Ascomycete plant pathogens

Unlike human and animal pathogens, widely distributed throughout the Ascomycota

- numerous genera and species that cause plant disease
- both host-specific and opportunistic parasites

Association between plants and fungi is ancient, parasitism has evolved and been lost repeatedly in fungal lineages

Plant pathogens classified according to the types of disease they cause, plant organs or tissues affected

- root, shoot, foliage disease, dieback
- seed rots, seedling diseases ("damping off")
- fruit rots, storage rots
- canker diseases of woody hosts

Plant pathogens

Pathogenicity: the ability to cause disease
Disease: A deviation from normal physiological function

The ability of fungi to cause disease is usually a direct result of parasitism

Parasite: an organism that obtains its nutrition from another organism

Biotrophic parasites do not immediately kill their hosts, have a prolonged association with living host tissue.

Necrotrophic parasites kill host tissue in advance of occupation. Often involves phytotoxins.

Plant pathogens

Some pathogens produce toxins that facilitate infection

host selective toxins are highly specific, affect only a single host species, and often a specific genotype

- host selective toxins interact with specific host gene product
- nonselective toxins are general phytotoxins

Some pathogens produce chemical analogs of plant growth regulators, cause galls and abnormal growth

Gibberellin was discovered from bakanae disease of rice, caused by *Gibberella fujikoroi*

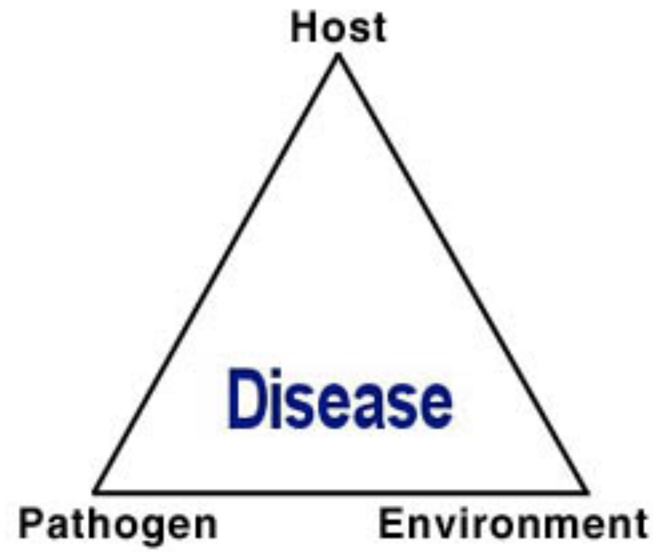
“green islands” cytokinins prevent host tissue from sensescence


Gibberellin plant growth regulators were discovered from *Gibberella fujikoroi*, which causes bakanae (‘foolish seedling’) disease of rice

Factors affecting disease development and severity are often represented by a disease triangle

Disease results from interaction of:
- susceptible host
- virulent pathogen
- conducive environment

All three factors affect disease



Host susceptibility and pathogen virulence are often genetically determined:
- pathogen avirulence genes (AVR)
- host resistance genes (R)

Plant pathogens, plant defenses

How do plants defend themselves from pathogens?

Plants defend themselves from fungal plant pathogens by:

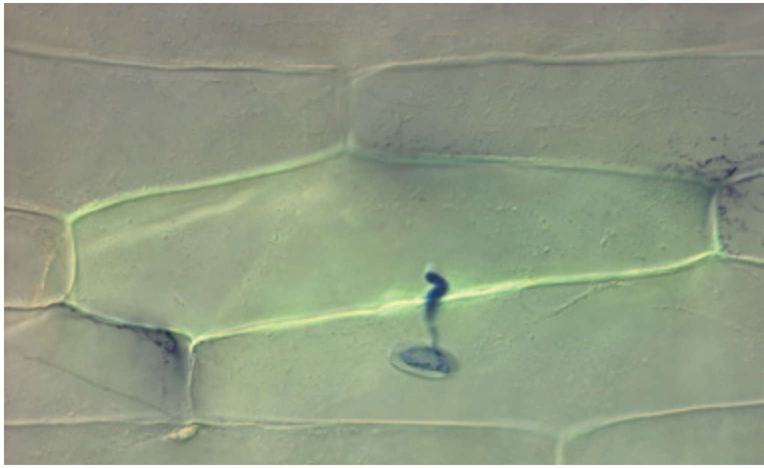
Physical barriers, cell walls, cuticle etc
Preformed chemical substances, fungal toxins
incorporated in cells, released when cells are wounded

Actively formed chemical substances, active defenses

e.g. phytoalexins, antifungal substances synthesized in response to wounds and specific fungal elicitor molecules

Hypersensitive response—death of particular cells or tissues in response to attempted infection by a pathogen

Hypersensitive response, programmed cell death



Gene for Gene concept

H. H. Flor 1942 demonstrated heritable resistance to a plant pathogen, "the Mendel of plant pathology"

Used the system flax and flax rust (*Melampsora lini*)

Varieties of flax differed in susceptibility to infection by different races of rust

Flor crossed rust races and tested offspring for ability to infect different flax varieties

Gene for Gene concept

The number of host resistance (R) genes in flax varieties determined the maximum number of pathogen avirulence (AVR) genes.

For every resistance gene in host there is a corresponding avirluence gene in the pathogen. Resistance is a dominant trait in host, avirulence is a dominant trait in the rust—a gene product is produced if gene is dominant.

The resistance reaction occurs only when a host resistance (R) gene and a corresponding dominant pathogen avirulence (AVR) gene are present in the interaction—both dominant genes.

Flor demonstrated inheritance of **avirulence** and was able to assign genotypes to different pathogenic races of *M. lini*.

Gene for Gene concept

Resistance occurs when the product of a pathogen **avirulence gene (AVR)** interacts with a product of a plant **resistance gene (R)**.

Certain fungi have evolved to be capable of parasitizing certain plants by adaptations that allow them to circumvent or suppress host defense reactions. A fungal pathogen able to colonize and parasitize a plant is **compatible**, i.e. disease occurs.

Parasitism of plants by fungi imposes selection pressure on hosts for development of resistance mechanisms. Resistance/ susceptibility may be specific to certain genotypes (races) of pathogen.

An evolutionary "arms race" between pathogens and hosts
"Red Queen" hypothesis

Pathogen genotype (AVR)

Host genotype (R)	*AA*	*Aa*	*aa*
RR	-	-	+
Rr	-	-	+
rr	+	+	+

recessive alleles in pathogen for AVR genes means the pathogen can cause disease, even if host dominant R gene is present.

- = incompatible, no disease

+ = compatible disease

recessive alleles in host for R genes means the pathogen can cause disease, even if pathogen has dominant AVR allele

Plant pathogens in Ascomycota

Taphrinomycotina (Archaeascomycetes)
includes closely related human pathogen *Pneumocystis carinii*

Taphrinales

Protomycetaceae
Protomyces
Cause galls and deformities of Umbelliferae and some Compositae, no economically important hosts
Taphrina
many species in the genus that cause defomities on foliage, catkins of some Betulaceae, ferns, “plum pocket” and witch’s brooms of some woody hosts

Peach leaf curl and almond leaf curl caused by *T. deformans*

Taphrinomycotina--Protomyces

Gall symptoms of Protomyces

Taphrinomycotina--Taphrina

Taphrina on leaf surface

Peach leaf curl

Taphrinomycotina--Taphrina

Saccaromycotina, ascomycetous yeasts

Plant pathogenic yeasts

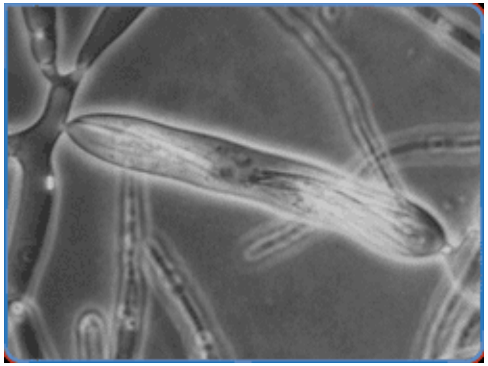
Classified in genera *Ashbya, Nematospora, Eremothecium*
Kurztmann (1995) suggested including all under *Eremothecium*

Most important species is *Eremothecium* (=*Nematospora*) *coryli*, which causes stigmatomycosis of hazelnut, pistachio, pecan

also can affect cotton, soybean, citrus, tomato

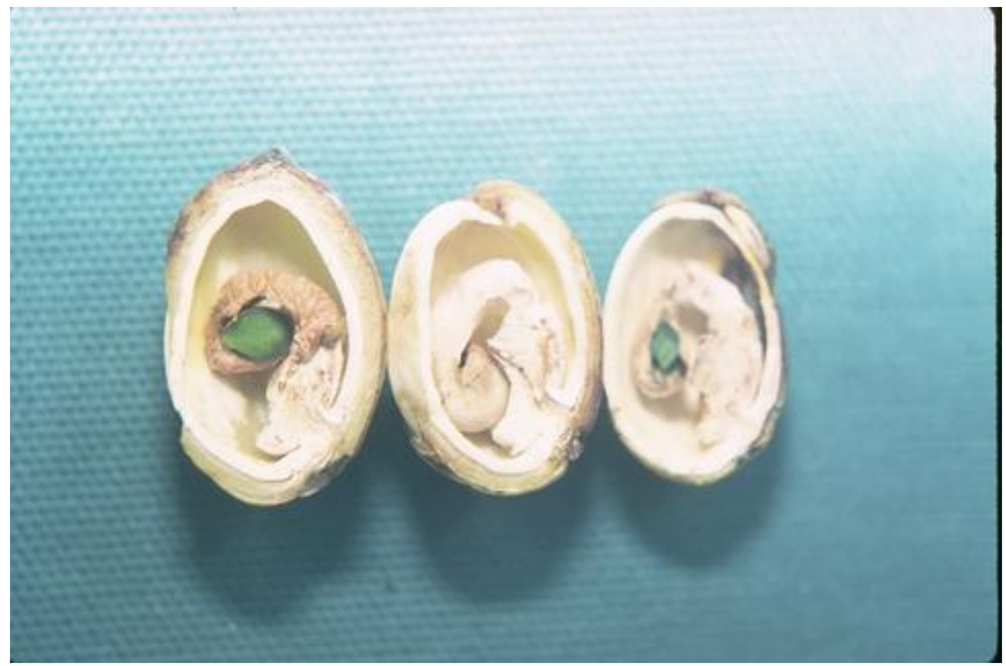
transmitted by Hemiptera (stink bugs)

Rancid pistachio caused by E. coryli



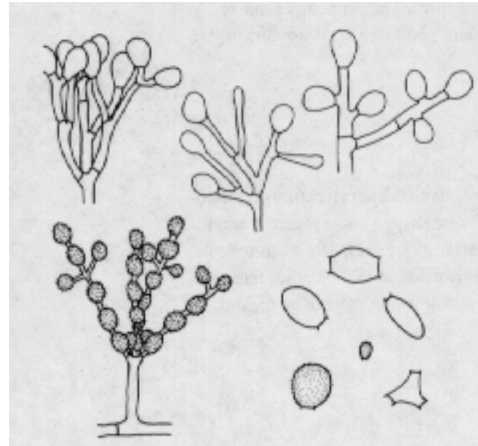
Dry rot of citrus

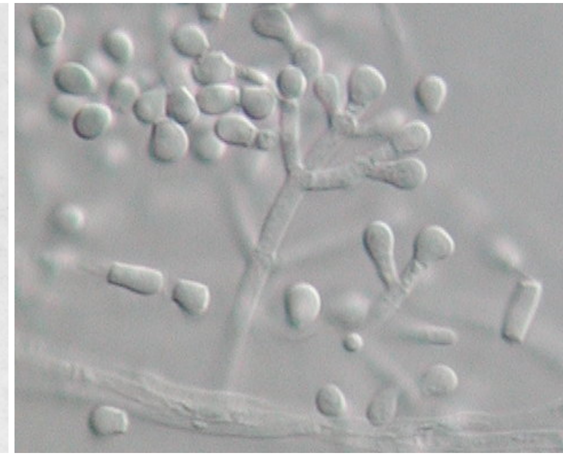
Stigmatomycosis of pistachio caused by *Eremothecium coryli*



Saccharomycotina--
Dipodascaceae

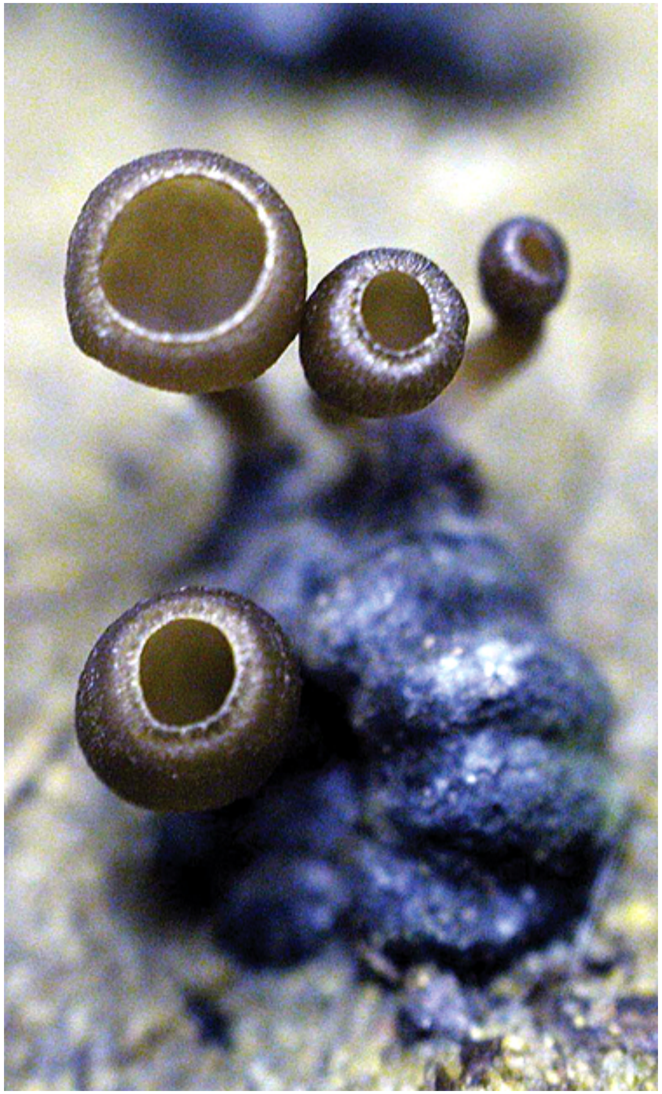
Galactomyces
anamorph: Geotrichum

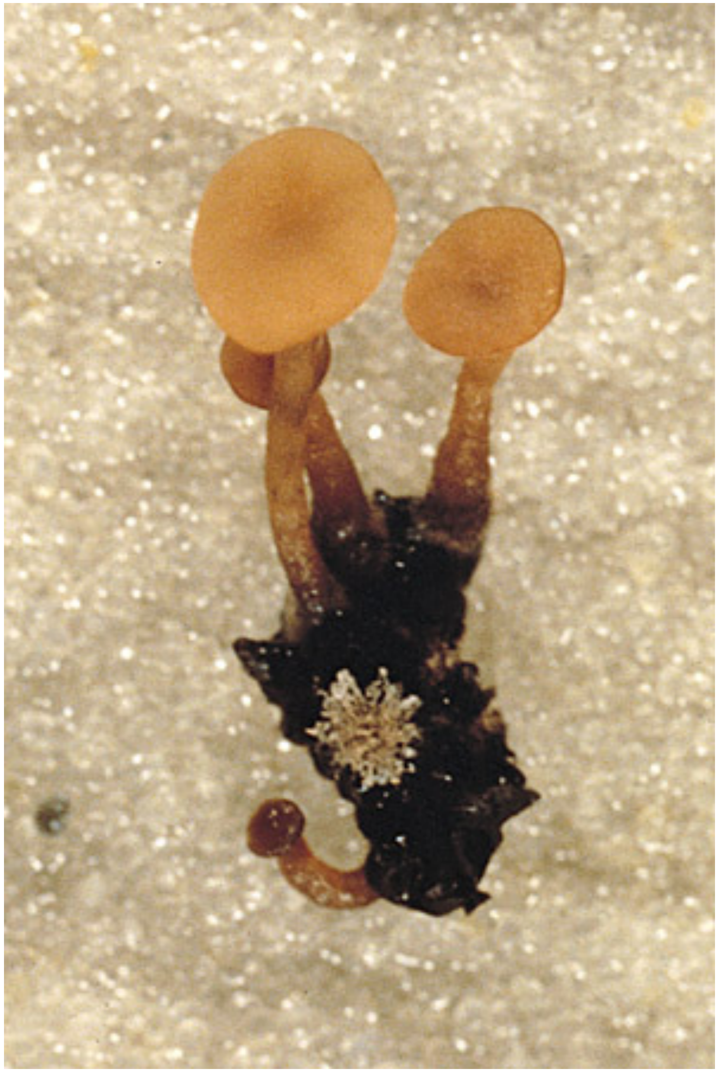




Causes Geotrichum (watery) rot of tomato, also infects ripe lemon, peach, muskmelon; sour rot of citrus fruit. The yeast is spread by flies.

Ascomycete Pathogens I.
Species with apothecial ascocarps



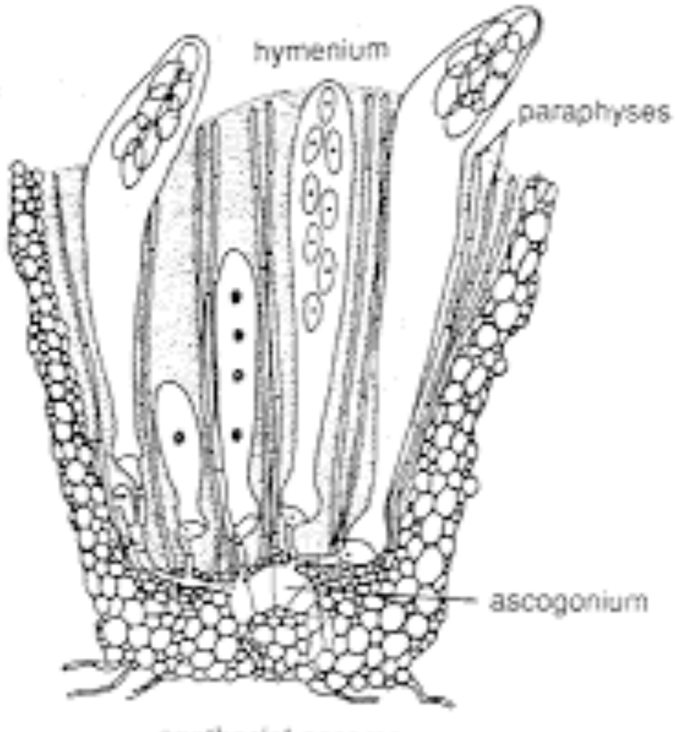


Images: APSnet

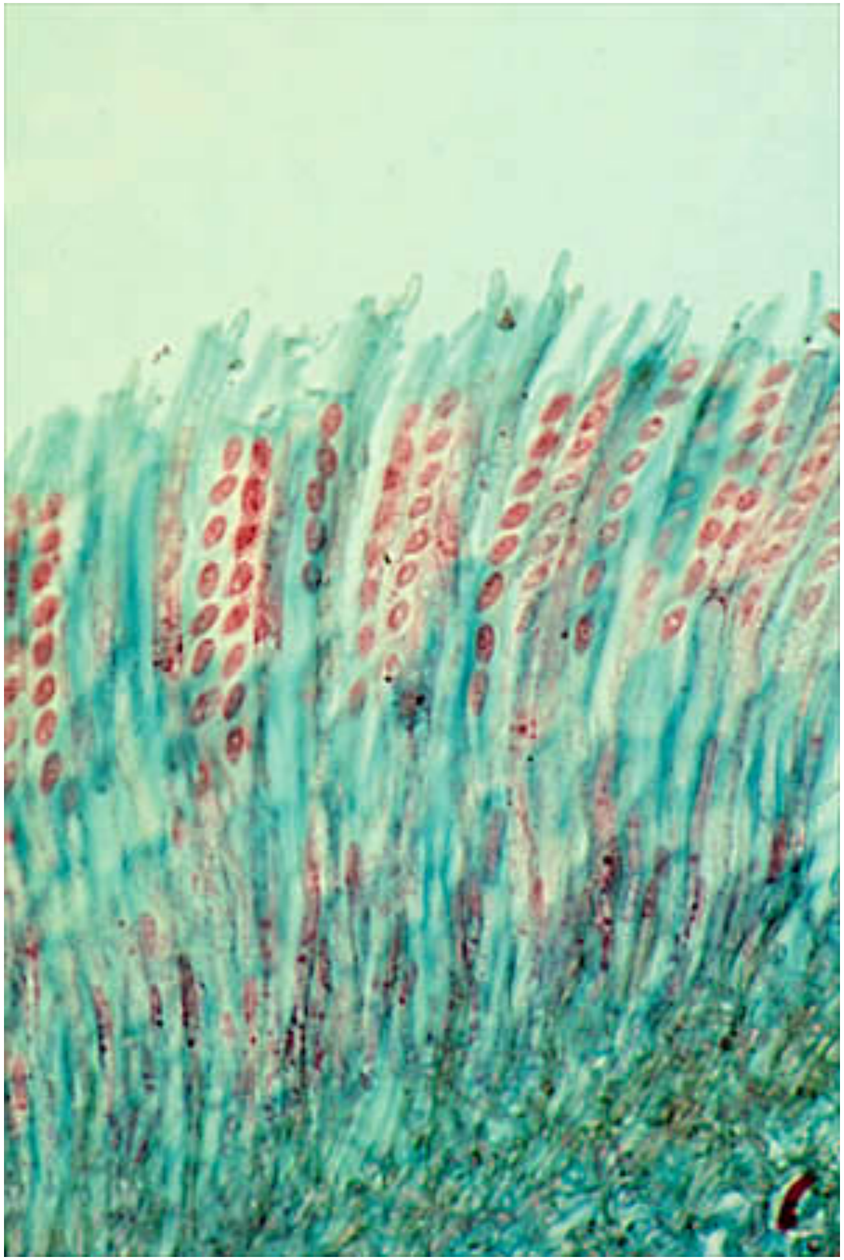
Plant pathogens in Ascomycota
Pezizomycetes & Leotiomycetes "Discomycetes"

Sexual fruiting structure an apothecium, disc like with exposed fertile surface (hymenium) with asci

hymenium: asci and paraphyses
epithecium: tips of paraphyses above asci
hypothecium: tissues immediately beneath the hymenium
excipulum: sterile tissue
clypeus: a stromatic cov



apothecial ascoma



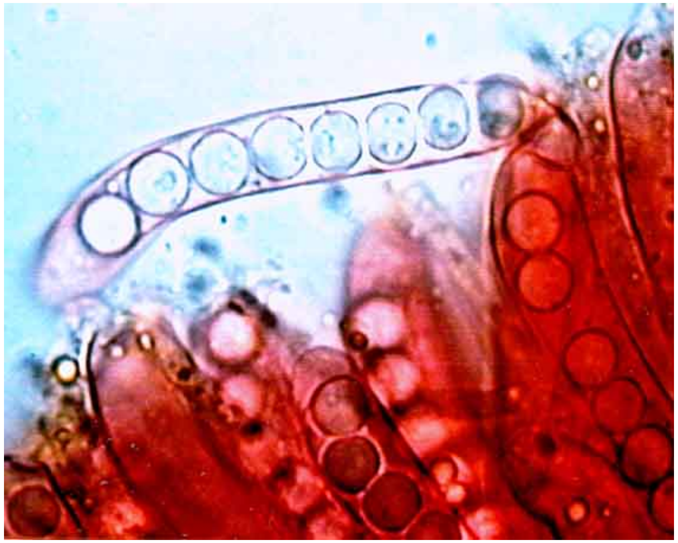
Operculate asci are only found in Pezizomycetes, “operculate discomycetes”

close relatives are morels, which are tasty but not pathogenic

Fungal pathogens in Pezizales, Caloscypha

Causes pre-emergence losses of seed in conifer nurseries
The fungus attacks seeds in cones that contact the forest duff
Can spread from infected seed to healthy seeds in cold storage

Caloscypha fulgens, a cold adapted pathogen, attacks seeds in stratification or sown in cold soils



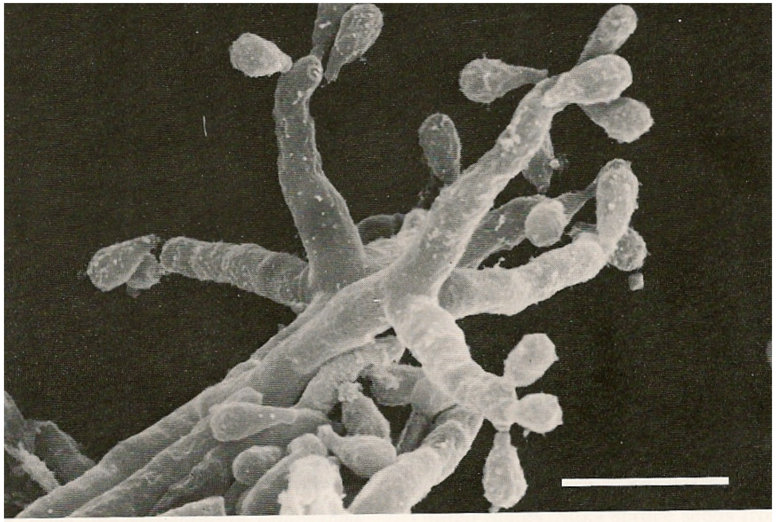


Figure 41. *Caloscypha fulgens* conidiophore and conidia (X 2400), bar is 10 μm (J.R. Sutherland, CFS).

Pezizomycetes--Rhizina root disease, Rhizina root rot

Rhizina undulata: ascomycete fungus, fruiting body an apothecium

Hosts
western redcedar, Englemann, Sitka, lodgepole, Douglas-fir, larch, western hemlock

Primary damage is to seedlings planted soon after fire, can also affect larger trees after fire damage, trees near edge of burned area

Apothecia on soil

Apothecium next to seedling

Pezizomycetes--*Urnula craterium* “Strumella canker”

Urnula and its anamorph *Conoplea globosa* can be found sporulating on symptomatic (cankered) trees.

Susceptible hosts are oaks, maple and other hardwoods (hickory, beech, chestnut, mainly affects young trees (< 10 cm diam)

Found in NE USA and E Canada, also reported from PNW, but uncommon

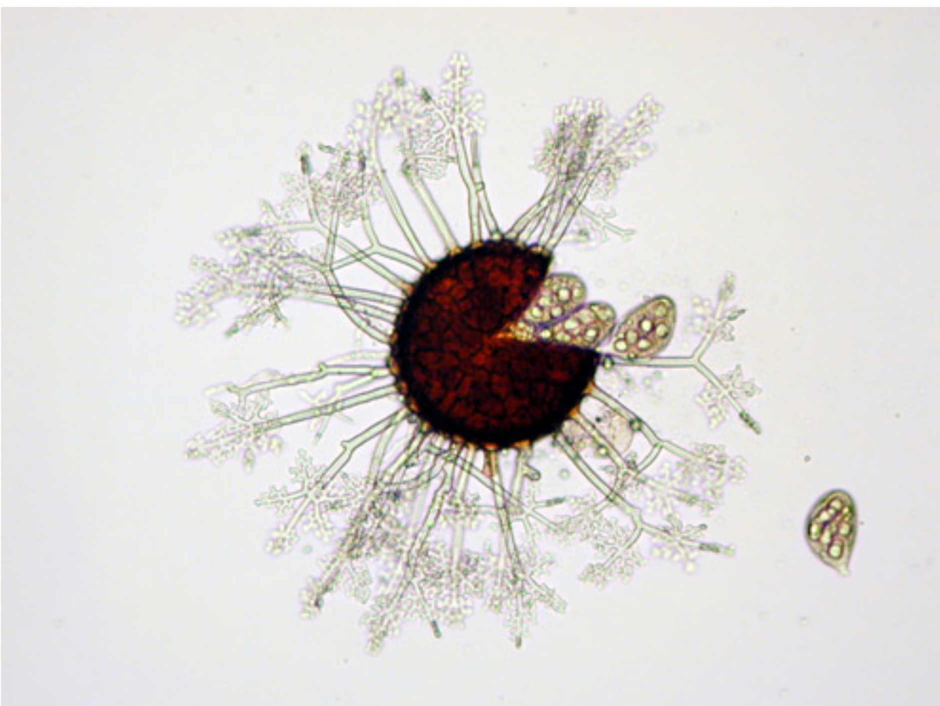
Anamorph is *Conoplea* (aka *Strumella*), its role in epidemiology is unknown

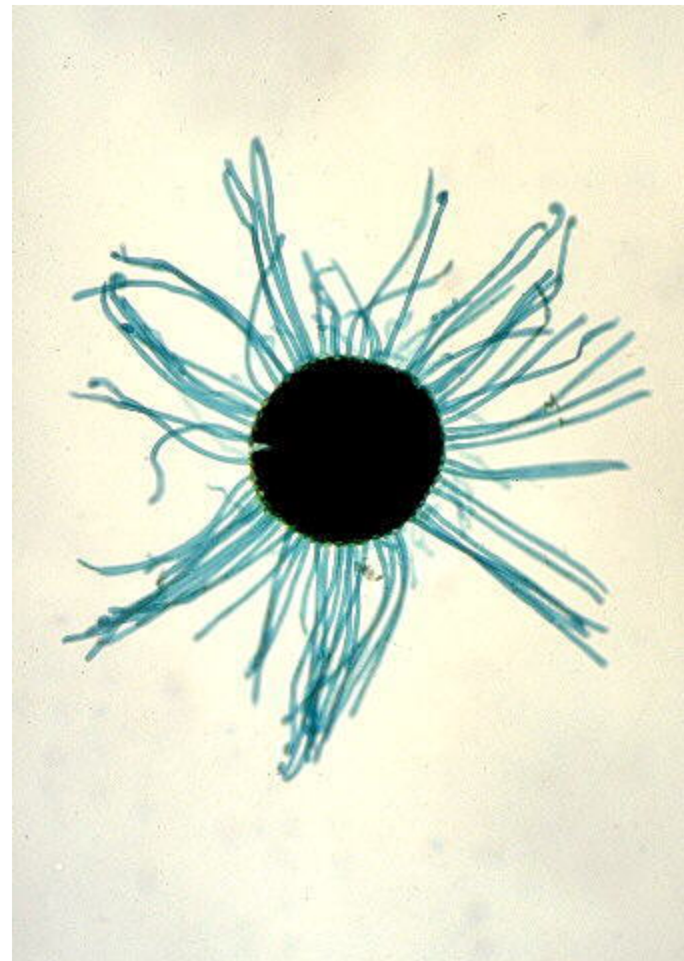
Leotiomycetes--Erysiphales, powdery mildews

Cleistothecial ascocarps (now called "chasmothecia") but related to fungi with apothecial ascocarps

Specialized foliage parasites, host specific, obligate biotrophs

Many plant species affected





Abundant conidia on leaves makes a white dust, hence "powdery mildews

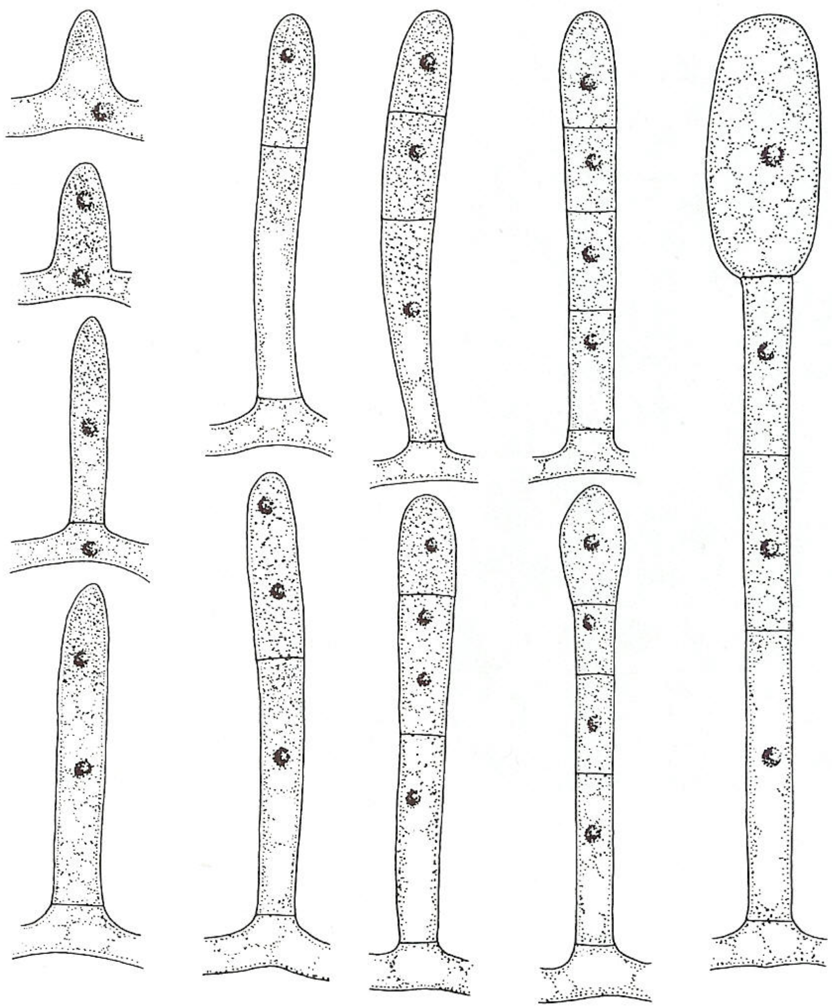
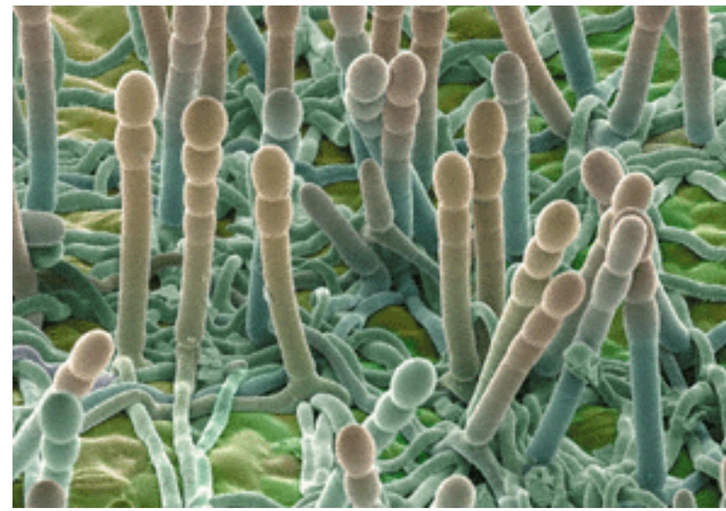
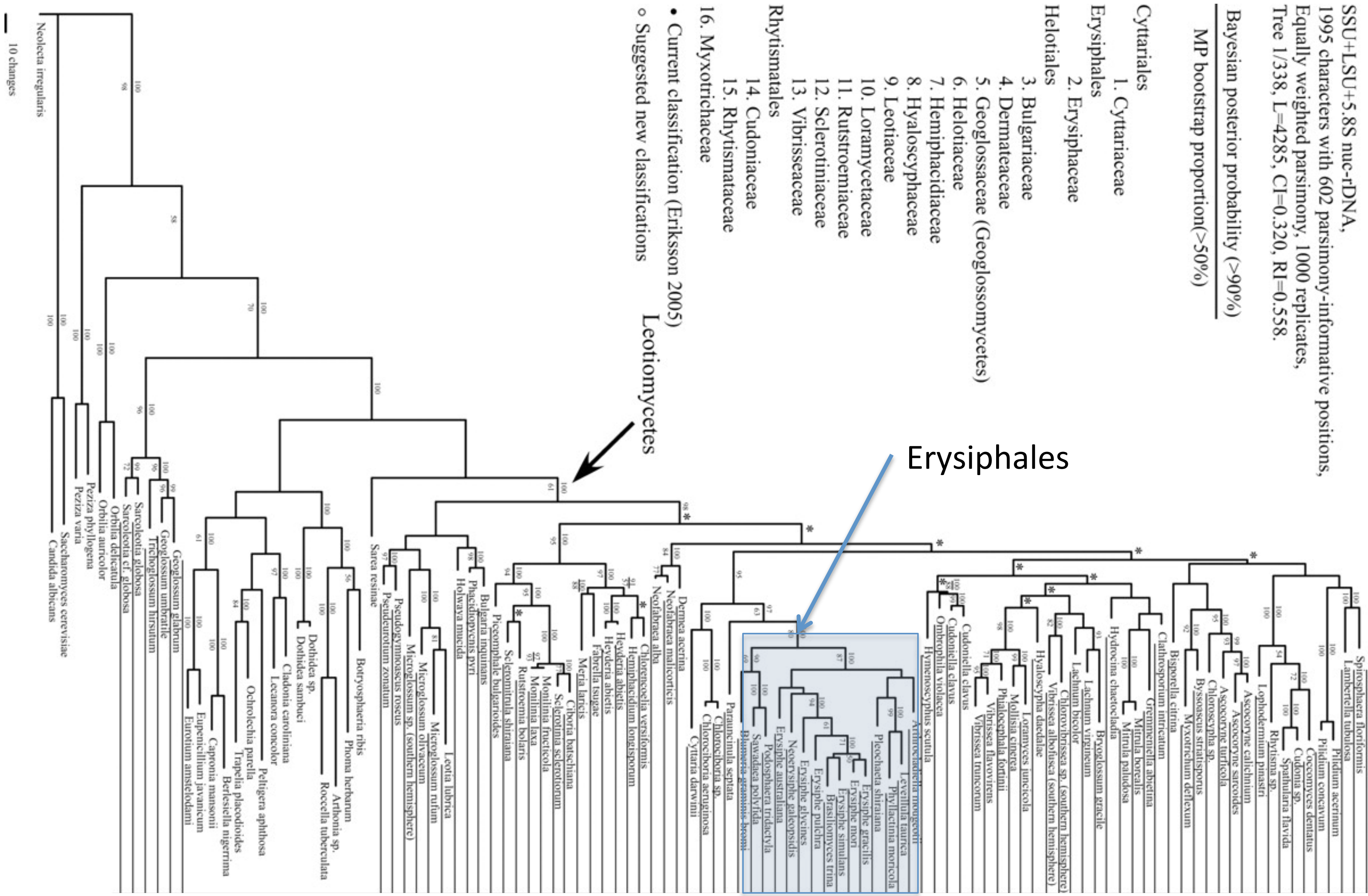


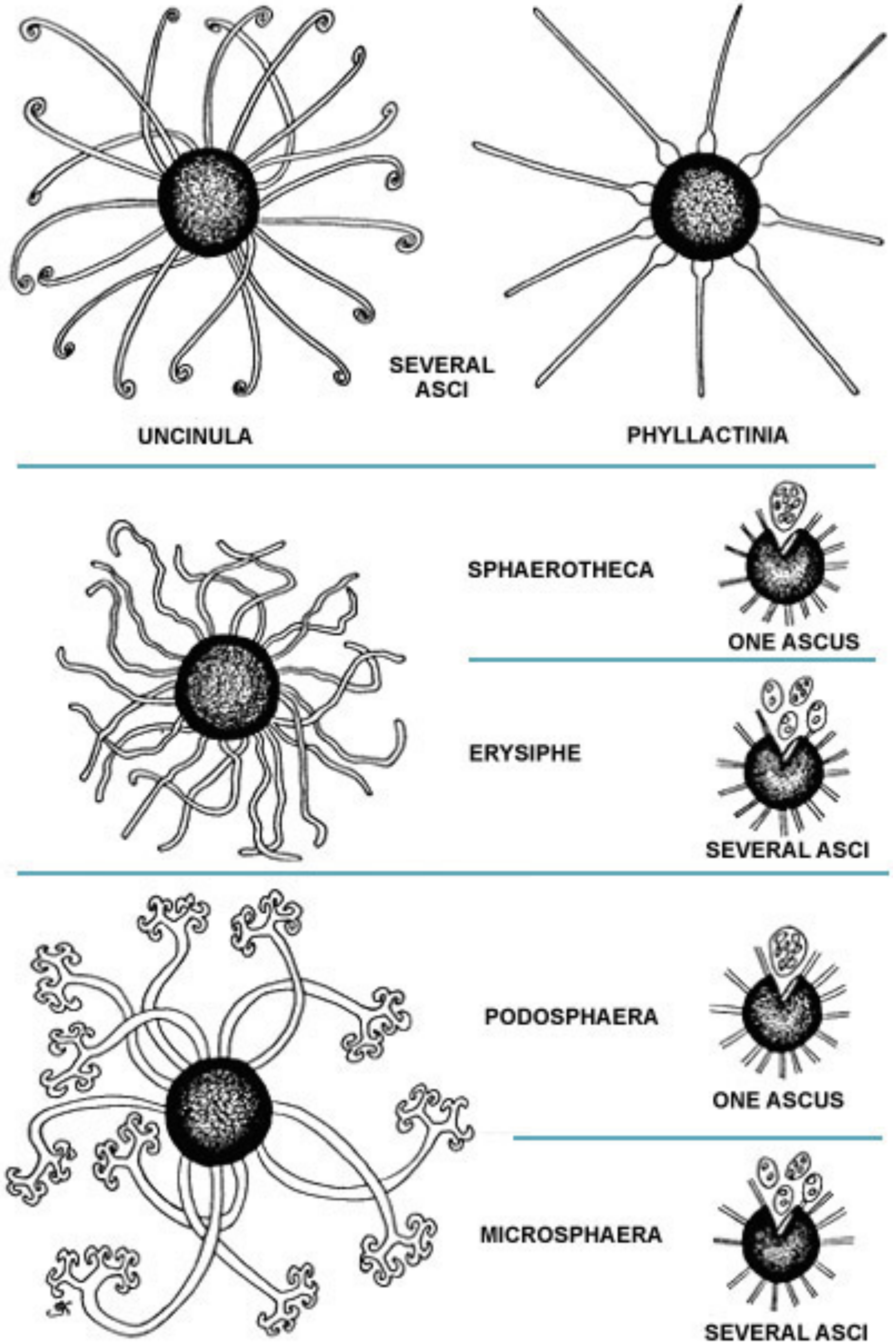
Figure 15-8 Conidiophore and conidium development in ***Erysiphe polygoni.*** [From E. Foex. 1912. ***Ann. École Nat. Agr. Montpellier*** 11:246–264. Redrawn from Yarwood (1957) by R. W. Scheetz. By permission of the ***Botanical Review.***]



The Oidium anamorph of *Erysiphe*

All Leotiomycetes have apothecial ascocarps except Erysiphales

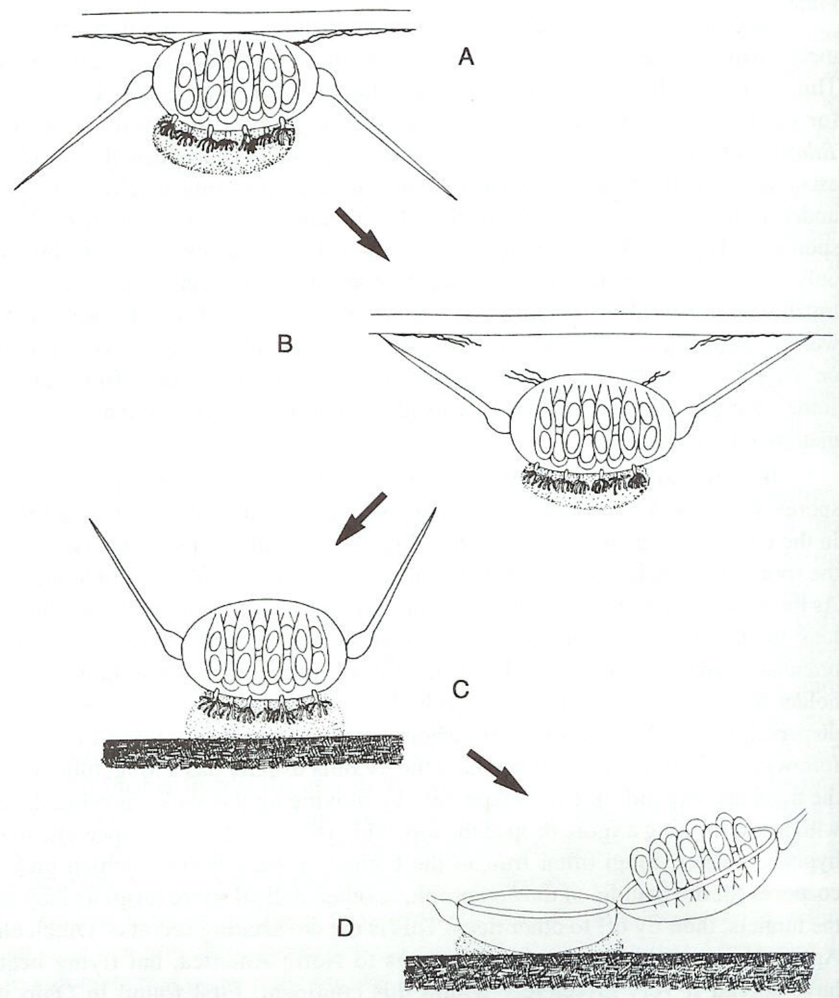




Ascocarps of Erysiphales have straightm curved, or branched hairs or appendages.

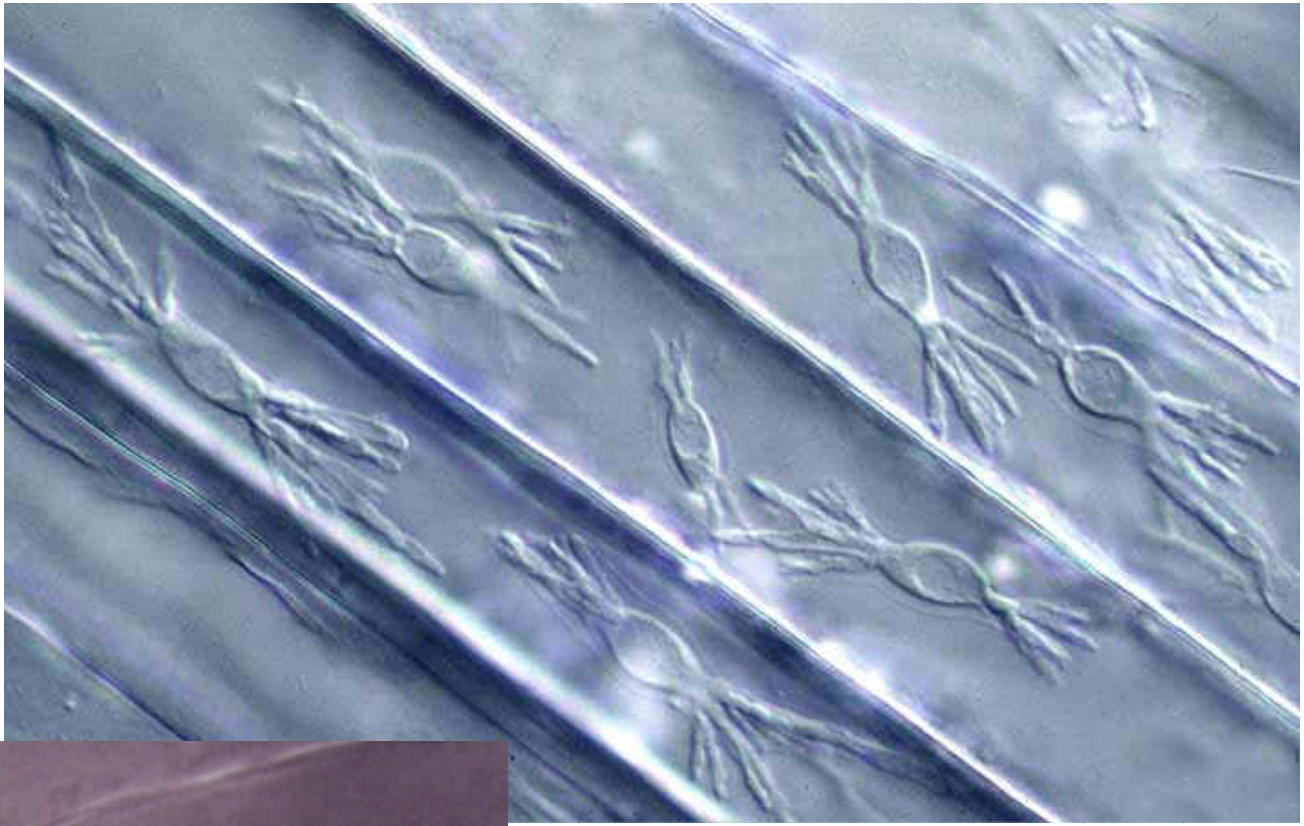
Taxonomy of Eryisiphales is based on whether ascocarp has a single ascus or multiple asci, and on shapes of appendages

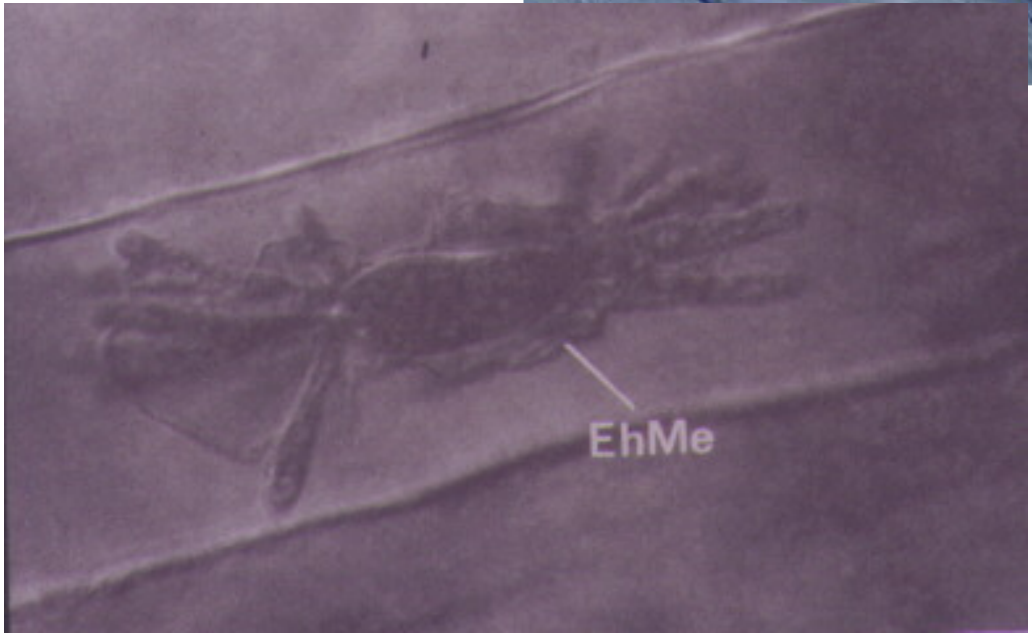
Appendages function in dispesal of Phyllactinia; the whole ascocarp can be a dispersal structure. Function of appendages of other Erysiphales is not known.



Dispersal of entire ascocarps of *Phyllactinia guttata* on *Corylus* (hazel)

Erysiphales have distinctive lobed haustoria





haustoria of *Blumeria graminis* in epidermal cells

Images APSnet

Soybean powdery mildew

Image APSnet

powdery mildew on melons

Image APSnet

Diseases caused by Sclerotiniaceae

Important life stage is a sclerotium, survival or overwintering structure

Sclerotinia white mold
Monilinia brown rot
Botrytis/Botryotinia gray mold
Mummyberry
Peach mummy

Sclerotiniaceae apothecia from germinating sclerotia

Sclerotinia sclerotiorum—white mold, very broad host range, many important annual, agriculturally important plants: carrot, bean, sunflower, broccoli, strawberry, many others

Sclerotinia

sclerotia of *S. sclerotiorum* on brussels sprouts

Symptoms and sclerotia of white mold on sunflower

white mold *Sclerotinia sclerotiorum*

lettuce drop

Tomato stem rot

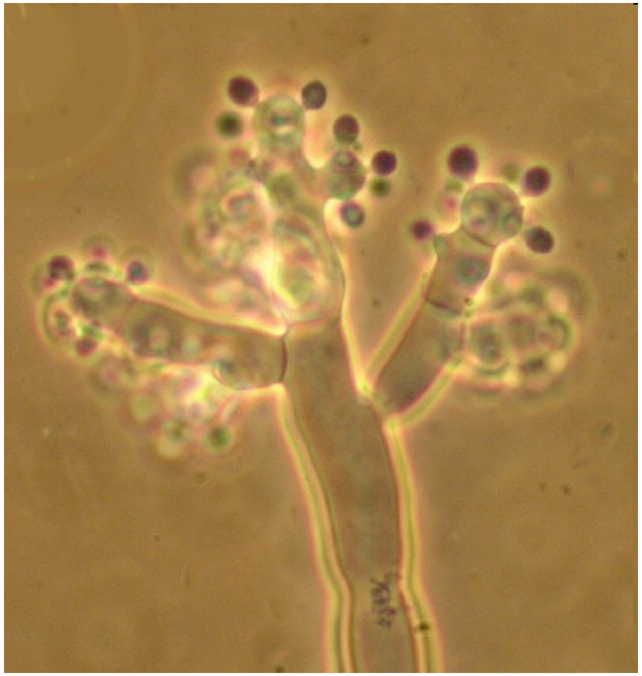
white mold of beans

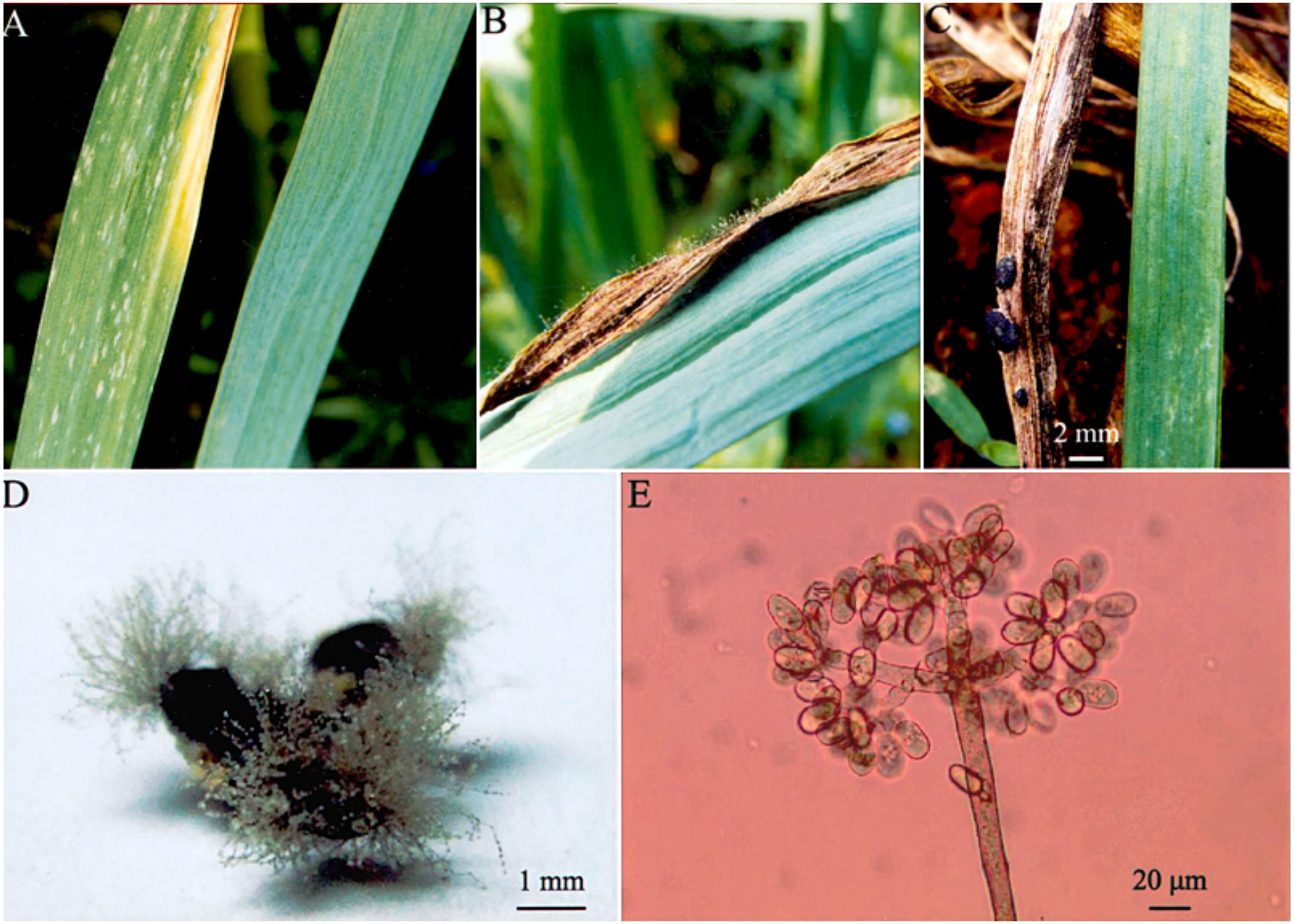
Sclerotinia sclerotiorum on strawberry

H. Costa, F. Ávila Rodrigues, L Zambolim. APSnet

Botrytis cinerea
an opportunist with broad host range
Teleomorph is *Botryotinia*, but rarely seen

B. cinerea is a generalist pathogen with a very broad host range. Gray mold affects many different plants.



Botrytis squamosa blight of garlic. A, Initial foliar symptoms (left) on a garlic leaf compared with a healthy garlic leaf (right); B, Sporulation of B. squamosa on a dead leaf (top, compared with a healthy leaf (bottom); C, Three black sclerotia produced by B. squamosa on a dead leaf (left); D, A sclerotium of B. squamosa germinated to produce profuse conidiophores and conidia; E, A conidiophore of B. squamosa with clusters of ellipsoidal conidia. Mr. M. D. Wu and Dr. G. Q. Li. APSnet.

Botrytis affects many different hosts

Bunch rot of grape

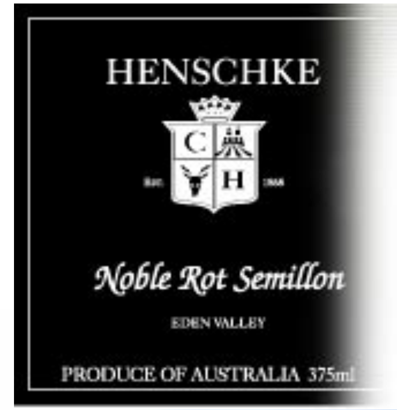
Douglas-fir dieback after frost injury; tissue susceptible to infection *by B. cinerea*

fruit rot

rose blight

grey mold
on beans

Noble Rot, intentional infection of grape clusters with *B. cinerea*



Ciborinia petal blight of Camellia

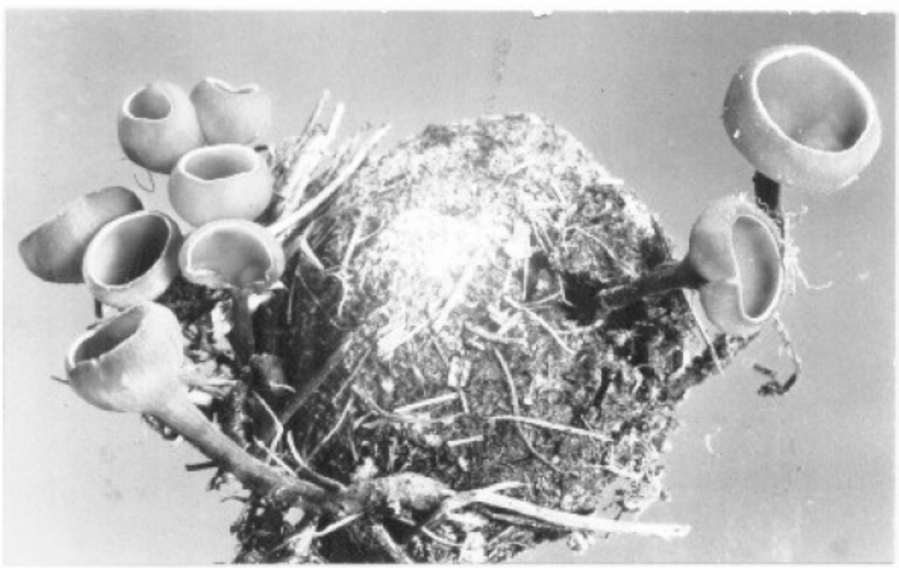
Ciborinia camelliae

Brown rot of stone fruits
Monilinia fructicola, M. laxa

Peach mummy disease
Affects stone fruits, peaches, apricots, nectarines, almonds, plums prunes, cherries
Also affects apples and pears

Four species of *Monilinia* affect Rosaceae fruits:

Monilinia fructicola widespread in NA, infects blossoms, twigs, fruits; primary host *Prunus* spp. but also apple, pear
M. fructigena occurs in Europe, primary host is apple, pear; does not infect blossoms or twigs
M. laxa infects both blossoms, twigs, fruits; co-occurs with *M. fructicola* in PNW, affects *Prunus* but also apple, pear
Monilia polystroma known only from anamorph, cause of brown fruit rots in Japan



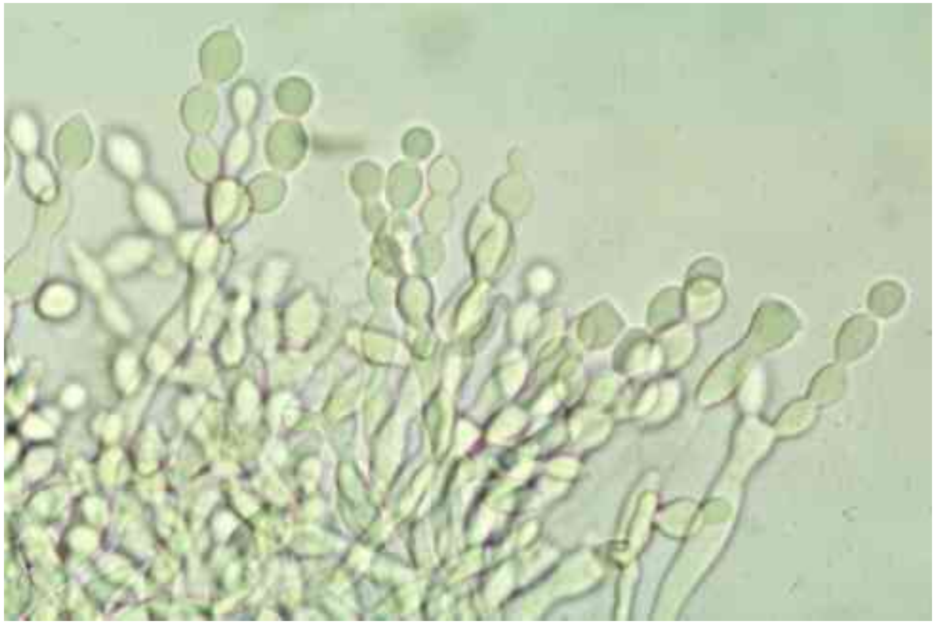
Monilinia

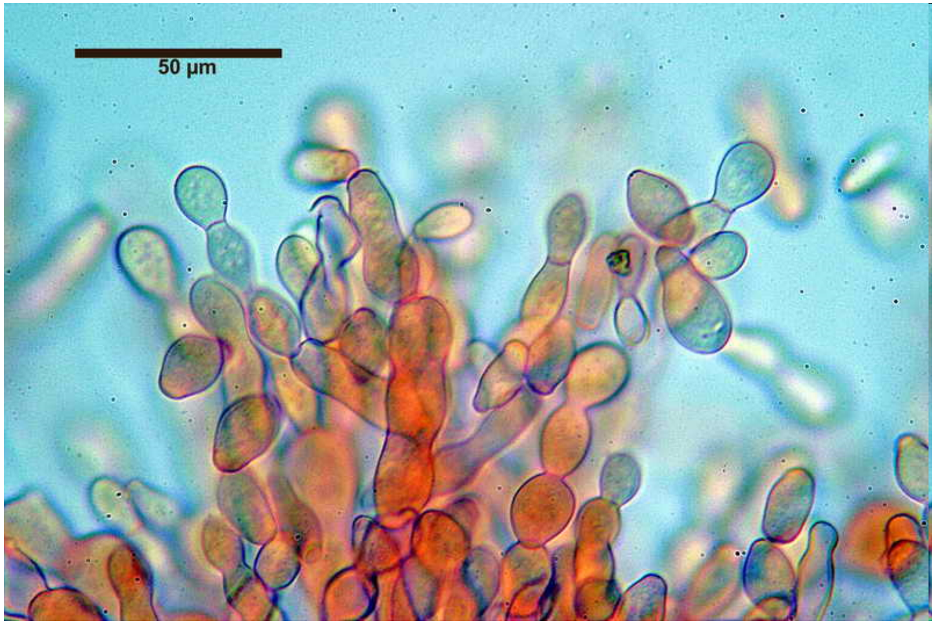
M. fructigena

M. fructicola

Powdery appearance on infected fruit is the *Monilia* anamorph. The fruit mummys become sclerotia

Monilia anamorph—the mold of brown mold





Floral mimicry: mummyberry disease

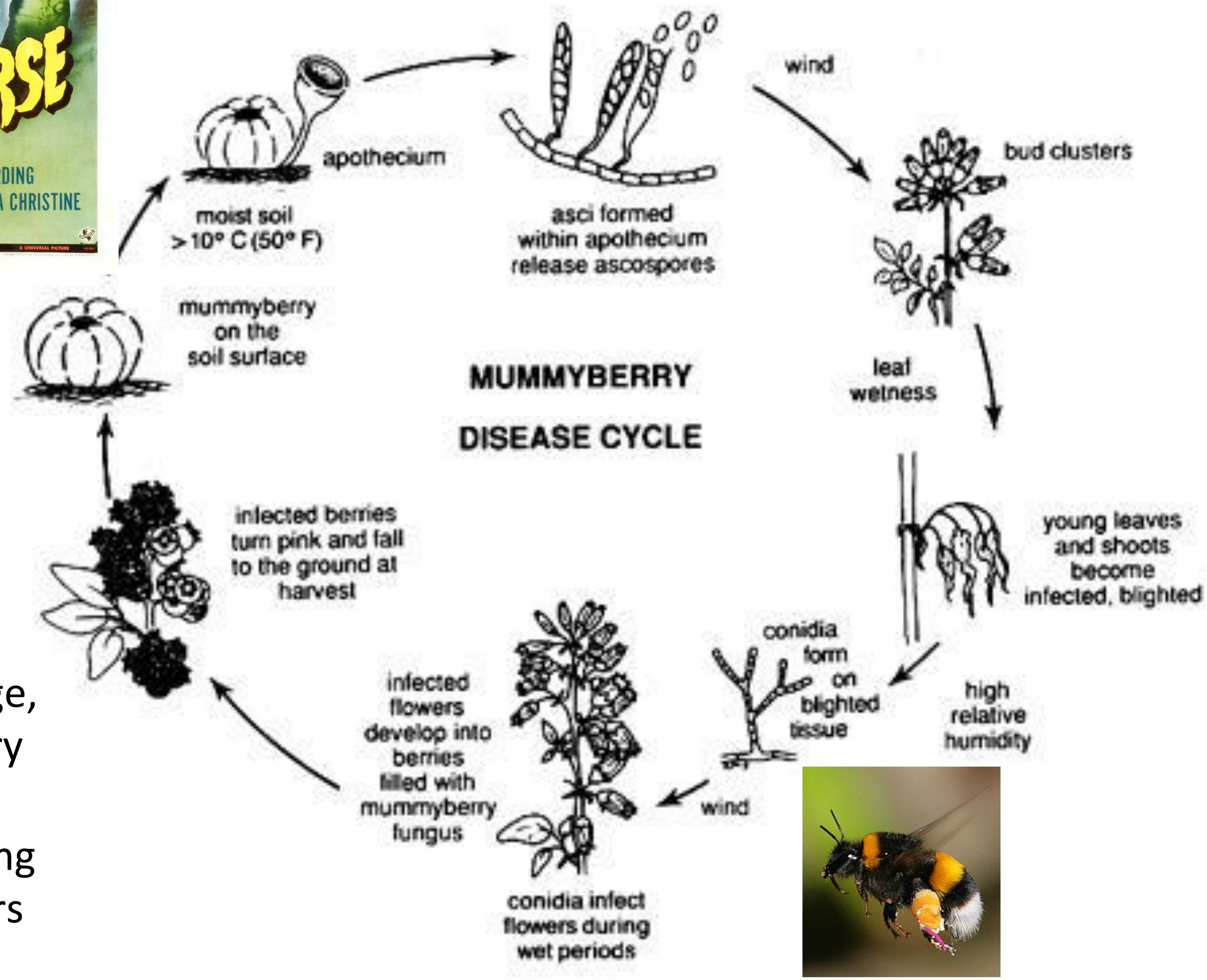
Monilinia vaccinii-corymbosi

Blueberry mummies, entire berry becomes a sclerotium, survives in soil over winter and germinates in spring

Mummy berry disease, flower mimicry

Both leaves and flowers can be infected, only infected flowers produce mummies (sclerotia). Infected foliage wilts and is attractive to pollinator insects like bees.

Bees visit the infected foliage, contact the conidia and carry them to flowers, which become infected. Developing berries from infected flowers become mummies.



Disease cycle of mummy berry.

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Lachnellula willkommii Larch canker

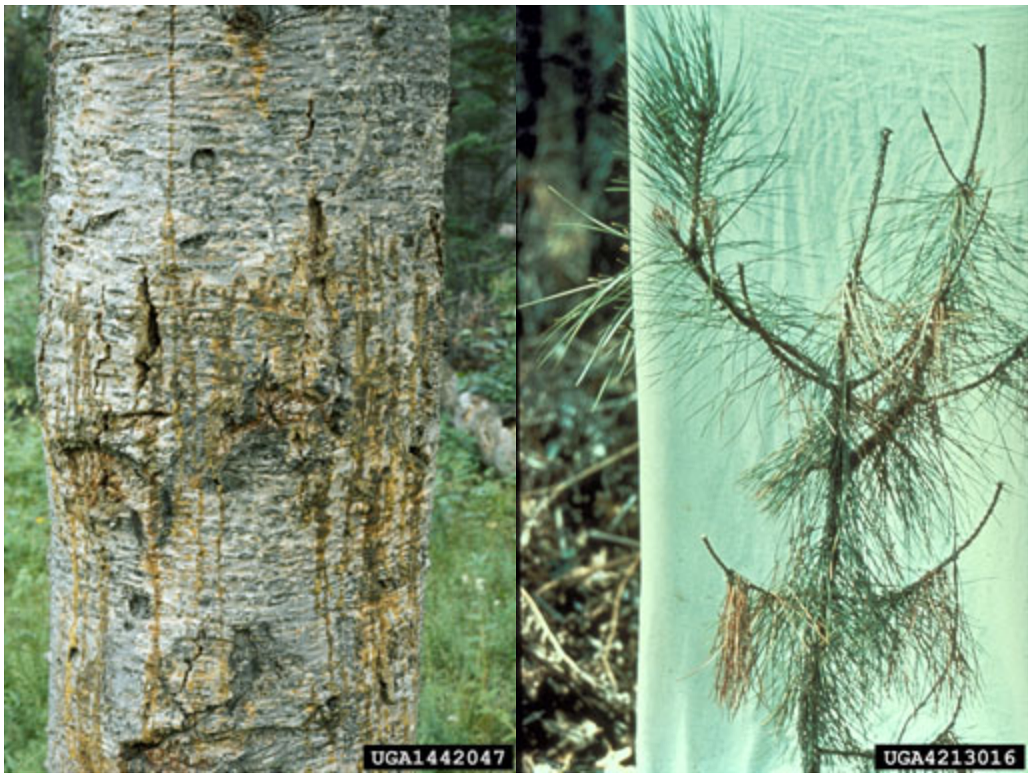
Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Cenangium ferruginosum dieback and canker of pine

Affects lodgepole, ponderosa, eastern white pine
Trees under drought stress or winter cold injury are predisposed to infection
"endophytic", inconspicuous colonist of bark that causes disease when trees are stressed
Impact is greater in NE USA, Asia (Korea, Japan)

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Gremmeniella abietina
Anamorph *Brunchorstia pinea*
Scleroderris canker



Affects pines in areas that have substantial winter snowpack

varieties abietina and balsamea in NA

Asian, NA and European races are recognized that differ in aggressiveness and host range

NA race affects lodgepole and jack pine, Eur race affects red pine and white pine in eastern NA

cold adapted (psychrophilic) grows at -6 to 5 C, on snow covered parts of trees

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Gremmeniella abietina

Brunchorstia conidia

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Dermateaceae

Blumeriella jaapii
Anamorph
Phloeosporella padi

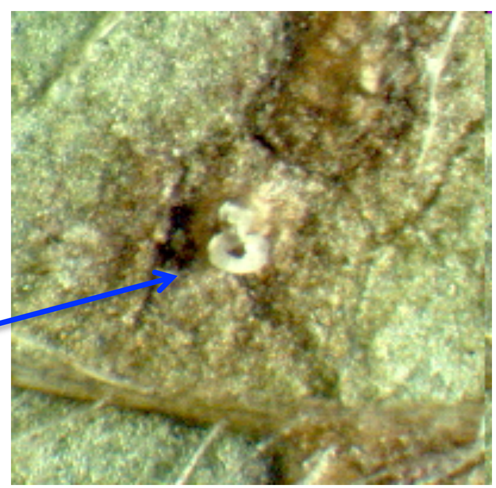
Cherry leaf spot

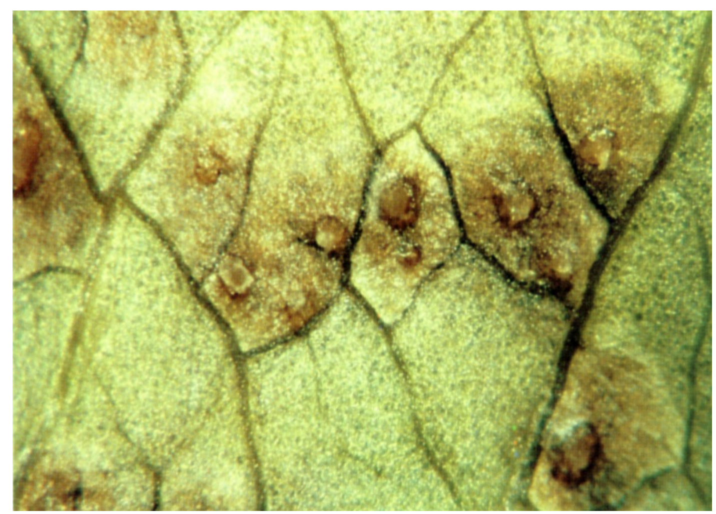
Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Phloeosporella padi

A coelomycete with pycnidia

masses of condia





Ascomycete pathogens: leaf spots, foliage blights and stem cankers

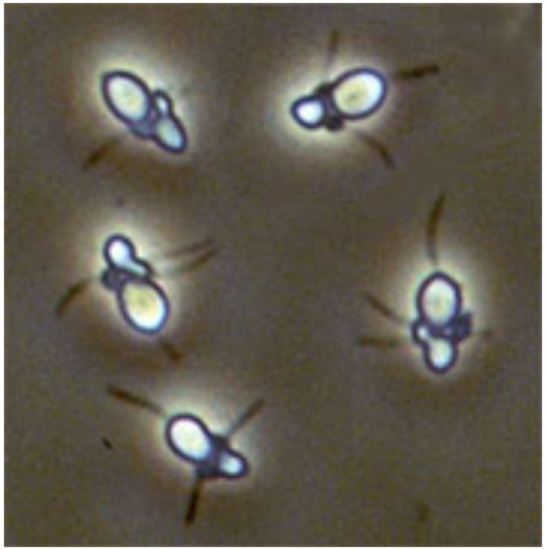
Diplocarpon black spot of rose

Figure 1. Spores of Diplocarpon rosae *stained with cotton blue.*

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Diplocarpon black spot of rose

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

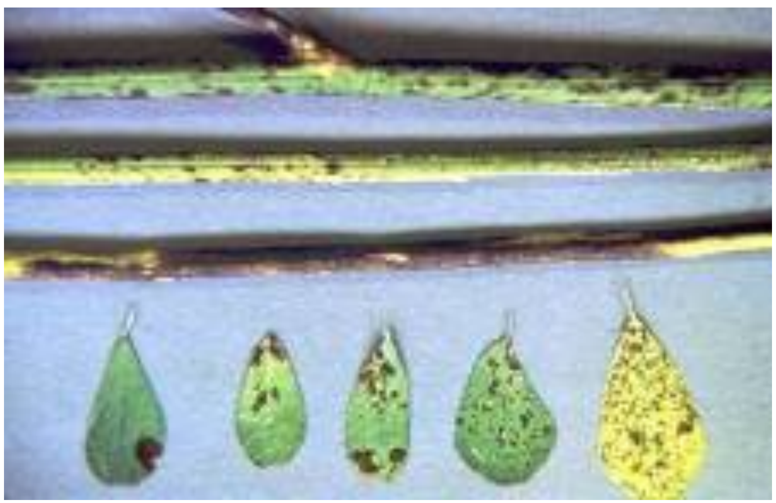


Entomosporium anamorph of *Diplocarpon*

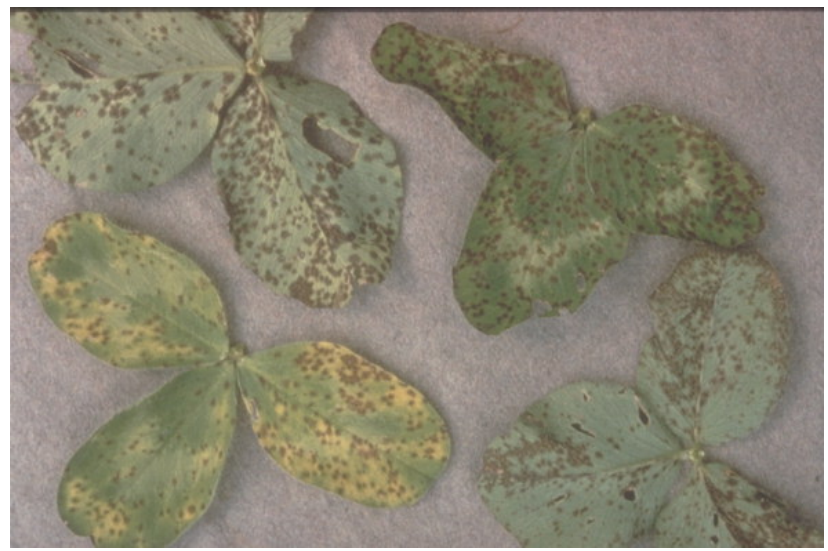
Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Pezicula cinnamomea, anamorph *Cryptosporiopsis*, canker of apple and pear
Also causes canker of Quercus robur in Europe

Ascomycete pathogens: leaf spots, foliage blights and stem cankers



Leptotrochila medicaginis
Yellow leaf blotch of alfalfa



Pseudopeziza alfalfae alfalfa leaf spot

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

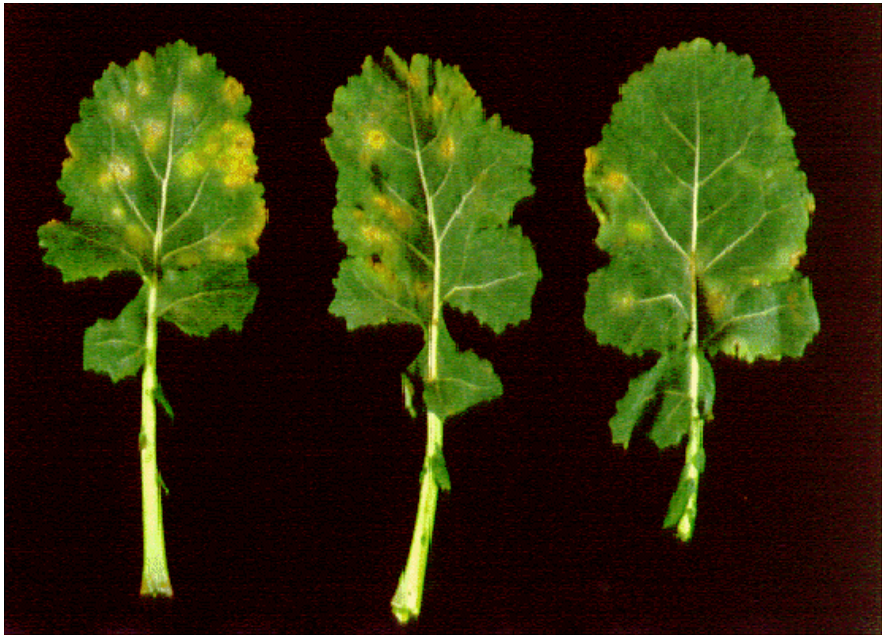
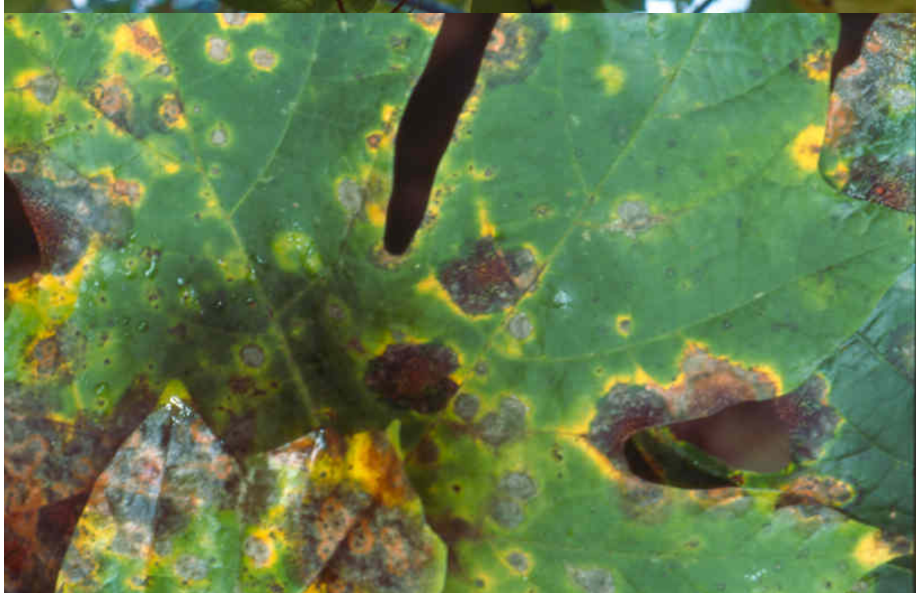


Image: Rothamstead Research

Pyrenopeziza brassicae
Light leaf spot of winter oilseed rape, *Brassica napus*

Ascomycete pathogens: leaf spots, foliage blights and stem cankers



Rhytisma punctatum

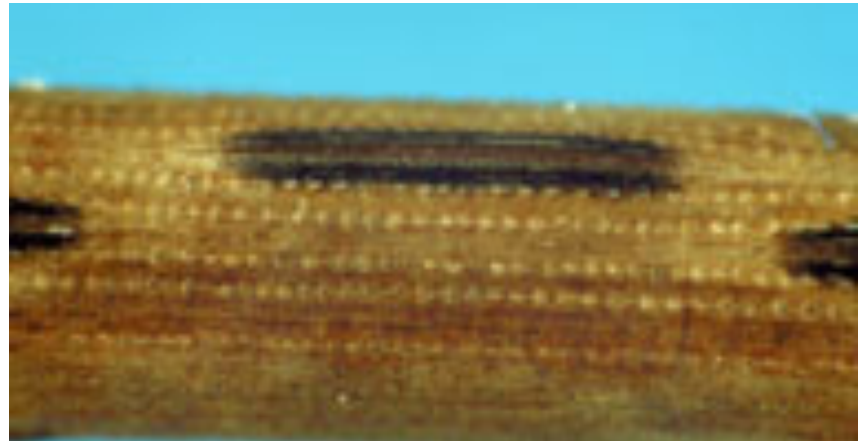
tar spot of maple

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Lophodermella and
Cyclaneusma needle casts of
Monterey,
lodgepole and ponderosa pine

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Lophodermella symptoms



Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Cyclaneusma minus

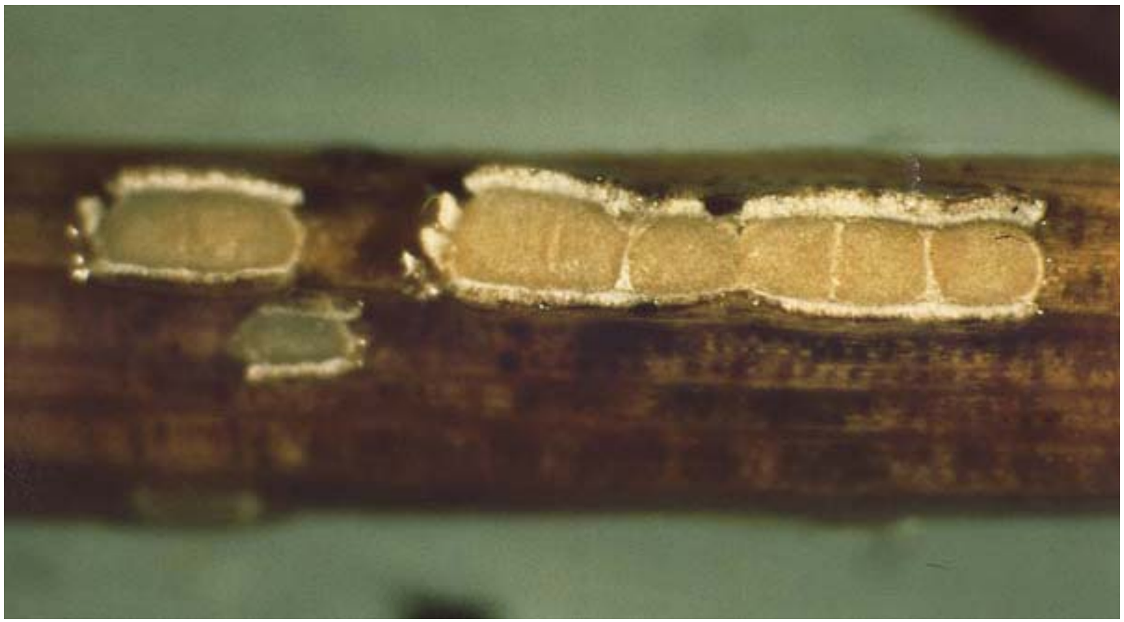
Also known by its older name *Naemacyclus minor*

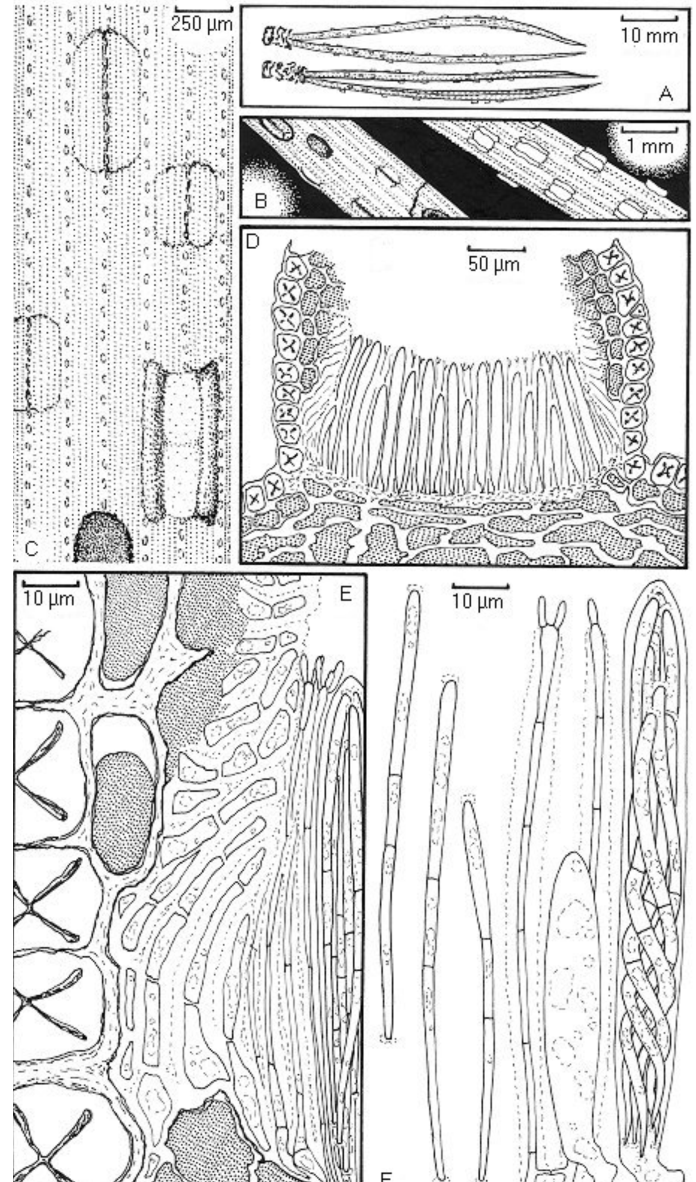
Numerous pine species are hosts, including *P. radiata, P. ponderosa*

Can be a significant cause of defoliation in young plantations when several consectutive years of favorable conditions occur.

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

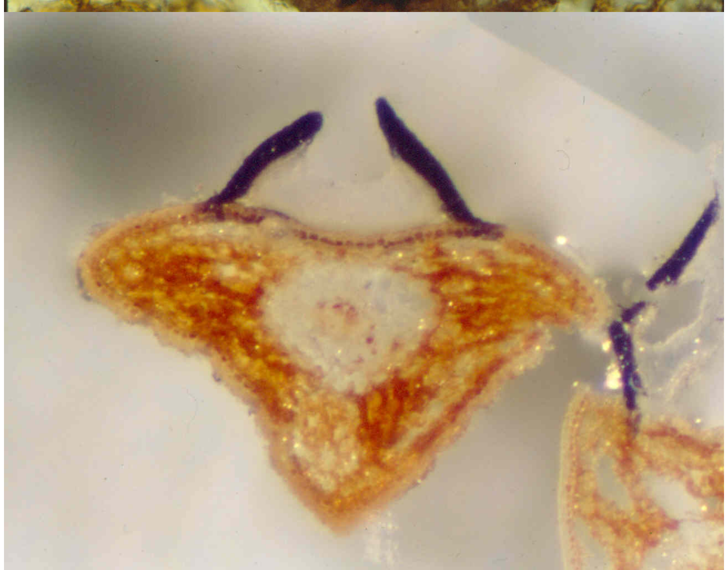
Cyclaneusma minus apothecia

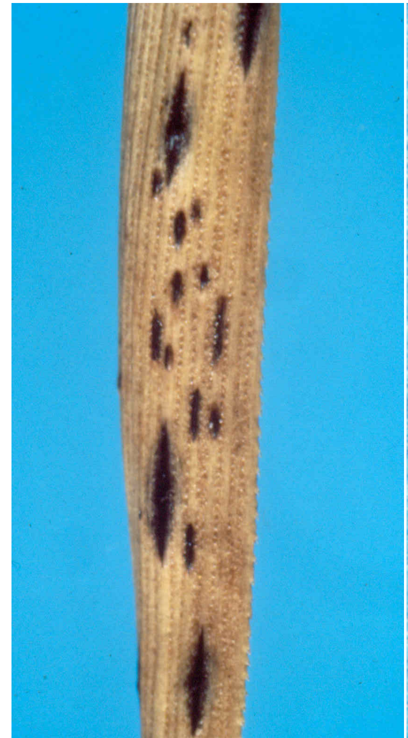


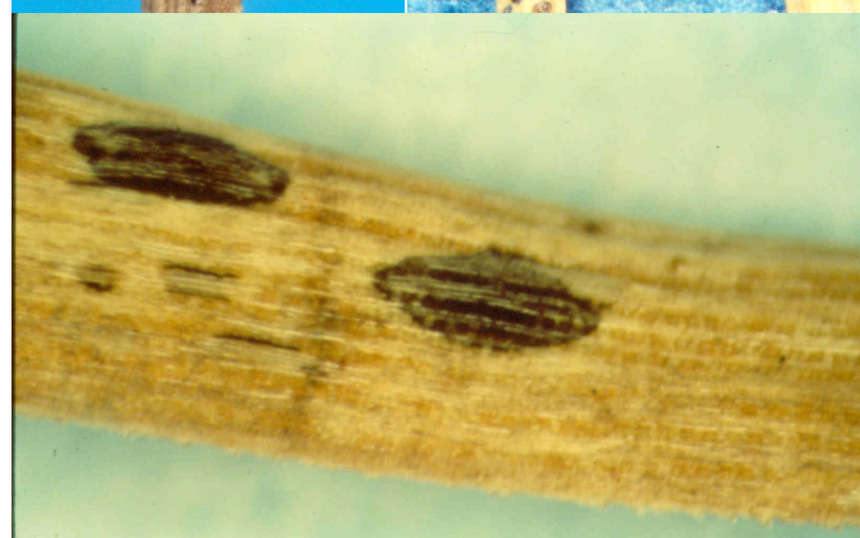


Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Lophodermium on pine



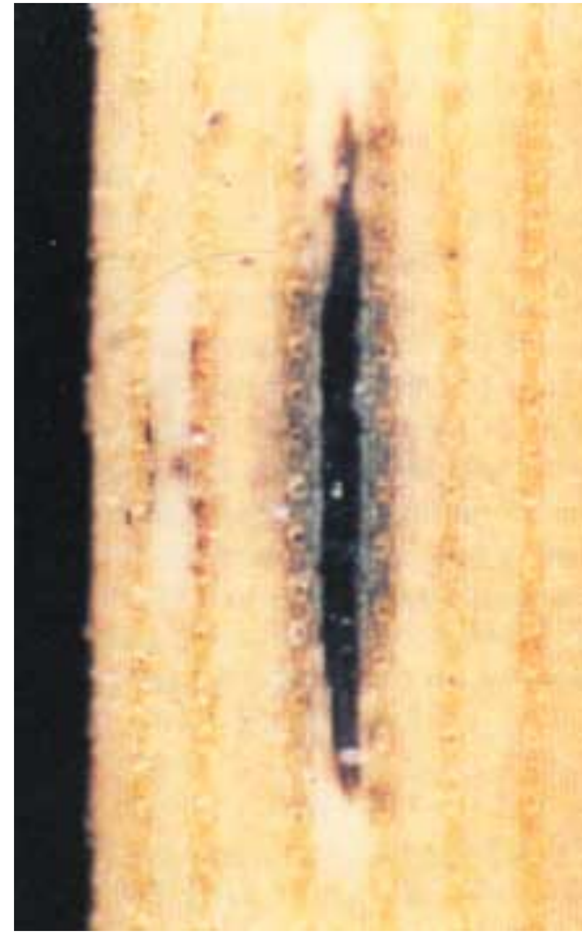




Ascomycete pathogens: leaf spots, foliage blights and stem cankers

L. pinastri

L. seditiosum



L. australe

Ascomycete pathogens: leaf spots, foliage blights and stem cankers

Ploioderma lethale foliage blight of loblolly pine