruit tree twig, nematode cysts on plant roots, or dark fungal fruiting bodies visible in leaf lesions.
Causal Agents of Disease

A pathogen is a living organism that can incite a disease. Pathogens cause infectious diseases that can spread from an infected plant to a healthy plant. Examples of pathogens that cause infectious diseases are bacteria, fungi, viruses, nematodes and parasitic plants. Plant diseases can also be caused by noninfectious (abiotic or nonliving) factors. Causes of disease by nonliving factors include problems associated with growing conditions such as drought and freezing damage, nutrient imbalances, and air pollution damage.

Some pathogens are restricted to a single plant species while others can infect a single plant genus and there are still others that can attack a large number of hosts that span many plant genera.

There are also several levels of parasitism that pathogens can have with their hosts. When a pathogen is capable of infecting a plant, the plant is considered susceptible to that pathogen. If a pathogen cannot infect a plant then the plant is considered resistant to that pathogen. Plants can vary in their response to pathogens from complete resistance, or no disease development to partial resistance, or a little disease development.

Inoculum and Pathogen Dissemination

Inoculum is any part of the pathogen that can cause infection. Examples of inoculum include fungal spores, bacterial cells, virus particles, or nematode eggs. Inoculum that survives the winter and causes the original or primary infection in the spring is called primary inoculum. Secondary inoculum causes additional infections throughout the growing season.

Inoculum is sometimes present at the site where a plant is grown and it can also be introduced from an outside source. Examples of inoculum already present at a planting site would include soil pathogens or pathogens that overwinter on perennial weeds. Examples of introduced inoculum would include infected plant material such as infected seeds, wind blown fungal spores and inoculum brought in by insect vectors.

Inoculum can be disseminated passively by wind, rain, insect vectors, and man, or disseminated actively such as nematodes or fungal zoospores swimming through water in the soil toward plant roots. An important concept to remember is that only a fraction of any pathogen’s inoculum will ever land on a susceptible host. The vast majority of inoculum typically lands on material that cannot be infected. Most pathogens produce a tremendous surplus of inoculum.
Pathogen Survival

Pathogens in temperate climates must have a way of overwintering when their host plants are dormant or absent. In perennial plants, pathogens can survive in infected plant parts such as roots, bulbs, stems, and bud scales. Annual plants, however, die at the end of the growing season and pathogens must survive in insect vectors, seeds, or form resistant resting structures.

Host Pathogen Interactions

The interactions of the three components of disease may be diagrammed as a disease pyramid. Plant disease occurs when a susceptible plant is infected by a pathogen under environmental conditions that favor disease, and enough time occurs for the three to interact. Each of these components can affect the amount of disease that occurs. For example, a host plant can have variable levels of resistance to the pathogen or may be at a nonsusceptible growth stage for infection. The pathogen may vary in its virulence to the host, or may not be present. The environment can influence disease levels through fluctuations above, or below the optimum temperature and humidity level needed for infection. The weather can also affect pathogen dispersal by wind, or rain, and can alter the migration of insect vectors. Lastly, the pathogen, host plant, and favorable environment conditions can occur together but if they cannot interact for a certain amount of time then disease cannot develop.

Description of Plant Diseases and Their Pathogens

In this introductory module I will attempt only a cursory summary of the many pathogens that you may encounter in your master gardener activities. I have organized the examples of pathogens and the diseases they cause taxonomically and have tried to give a few examples of the diseases they cause in order to treat a seemingly baffling mixture of plant diseases in a limited space.

A listing of many common plant diseases are described in Table 1. Symptoms and a partial list of susceptible plants are included. Many of these diseases can also be found in Bulletin 74, Guide to Pest Management Around the Home.

Plant Diseases Caused by Fungi

The study of fungi is called mycology after the Greek word mykes which refers to fungi. Fungi are filamentous organisms that are for the most part microscopic, but some produce large structures such as toadstools or mushrooms. Approximately 100,000 fungal species have been described and most of them are beneficial or benign. There are about 8,000 fungal species that cause plant diseases. Since fungi lack chlorophyll they cannot manufacture their own food and therefore need to draw their sustenance from other living things. Fungi grow as microscopic threads or
filaments that branch in all directions. These filaments are called hyphae, which originates from a Greek word for web, and many hyphae are collectively called mycelium. Specialized aggregates of mycelium with a hard rind, known as sclerotia, enable some fungi to survive unfavorable climatic conditions.

Reproduction

The main reproductive unit is the spore. Spores are frequently formed in specialized structures on the mycelium. Fungi can be differentiated and identified by their spore morphology and spore bearing structures. They can also reproduce by regenerating from pieces of mycelium.

Asexual spores involve no genetic changes and are simply a means of dispersal or survival. Sexual spores are the result of a recombination of genetic material and give rise to genetic variation in a fungal species. This variation enables a fungus to adapt to a variety of conditions.

I Plant Pathogenic Fungi

A. The Water Molds, Downy Mildews and White Rust (class Oomycetes)

This class of fungi contains the water molds, so called because of their dependance on wet conditions for reproduction and growth. This class also includes the downy mildew and white rust fungi. They form thick walled spores called oospores. The oospores can survive adverse conditions. They also produce motile spores than can swim through water.

The genera Pythium and Phytophthora are two important members of the water mold group. The genus Pythium causes damping off diseases of many plants as well as seed decay, root rots, and also blights on turf grass. Phytophthora is famous for the disease, late blight of potato, as well as the causal agent for root diseases on a wide variety of landscape plants. Dispersal is by transport by spores that can swim in water or by transport of oospore infected plants or soil.

Another group of organisms in this class are the downy mildew fungi. Examples of diseases in this group are downy mildew of grape, caused by genus Plasmopora, downy mildew of lettuce caused by the genus Bremia, and downy mildew of onions caused by the genus Peronospora.

The genus Albugo is called the white rust fungus because of the white pustules formed on diseased plants. An example of a disease caused by Albugo is white rust of crucifers. Spore dispersal for this disease is accomplished by wind.
Examples of Diseases caused by Fungi in the Oomycetes

Phytophthora Diseases of Rhododendron

Plants in the genus Rhododendron, are known to most homeowners as species and cultivars of azaleas and rhododendrons. Phytophthora causes root rot and dieback of rhododendrons in the landscape. The fungus becomes a problem where there is excess moisture. Infected roots die and cause the leaves to turn yellow. Leaves wilt and will typically roll inward towards the leaf midrib before turning brown. Highly susceptible cultivars can die within two weeks, while more resistant plants may not turn brown until weeks after the plants have developed wilt symptoms. The entire root system may become diseased or portions may escape infection and support the plant until other stress factors cause death. On older plants symptoms of root rot may be present a season or more before death. In such cases plants often decline in vigor and suffer additional damage from other pathogens or insect pests.

Phytophthora dieback of rhododendron is caused from inoculum splashed onto the foliage from the soil. Plants with dieback develop symptoms on current season growth. Infected leaves show chocolate brown lesions that can expand and cause dieback of shoot tips. Infected leaves curl inward and remain attached to the stem. In most cases dieback is restricted to current seasons growth and mature leaves are resistant. However if mature leaves become infected though the petioles they usually fall off shortly after infection.

Pythium Seed Rot and Damping Off

Damping-off caused by Pythium, affects seeds, seedlings and seedling roots both during germination and after emergence. Damping-off also affects young transplants but rarely kills older plants, although these plants can develop root lesions and become stunted. The first indication of seed rot are usually poor stands or low germination rates. Seeds become soft, mushy, then turn brown and eventually disintegrate. Seedlings that have already emerged suffer root damage at or just below the soil line. The infected tissues become discolored and collapse which leaves the lower part of the stem much thinner than the upper part of the seedling. This causes the seedling to fall over and as the fungus continues to infect the remaining tissue, the seedling quickly withers and dies. When disease conditions are optimum the fungus can be seen as a fine webbing on the invaded tissue. Several other fungi belonging to other fungal groups can also cause damping off.

B. The Bread Molds (class Zygomycetes)

Members of this class of fungi are called the bread molds, named after one of the principle organisms in the class, Rhizopus. This fungus is frequently seen on moldy bread. The spores are wind blown.
An Example of a Disease caused by a Zygomycete

**Choanephora Soft Rot of Squash**

Soft rot of squash, caused by *Choanephora*, appears first on the blossoms or at the blossom end of the fruit. The fungus growth develops on the surface of the infected tissue and looks like dark headed pins in a pin-cushion. Affected flowers collapse quickly and the disease continues to spread into the fruit. Infected fruit becomes soft and begins to rot within a couple of days. Inoculum can be spread by wind, bees and cucumber beetles. This disease is favored by periods of high humidity and rainfall.

**C. The Sac Fungi (class Ascomycetes)**

These fungi are called the sac fungi because the sexual spores (ascospores) are enclosed in a microscopic sac (ascus). In turn, the sacs are often within fruiting bodies (structures that contain spores) that resemble tiny black dots to the unaided eye. Other times, however, the sacs are "naked" and not contained within any structure. Asexual spores produced are called conidia.

**Oak Leaf Blister**

Oak leaf blister is caused by the fungus *Taphrina coerulescens*. This fungus produces its sexual spores (ascospores) in a naked layer of sacs on the leaf surface. The symptoms begin in the spring on the developing young leaves as they expand. Spores that survived the winter on bud scales are carried by rain or wind to the leaves where they penetrate and infect directly through the leaf cuticle. As the mycelium begins to grow in the leaf tissue it causes cell enlargement and distortion of the developing leaves. As infection progresses the hyphae push through the leaf surface and produce a felt-like layer of sacs on the leaf surface. The new spores will infect other young leaf tissue. As leaves mature they become resistant to infection. This disease is favored by cool temperatures and high humidity at the time of bud break.

**Powdery Mildew of Lilac**

Powdery mildews are usually host specific (i.e. one species of fungus usually only attacks one genus, or even just one species, of plant). They grow over the surfaces of leaves as well as twigs and stems. Powdery mildew of lilac is caused by the *Microsphaera syringae*. The fungus produces sexual spores (ascospores) in a sacs contained within tiny, black fruiting bodies. These are often visible as small black specks within the coating of white mildew. The fungus overwinters as spores on fallen leaves. Spores are carried to the leaves by air currents. The first symptoms of infection usually occur in mid summer as a superficial white coating of mycelium on older leaves. Disease spread occurs as asexual spores (conidia) are released from the surface layer of mycelium. Powdery mildew spores are some what unique in that they
don't require high humidity levels to cause infection. The disease is more severe on common lilac than other varieties.

Sycamore anthracnose is caused by *Apiognomonia veneta*. The pathogen is in the class of ascomycetes that produce their ascospores within a dark colored perithecium. This disease includes leaf anthracnose, twig blight and canker symptoms on plane trees and sycamores. The disease cycle is most active in cool wet weather. This pathogen overwinters in the twigs and buds and will cause dieback of these tissues. Repeated twig dieback will result in crooked branches and clusters of twigs arising from a common point because of terminal bud dieback. Twig and shoot blight can also arise from cankers that kill new shoots at the base soon after they emerge and begin rapid growth in the spring. Leaf symptoms result from direct infection of tissue and characteristically extend along the veins. As the leaf anthracnose spreads and intensifies there is extensive leaf drop. Disease spread is primarily through conidia that are washed onto tissue by wet weather. Mycelium from infected leaves will grow down into leaf petioles and into twigs thus starting the disease cycle again.

Black Knot of Cherry

Black knot of cherry is caused by *Apiosporina morbosa*. Sexual spores (ascospores) are formed within cavities embedded in a mass of fungal tissue called stroma. The stroma are the black "knots" the diseased is named after. This disease is prevalent on wild chokecherry, plums, and black cherry. Infection takes place in the spring from ascospores that penetrate the green tissue on new shoots. After penetration the mycelium grows throughout the stem tissue but causes no symptoms until autumn. Symptoms begin as swellings on branches and twigs as a result of growth hormones released by the pathogen. Swelling is slowed by winter, but growth resumes again in the spring. The bark over the swelling typically cracks and reveals an olive green stroma that eventually darkens over the summer. The stroma hardens and turns black over the next winter. The perennial growth of the stroma will girdle and cause shoot dieback.

Cyclaneusma Needle Cast of Pine

*Cyclaneusma minus* produces its sexual spores in a sacs contained in cup shaped structures that split longitudinally to release spores during wet weather. The pathogen infects Scots, Austrian, mugo, Virginia, and eastern white pines. Infections from wind blown ascospores occur from mid-April through August, with a second period of infection in late fall. Needles of all ages are susceptible and penetration takes place through stomata (singular= stomate). Stomata are microscopic openings in leaves and needles that allow gases to pass in and out. Diseased needles usually don't show symptoms until 10-15 months after infection. Since ascospores are liberated throughout the year, so there are many overlapping generations. The primary symptom is the yellowing and dropping of second year foliage in the fall. Symptoms
first appear as light green spots that enlarge to yellow bands, with the entire needle then turning yellow. Severely infected trees have a distinct yellow appearance before needle drop in the fall. After several seasons of disease infested trees retain only the current seasons growth.

D. The Imperfect Fungi (class Deuteromycetes)

These fungi do not reproduce by sexual spores. They are only known to produce asexual spores (conidia) thus are called Imperfect Fungi.

Examples of Diseases Caused by the Imperfect Fungi

Verticillium Wilt of Woody Plants

Verticillium wilt is caused by the soilborne fungi V. dahliae and V. albo-atrum. Spores are produced freely on the host. Infection starts by direct penetration of the pathogen on the feeder roots or in wounds. Mycelium grows into the root cortex and vascular system where it releases spores that are carried upward with the sap. Where the spores lodge and germinate new mycelium grows continuing the disease cycle. The mycelium causes tissue death within the vascular system and this gives rise to dark blackish streaks in the sapwood. Wood killed by the pathogen does not conduct water or nutrients to the leaves. Wilting and death of all the leaves on a branch indicates infection of the current seasons wood at the branch base or trunk below.

Diplodia Tip Blight of Pine

Sphaeropsis blight, also called Diplodia tip blight, attacks two and three needle pines. This fungus, Sphaeropsis minus, produces conidia within small, black fruiting bodies (pycnidia). The most devastated pines are usually Austrian and Scots. Conidia are spread in the early spring by splashing rain to new shoots that are just expanding. The pathogen penetrates green tissue directly and infects new needles through stomata. Infected buds stop elongation and dying shoots turn straw colored. Dying tissue is typically resin soaked and clusters of stunted straw colored shoots on lower branches are diagnostic of Sphaeropsis blight. Pycnidia can be seen in the fall on needle bases, fascicle sheaths and cone scales.

E. The Club Fungi (class Basidiomycetes)

Members of this group of fungi are called the club fungi because they produce their sexual spores within a microscopic, club shaped structure. The club shaped structures are then contained in larger fruiting bodies. Often these fruiting bodies are quite large and fleshy structures such as mushrooms, puffballs, and conks. These fleshy fungi can be associated in beneficial relationships with tree roots as mycorrhizal fungi. Many club fungi cause root rots and wood decay diseases in trees. Both the rust and the
smut fungi cause some of the most destructive crop diseases known. They have both caused famines and large food losses throughout recorded history. Many of these fungi have complex life cycles. For example many of the rust fungi must infect two unrelated plant genera to complete their reproductive cycle.

**Examples of Diseases Caused by the Basidiomycetes**

Cedar-Apple Rust

Cedar-apple rust is caused by *Gymnosporangium juniperi-virginianae*. This pathogen needs both cedar and apple to complete its two year life cycle. Cedars become infected in late summer or autumn and galls appear the following spring. The galls continue to grow through the summer until they reach full size in the fall. Following spring rains these galls swell 2-3 times their former size and produce bright orange-yellow, horn-shaped gelatinous masses of spores. The spores are spread by wind to apple where they infect young leaves, green stems and sometimes young fruit. Lesions on apple leaves first appear as orange-yellow spots on the upper leaf surface. By midsummer orange-yellow lesions also develop on the lower leaf surface. These lesions produce the spores which will be windborne back to cedar thus completing the 2 year disease cycle.

Corn Smut

Corn smut is caused by *Ustilago maydis*. When mature corn plants are infected by smut spores they develop lesions on the growing tissues of the axillary buds, individual flowers of the ear and tassel, leaves and stalks. Infections of corn seedlings result in stunted plants or cause death. Mycelium grows throughout the infected tissues and stimulates the host cells to divide and produce galls. When the galls mature they rupture and reveal a mass of sooty black spores. These spores can then cause new infections or they can overwinter in crop debris and germinate next spring to reinitiate the disease cycle.

F. The Sterile Mycelium Fungi (class Mycelia Sterilia)

These fungi do not produce asexual or sexual spores and are identified by the morphology of their mycelium. This class contains the genera *Rhizoctonia* and *Sclerotium* that cause root and stem rots on a wide variety of plants. They survive adverse conditions by the formation of dense clumps of mycelium called sclerotia.

An Example of a Disease caused by a Fungus in the Mycelia Sterilia

Southern Blight

Southern blight is caused by *Sclerotium rolfsii*. This disease typically affects
herbaceous hosts or young woody plants not yet protected with a thick layer of bark. The pathogen infects plants at the soil line during hot, wet weather and causes death by girdling the plant at the crown. Under moist conditions a web of mycelium develops on the surface of the host and the surrounding soil. As the plant dies sclerotia develop on the surface of the infected tissue. The sclerotia, 1-2mm in size, are white at first and then turn brown. Sclerotia can be dispersed in soil or irrigation water and can persist dormant in the soil or survive in crop debris and weed hosts.

II. Plant Diseases Caused by Bacteria

Bacteria are simple single celled organisms that are microscopic in size. Approximately 1,600 bacterial species have been described and about 80 species are plant pathogens. Most bacteria can be grown in culture. Almost all plant pathogenic bacteria are rod shaped, with the exception of Streptomyces, which is filamentous. Most plant pathogenic bacterium have flagella or "tails" that allow them to swim through films of water.

Reproduction

Bacteria multiply and divide asexually by splitting into two equal halves. Bacteria can go through this process very rapidly and under favorable conditions may divide every 20 minutes. At this doubling rate of reproduction one bacterium could produce one million bacteria in the time span of about ten hours.

Bacteria invade plants through wounds or natural openings such as lenticels (minute openings in the bark that allow gases to enter and exit) or stomata (minute openings in leaves and needles that allow gases to enter and exit). Wounds can occur from cultivation practices, and from nematode or insect feeding, as well as from larger animals such as birds. Bacteria can be spread from plant to plant by soil, water, infected seeds or plant parts, pruning tools, and insects. Most plant pathogenic bacteria develop in their host, but have the ability to also remain active for a period of time on plant debris, or in some cases, they can survive in the soil.

There are seven major genera of plant pathogenic bacteria and within each genus there are numerous species and subspecies or pathovars. In a lab situation, bacterial pathogens are often separated by differential growth media, flagellar arrangement, chemical composition of their cell walls, nutrition requirements, and serological techniques.
Examples of Diseases Caused by Bacteria

Crown Gall

Crown gall is caused by the bacterium *Agrobacterium tumefaciens*. This bacterium can survive for many years in the soil. Crown gall appears first as small outgrowths on the stem and roots, especially near the soil line. The bacterium infects fresh wounds on roots or at the crown of the plant. As the pathogen begins to multiply it releases a piece of DNA into the plant cells which causes unregulated cell division to take place, thus forming galls. Once the piece of DNA is released, the actual bacterium is no longer needed for disease development; uncontrolled growth continues as the DNA moves from cell to cell. As the surface of the galls are weathered away, the crown gall bacterium is released back into the soil.

Fire Blight of Apples and Pears

Fire blight is caused by *Erwinia amylovora* and is the most important bacterial disease of rosaceous plants. Fire blight is most destructive in apple and pear orchards, but is also a problem on ornamental apples and pears in the landscape. The pathogen overwinters in cankers on the tree and bacteria are carried by wind, rain, or insects. The first symptom is blossom blight. Flowers appear water soaked, shrivel and turn brown. The bacterium progresses from the infected flower into the fruit spurs and then into the twigs. The disease intensifies as shoot tips are blighted and take on the typical "shepherds crook appearance". Blighted pear shoots turn black as if scorched by fire. The progress of the pathogen slows in woody branches and the bacterium forms cankers that will provide bacteria to start the next infection cycle the following year.

Bacterial Wilt of Cucurbits

Bacterial wilt is caused by *Erwinia tracheiphila*. The most susceptible plants are cucumbers and muskmelons, followed by pumpkins, squash and watermelons. The pathogen overwinters in the gut of the cucumber beetle. The disease cycle begins as beetles feed on seedlings and release bacteria into the plant’s vascular system. Secondary disease spread occurs when beetles pick up bacteria from newly infected plants and then fly to healthy plants within the crop. Wilt symptoms appear first on individual leaves, then lateral shoots, and finally entire plants. The larger the plant at the time of infection the longer the time between first symptoms and death. The bacteria multiply very rapidly inside the vascular tissues and plug the nutrient and water conducting vessels. This results in wilting and dieback of shoots.
Bacterial Leaf Scorch of Elm, Oak and Sycamore

Bacterial scorch is caused by *Xylella fastidiosa*. This bacterium is distinct in that it has no flagella. Also, since it cannot be grown on conventional culture media it is called fastidious. It is limited to the xylem, or water conducting tissue, of its host plants. The entire life cycle is still not known since these diseases were unreported until 1980. Trees begin to show leaf scorch symptoms in midsummer. Scorch appears first on scattered upper and outer branches in the crown. Symptoms progress from the oldest leaves on a shoot toward the youngest at the tip. Bacterial scorch can be distinguished from other scorch symptoms by a band between the scorched areas and the green areas, irregular scorch patterns around the leaf edge, the scattered appearance of affected shoots in the tree crown, and the progression of symptoms from oldest leaves to youngest.

III. Plant Diseases caused by Mycoplasma-like Organisms

Mycoplasmas associated with plant diseases were first described in 1967. Most but not all pathologists consider them to be valid plant pathogens. Prior their description, many of the diseases mycoplasmas are associated with were once lumped together with plant virus diseases. Since 1967, mycoplasmas have been associated with more than 200 plant diseases affecting several hundred plant genera.

Mycoplasmas are very small organisms found in the phloem (food conduction tissue) of diseased plants. Mycoplasmas differ from bacteria in that they don't have a cell wall and have various shapes. Spiroplasmas are helical mycoplasmas. Mycoplasmas reproduce by dividing in half and by budding off new mycoplasmas. Mycoplasmas have no flagella ("tail") and do not produce spores. Mycoplasmas are spread by leafhoppers, planthoppers, and psyllid insects as well as by grafting and by parasitic plants like dodder.

Plant Pathogenic Mycoplasmas

Aster Yellows

The aster yellows mycoplasma attacks many ornamentals, vegetables and weeds. The symptoms of aster yellows infection are a general yellowing and dwarfing of the plant. Other symptoms include abnormal proliferation of shoots that produce witches'-brooms and deformation and color changes of flowers. The mycoplasma can overwinter in weeds such as dandelion, wild chicory, thistle, wild carrot, and wide-leaved plantain. The disease is spread from the infected weeds to healthy plants by leafhoppers in the spring. Control of this disease relies on weed and insect vector control in the crop. Although not always available, resistant plant varieties can reduce losses.
IV. Plant Diseases Caused by Nematodes

Plant parasitic nematodes are tiny, microscopic worms. There are also many other free-living or nonplant feeding nematode species found in every kind of habitat. All plant parasitic nematodes have a needle-like structure called a stylet. The stylet is located in the nematode head and is used to puncture plant cells so that the nematode can consume the cellular contents. A stylet can be likened to a straw.

Nematodes can be classified either as endoparasites that burrow into tissues and feed internally within a plant, or as ectoparasites that feed from the surface of plant tissues. Both of these kinds of nematodes may also be further classified as either migratory or sedentary. Migratory forms are mobile throughout all stages in their life cycle except the egg stage. Sedentary forms enlarge and become immobile once they start to feed.

Soil nematodes cause damage to root tissues and interfere with the uptake of water and nutrients from the root to the shoot. In addition to the direct injury nematodes cause to plants they sometimes also inject toxic substances into the cells they feed. This causes further cell damage. Certain plant parasitic nematodes can spread viruses. Others cause severe enough feeding wounds to allow other soil pathogens such as fungi and bacteria to gain entry into damaged plants.

Some nematodes have broad host ranges while others attack very specific plants. Many nematode species can also survive and complete their life cycles on weeds. Most nematodes have large food reserves that allow them to survive for long periods of time without a host. Some nematodes can live as long as a year without a host and many can even survive through the winter in frozen soil. A few plant parasitic nematodes can lie in a dormant state within a cyst for many years.

Plant Pathogenic Nematodes

Meloidogyne

One of the most common and easily recognized nematodes is Meloidogyne or the root-knot nematode. The juvenile stage enters the root tips and migrates to the center of the root. There the nematode feeds and injects toxins that cause the cells around it to divide and swell, producing a gall. Depending on the plant and the nematode species, root galls can range in size from 4-25 mm across. The northern root-knot nematode causes small galls on strawberries and many ornamentals. The southern root-knot nematode causes large root galls on plants such as tomatoes, cucurbits, and carrots.
Another commonly encountered nematode genus is *Pratylenchus* or the lesion nematode. Lesion nematodes are endoparasites of roots. They burrow tunnels through the root cortex. All life stages are mobile and migratory so they can repeatedly enter and exit roots. Typical symptoms include plants with many dead roots and roots with brown lesions. Wounds caused by lesion nematodes allow other soil pathogens access into roots, resulting in further root decay. Plants attacked include many annual and perennial ornamentals, many turf grass cultivars, tomatoes and strawberries.

The pine wood nematode, *Bursaphelenchus*, is not soil borne but is instead carried from dying pines to healthy pines by long horned beetles. The beetles feed on healthy pines during the months of June and July and introduce the nematodes into the water conducting tissue of the tree. The nematodes are then transported throughout the tree. Wilt symptoms in pines is usually evident in August and September. The nematodes can also be introduced into stressed pines when the long horned beetles lay eggs in the trunk.

V. Parasitic Plants

Several seed plants are capable of parasitizing other plants. Examples of these include dodder, mistletoe, witchweed, and broomrape. Dodder and mistletoe attach to aerial portions of a plant, while witchweed and broomrape attach to plant roots. In New York State dodder is the only parasitic plant common in home gardens. Dodder produces twining yellow to orange stems that resemble spaghetti. It also produces small structures called haustoria that actually penetrate into the host plant’s vascular system. The dodder plant derives all of its nourishment directly from the host plant.

VI. Plant Diseases Caused by Plant Viruses

Plant viruses differ from all other plant pathogens. They are not made up of cells and they can only be seen with the aid of an electron microscope. Viruses do not have Latin names but are named with common names from the first host plant they were studied in. Individual viruses are referred to as virus particles. Viruses are composed of a small piece of either DNA or RNA encapsulated inside a protein coat. There is debate whether or not viruses themselves can be considered living organisms.

Viruses do not divide or produce any kind of reproductive structures such as spores. Instead viruses multiply by taking control of the plant cell and force it to
manufacture more virus particles. Viruses can spread within infected plant tissues, and can be spread to other plants by vectors such as insects and nematodes.

Viruses cannot be cultured on artificial media since they need living cells to multiply. Serological tests (eg. ELISA) and genetic sequencing are currently the most common methods used to detect viruses. Most plant viruses cause systemic infections and there is no cure for infected plants; once a plant is infected with a virus it is infected for life. Viruses do not kill cells by consuming them, but instead they disrupt normal cellular processes.

Viruses in nature rely on vectors such as insects, mites, nematodes, fungi, and parasitic plants to spread from plant to plant. They can also be spread by vegetative propagation, sap, seeds, and pollen. Viruses can be spread relatively long distances when insect vectors such as aphids carried on the prevailing winds.

In addition to typical viruses there are disease agents called viroids. Viroids are small, naked, circular pieces of single stranded RNA capable of infecting plants. Viroid disease symptoms generally resemble those caused by virus infections.

Plant Pathogenic Viruses

Tobacco Mosaic Virus (TMV)

Tobacco mosaic virus (TMV) is very common and worldwide in distribution. It infects more than 150 plant genera that include major agronomic crops, vegetables, fruit, and ornamentals. The most common symptom of TMV is a mosaic pattern of dark green and light green areas on infected plant leaves. TMV is spread by infected sap, grafting, dodder, and seed. TMV is not spread by insects. The most common means of transmission is by people handling infected and healthy plants simultaneously.

Control measures are usually accomplished with sanitation and the use of resistant varieties. People who use tobacco products should wash their hands with soap before handling plants. Weeds and plant debris can serve as inoculum sources for TMV. Control of TMV is complicated by the fact that TMV is one of the most stable viruses known. TMV is very heat stable and very long lived in plant sap and plant debris. TMV under laboratory storage conditions has remained infective in dried leaf tissue for more than 50 years.

Tomato Spotted Wilt Virus (TSWV) and Impatiens Necrotic Spot Virus (INSV)

Tomato spotted wilt virus (TSWV) was first described as a disease of tomatoes, however it has a very wide host range that includes many commonly grown ornamental flowers, vegetables and common weeds. Impatiens necrotic spot virus
(INSV) is a very similar virus that was separated out from TSWV only a couple of years ago. The disease cycle, symptoms, and control methods are the same for both viruses. Black, brown, reddish, or yellowish concentric rings, although not always present, are symptoms of virus infection. Both viruses are exclusively transmitted by the insects called thrips. Thrips are tiny, winged insects that feed on plants by sucking sap from the cells of leaves and flowers. Only immature thrips can acquire the viruses and only adult thrips can transmit the viruses. Weeds can act as reservoirs of the viruses over the winter where the immature thrips can acquire it and spread it to healthy plants as adults. The primary methods of control are to monitor and control populations of thrips and practice weed control. It is also important to start with healthy plant material and to rogue out suspected infected plants. The viruses are not known to infect seed.

VII. Environmental Disorders

Disorders caused by environmental factors are not contagious, however they can cause substantial plant damage. In general most environmental problems are caused by deficiencies or excesses of normal factors that support life.

A. Temperature Effects

Plants may be damaged by very high or very low temperatures. Rapid temperature changes are most likely to cause injury. Damage by late frosts include freeze injuries to fruit buds of peaches, cherry, apricots and strawberries. Low temperatures in winter can cause bark splitting or frost cracks on the sunny side of many tree species in the landscape. Tropical indoor plants are prone to low temperature injury both in the home and while in transport. Cold injury symptoms usually show up as a blackening of the tissues and may not appear until a week after the injury has occurred.

High temperature injury includes sunscald on indoor plants that are moved outside too quickly in the spring before the plant has had time to acclimatize itself to sunlight. Fleshy vegetables such as tomatoes, peppers, and potatoes will also show sunscald injury in the home vegetable garden, particularly if their foliage has been defoliated by leaf spot diseases.

B. Moisture Effects

Excessive moisture and drought both damage plants. Poor drainage results in root decay because of reduced oxygen levels in the root zone. The damaged roots thus result in wilting and death of the leaves and shoots. Proper drainage is important to outdoor plants as well as indoor plants. More house plants suffer from overwatering practices than for any other reason. Drought injury causes wilting, scorch of the foliage, and stunting as well as abortion of flowers and fruit.
Other injury that sometimes occurs under excessive moisture conditions is swelling or oedema. This shows up as numerous swollen bumps primarily on the bottoms of leaves. Later after the swelling the area turns brown and becomes corky in texture. This damage is common on certain herbaceous plants such as geraniums (especially ivy geraniums).

C. Nutritional Effects

Plants require both macro and trace elements to maintain healthy growth. Lower than optimum levels of nutrients usually result in growth reduction. Chronic nutrient deficiency can result in severe decline or death in extreme situations. Some minerals and salts are toxic if present in high concentrations and can interfere with normal metabolism. A common problem in home gardens is blossom end rot of tomato and peppers. This is caused by a localized calcium deficiency in the fruits. It can be brought on by water stress; excessive amounts of fertilizer can also help reduce the uptake of calcium from the soil. Avoiding overfertilization and keeping moisture levels constant help prevent blossom end rot from developing.

D. Salt Injury

Each winter tons of de-icing salt are used on New York roads to help keep them free of ice and snow. Unfortunately such salts also can cause damage to sensitive plants. Salt-laden water sprayed on foliage, especially evergreens like eastern white pine, directly causes damage. Conifer needles turn brown, beginning at the tips and progressing toward the base. The injury intensifies as the weather turns warmer in the spring. Sides of the trees away from the highway or road receives less salt spray, thus may be only slightly damaged or show no damage at all. Salt from sea water can cause the same symptoms on plants.

Salt can also accumulate in soils and damage twigs and leaves as it is absorbed by roots and transported throughout the tree. Salt ions may replace calcium and other nutrients in the soil, thus leading to nutrient deficiency. Excess salt also raises soil pH, leading to further nutrient deficiency problems. Plants showing low tolerance of salt include apple, azalea/rhododendron, beech, boxwood, black cherry, cotoneaster, dogwoods, douglas-fir, balsam and white fir, forsythia, ginkgo, hemlock, holly, lilac, oak, eastern white pine, plum, cultivated roses, white spruce, sycamore, tulip tree, and yew.

E. Air Pollution

The most serious damage to plants from air pollutants are caused by gases in the atmosphere such as ozone, sulfur dioxide, hydrogen fluoride, nitrogen dioxide, and peroxycetyl nitrate (PAN). Some of these pollutants, such as sulfur dioxide and hydrogen fluoride, are produced directly from industrial sources; others, such as
ozone and PAN. are produced as secondary byproducts of photochemical reactions. Incompletely burned hydrocarbons released from automobiles as well as from industrial complexes, oil refineries, etc. react with sunlight and result in the production of both ozone and PAN. These gases enter plants through their stomata and cause characteristic bronzing or stippling symptoms on leaves.

Another pollution problem that has adverse effects on plants is acid rain. Acid rain is caused by the combustion of fossil fuels (coal, oil) that produce sulfur and nitrogen oxides. These oxides combine with atmospheric moisture to form sulfuric and nitric acid respectively. This highly acidified rain water can cause direct damage to plant leaves and can alter the soil pH. Changes in soil pH ultimately influence the availability of soil nutrients causing growth reductions and decline. Acid rain damage to vegetables has been shown to occur but injury to ornamental plants, especially woody ornamental plants, is not as documented.

Principles of Plant Disease Control

People who encounter plant diseases usually want to know the best management measures. Unfortunately, by the time the disease symptoms appear it is often too late to reverse the damage. In some cases there are no acceptable control measures available that will halt the disease short of plant removal. Diagnosis of the disease can allow planning for a management method to prevent the disease next season. The various controls for diseases can be classified as exclusion strategies, inoculum reduction methods, chemical control, and biological control. Integrated pest management (IPM) strategies may utilize any or all of these methods.

A. Exclusion

Exclusion strategies try to prevent or exclude a pathogen from an area. On a national scale this involves quarantine laws and plant inspectors stationed at points of entry into the country. On a homeowner scale this involves purchasing disease free plants and inspecting plants carefully before planting them in your yard. An example of this principle can be seen in many fruit catalogs that advertise disease free plants or virus indexed plants that are certified virus free. The principle of disease free plants holds true for the purchase of disease free bulbs and seeds. Nursery plants should have health inspection certificates.

B. Inoculum Reduction

Inoculum reduction involves the elimination, removal, or reduction of plant pathogens from an area. Many gardeners practice inoculum reduction by removal of infected plants, pruning of diseased tissue, removal of fallen fruit or leaves, soil sterilization, and the use of amendments (such as composts) that favor microflora antagonistic to
the pathogen.

C. Chemical Controls

Plant diseases can be managed chemically with fungicides and bactericides. There are very few nematicides registered for homeowners and there are no chemicals that will kill viruses. Most fungicides are protective in nature which means that they have to be applied before a pathogen infects a plant. A few of the newer fungicides (systemics) can be applied after infection for disease control. Frequently it is too late to spray once disease symptoms are noticed. If you diagnose the disease in this season you can plan for control next season. Sometimes the disease symptoms that are obvious are not severely damaging to the plant (example, rose mosaic virus). Other diseases, such as anthracnose diseases, are difficult to control on large trees and their severity fluctuates with the prevailing weather conditions. In some cases it may be difficult to grow particular plants without a spray schedule. The best long term solution may be to replace high maintenance plants with disease resistant cultivars.

Fungicides classified as "multi-site toxicants" are broad spectrum surface protectants. These chemicals disrupt a wide variety of life processes in the fungal cell and resistance is seldom a problem in normal use.

Examples of multi-site fungicides:

a. inorganic chemicals
   1. sulfur
   2. heavy metals: copper sulfate, Bordeaux mixture, copper hydroxide (Kocide), other coppers - eg. (Physan)
b. organic chemicals
   1. carbamates and related compounds: Maneb, Mancozeb
   2. Phthalimides: eg. Captan, Folpet
   3. chorothalonil: eg. Daconil, Bravo

A second major group of fungicides can be classified as "single site toxicants". These fungicides have a narrower spectrum of activity and often have systemic and eradicant activity. Development of resistant fungal populations can be a limiting factor in the use of these compounds.

Examples of single-site fungicides:

a. benzimidazoles (wide spectrum except water molds)
   1. benomyl: eg. Benlate, Tersan 1991; note that Benlate may not be used on ornamental plants.
b. dicarboximides (effective against Botrytis)
   1. Ipriodione: eg. Chipco 26019
   2. vinclozolin: eg. Ornalin
c. dithiocarbamates (wide spectrum except water molds)
   1. thiophanate-methyl: eg. Clearys 3336, Dragon 3336, Topsin M

d. sterol biosynthesis inhibitors (wide spectrum except water molds)
   1. triforine: eg. Funginex
   2. triadimefon: eg. Bayleton
   3. fenarimol: eg. Rubigan

e. phenylamides (effective only on water molds)
   1. metalaxyl: eg. Subdue

f. thiadiazole (only water molds)
   1. ethazole: eg. Truban

g. antibiotics (some fungi and bacteria)
   1. streptomycin: eg. Agristrep

A third category of fungicides is a collection of products that protect plants through mechanical means, or undefined modes of action.

Examples in this category of fungicides include:

a. epidermal coatings (anti-transpirants)
   1. eg. Wilt Pruf, Vapor Guard

b. undefined modes of action
   1. eg. baking soda, horticultural oils, Neem oils and waxes

D. Biological and Integrated Pest Management Controls

Biological control of plant pathogens involves the use of antagonistic microorganisms before or after infection takes place. Some of the work that has shown success is biocontrol of crown gall with strain K84 of Agrobacterium radiobacter. Control is based on production of an antibiotic specific to the related crown gall bacterium by strain K84. Commercial biological control agents are available as seed treatments and soil amendments to protect plants against soil pathogens. Currently the bacteria Bacillus subtilis and Pseudomonas spp. and the fungi Gliocladium virens and Trichoderma spp. are the organisms with the most applications in biological control strategies.

Integrated pest management (IPM) strategies utilize the integrated use of control procedures covering pathogen exclusion, inoculum reduction, chemical control, and resistant cultivars. IPM procedures rely on minimal pesticide use and require a thorough understanding of a pathogen’s life cycle in order to effectively target control measures. Close examination of plants at regular intervals is an essential part of all IPM programs.
Table 1 - Categories of Plant Diseases, Symptoms and Examples of Susceptible plants.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Susceptible plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracnose</td>
<td>Dead spots with definite margins, often with pinkish slimy spore masses, on leaves, stems, or fruit.</td>
<td>Sycamore, Oak, Maple, Dogwood,</td>
</tr>
<tr>
<td>Bacterial Diseases</td>
<td>All types of diseases, galls, blights, rots, leaf spots, caused by bacteria.</td>
<td>English Ivy, Apple, Pear, Mountain Ash, Cotoneaster, Vinca, Corn, Cucumber, Tomato, Plum, Cherry</td>
</tr>
<tr>
<td>Black Knot</td>
<td>Black, knotty enlargement of woody tissue.</td>
<td>Cabbage, Cauliflower Rose, Juniper, Pachysandra, Periwinkle, Pine, Tomato, Tuff, Boxwood, Pine, Spruce</td>
</tr>
<tr>
<td>Blackleg</td>
<td>Darkening at the base of a plant.</td>
<td>Cabbage, Cauliflower Rose</td>
</tr>
<tr>
<td>Black spot</td>
<td>A dark leaf spot on rose.</td>
<td>Juniper, Pachysandra, Periwinkle, Pine, Tomato, Tuff</td>
</tr>
<tr>
<td>Blights</td>
<td>General killing of leaves, flowers, stems.</td>
<td>Boxwood, Pine, Spruce</td>
</tr>
<tr>
<td>Cankers and Dieback</td>
<td>Localized lesions on stems or trunks, sometimes accompanied by dying back from the top.</td>
<td>Cabbage, Cauliflower, Broccoli, Seedlings in general</td>
</tr>
<tr>
<td>Club Root</td>
<td>Distorted swollen roots.</td>
<td>Ornamentals and Vegetables in general, Grape, Lettuce, Onions, Rose</td>
</tr>
<tr>
<td>Damping Off</td>
<td>Sudden wilting of seedlings or rotting of seeds in soil.</td>
<td>Tuff Azalea, Euonymus, Forsythia, Vinca, Tomato, Oak, Peach</td>
</tr>
<tr>
<td>Dodder</td>
<td>Parasitic seed plant with orange tendrils.</td>
<td>Cabbage, Cauliflower, Broccoli</td>
</tr>
<tr>
<td>Downy mildews</td>
<td>With internal mycelium but fruiting structures protruding to form white, gray, or violet patches.</td>
<td>Seedlings in general</td>
</tr>
<tr>
<td>Fairy Rings</td>
<td>Mushrooms growing in circles</td>
<td>Ornamentals and Vegetables in general, Grape, Lettuce, Onions, Rose</td>
</tr>
<tr>
<td>Galls</td>
<td>Noticeable enlargements of leaves, stems, or roots.</td>
<td>Tuff Azalea, Euonymus, Forsythia, Vinca, Tomato, Oak, Peach</td>
</tr>
<tr>
<td>Leaf Blister, Leaf Curl</td>
<td>Leaf deformities</td>
<td>Elm, Sycamore, Pin Oak, Grape</td>
</tr>
<tr>
<td>Diseases</td>
<td>Discoloration as if by intense heat</td>
<td>Maple, Dogwood, Oak, Turf, Pine, Spruce</td>
</tr>
<tr>
<td>Curl Diseases</td>
<td>Delimited dead areas in leaves</td>
<td>Boxwood, Pine, Tomato, CatTots, Strawberries, Turf</td>
</tr>
<tr>
<td>Leaf Scorch</td>
<td></td>
<td>Plants in general</td>
</tr>
<tr>
<td>Leaf Spots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needle casts</td>
<td>Conspicuous shedding of evergreen foliage</td>
<td></td>
</tr>
<tr>
<td>Nematodes</td>
<td>Causing decline diseases</td>
<td></td>
</tr>
<tr>
<td>Nonparasitic Diseases</td>
<td>Due to environmental conditions rather than specific organisms.</td>
<td></td>
</tr>
<tr>
<td>Disease Type</td>
<td>Description</td>
<td>Affected Plants</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Powdery Mildews</td>
<td>Superficial white powdery growth on leaves and flowers.</td>
<td>Lilac, Rose, Oak, Sycamore, Apple, Grape, Cucumbers, Squash, Apple, Peach, Grape, Tomato, Potato, Squash</td>
</tr>
<tr>
<td>Rots</td>
<td>Soft or hard decay or disintegration of plant tissues.</td>
<td>Apple, Peach, Grape, Tomato, Potato, Squash, Apple, Cedar, Hawthorn, Aster, Snapdragon, Turf</td>
</tr>
<tr>
<td>Rusts</td>
<td>With reddish or rust-colored spore masses.</td>
<td>Apple, Cedar, Hawthorn, Aster, Snapdragon, Turf</td>
</tr>
<tr>
<td>Scab</td>
<td>Raised or crustlike lesions on leaves or fruit</td>
<td>Apple, Pear, Potato, Turf, Corn, Turf</td>
</tr>
<tr>
<td>Scurf</td>
<td>Flaky or scaly lesions</td>
<td></td>
</tr>
<tr>
<td>Slime Molds</td>
<td>Found in lawns</td>
<td></td>
</tr>
<tr>
<td>Smuts</td>
<td>With sooty black spore masses</td>
<td></td>
</tr>
<tr>
<td>Snowmold</td>
<td>Light patches in turf, especially early spring</td>
<td></td>
</tr>
<tr>
<td>Sooty mold</td>
<td>Superficial black mycelium growing in insect exudate.</td>
<td>Ornamentals, Dogwood, Grape, Raspberry, Ornamentals, Fruits and Vegetables in general, Elm, Maple</td>
</tr>
<tr>
<td>Spot Anthracnose</td>
<td>Light spots with raised darker borders or scabby lesion caused by <em>Elsinoe</em> species.</td>
<td></td>
</tr>
<tr>
<td>Virus Diseases</td>
<td>Mosaics, ring spots, yellows, wilt caused by viruses.</td>
<td></td>
</tr>
<tr>
<td>Wilts</td>
<td>Systemic diseases, with wilting, death of leaves, and branches.</td>
<td></td>
</tr>
</tbody>
</table>
Review Questions:

1. How would you define a plant disease?
2. What are some examples of disease symptoms?
3. How would you define a pathogen and give some examples?
4. How are pathogens dispersed?
5. How do pathogens survive?
6. Give some examples of important fungal, bacterial, nematode, and viral pathogens.
7. What are some examples of environmental diseases?
8. How do you implement IPM control practices in plant disease control?
References:


Compendium of Turfgrass Diseases
Compendium of Rose Diseases
Compendium of Ornamental Foliage Plant Diseases
Compendium of Apple and Grape Diseases
Compendium of Corn Diseases
Compendium of Rhododendron and Azalea Diseases
Compendium of Grape Diseases
Compendium of Strawberry Diseases
Compendium of Elm Diseases
Compendium of Raspberry and Blackberry Diseases and Insects

These compendia are published by the American Phytopathological Society APS), 3340 Pilot Knob Road, St. Paul, MN 55121-2097. They currently cost $30 each including postage. Each compendium covers common diseases found on the various plants listed. The color photographs in the center of each publication are helpful though the language in the body of the text is somewhat technical.


Glossary (for reference only)

acervulus (pl. acervuli) - saucer-shaped or cushion-like fungal fruiting body bearing conidiphores, conidia, and sometimes setae

anamorph - the asexual form (also called the imperfect state) in the life cycle of a fungus, in which asexual spores (such as conidia) or no spores are produced

anthracnose - disease caused by acervuli-forming fungi (order Melanconiales) and characterized by sunken lesions and necrosis

apothecium (pl. apothecia) - open, cuplike or saucerlike, ascus-bearing fungal fruiting body

ascocarp - sexual fruiting body (ascus-bearing organ) of an ascomycete

ascomycete - member of a class of fungi that produce sexual spores (ascospores) endogenously within an ascus

ascospore - sexual spore borne in an ascus

ascus (pl. asci) - a sac where ascospores (typically eight) are produced

asexual - vegetative; without sex organs, sex cells, or sexual spores, as the anamorph of a fungus

basidiomycete - member of a class of fungi that form sexual spores (basidiospores) on a basidium

basidiospore - haploid spore of a basidiomycete

basidium (pl. basidia, adj. basidial) - short, club-shaped fungal cell on which basidiospores are produced.

biological control - disease or pest control through counterbalance by microorganisms and other natural components of the environment

blight - any sudden, severe, and extensive spotting, discoloration, wilting, or destruction of leaves, flowers, stems, or entire plants, usually attacking young, growing tissues (in disease names, often coupled with the name of the affected part of the host, e.g., leaf blight, blossom blight, shoot blight)

budbreak - the stage of bud development when green tissue becomes visible.

canker - necrotic, localized diseased area usually on a stem or branch

causal agent - organism or agent that produces a given disease

chlamydospore - thick-walled or double-walled asexual resting spore formed by modification of a hyphal segment

cleistothecium (pl. cleistothecia) - closed, usually spherical, ascus-containing structure of a powdery mildew
fungus

clone - vegetatively (asexually) propagated plant or member of a group of such plants derived from a single original plant

conidiophore - specialized fungal hypha on which conidia are produced

conidium (pl. conidia) - asexual spore formed by constriction and detachment of part of a hyphal cell at the end of a conidiophore and germinating by a germ tube

cultivar (abbr. cv.) - a cultivated plant variety or cultural selection

discomycete - member of a group of ascomycete fungi that generally bear asci on apothecia

dormancy - nongrowing condition of a plant

ectoparasite - parasite living outside its host

endemic - native to or peculiar to a locality or region

endoparasite - parasite living within its host epidemic - general and serious outbreak of disease

eradicate - to destroy or remove a pest or pathogen after it has caused a disease to become established

erumpent - breaking out or erupting through the surface

fastidious - having special growth and nutritional requirements

flagellum - hairlike or taillike or whiplike appendage of a bacterial cell or fungal zoospore, providing locomotion

fructing body - any of various complex, spore-bearing fungal structures

fungicide (adj. fungicidal) - chemical or physical agent that kills or inhibits the growth of

gall - outgrowth or swelling of unorganized plant cells produced as a result of attack by bacteria, fungi, or other organisms

genus (pl. genera) - group of related species germinate - to begin growth of a seed or spore

girdle - to circle and cut through; to destroy vascular tissue as in a canker or knife cut that encircles the stem.

host - living plant attacked by or harboring a parasite and from which the invader obtains part or all of its nourishment

hypha (pl. hyphae, adj. hyphal) - tubular filament of a fungus
incubation period - the time between infection by a pathogen and the appearance of symptoms

infection - process in which a pathogen enters, invades, or penetrates and establishes a parasitic relationship with a host plant

infectious - capable of spreading disease from plant to plant

inoculum - pathogen or pathogen part (e.g., spores, mycelium) that infects plants intercellular - between cells intracellular - within cells isolate - pure microbial culture, separate from its natural origin

larva (pl. larvae) - juvenile stage of a nematode between the embryo and the adult; juvenile stage of an insect

latent - present but not manifested or visible, as a symptomless infection lesion - wound or delimited diseased area

morphology - the study of the form of organisms

mosaic - disease symptom characterized by nonuniform foliage coloration, with a more or less distinct intermingling of normal and light green or yellowish patches, usually caused by a virus; mottle

mottle - disease symptom characterized by light and dark areas in an irregular pattern on leaves or fruit

necrosis (adj. necrotic) - death of tissue, usually accompanied by darkening to black or brown

nematicide - agent that kills or inhibits nematodes

oospore - thick-walled, sexually derived resting spore of an oomycete fungus

parasite - organism that lives with, in, or on another organism (host) to its own advantage and to the disadvantage of the host

pathogen (adj. pathogenic) any disease-producing organism

perithecium (pl. perithecia) - a flask-shaped or subglobose, thin-walled ascocarp (fungal fruiting body), containing asci and ascospores and having an ostiole (spore) at the apex, through which spores are expelled or otherwise released

primary infection - the first infection of a plant, usually in the spring by a pathogen that has overwintered

primary inoculum - inoculum (usually from an overwintered source) that initiates disease in the field, as opposed to inoculum that spreads disease during the season
protectant - agent, usually a chemical, applied to a plant surface in advance of a pathogen to prevent infection

pustule - blisterlike, small erumpent spot, spore mass, or sorus

resistance (adj. resistant) - property of host plants that prevents or impedes disease development

resting spore - temporarily dormant spore, usually thick-walled, capable of surviving adverse environments

ring spot - disease symptom characterized by yellowish or necrotic rings enclosing green tissue, as in some plant diseases caused by viruses

rot - softening, discoloration, and often disintegration of succulent plant tissue as a result of fungal or bacterial infection

scab - crustlike disease lesion

sclerotium (pl. sclerotia) - hard, usually darkened and rounded mass of dormant hyphae with differentiated rind and medulla and thick, hard cell walls, which permit survival in adverse environments

secondary infection - infection resulting from the spread of infectious material produced after a primary infection or from other secondary infections without an intervening inactive period

secondary inoculum - inoculum produced by an infection initiated earlier in the same growing season

secondary rot - rot caused by a secondary organism

sign - indication of disease from direct visibility of the pathogen or its parts

sp. (pl. spp.) species (sp. used after a genus name refers to several species without naming them individually)

sporangium (pl. sporangia) - fungal structure producing asexual spores, usually zoospores

spore - reproductive body of fungi and other lower plants containing one or more cells; a bacterial cell modified to survive an adverse environment

sporulate - to produce spores

symptom - indication of disease by reaction of the host

tolerance - capacity of a plant or crop to sustain disease or endure adverse environment without serious damage, injury, or loss of yield

toxin - poisonous substance of biological origin
transmit - to spread or transfer, as in spreading an infectious pathogen from plant to plant or from one plant generation to another

vascular - pertaining to conductive tissues (xylem and phloem)

vector - agent that transmits inoculum and is capable of disseminating disease

viable (n. viability) - able to germinate, as seeds, fungus spores, sclerotia, etc.; capable of growth

viroid - the smallest known infectious agent, consisting of nucleic acid and lacking a protein coat

virulent - pathogenic, capable of causing disease

water-soaked - describing plants or lesions that appear wet and dark and are usually sunken and translucent

witch’s-broom - disease symptom characterized by an abnormal, massed, brushlike development of many weak shoots arising at or close to the same point

zoospore - fungal spore with flagella, capable of locomotion in water

David Clement version 2, 1993
Diane Karasevicz modification 1/95
## Related Resources

### Plant Diseases and Pests

<table>
<thead>
<tr>
<th>Title</th>
<th>Item Code</th>
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Cornell Website information on **Plant Diseases**

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[http://plantclinic.cornell.edu/](http://plantclinic.cornell.edu/)

[http://www.gardening.cornell.edu/pests/index.html](http://www.gardening.cornell.edu/pests/index.html) (includes more pest links than plant diseases)

**Cornell Visual Presentation Resources in Plant Diseases**

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**DISEASES / PLANT PATHOLOGY**

**General**

85. *General Plant Pathology* Slide Set (49 slides & script) W. Westcott III  
138. Basic *Plant Pathology* Slide Set (154 slides & script) D. Karasevicz, Cornell University  
143. *A Systematic Approach to Diagnosing Plant Damage* Slide Set (128 slides & script) Oregon State University. Suggested for advanced Master Gardener training

**Fruit**

101. *Diseases & Insects in the Home Orchard* Slide Set (42 slides & script) C. Klass & D. Pinnow, Cornell University

**Houseplants**


**Trees & Shrubs**

71. *Tree Diseases* Slide Set (60 slides & script) G. Hudler, Cornell University  
83. *Pest Management for Urban Trees* Slide Set (62 slides & script) G. Hudler, Cornell University  
103. *Diseases of Landscape Ornaments* Slide Set (80 slides & script) C.C. Powell & T.D. Sydnor  
117. *Diseases of Trees & Shrubs Significant in NYS* Slide Set (43 slides & script) Selected photographs from W. Sinclair’s Reference Book: Diseases of Trees & Shrubs  
125. *Christmas Tree Pests* Slide Set (52 slides & script) G. Hudler, Cornell University

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38. *Diseases of Turfgrass* Slide Set (66 slides & script) R. Smiley, Cornell University

**Vegetables**

134. *Late Blight: A Serious Disease of Potatoes and Tomatoes* Slide Set (16 Slides & Script) D. Karasevicz, Cornell University
Related Resources

### Plant Diseases and Pests

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