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GLOSSARY

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This is a revision of a 2000 publication of the same title, which has been archived.

Identification of Powdery Mildew Fungi anno 2006

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OBJECTIVES:

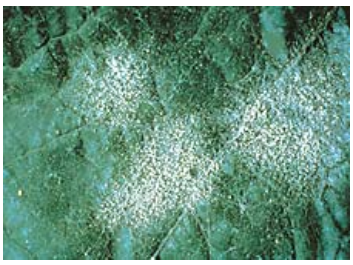
1. To observe powdery mildew diseases.
2. To use characteristics of asexual and sexual fruiting structures on fresh material to identify pathogen to genus.

INTRODUCTION:

Powdery mildew fungi are obligate, biotrophic parasites of the phylum Ascomycota of Kingdom Fungi. The diseases they cause are common, widespread, and easily recognizable. Infection by the fungus is favored by high humidity but not by free water. Individual species of powdery mildew fungi typically have a very narrow host range.

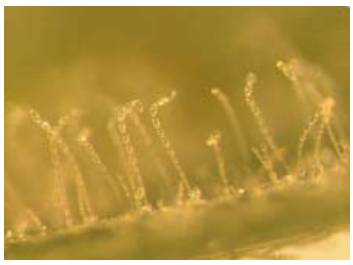
Unlike most fungal pathogens, powdery mildew fungi tend to grow superficially, or **epiphytically**, on plant surfaces. During the growing season, hyphae are produced on both upper and lower leaf surfaces, although some species are restricted to one leaf surface only. Infections can also occur on stems, flowers, or fruit. Specialized absorption cells, termed **haustoria**, extend into the plant epidermal cells to obtain nutrition. While most powdery mildew fungi produce epiphytic mycelium, a few genera produce hyphae that are within the leaf tissue; this is known as **endophytic** growth.

Conidia (asexual spores) are also produced on plant surfaces during the growing season. They develop either singly or in chains on specialized hyphae called **conidiophores**. Conidiophores arise from the epiphytic hyphae, or in the case of endophytic hyphae, the conidiophores emerge through leaf stomata.



Hyphae and conidia of powdery mildew on the surface of a grape leaf. (Courtesy J. Schlesselman)

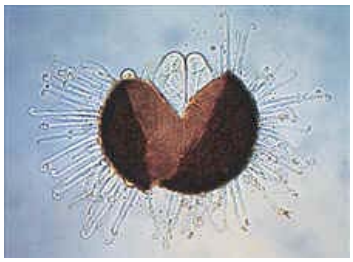
Conidia of powdery mildew in pseudochains, shown in profile. (Courtesy W. Gärtel)



Conidiophores of powdery mildew producing true chains of conidia (*Blumeria graminis*). (photo by N. Shishkoff)

At the end of the growing season, powdery mildew fungi produce sexual spores, known as **ascospores**, in a sac-like **ascus** (pl. **asci**) enclosed in a fruiting body called a **chasmothecium** (pl. chasmothecia) (**cleistothecium** is a former term for this structure that is still widely used). The chasmothecium is generally spherical with no natural opening; asci with ascospores are released when a crack develops in the wall of the fruiting body. This type of fruiting body is unique among the Ascomycota. A variety of appendages may occur on the surface of the chasmothecia. These appendages are thought to act like the hooks of Velcro fastener, attaching the fruiting bodies to the host, particularly to the bark of woody plants, where they overwinter.

Epiphytic hyphae and chasmothecia on leaf surface. (Courtesy W. Gärtel)



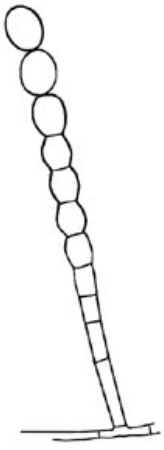
Ruptured chasmothecium showing several asci containing ascospores. *Erysiphe* (Section *Uncinula* sp.) (Courtesy B. Kendrick)

The taxonomy of powdery mildew fungi (order Erysiphales) recently underwent extensive revision based on DNA sequence data. Previously, identification was based largely on the teleomorph (sexual stage) and the morphology of the chasmothecium and its appendages, but the morphology of structure is not as conserved as originally assumed. With the new taxonomy, identification of powdery mildews now also requires attributes of the anamorph (asexual stage), so that it incorporates characteristics of the whole fungus (anamorph plus teleomorph, i.e., the holomorph). Powdery mildew genera are now grouped into five tribes, and some genera have been added or merged. The chart below shows the tribes and some representative genera of each; the previous teleomorphic names (and less commonly used anamorphic names) are given to aid in reference to the older literature.

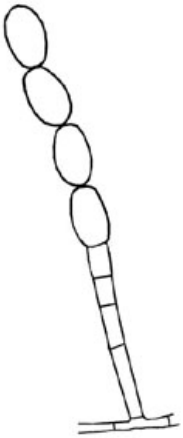
Tribe	New holomorphic genus	Anamorphic genus	Former teleomorphic genus	Common Hosts
Phyllactineae	*Phyllactinia*	*Ovulariopsis*	*Phyllactinia*	trees and shrubs
	Leveillula	*Oidiopsis*	*Leveillula*	Solanaceae
Erysipheae	*Erysiphe* section *Erysiphe*	*Oidium*	*Erysiphe* section *Erysiphe*	legumes
	Erysiphe section *Microsphaera*	*Oidium*	*Microsphaera*	trees and shrubs
	Erysiphe section *Uncinula*	*Oidium*	*Uncinula*	trees and shrubs
Blumeriae	*Blumeria*	*Oidium*	*Blumeria/Erysiphe*	grasses
Golovinomyceteae	*Golovinomyces*	*Oidium*	*Erysiphe* section *Golovinomyces*	cucurbits and composites
Cystotheceae	*Podosphaera* section *Podosphaera*	*Oidium*	*Podosphaera*	Rosaceae
	Podosphaera section *Sphaerotheca*	*Oidium*	*Sphaerotheca*	

A major distinction for identification is whether conidia are produced in chains or singly. However, this distinction can be difficult to observe, and in some genera, particularly in the Erysipheae, conidia that are produced singly can “stick together” to form **pseudochains**, which are not true chains.

conidiophore producing single conidium.



conidiophore producing conidia in true chain.



conidiophore and pseudochain.

Other characteristics that aid in classification are the location of mycelium (epiphytic or endophytic) and host specificity. In addition, the presence of one or several asci in each chasmothecium can also be useful for identification. From a practical perspective, the morphology of chasmothecium appendages remains important as a connection with the older descriptions and references concerned with powdery mildew diseases.

Powdery mildews are polycyclic diseases that can impair photosynthesis, stunt growth, and increase the rate of senescence of host tissue. The diseases they cause may be slight or, in some situations, if left untreated, they may result in severe economic losses on crops such as apples, grapes, cucurbits, and cereals.

MATERIALS

- Fresh and dried plant materials with powdery mildew signs
- Clear scotch tape
- Dissecting needles/ single-edge razor blades
- Microscope slides
- Coverslips

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PROCEDURES

Asexual stage
With a dissecting microscope, examine the surface of a diseased leaf. Look for the presence of mycelium on the leaf surface (epiphytic growth). Genera that are partially or completely endophytic will show reduced mycelium on the surface of the leaf.

Observe the leaf surface for conidia and conidiophores produced on the plant surface by epiphytic hyphae, or emerging through stomata from endophytic hyphae. Folding a section of the leaf may allow these structures to be more easily observed in profile along the crease.

Using a piece of clear tape (smaller than the microscope slide), hold one end of the tape and lightly smooth the rest of the tape (sticky side down) over the conidia and conidiophores. Place the tape, sticky side down, on a drop of water on the microscope slide. Observe with a compound microscope. Attempt to locate an intact conidiophore with conidia, and determine if the conidia are borne on the conidiophore singly or in chains.

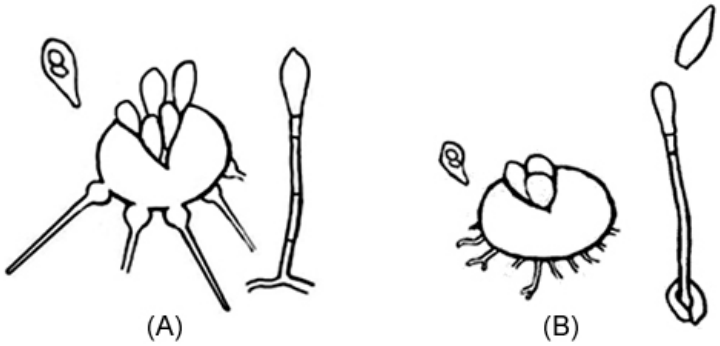
Sexual stage
Examine fresh or dried leaves using a dissecting microscope for small black spherical structures (chasmothecia). Remove several with scotch tape (as above) or with a moistened dissecting needle or razor blade, place them in a drop of water on a microscope slide, and add a coverslip if necessary. If the slide is placed over a white sheet of paper, it is possible to see if you have successfully moved some of the (black) chasmothecia to the drop of water on the slide.

Examine the chasmothecium with a compound microscope. Using the descriptions in the key below, determine the type of appendages present on the surface of the fruiting body. After observing the appendages, press gently on the coverslip or tape with the blunt end of a dissecting needle to break open the fruiting body and allow the asci to be released. Immediately examine microscopically to determine if one or several asci are contained in each chasmothecium.

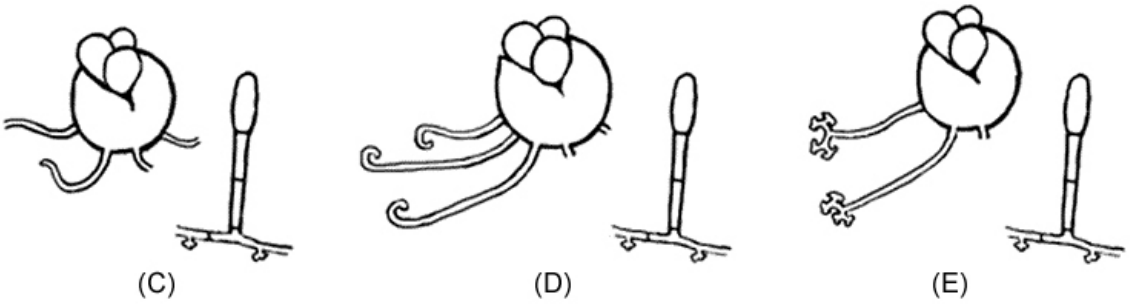
Use the following key and diagrams of some of the common powdery mildew genera to identify the causal agent to genus. [Note: the section name is generally the genus name in literature published before 2003.]

Key to Genera of Powdery Mildew Fungi

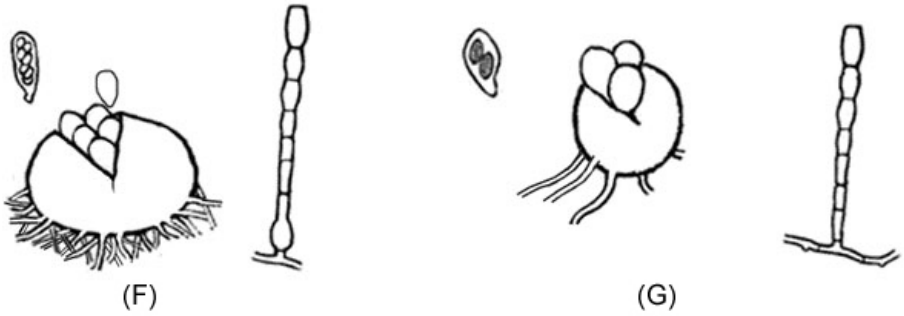
Conidia formed singly
  Mycelium partially endophytic
    Chasmothecium contains several asci
      Appendages straight, bristle-like, with bulb-like base……..…...…..……..….....*Phyllactinia* (A)
      Appendages simple, hypha-like……..……..……..……...…..…..……*Leveillula* (B)



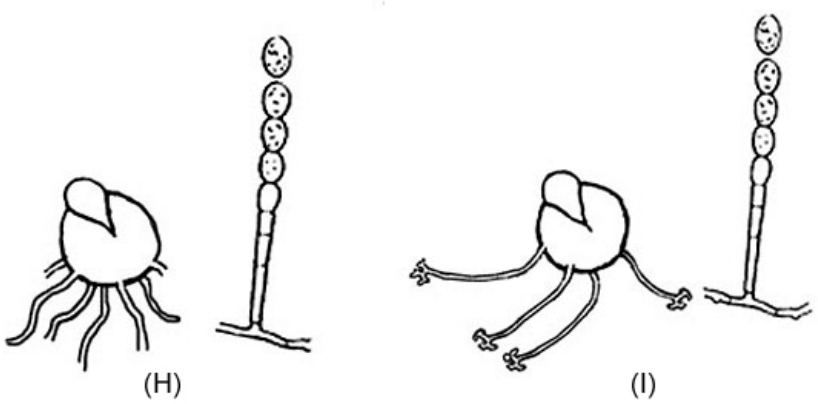
Conidia formed singly (or in pseudochains)
Mycelium epiphytic
Chasmothecium contains several asci
Appendages simple, hypha-like…….....*Erysiphe* (section *Erysiphe*) (C)
Appendages coiled or hooked at tip.....…….....….....…*Erysiphe* (section *Uncinula*) (D)
Appendages branched dichotomously at tip...……..…*Erysiphe* (section *Microsphaera*) (E)



Conidia formed in true chains
Mycelium epiphytic
Chasmothecium contains several asci
Appendages short, simple, hypha-like; infects grasses…..…….....……*Blumeria* (F)
Appendages hypha-like, flexuous, simple or irregularly branched; infects dicots…....*Golovinomyces* (G)



Conidia formed in true chains
Mycelium epiphytic
Chasmothecium contains a single ascus:
Appendages simple, hypha-like……..…..……..….*Podosphaera* (section *Sphaerotheca*) (H)
Appendages bristle-like, branched dichotomously at tip…..…...*Podosphaera* (section *Podosphaera*) (I)



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OBSERVATIONS

Diagram the conidiophores and conidia seen on the diseased leaf.

In the table below, record the location of conidiophores, the type of conidia formation, the number of asci per chasmothecium, and a description of the appendages found on the chasmothecium. Using this information, determine the pathogen genus for each powdery mildew.

Plant host	Conidiophores (arising from epiphytic hyphae or emerging through stomata)	Conidia formation (singly, or in chains)	# of asci per chasmothecium (one or several)	Appendage morphology	Pathogen genus

Conclusions and Questions

What physiological functions of the plant are impaired by powdery mildew fungi?

What is the function of the chasmothecium in the disease cycle?

What is the function of the conidia in the disease cycle?

Why are fungal pathogens frequently assigned to more than one genera? Why is the generic name based on the holomorph (whole fungus) concept important in the powdery mildews?

Speculate as to why free water on the surface of a plant might be unfavorable to a powdery mildew pathogen.

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