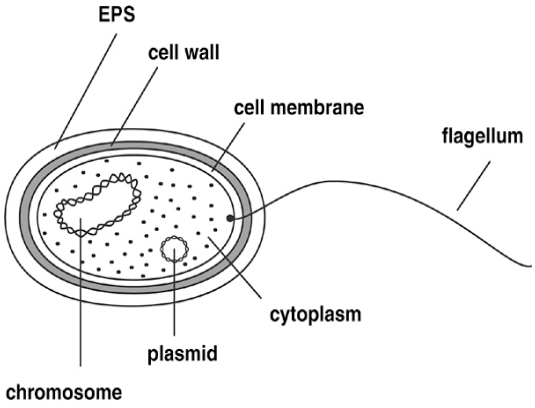
BACTERIAL PLANT PATHOGENS AND SYMPTOMOLOGY

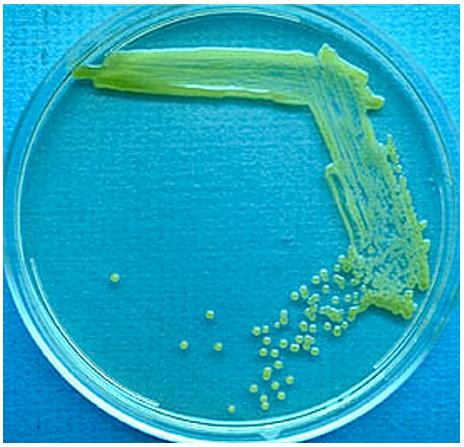
Bacteria are microscopic **prokaryotic** (a cell in which the nuclear material is not enclosed by a nuclear membrane) and, for the most part, single-celled microorganisms. A single teaspoon of healthy topsoil contains about a billion bacterial cells, 120,000 fungal cells and 25,000 algal cells. The genetic material of bacteria consists of a single DNA molecule suspended in the cells cytoplasm. Bacteria do not have a true nucleus as do animals, plants and fungi. Some bacteria also have small gene-carrying entities within their cytoplasm called **plasmids**. Plasmids are extra-chromosomal, self-replicating genes that are responsible for such characteristics as resistance to streptomycin, copper and other antibiotics. Bacteria come in four shapes, there are **coccus** (spherical), **bacillus** (rod shaped) and **spirochetes** (spiral). Most phytopathogenic bacteria are rod shaped bacillus the only exception being *Streptomyces* (family Actinomycetes) which is a **filamentous** (thread-like, filiform) bacteria. Also, most of these bacteria have flagella which are whip-like structures projecting from a bacterium that functions as an organ of locomotion. Some species of bacteria have only one flagellum (**monotrichous)** or a tuft of two or more flagella at one end of the cell. These are called **polar** flagella. Other species will have flagella distributed over the entire surface of the cell. These are termed **peritrichous** flagella.



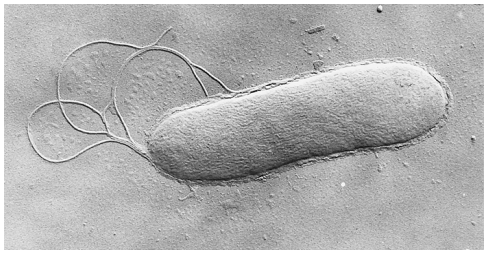
Of the over 15,000 identified species of bacteria most are saprophytic and are of great benefit in decomposing dead and rotting organisms thereby releasing their nutrients back into the environment. This is the most important roll that bacteria play in nature. Plants rely on nitrogen from the soil but cannot directly acquire it from the gaseous nitrogen in the atmosphere. The primary way nitrogen is supplied to plants is through the mineralization of organic material in the soil. However, **nitrogen fixation** by bacteria such as *Rhizobium spp*. and *Cyanobacteria spp*. is almost as important as mineralization, and is a primary source of nitrogen. As these bacteria metabolize they convert gaseous nitrogen into nitrates or nitrites that become available to plants.

Most phytopathogenic bacteria are **aerobic** (live in the presence of oxygen) and some are **facultative anaerobes** which can grow with or without oxygen. Some bacteria have thick, rigid cell walls which will retain dye from a cell staining method developed by Christian Gram, while other bacteria will not accept this stain. This method of staining results in the bacteria being classed as **Gram-positive** or **Gram-negative** and is an important factor in identification and classification. Gram-positive bacteria appear purple and Gram-negative bacteria appear pink under magnification. Bacteria are also distinguished by the different kinds of enzymes they either can or cannot use for nourishment and the nutrient media on which they can grow.

Rod shaped bacteria reproduce asexually by the process of **binary fission** (the transverse splitting in two of a bacterial cell). This process takes place when the **cytoplasmic membrane** grows inward dividing the cytoplasm into two approximately equal parts. When the cell walls are completely formed the cell splits into two cells. During this process the nuclear material duplicates itself and becomes distributed equally between the two cells. Bacteria can reproduce at a very rapid rate; some species can divide every 20 minutes under ideal conditions. It is conceivable that a single bacterium could produce one million progeny in less than 24 hours. However, with limited food supply, environmental conditions and other factors the optimum conditions rarely occur in nature.



There are around 200 species of phytopathogenic bacteria and almost all of them are **parasites** within the plant, on its surface, in plant debris or in the soil as **saprophytes**. Dissemination of bacteria can be accomplished by several means. Some bacteria can survive on inanimate objects, in water or inside insects. It is important to know the survival characteristics of bacteria for effective management strategy and intervention in dissemination. Some species have the ability to move short distances in water on their own power by use of their **flagella**. Most bacteria, however, are disseminated by passive agents such as air and insects, water and soil movement, and to a lesser degree by humans, water and other animals. Infected seeds and transplants can also be a source of inoculums. Most bacteria require a wound or natural opening (e.g. stomata, lenticels or hydathodes) to gain entry into the host tissue and also require warm, moist conditions to establish a **colony**. Windblown soil and sand will commonly cause wounds which can facilitate bacterial infections.



Bacteria colonize a host by growing between the cells and absorbing the cells nutrients that leak into intercellular space or grow within the vascular tissue of the plant. Depending on the species of bacteria and the tissue infected they produce and release **enzymes** that degrade cell walls, **growth regulators** that alter the plants normal growth, **toxins** that degrade cell membranes and **complex sugars** that plug water conducting tissue.

The following is a general classification (Agrios, 5th Ed, 2005) of phytopathogenic prokaryotes with the exception of the Division Tenericutes, Class Mollicutes, which will be addressed in a later section. Genera in **bold** type are common plant pathogens.

Kingdom: Procaryotae

Bacteria – Have cell membrane and cell wall and no nuclear membrain.

Division: Bacteria – Gram-positive

Class: Proteabacteria – Mostly single celled bacteria.

Family: Enterobacteriaceae

Genus: ***Erwinia***, causing fire blight of pear and apple, Stewart's wilt in corn, and soft rot of fleshy vegetables.

Pantoea, causing wilt of corn.

S*erratia, S. marcescens*, a phloem-inhabiting bacterium causing yellow vine disease of cucurbits.

Sphingomonas, causing brown spot of yellow Spanish melon fruit.

Family: Pseudomonadaceae

Genus: ***Acidovorax***, causing leaf spots in corn, orchids and watermelon.

Pseudomonas**,** causing numerous leaf spots, blights, vascular wilts, soft rots, cankers, and galls.

Ralstonia, causing wilts of solanaceous crops.

Rhizobacter, causing the bacterial gall of carrots.

Rhizomonas, causing the corky root rot of lettuce.

Xanthomonas**,** causing numerous leaf spots, fruit spots, blights of annual and perennial plants, vascular wilts and citrus canker.

Xylophilus, causing the bacterial necrosis and canker of grapevines.

Family: Rhizobiaceae

Genus: ***Agrobacterium***, the cause of crown gall disease.

Rhizobium, the cause of nitrogen-fixing root nodules in legumes.

Family: still unnamed

Genus: ***Xylella***, xylem-inhabiting, causing leaf scorch and dieback disease on trees and vines.

Candidatus liberobacter, Phloem inhabiting, causing citrus greening disease.

Unnamed, laticifer-inhabiting, causing bunchy top disease of papaya.

Division: Firmicutes - Gram-positive bacteria.

Class: Firmibacteria – Mostly single celled bacteria.

Genus: *Bacillus*, causing rot of tubers, seeds, and seedlings and white stripe of wheat.
Clostridium, causing rot of stored tubers and leaves and wetwood of elm and poplar.

Class: Thallobacteria – Branching bacteria.

Genus: ***Arthrobacter***, causing bacterial blight of holly, thought to be the cause of Douglas-fir bacterial gall.
Clavibacter, causing bacterial wilts in alfalfa, potato, and tomato.
Curtobacterium, causing wilt in beans and other plants.
Leifsonia, causing ratoon stunting of sugarcane.
Rhodococcus, causing fasciation of sweet pea.
Streptomyces, causing common potato scab.

Diagnostics Symptoms of Bacterial Infections

Symptoms of bacterial infection in plants are much like the symptoms in fungal plant disease. They include leaf spots, blights, wilts, scabs, cankers and soft rots of roots, storage organs and fruit, and overgrowth.

Bacterial spots: the most common symptom of bacterial disease is leaf spots. Spots appear on leaves, blossoms, fruits and stems. If the spots appear and advance rapidly the disease is considered a **blight**. Spots on leaves of dicotyledonous plants often have a rotten or fishy order, are water soaked and are initially confined between the leaf veins and will appear **angular**. In some cases **bacterial ooze** will be present; this is diagnostic for bacterial infections. Sometimes a **chlorotic halo** will surround the bacterial lesion of an infected leaf. Spots may coalesce causing large areas of necrotic tissue. Bacterial spots will appear as streaks or stripes on monocotyledonous plants. Almost all bacterial leaf spots and blights are caused by the genera *Pseudomonas* and *Xanthomonas*.

Cankers: primarily *Pseudomonas* and *Xanthomonas* cause canker disease of stone fruit

and pome fruit trees, and canker disease of citrus respectively. Canker symptoms can appear on

Trunks, stems, twigs and branches. The most conspicuous symptom of a bacterial canker disease in stone and pome fruit trees is the development of **cankers** and **gum** exudation (gummosis). Cankers can be slightly sunken, dark brown and much longer than broad. The cortical tissue of the canker can be orange-brown to dark brown. Gum is produced in most cankers and some branches and twigs. Cankers that do not produce gum may have a sour odor and be soft, sunken and moist. Cankers that girdle trunks and branches can result in leaf stress and eventual dieback of the portion of the tree distal to the canker.

Bacterial Galls: bacterial galls can be produced by the genus *Agrobacterium* and certain species of *Arthrobacter*, *Pseudomonas*, *Rhizobacter* and *Rhodococcus*. *Agrobacterium tumefaciens*, *A. rubi* and *A. vitis* alone are responsible for galls in over 390 plant genera worldwide. Galls of these genera have been referred to as crown gall, crown knot, root knot and root gall. Species of these bacteria are thought to be present in most agriculture soil. A wound in the host is required for the pathogen to gain entry into the host tissue. Gall tissue is composed of disorganized, randomly proliferating cells that multiply in the intercellular (between the cells) spaces in the vicinity of the wound. In the presence of the pathogen rapid and continuous cell division (hyperplasia and hypertrophy) of the plant tissue persists. Gall damage can be benign to deadly. Crown gall first appears as **small, whitish, soft round overgrowths** typically on the plants **crown** or at the main root. The color of galls (tumors) caused by *A. tumefaciens* can be orange-brown and

as it enlarges the surface can become **convoluted** and dark brown. This is most often found in commercial nurseries.

Bacterial Vascular Wilts: Vascular wilts caused by bacteria primarily affect herbaceous plants such as vegetables, field crops, ornamentals and some tropical plants. The causal pathogen enters, multiplies in, and moves through the **xylem vessels** of the host plant and interferes with the translocation of nutrients and water by producing gum. The pathogen will often destroy parts of the cell wall of the xylem vessels resulting in pockets of bacteria, gums and cellular debris. The symptoms of bacterial wilt disease include **wilting** and **death** of the aboveground parts of the plant. In some cases **bacterial ooze** seeps out through stomata or cracks onto the surface of infected leaves. Usually this ooze dose not occur until the infected plant tissue is dead.

Bacterial Soft Rots: Primarily the bacteria that cause soft rots in living plant tissue include *Erwinia spp*., *Pseudomonas spp*., *Bacillus spp*. and *Clostridium spp*. Many soft rots are caused by non-phytopathogenic bacteria which are saprophytes that grow in tissue that has been killed by pathogenic or environmental causes. Soft rots attack a large number of hosts and are best known for causing disease in fleshy plant structures both above and below ground. These bacteria are almost always present where susceptible plants under stress are in the field or in storage. Soft rot pathogens enter the host through wounds. After entering the host tissue these bacteria produce enzymes that break down the middle lamella causing separation of the cells at the site of the infection. The cells die and disintegrate. Rotting tissue becomes **watery** and **soft** and bacteria will form a **slimy foul smelling ooze** that will ooze

out of infected tissue. Bacterial ooze is diagnostic of soft rot diseases.

Bacterial scabs: bacterial scabs primarily infect belowground parts of plants such as potatoes. Common scab of potato is caused by Streptomyces scabies which cause localized **scabby lesions** on the outer surface of the tuber. Typically **corky tissue** will form below and around the lesion. Rot pathogens can gain entrance into the host tissue through these lesions and further degrade the host.

Selected References:

Agrios, 5th ed. 2005, Plant Pathology
WSU, OSU U of I, 2005, Pacific Northwest Plant Disease Handbook

Jim Cooper, Master Gardener
WSU County Extension, SJI
Edited by Dr. Tom Schultz