

FUNGAL PLANT PATHOGENS AND SYMPTOMOLOGY

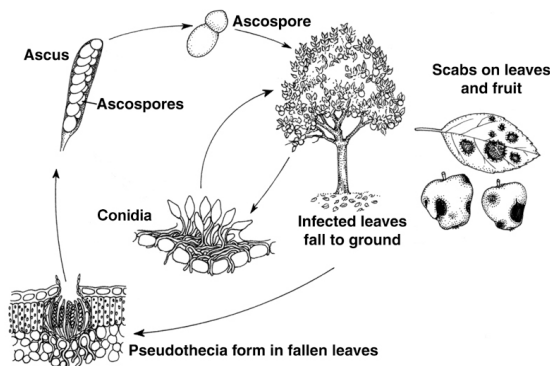
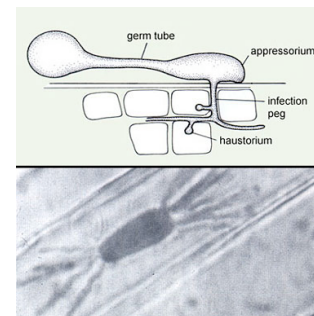
Fungi are spore-forming, non-chlorophytic, eukaryotic (cells having true nuclei) organisms and most of the true fungi are filamentous and branched. Most of the over 100,000 species of fungi are saprophytes. However, over 20,000 species of fungi are parasites and cause disease in crops and plants (USEPA 2005). Fungal parasites are by far the most prevalent plant pathogenic organism. All plants are attacked by one species or another of phytopathogenic fungi. Individual species of fungi can parasitize one or many different kinds of plants.

The body, or thallus, of most of the higher fungi is called a **mycelium** (pl. **mycelia**). The mycelium is made up of thread-like structures called **hyphae** (sing. **hypha**). Hyphae grow only from their tips, and under favorable conditions can grow indefinitely. Hyphae, most often, are partitioned by cross walls called **septa** (sing. **septum**). Septate hyphae are divided into individual cells by these internal walls. Septa usually have a **central pore** which allows small organelles, and in some cases nuclei, to pass from one cell to another. The hyphae of the classes **Ascomycetes**, **Basidiomycetes** and **Deuteromycetes** are septate and the hyphae of class **Oomycetes** and **Zygomycetes** are nonseptate or **coenocytic**. Coenocytic hyphae have multiple nuclei in a common cytoplasm.



Rhizomorphs of *Armillaria* sp.

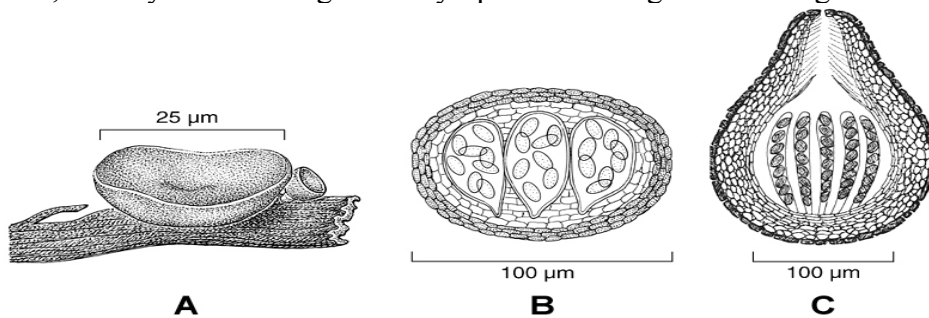
Hyphae produce specialized simple or branched projections called **haustoria** (sing. **Haustorium**). Haustoria penetrate the host tissue and act as nutrient absorbing organs. Haustoria contain nuclei and a concentrated number of mitochondria. The haustoria do not rupture the host cell protoplasmic membrane but invaginate itself into the cell thus greatly increasing the absorptive surface of the fungus.



Reproduction of fungi is primarily by means of spores. Spores are reproductive bodies that consist of one or a few cells. In function they are analogous to the seeds of green plants. Spores are produced by sexual and asexual reproduction. Sexual reproduction involves the union of two compatible nuclei as produced by **meiosis**. For many phytopathogenic fungi the sexual cycle

occurs only once during each growing season. Sexually produced spores include oospores, zygospores, ascospores and basidiospores characteristic of the phyla Oomycota, Zygomycota, Ascomycota and Basidiomycota respectively. Asexual reproduction usually occurs by means of **mitosis** which produce mitotic spores, mycelial fragmentation, fission and budding. With asexual reproduction the repeating cycles of infection can continue throughout the growing season. Asexual spores may be classified as **oidia** (formed by fragmentation of hyphae into individual cells), **conidia** (borne on tips or sides of specialized branches of hyphae) and **sporangiospores** (a nonmotile spore born in a sporangium or case). There are many types and different characteristics of fruiting bodies, spores and mycelium. Fungi are both classified and identified by these features.

The classification of pathogenic fungi is important for identifying and diagnosing plant disease. Each kingdom, phylum, class, order, genus and specie has its own identifying characteristics. Many of the diagnostic factors in identifying different fungi are very subtle and without proper lab equipment and skill are difficult to identify down to the species level. If we can identify the type of fruiting body and/or spores that are associated with a particular phylum, we can narrow down our search considerably. Most often, we rely on visual signs and symptoms for diagnosis of fungal disease.



Ascomycete fruiting bodies (sexual). A - Apothecium, B - Cleistothecium, C - Perithecium

The primary phyla dealt with in plant pathology and disease diagnosis are listed below. This outline is very brief and only includes a few of the more important pathogens and problems. Also included are some of the more important characteristics of each phylum. For further clarification on fungal taxonomy, you can refer to any number of resources at the Extension office. Also, the internet is an excellent source of information on this subject.

Fungal-like organisms (lower fungi):

Kingdom: Protozoa

Phylum: Plasmodiophoromycota (endoparasitic slim molds)
 e.g.: *Plasmodiophora brassicae*, causing club root of crucifers -
Spongophora subterranean, causing powdery scab of potato tubers.

Kingdom: Chromista

Phylum: Oomycota (biflagellate zoospores. Simple pored nonseptate hyphae. Asexual spores - sporangiospores, motile and non-motile. Sexual spores – zoospores) e.g. Chrysanthemum White Rust, *Phytophthora ssp.* diseases, Downey Mildew.

True Fungi:

Kingdom: Fungi

Phylum: Chytridiomycota (zoospores, lack true mycelium)
e.g. parasitic on roots of cabbage and many other plants.

Phylum: Zygomycota (saprophytes or parasites of plants, (Humans and animals.) No zoospores. Simple pored nonseptate Hyphae. Asexual spores - Sexual nonmotile sporangiospores.
e.g. Rhizopus - bread molds, rots of fruits and vegetables.

Phylum: Ascomycota (the sac fungi - most have both teleomorphic (sexual) and anamorphic (asexual) stages. Simple septate hyphae. Produce sexual spores (ascospores) or asexual spores (conidia) on free hyphae or in asexual fruiting bodies such as Cleistothecium, Perithecium, Apothecium and Pycnidium). This phylum is responsible for most of our phytopathogenic fungal diseases.

Some important pathogens in this phylum:

Peach leaf curl (*Taphrina sp.*)
Powdery mildew (*Podosphaera*, (apple)
Microsphaera (azalea) etc.
Vascular wilt diseases (*Verticillium*, *Fusarium* etc.

Some important signs and symptoms:

Many leaf disorders
Fruit and vegetable rots
Root, stem and soft rots
Brown rot (*Monilinia*)
Cankers
Anthracnoses

Class: Deuteromycetes (Mitosporic or imperfect fungi-also

known as Fungi Imperfecti. Sexual reproduction and structures are rare, lacking or unknown. Simple septate hyphae with some exceptions. Asexual spores - conidia produced in pycnidia and acervuli).

Some examples:

Asexual (<u>anamorphic stage</u>)	Sexual (<u>teleomorphic stage</u>)
<i>Penicillium</i>	<i>Talaromyces</i>
<i>Verticillium</i>	<i>Hypocrea</i>
<i>Septoria</i>	<i>Mycosphaerella</i>
<i>Botrytis</i>	<i>Botryotinia</i>
<i>Rhizoctonia</i>	<i>Thanatephorus</i>

This class is responsible for many rots, wilts, molds, leaf spots and other symptoms.

Phylum: Basidiomycota (club and mushroom fungi) - complex septate hyphae, clamp connections. Asexual spores - conidia, oidia. Sexual spores - basidiospores produced externally on club-like spore producing structures called basidium)
For example:

Order: **Ustilaginales** - smut fungi

Corn smut

Loose smut of barley, wheat etc

Bunt of wheat

Order: **Uredinales** - rust fungi

Hollyhock

Cedar-apple

White pine blister

Needle rusts

Cereal rusts

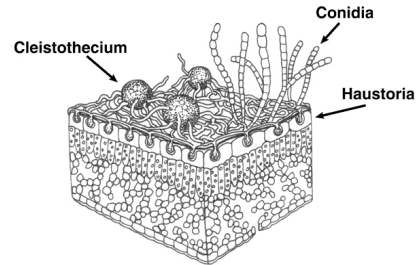
Order: **Agaricales** - mushrooms

e.g.: *Armillaria spp.* - root rot of fruit and forest trees. Common signs in *Armillaria* are mushrooms at the soil level and mycelia under the bark of the basal portion of the tree
Agaricus bisporus – common edible mushroom.

Diagnostic Signs and Symptoms of Fungal Infections

Fungi can cause general or localized **signs** and/or **symptoms**. In the majority of cases, fungal infections cause general necrosis of host tissue and often cause stunting, distortions and abnormal changes in plant tissue and organs.

The most distinctive and easily identifiable characteristics of fungal infections are the physical presence of signs of the pathogen. Signs include **hyphae**, **mycelia**, **fruiting bodies** and **spores** of the fungal pathogen are significant clues to proper identification and diagnosis of a disease. The fruiting bodies of fungi range from microscopic to macroscopic. They come in many shapes and configurations and have their individual characteristics. The fruiting bodies, along with spores, and mycelium, in most cases can lead to an accurate identification of the disease. The following symptoms are common in fungal infections whether alone or in combination with other fungal pathogens.



Powdery mildew on leaf surface

Leaf Spots are very common in both biotic and abiotic plant disorders. Fungal leaf spots often take the form of localized lesions consisting of necrotic and collapsed tissue. Leaf spots can vary in size and are generally **round** and **concentric**, but can be ovoid or elongated on both leaves and stems of the host. The typical fungal leaf spot will have a “**bull's-eye-like**” appearance consisting of roughly concentric rings that may display zones of **different colors** such as yellow, red or purple, and will often have a **tan center**. As the spots develop, they are not restricted by the leaf veins as can be the case in bacterial leaf spots. Fungal leaf spots will usually have a dry texture but are not dry and papery.

Other common symptoms of fungal infections can be:

Anthracnose: an ulcer-like lesion that can be necrotic and sunken. These lesions can appear on the fruit, flowers and stems of the host - e.g. Apple Anthracnose of stems and or leaves (*Cryptosporiopsis sp.* Formally *Pezicula sp.*), or Dogwood Anthracnose (*Discula destructiva*).



Canker: a localized necrotic lesion on woody tissue, often sunken - e.g. Apple European Canker (*Nectria galligena*), Douglas fir, upper Twig Canker (*phomopsis sp.*), and many more.



Apple Anthracnose
Cryptosporiopsis sp.

Damping Off: a rapid collapse and death of very young seedling. Either the seed rots before emergence or the seedling rots at the soil line and falls over and dies. Several soil-born fungi cause this disease. The most common genera involved are *Fusarium*, *Rhizoctonia* and *Pythium*.



Damping Off of seedlings



Apple Scab – *Venturia inaequalis*

Scab: localized lesion on host fruit leaves tubers and other plant parts. These infections usually result in a roughened, crust-like area on the surface of the host - e.g. Apple Scab (*Venturia inaequalis*) and Pear Scab (*Venturia pirina*).

Soft and dry root rots: rot and disintegration of fleshy leaves, roots, tubers and fruit - e.g. Damping Off of seedlings, Rhododendron *Phytophthora* Root Rot (*P. cinnamomi*), *Armaillaria* spp. Root Rot of trees and hundreds of other plants.





Blight: rapid generalized browning and death of leaves, floral organs, stems and branches. Blights can refer to both biotic and abiotic disorders - e.g. Cherry Brown Rot Blossom Blight (*Monilinia fructicola* and *M. laxa*), Tomato Early Blight (*Alternaria tomatophilai*, formally, *A. solani*) and Tomato and Potato Late Blight (*Phytophthora infestans*). *P. infestans* was responsible for the great potato famine in Ireland in 1845.

Dieback: progressive death of shoots and twigs generally starting at the tip of the infected plant part - e.g. Shoot Dieback of Apple due to Brown Rot of Cherry (*Monilinia sp.*) and Poplar Shoot Dieback (*Venturia populina*). Bacteria are probably more commonly associated with Diebacks (*Pseudomonas syringae*).



Phytophthora Root Rot

Decline: progressive loss of vigor over a period of time. General decline can be caused by many factors including fungal, bacterial, environmental and other factors, usually in combination.

Other symptoms associated with excessive growth (**hyperplasia**) or enlargement (**hypertrophy**) and distortion of plant parts can be demonstrated by the following:

Galls: enlarged parts of plant organs, usually caused by excessive multiplication or enlargement of plant cells - e.g. Camellia Leaf Gall (*Exobasidium camelliae*), Plum and Prune Black knot (*Apiosporina morbosa*), Pine Western Gall Rust (*Peridermium harknesii*), Clubroot - (*Plasmodiophora brassicae*) enlarged roots that look like clubs or spindles - e.g. Clubroot of Crucifers (*Plasmodiophora brassicae*), Burr Knot of apples caused by environmental and/or genetic factors can be similar to bacterial galls.



Almond Leaf Curl - *Taphrina sp.*

Leaf Curls: curling, thickening & distortion of leaves - e.g. Almond Leaf Curl, Peach Leaf Curl, Pear Leaf Blister, Maple Leaf Curl and many more caused by *Taphrina sp.*

Other fungal symptoms can include:

Wilts: generalized loss of turgidity as in vascular wilts – Maple Verticillium Wilt, Damping Off and so on. Both woody and herbaceous plants are subject to wilts.



Maple Verticillium Wilt - *Verticillium sp.*



Powdery mildew

Mildews: mycelium, fruiting bodies and necrotic tissue. E.g. Powdery Mildews, Downey Mildews.



Rusts: infected plants will most of the time have many small lesions on stems or leaves, usually a rust color but can also be black or white.

Smuts: mycelium or black spores on seeds, in the form of galls or seeds “replaced” by spores.





Madrone Fungal Canker - *Fusicoccum* sp.

Selected References

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