DISEASE CLASSIC

Crown Gall

Hosts members of 93 families of plants, including pome fruits, stone fruits, nuts, ornamentals, and vines and canes

Pathogen *Agrobacterium tumefaciens*

Symptoms and Signs Plants with crown gall develop tumorous overgrowths, called galls. Crown galls typically form on the root "crown" of the plant near the soil line but also can form on roots or on aboveground stems and twigs. The galls are initially small and usually white or tan, more or less round, and spongy in texture. As the galls enlarge, the outer tissue gradually darkens to brown and becomes convoluted and rough, and the inner tissue becomes hard. On perennial hosts, the galls are perennial and often grow to about 2.5 centimeters (1 inch) in diameter.

Disease Cycle *A. tumefaciens* can survive in soil as a saprophyte for short periods (but survives for much longer in the rhizosphere of many crop and weed hosts) before it invades a host plant through a wound. Once within the plant, the bacterium induces formation of a gall by transferring a piece of its plasmid DNA into the cell of the plant, where it becomes integrated into the plant's genome. Genes on this tumor-inducing (Ti) plasmid cause the plant cell to divide repeatedly, thus forming the tumor, and to produce compounds that are used by the bacterium as food. The bacteria live and multiply in the intercellular spaces of the gall and are released back into the soil when the gall eventually deteriorates.

Management Crown gall can be managed by avoiding infested fields, by planting certified disease-free plants or crown gall-resistant plants, by treating roots of young transplants with antagonistic strains of *Agrobacterium radiobacter*, and by roguing infected plants. Tools used for grafting or pruning should be disinfested frequently.

Significance Crown gall is an economically important disease on a wide range of hosts. Also, the Ti plasmid of *A. tumefaciens* is commonly used to introduce desirable genes into plants (genetic engineering). (See Chapter 9.)

CD **Plant Disease Lessons:** Crown gall

plant roots and produce an antibiotic that is specifically toxic to *A. tumefaciens*, thus killing the bacteria and reducing infection. Considerable research is in progress to find other antagonistic bacteria that will protect plants from infection by pathogenic bacteria (see Chapter 11).

Host plant resistance is a very important management strategy for bacterial diseases, but resistant cultivars must be selected for each different disease (Figure 3.19). Resistance may be due to physical barriers, such as a thicker cuticle or greater numbers of trichomes, or to chemical barriers, such as inhibitors. If the resistance is due to only one gene in the host plant (single gene resistance), new strains of bacteria may quickly evolve that can overcome the resistance and infect the previously resistant host.

The complete genome sequences of some plant-pathogenic bacteria have been determined, and such studies are under way for a number of others. This information may lead to the identification of novel resistance genes that can be incorporated into plants through genetic engineering.

Molecular biologists are beginning to understand the details of host-pathogen interactions in bacterial diseases. It has long been known that the ability of bacteria to multiply quickly under favorable conditions is a key to their success as plant pathogens. Modern research suggests that bacterial populations actually communicate with each other (**quorum sensing**) during infection and colonization. This knowledge may lead to new approaches to management (see Chapter 11).

Management of bacterial diseases of plants is often difficult and complex, requiring a combination of strategies. Host plant resistance and crop rotation are widely used management strategies, but eradication of bacteria in host plants or in vector populations and exclusion of bacteria from planting seed or stock also are important.

Figure 3.19. Pepper plants susceptible (left) and resistant (right) to specific strains of the leaf spot bacterium, *Xanthomonas axonopodis* pv. *vesicatoria*.

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Questions

1. Compare the sizes, shapes, and genome compositions of a typical bacterium and fungus that infect plants. How is genetic variation introduced into the populations of these two types of plant pathogens?
2. What are some important differences between common bacteria and fastidious bacteria as plant pathogens?
3. What advantages do many fungi have as plant pathogens compared with bacteria? Consider various stages of the disease cycle, including survival, dispersal, and infection.
4. What symptoms and signs suggest infection by a bacterial pathogen? What are some typical symptoms that you would expect to see in a plant infected by (a) a xylem-limited fastidious bacterium and (b) a phytoplasma or a spiroplasma?
5. Would you expect to see bacterial streaming if you cut (a) a twig from an apple tree with fire blight or (b) a gall from a rose with crown gall? Explain why or why not.
6. Bacterial diseases are more common in warmer climates. What are some ways that bacteria can survive in winter conditions?

DID YOU KNOW?

The Centers for Disease Control and Prevention (CDC) estimate that 50 million pounds of antibiotics are produced annually in the United States. About half of the antibiotics are used by humans in prescriptions from doctors, and 40% are used for animal diseases and production. The combined use of streptomycin and oxytetracycline on plants accounts for about only 0.1% of all antibiotics produced annually in the United States. Nearly all of this is applied to fruit trees (apples and pears) for management of fire blight (*Erwinia amylovora*).

Management Strategies for Bacterial Diseases

Exclusion

- Impose quarantines (local and international).
- Grow plants in dry environments.
- Plant pathogen-free seed or stock.

Eradication

- Rotate to nonhosts.
- Rogue weed hosts.
- Destroy infested plant debris.
- Use heat treatment of seeds or propagative material.
- Apply antibiotics.
- Apply insecticides (to kill infective vectors).

Protection

- Apply copper chemicals.
- Apply antibiotics.
- Apply bacterial antagonists.
- Minimize leaf wetness.
- Plant resistant hosts.

7. What are the principal means of spread of plant-pathogenic bacteria from one host to another? How are these similar to or different from the principal means of spread of plant-pathogenic fungi?
8. Of the bacterial diseases described in this chapter, which are monocyclic and which are polycyclic in a typical growing season?
9. Explain and give an example of a strategy used to manage bacterial diseases in each of the following categories: eradication, exclusion, and protection.
10. Explain why insecticides are sometimes used to protect high value crops from infection by phytoplasmas but are not used in apple orchards for fire blight.

Challenge questions

1. *Erwinia amylovora* (fire blight) was accidentally introduced into England in 1957 and into Europe in 1966 and has spread from there. Using your knowledge of the environmental conditions of these areas, what do you expect the impact of fire blight to be on apple and pear production in these areas?
2. Soft rot bacteria can destroy almost any fleshy plant product in storage. They are found in nearly every soil. What practices at harvest and in the preparation and maintenance of a cold storage facility will improve the shelf life of potatoes, squash, or lettuce?
3. You have been shipped a set of culture plates containing bacterial isolates for use in a resistance screening program, but the labels have come off. You know that the set includes isolates of *Xanthomonas, Erwinia, Pseudomonas*, and *Clavibacter*. What laboratory tests can you do to identify these isolates to genus?
4. Alfred Fischer and Erwin Smith engaged in a classic and bitter debate in the late nineteenth century regarding the existence of bacterial diseases of plants. Given the times and what you know about bacterial diseases, why was this so controversial?

CD-Rom Resources

Illustrated Glossary

Special Topics

Bacteria as plant pathogens
Fastidious vascular-colonizing bacteria

Plant Disease Lessons

Bacterial fruit blotch of cucurbits
Bacterial spot of pepper and tomato
Blackleg of potato
Citrus canker
Crown gall
Fire blight of apple and pear
Stewart's wilt of corn

WORDS TO KNOW

The CD-Rom provides links from the words in this list to definitions in the Illustrated Glossary.

actinomycete
aerobic
anaerobic
antibiotic
bacilliform
bacterial streaming
bacteriophage
bacterium (pl. bacteria)
capsule
cell wall
chemotaxis
coccus
colony
conjugation
crop rotation
dilution plating
dilution streaking
epiphyte
eradication
exclusion
extracellular polysaccharides (EPS)
fastidious
fission
flagellum (pl. flagella)
gall
genome
Gram-negative
Gram-positive
Gram stain
hydathode
intercellular
intracellular
latent period
lenticel
middle lamella (pl. middle lamellae)
mollicute
mutation
nectary
nucleoid
ooze
pathovar (pv.)
peritrichous
phloem necrosis
phytoplasma
plasmid
pleomorphic
polar
prokaryote
propagative transmission
protection
quorum sensing
ribosome
saprophyte
scorch
selective medium
soft rot
spiroplasma
stoma (pl. stomata)
stylet
subspecies
toxin
water-soaked
wilt
witches' broom
wound
xylem-limited fastidious bacteria
yellows

Exercises

Exercise 3.1. Label the structures on the drawing of a bacterial cell.

Exercise 3.2. Identify the symptoms and signs of bacterial diseases.

Internet Resources

APS*net* Resources

Xanthomonadins, unique yellow pigments of the genus *Xanthomonas*
Antibiotic use for plant disease management in the United States
Phytoplasma casts a magic spell that turns the fair poinsettia into a Christmas showpiece

Recommended Websites

Bacterial Nomenclature Up-to-date
Citrus Canker: The Threat to Florida Agriculture
Plants, Pathogens and People: Crown Gall
Xylella fastidiosa Website

Internet Research

Internet Research Exercise 3.1. Using the APS list, *Common Names of Plant Diseases*, select a bacterial disease of an annual herbaceous plant. Consult the Internet and other resources to find the answers to the following questions:

a. What is the name of the bacterium?
b. How does the bacterium survive adverse environmental conditions?
c. What host plants does the bacterium infect?
d. How is the bacterium disseminated horizontally (plant to plant) and vertically (to the next generation)?
e. What management practices are recommended?

Internet Research Exercise 3.2. Find a fact sheet or disease profile of a bacterial disease on a plant of interest. What are the symptoms and signs of the disease? How is diagnosis confirmed (i.e., how is the bacterium identified?) What diseases caused by other pathogens might be confused with this disease?