PARASITISM AND DISEASE DEVELOPMENT

Lecture 3
Pathogen and Pathogenicity

- **Pathogen**: a disease causing agent.

- **Pathogenicity**: ability for an organism to interfere with one or more essential functions of another organism causing disease.

- **Virulence**: The degree of pathogenicity of a pathogen.
Parasite and Parasitism

- **Parasite**: organisms that live on or in another organism and obtains its food from the latter.

- **Parasitism**: the removal of food by a parasite from its host.

- **Plant Parasite**: organism that becomes intimately associated with the plant and multiplies/grows at the expense of the plant.

- **Saprophyte**: organisms that live on dead matter and secrete enzymes to break down material for energy.
Parasites

- Tend to have narrow host range — except viruses.
- Does not need to kill plant cells to complete lifecycle.
- Intimate relationship with plant — continuous absorption of nutrients.
- Grows inter- and intra-cellularly.
- Infected plants tend to be stunted poor vigor.

Saprophytes

- Tend to have broad host range.
- Kills plant tissues to acquire nutrients for growth and complete lifecycle.
- Secrete enzymes and toxins.
- Grows inter-cellularly.
Life strategies of plant pathogens

**Parasite**
- **Obligate Parasite**: A parasite organism that cannot complete its life cycle without exploiting a suitable host.
- **Facultative Parasite**: An organism that is usually saprophytic but which under certain conditions may become parasitic.

**Saprophyte**
- **Obligate Saprophyte**: An organism which can only live off dead organic matter.
- **Facultative Saprophyte**: A mainly parasitic organism with the ability to survive for a part of its life cycle as a saprophyte and be cultured on artificial media.
THE DISEASE CYCLE

- **Disease cycle definition:** The chain of events involved in disease development, including the stages of development of the pathogen and the effect of disease on the host.

- The disease cycle involves changes in the plant and its symptoms as well as those in the pathogen and spans periods within a growing season and from one growing season to the next.
The primary events in a disease cycle are:

1. Inoculation,
2. Penetration,
3. Establishment of infection,
4. Colonization (invasion),
5. Growth and reproduction of the pathogen,
6. Dissemination of the pathogen,
7. and survival of the pathogen in the absence of the host, i.e., overwintering or oversummering (overseasoning) of the pathogen.
Stages in development of disease cycle

The Disease Cycle

- Infection
- Invasion
- Colonization
- Pathogen Growth and/or Reproduction
- Symptom Development
- Dissemination
- Dormant Period
- Production of Dormant Stage

Secondary Inoculum

Primary Inoculum

Incubation

Penetration

Attachment

Host Recognition

Dissemination of 2° Inoculum
Inoculation

- **Inoculation is the initial contact of a pathogen with a site of plant where infection is possible.**

- **Inoculum:** The pathogen(s) that lands on or is otherwise brought into contact with the plant

- The inoculum is any part of the pathogen that can initiate infection.
Examples of inoculums:

- Thus, in fungi the inoculum may be
  - Spores
  - **Sclerotia** (i.e., a compact mass of mycelium), or fragments of mycelium.

- Bacteria
  - Mollicutes, protozoa, viruses, and viroids.
  - Adult nematodes, nematode juveniles, or eggs.
  - In parasitic higher plants, the inoculum may be plant fragments or seeds.
Types of Inoculum

- **Primary inoculum**: An inoculum that survives dormant in the winter or summer and causes the original infections in the spring or in the autumn, and the infections it causes are called primary infections.

- **Secondary inoculum**: An inoculum produced from primary infections and it, in turn, causes secondary infections.
Sources of Inoculum

- Survival in perennial plants, such as shrubs and trees.
- Plant debris or soil seed, transplants, tubers, or other propagative organs.
- Outside sources of inoculum may be nearby plants or fields.
- Vector, such as an insect.
1. Attachment of Pathogen to Host

- Pathogens such as mollicutes, fastidious bacteria, protozoa, and most viruses are placed directly into cells of plants by their vectors and, in most cases, they are probably immediately surrounded by cytoplasm, cytoplasmic membranes, and cell walls.

- Fungi and bacteria produce Gelatinous substances to help them stick to leaf surface.
2. Spore germination
- Mainly Fungi – spore germinates forming germ tube and moves along host to find opening/weak/point.

2.3 Appressorium Formation
- Fungi only – Formation of appressorium and “softening enzymes” and prepares for penetration into plant.

2.4 Recognition between host and pathogen.
Pathogens penetrate plant surfaces by:

- Direct penetration of cell walls,
- Through natural openings,
- or through wounds.
Some **fungi** penetrate tissues in only one of these ways, others in more than one.

**Bacteria** enter plants mostly through wounds, less frequently through natural openings, and never directly through unbroken cell walls.

**Viruses, viroids, mollicutes, and protozoa** enter through wounds made by vectors, although some viruses and viroids may also enter through wounds made by tools and other means.

**Parasitic higher plants** enter their hosts by direct penetration.

**Nematodes** enter plants by direct penetration and, sometimes, through natural openings.

Penetration does not always lead to infection. Many organisms actually penetrate cells of plants that are not susceptible to these organisms and that do not become diseased.
Direct penetration

- Direct – Formation of appressorium, and penetration peg
Contact during infection by fungal pathogen
Penetration through Natural Openings

- Stomata,
- Hydrathodes,
- Lenticels
Penetration through wounds

- Through wounds
- Through natural cracks between main and lateral roots
- Fungus kills and macerates cells ahead of its advance
Infection

- **Infection:** is the process by which pathogens establish contact with susceptible cells or tissues of the host and procure nutrients from them.

- Successful infections result in the appearance of **symptoms**, i.e., discolored, malformed, or necrotic areas on the host plant.

- Some infections, however, remain **latent**, i.e., they do not produce symptoms right away but at a later time when the environmental conditions or the stage of maturity of the plant become more favorable.
Infection

- The time interval between inoculation and the appearance of disease symptoms is called the **incubation period**.
Pathogen spread through plants.

Various pathogens invade hosts in different ways and to different extents.

Most fungi spread into all the tissues of the plant organs (leaves, stems, and roots) they infect, either by growing directly through the cells as an intracellular mycelium or by growing between the cells as an intercellular mycelium.
In apple scab disease, the pathogenic fungus grows only between the cuticle and the epidermal cells of leaves and fruit.

In powdery mildews the fungal mycelium grows only on the surface of host plants, but sends haustoria into the epidermal cells.

In many diseases the fungal mycelium (stained red here) grows only intercellularly (between the cells)
Bacteria invade tissues intercellularly, although when parts of the cell walls dissolve, bacteria also grow intracellularly.

Bacteria causing vascular wilts, like the vascular wilt fungi, invade the xylem vessels.

Most nematodes invade tissues intercellularly, but some can invade intracellularly as well.

Many nematodes do not invade cells or tissues at all but feed by piercing epidermal cells with their stylets.
Viruses, viroids, mollicutes, fastidious bacteria, and protozoa invade tissues by moving from cell to cell intracellularly. Viruses and viroids invade all types of living plant cells.
Individual fungi and parasitic higher plants generally invade and infect tissues by growing on or into them from one initial point of inoculation.

Most of these pathogens, whether inducing a small lesion, a large infected area, or a general necrosis of the plant, continue to grow and branch out within the infected host indefinitely so that the same pathogen individual spreads into more and more plant tissues until the spread of the infection is stopped or the plant is dead.

In some fungal infections, however, while younger hyphae continue to grow into new healthy tissues, older ones in the already infected areas die out and disappear so that a diseased plant may have several points where separate units of the mycelium are active.
Growth and Reproduction of the Pathogen (Colonization)

- All other pathogens, namely bacteria, mollicutes, viruses, viroids, nematodes, and protozoa, do not increase much, if at all, in size with time, as their size and shape remain relatively unchanged throughout their existence.

- These pathogens invade and infect new tissues within the plant by reproducing at a rapid rate and increasing their numbers tremendously in the infected tissues.

- The progeny may then be carried passively into new cells and tissues through plasmodesmata (viruses and viroids only), phloem (viruses, viroids, mollicutes, some fastidious bacteria, protozoa), or xylem (some bacteria); alternatively, as happens with protozoa and nematodes and somewhat with bacteria, they may move through cells on their own power.
Growth and Reproduction of the Pathogen (Colonization)

- Plant pathogens reproduce in a variety of ways
- Fungi reproduce by means of spores, which may be either asexual or sexual.
Growth and Reproduction of the Pathogen (Colonization)

- Parasitic higher plants reproduce just like all plants, i.e., by seeds.
- Bacteria and mollicutes reproduce by fission in which one mature individual splits into two equal, smaller individuals.
- Viruses and viroids are replicated by the cell.
- Nematodes reproduce by means of eggs.
Dissemination of the Pathogen

- A few pathogens, such as nematodes, oomycetes, zoosporic fungi, and bacteria, can move short distances on their own power and thus can move from one host to another one very close to it.
Survival of pathogen without a host (Overwintering and/or Oversummering of Pathogens)

- **Fungi:**
  - Mycelium in cankers, bud scales, seeds, tubers, and plant debris;
  - Spores; and sclerotia
  - Soil inhabitants – survive in soil indefinitely (saprophytes)
  - Soil transients – survive in soil for short period of time (parasites)
  - Parasitic Plants: Seeds and vegetative from on host

- **Bacteria:** same way as fungi;
  - Infected plants, seeds, tubers, and plant debris;
  - In the bodies of insect vectors.
  Survive better in large slimy colonies than as small groups
Survival of pathogen without a host (Overwintering and/or Oversummering of Pathogens)

- **Viruses:**
  - Survive only in living plant tissues;
  - Roots of perennial plants, seeds of some hosts,
  - And insect vectors.

- **Nematodes:**
  - Survive as eggs in the soil;
  - or life stages that are dormant in seeds and bulbs.
Overwintering and/or Oversummering of Pathogens

**FIGURE 2-21** Forms and locations of survival of fungi and bacteria between crops.
Disease Epidemics:

- Monocyclic: completes 1 disease cycle in a year
  - 1° inoculum is only inoculum for entire year.
  - Disease increases year to year as inoculum builds.
Disease Epidemics:

- Polycyclic: 2 or more disease cycles in a year
  - Most pathogens
  - Disseminated by air and airborne vectors
  - Create explosive epidemics – Late Blight, Powdery Mildew, and Rusts.
Disease Epidemics:

- Polyetic – requiring two or more years to complete lifecycle (considered monocyclic)
  - typical of many vascular wilt pathogens
Example of disease cycle

Fig. 1. Disease cycle of apple scab

Courtesy A. L. Jones and T. B. Sutton