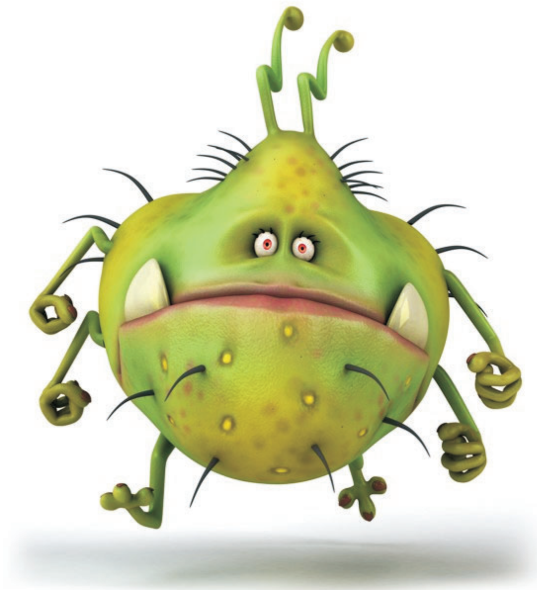
Plant Defenses and Pests Controls

IF YOU CATCH A COLD, your immune system typically kicks in to destroy the invading cold virus. A similar action takes place if you have an infected wound. Our bodies have built-in defenses. Plants have defense mechanisms, too. This unit takes a look at how plants defend themselves.



Objectives:

1. Describe the interactions of plants with mutualistic, commensalistic, parasitic, and predatory organisms.
2. Explain ways in which plants defend themselves against insects and pathogens.
3. Explain various pest management systems.

Key Terms:

alkaloids
bactericides
biological control
chemical control
commensalism
compartmentalization
cultural control
epiphytes
fungicides
genetic control
herbicides
herbivory organism
insecticides
integrated pest management (IPM)
miticides
mutualism
nematocides
nematodes
nodule
parasites
parasitism
pathogen
physical control
predatory organism
secondary metabolites
symbiosis
tannins

Plants Interactions with Other Organisms

All living organisms interact with other living things. Some organisms develop close associations with other organisms. Plants have complex relationships with other organisms.

SYMBIOSIS

A long-term relationship between plants and organisms of another species is **symbiosis**. Symbiosis is based on Greek; *sym* means "together" and *bios* means "life." Types of symbiosis include mutualism, commensalism, and parasitism.

Mutualism

Mutualism is a form of symbiosis in which both species benefit. Lichens are a classic example of symbiosis between an alga and a fungus. The alga provides food, and the fungus provides water and nutrients.

Soybeans and other legumes have a symbiotic relationship with *Rhizobium* bacteria that is mutual. *Rhizobium* bacteria enter the roots of legumes through root hairs. They multiply and inhabit cells of the cortex. These cells divide and produce a swelling (**nodule**) on the plant root. It is within the nodule that nitrogen fixation occurs. In this relationship, the bacteria receive carbohydrates from the plant, and the plant receives a usable form of nitrogen.

FIGURE 1. Lichens are a classic example of a mutualistic symbiosis between an alga and a fungus.

Commensalism

Commensalism is a form of symbiosis in which one species benefits and the other species is neither harmed nor helped. A good example of commensalism involves rainforest trees and epiphytes. **Epiphytes** are plants that do not normally root in soil, but they will grow on other plants, such as trees. The location on a tree branch provides better access to light, water, and nutrients that leach out of tree leaves. Orchids, bromeliads, and Spanish moss are common epiphytes.

Parasitism

Parasitism is a form of symbiosis in which one species—a parasite—benefits at the expense of another species. Organisms that live in, with, or on another organism are **parasites**. Parasites do not contribute to the host and usually cause some harm. Parasitism is similar to predation. It differs, however, in that parasites act more slowly than predators and do not always kill the host. A **predatory organism** is an entity that kills and devours another organism. An **herbivory organism** is an entity that benefits at the expense of another organism (e.g., a caterpillar that eats plant leaves).

Some plants (e.g., mistletoe and dodder) are parasitic on other plants. Yet crown gall is a parasitic bacterial disease caused by *Bacteria tumefaciens*. The bacteria invade small wounds on plants where they cause tumor-like growths. The bacteria multiply, so the plant is weakened. Also, many nematode species are parasitic. **Nematodes** are microscopic, multicellular worms found in soil. Numerous nematode species weaken plants by feeding on plant roots.

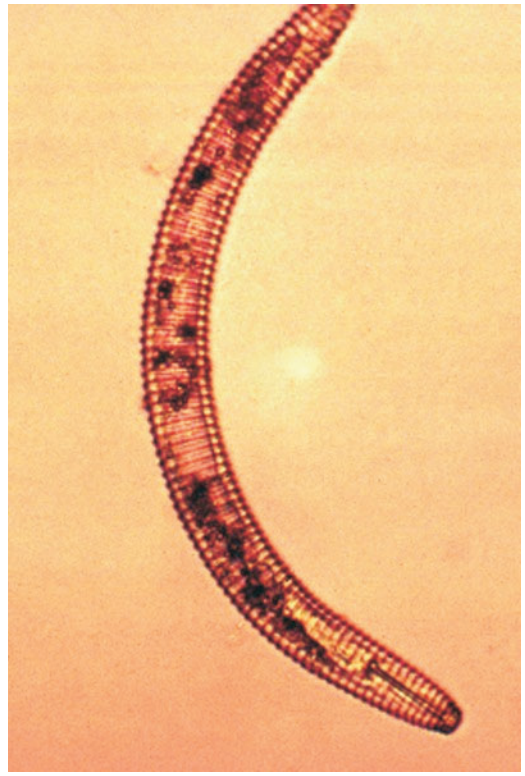


FIGURE 2. Pictured is a greatly magnified nematode—a parasite that can destroy plant roots. (Courtesy, Frank Killebrew, Mississippi State University)

Plant Defenses

Angiosperms existed a million years ago, so obviously they had ways to defend themselves from pathogens and insects. Flowering plants have provided insects with food, shelter, and sites for reproduction. Every plant communicates uniquely with its own small group of specialist insects. The insects are often critical for the plant survival. Some insects pollinate the flowers, enabling reproduction to occur. Meanwhile, some insects protect plants from attacks by other animals. A third group of specialists feed on the plants and control their population.

The color, size, and shape of flowers attract pollinating insects at appropriate times. Plants also use chemical messages to signal insects. Volatile chemicals are used by plants as attractants, most notably in the floral scents. Chemicals are released to call in predatory insects when plants are under attack. All plants can contain complex mixtures of compounds that, through the sense of smell and taste, repel all but specialist insects. Every plant has a unique combination of signal chemicals.

SECONDARY PLANT METABOLITES

The plant adaptation that resulted in the production of secondary plant metabolites led to the survival and dominance of flowering plants. These bad tasting and sometimes toxic compounds are a powerful means of defense. **Secondary metabolites** are compounds that can be divided into six distinct classes based on plant material and extract. The six classes are alkaloids, tannins, cyanogenic glycosides, saponins, cardiac glycosides, and phenolics.

Alkaloids and Tannins

FIGURE 3. This wasp may have picked up scents released by a plant under attack by a caterpillar.

Plants produce a multitude of repellent chemicals to protect themselves from insect attacks. **Alkaloids** and **tannins** are bitter, toxic secondary metabolites contained in the leaves and plant sap. Non-specialist insects and other animals that attempt to feed on the plant are repelled, injured through digestive malfunctions, or even killed. The repellent substances are costly for the plant to produce and may just be produced when the plant is actively under attack. These substances then are translocated to parts of the plant not yet under attack.

Plants have defenses against specialist feeders. Attacking insects trigger the production of plant scents that are released with the insects' body odor. Specialist predators pick up these signals and are attracted to the plant where they attack the herbivores. The signals may take a day or more to reach full intensity and disappear soon after the damage stops.

Non-native crop and garden plants have no insect guardians to respond to their "cries for help." Plant breeders have produced hybrids and, in the process, may have unwittingly bred out the natural defenses and signals, thereby making new plant varieties vulnerable to pest attacks.

Antimicrobial Secondary Metabolites

Plants manufacture antimicrobial secondary metabolites that are toxic to pathogens. A **pathogen** is an organism capable of causing disease. Viruses, bacteria, and fungi are common microscopic pathogens that cause disease and plant decay. Plants are resistant to most plant pathogens, and each living cell of a plant has the genetic coding to produce chemicals to combat pathogens.

Trees have an interesting ability to defend themselves from decay. When wounded, trees produce chemicals—including phenols, resin, and terpenes—that inhibit decay caused by fungi and bacteria. The spread of infection is inhibited and stopped by these chemicals. The formation of a chemical barrier is **compartmentalization**. The concept of compartmentalization is fairly simple. When a tree is injured, all the wood present at the time of the injury could become subject to decay. Wood produced after the injury is walled off from infection by the tree's defensive chemicals. The new wood is protected from decay by the chemical barrier.

At the base of every branch, there is a branch bark ridge and a collar. The branch bark ridge is a raised line of bark that forms on the upper side of where the branch joins the trunk. The collar is swollen trunk tissue surrounding the base of the branch. These structures have the ability to manufacture chemicals that inhibit the spread of decay in the trunk. In nature, decay that has entered a branch spreads until it reaches the chemical zone at the base of the branch. The branch eventually falls off the tree. Then the tree forms a callus, or protective growth of tissue, over the wound.

Pest Management Systems

Integrated pest management (IPM) is an ecologically based approach to controlling plant pests that involves monitoring crops for problems, understanding crop/pest relationships, and determining acceptable economic thresholds for pest populations. An integrated pest management program uses physical, cultural, biological, and chemical means to manage pest populations.

PHYSICAL CONTROL

Physical control is a pest management system whereby pests are destroyed or removed from the plant or area using tools or equipment. Examples of mechanical control are cultivation, mowing, mulching, and the removal of infested plant material.

CULTURAL CONTROL

Cultural control is a collection of cropping practices adopted that are not conducive to pest survival. Cultural control includes maintaining healthy plants by providing optimal growing conditions. This involves practices such as timely irrigation and fertilization. Examples of

ON THE JOB…

CAREER CONNECTION: Plant Pathologists

Plant pathologists study the causes of plant disease, including environmental factors, diseases, and nutrition. They have a firm understanding of pathogens as bacteria, viruses, and protozoa. Plant pathologists continually seek ways to combat plant diseases. They are increasingly turning their attention to plant defense mechanisms and how they function.

Plant pathologists use technologically advanced equipment in their work, which is performed mostly in laboratories. Plant pathologists will study plants and their diseases in natural environments.

Plant pathologists are often employed in academic institutions, non-profit organizations, private consulting firms, and government agencies. They work with plant breeders, farmers, entomologists, and botanists in farms and gardens.

cultural control are crop rotation, roguing, trap cropping, planting resistant plant varieties, and using certified seed.

BIOLOGICAL CONTROL

Biological control is the use of living organisms to control pests by taking advantage of natural predator-prey relationships, parasites, and bacteria and fungi or by altering the reproductive cycle of the pest. An example is the introduction of ladybugs to control aphid populations.

GENETIC CONTROL

Genetic control is the altering of plants through genetic engineering to contain natural toxins to some pests. An example is the development and use of Bt corn and Bt cotton that make chemicals toxic to caterpillars that would normally feed upon them.

CHEMICAL CONTROL

Chemical control is the use of pesticides to manage pest populations. Different types of pesticides have been developed to specifically deal with certain pests. **Insecticides** are chemicals developed to control insects. Chemicals used to control nematodes are **nematocides**. Meanwhile, **fungicides** are chemicals used to control diseases caused by fungi. In addition, **bactericides** are chemicals used to control diseases caused by bacteria. **Herbicides** are chemicals used to control herbs or weeds. **Miticides** are chemicals used to manage mite populations.

Summary:

A long-term relationship between plants and organisms of another species is symbiosis. Types of symbiosis are mutualism, parasitism, and commensalisms.

Plants use chemical messages that signal insects. Secondary plant metabolites are bad tasting and sometimes toxic compounds used by plants for defense. Alkaloids and tannins are bitter, toxic secondary metabolites contained in the leaves and plant sap. Plants manufacture antimicrobial secondary metabolites that are toxic to pathogens. When wounded, trees produce chemicals (e.g., phenols, resin, and terpenes) that inhibit decay caused by fungi and bacteria in a process called compartmentalization.

Integrated pest management is an ecologically based approach that involves monitoring crops for problems, understanding crop/pest relationships, and determining acceptable economic thresholds for pest populations. An integrated pest manage-

ment program uses physical, cultural, biological, and chemical means to manage pest populations.

Checking Your Knowledge:

1. What is symbiosis?
2. How do mutualism, parasitism, and commensalism compare?
3. How do secondary plant metabolites work?
4. What are antimicrobial secondary metabolites?
5. What are the components of an integrated pest management program?

Expanding Your Knowledge:

Create a poster illustrating examples of mutualism, parasitism, and commensalism. Another option is to prepare a set of flashcards for each of the terms presented in this unit.

Web Links:

Symbiosis

http://www.marietta.edu/~biol/biomes/symbiosis.htm

Plant Defenses

http://www.apsnet.org/edcenter/intropp/topics/Pages/OverviewOfPlantDiseases.aspx

Metabolism of Plants

http://www.biologie.uni-hamburg.de/b-online/e20/20.htm

Plant Stress and Defense Mechanisms

http://scidiv.bellevuecollege.edu/rkr/biology213/lectures/pdfs/PlantDefenses213.pdf

Agricultural Career Profiles

http://www.mycaert.com/career-profiles