# Fungal Diseases of Vegetables

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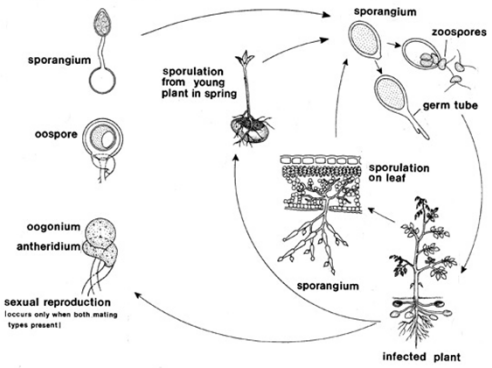
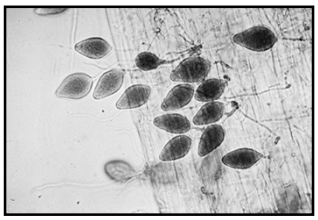


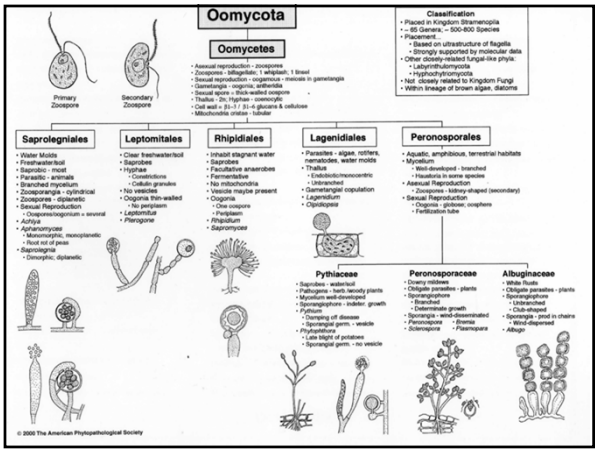

## Oomycota

- **Sexual spore is a oospore**
- **Hyphae are coenocytic**
- **Asexual zoospores, formed within a sporangium**
- **Aquatic, amplibious, terrestrial habitats, obligate parasite**

## Asexual Reproductive Structures of Oomycetes

**Sporangium borne on a sporangiophore**

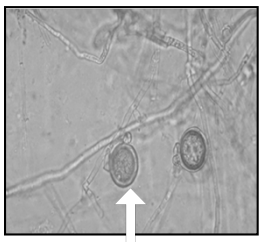





## Hyphae of Oomycetes

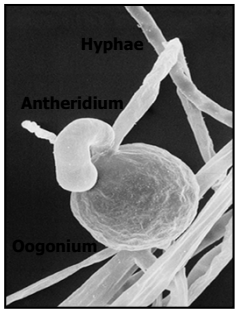
**Hyphae of Oomycetes**

- **Nuclei = 2N**
- **Few cell walls (septa)**
- **Coenocytic hyphae**
- **Fungus hyphae have many cell walls – septate hyphae**
- **Composed primarily of cellulose**
- **Cell walls of fungi mostly chitin**



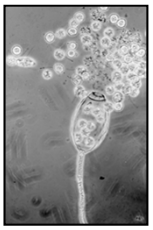
## Antheridium and Oogonium of an Oomycete

- Meiosis; 2N to 1N
- Migration of 1N nuclei from antheridium into oogonium
- Nuclei fuse to reestablish 2N nuclear condition (diploid)



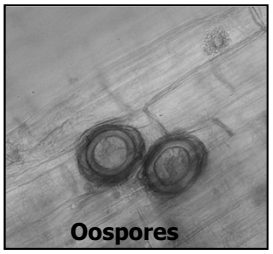

## Germination of Zoospores

Motile after release from sporangium
move to infection court
cease motility and germinate
germ tube penetrates host



## Spore Type of Oomycetes Oospore

- Thick cell walls
- Site of genetic recombination
- Survival
- Embedded in plant tissue
- Free in soil
- Surface of seed

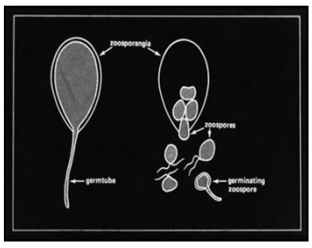



## Plant Pathogenic Oomycetes

- Multiple species within genera of:
  - *Phytophthora*
  - *Pythium*
  - *Peronospora*
  - *Plasmopsora*
  - *Bremia*
  - *Aphanomyces*

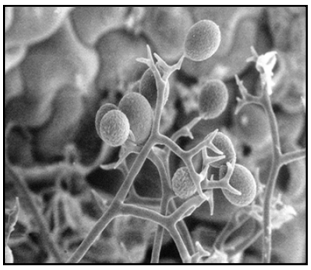
## Germination of Sporangium

- Sporangia germinate directly – germ tube
- Germinate by releasing zoospores

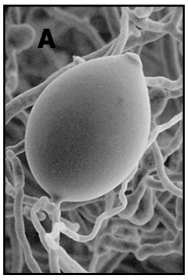


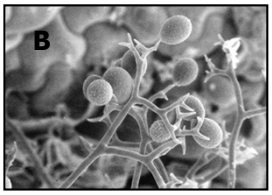

## Sporangia of Downy Mildew Fungi

- Sporangiophores are branched
- Many sporangia borne on one sporangiophore
- *Peronospora* is common cause of downy mildew

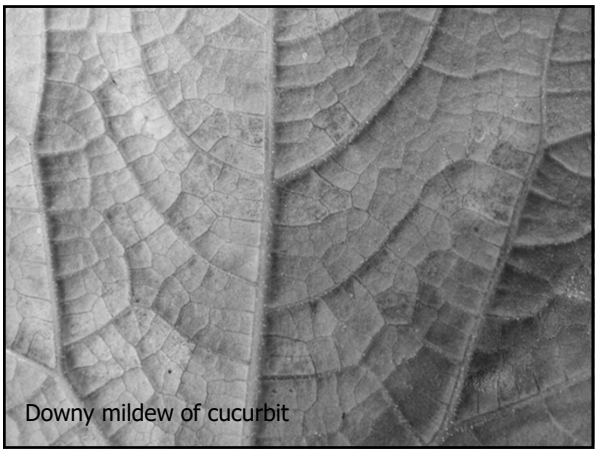


## Phytophthora compared to Downy Mildew Fungi



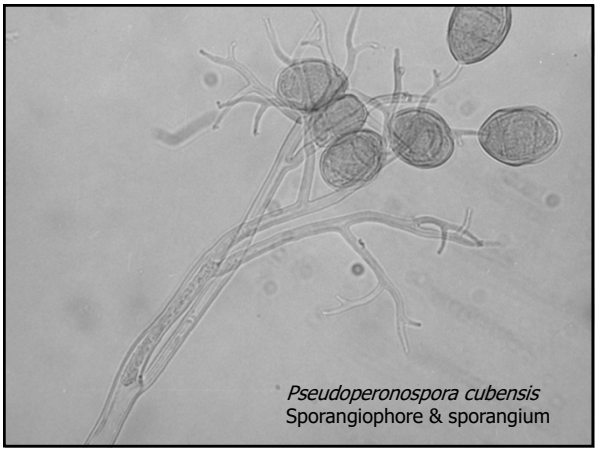




**A = Phytophthora**
**B = Downy mildew fungus**



Downy mildew of cucurbit

Downy mildew of kale



*Pseudoperonospora cubensis*
Sporangiophore & sporangium

Downy mildew of cucurbit

## Trophic Types within Oomycetes

- **Biotrophic**
  - **Obligate parasites**
    - **Downy mildew pathogens**
  - **Facultative parasites**
    - ***Phytophthora infestans***
- **Necrotrophic**
  - **Facultative parasites**
    - ***Pythium species***
    - ***Phytophthora species***
    - ***Aphanomyces species***

## Diseases Caused by Oomycetes

**Seed, stems and roots**

- *Pythium*
  - Damping off
  - Root rots
- *Phytophthora*
  - Root and stem rots
- *Aphanomyces*
  - Root rots

**Foliage and fruits**

- Late blight
  - *Phytophthora infestans*
- Downy mildew
  - *Peronospora*
  - *Plasmopora*
  - *Bremia*
- Blight of turfgrass
  - *Pythium*

## Oomycetes: *Pythium*, *Phytophthora* & *Aphanomyces*

- Nectrophic pathogens
- Cause seedling and root rot diseases
- Dormant inoculum: oospores
- Primary inoculum: zoospores
- Source: soil, hose nozzles, used plastic pots

## Diseases caused by Oomycetes Seed rots and Seedling Damping-off

- Pre-emergence damping-off
- Wet soil conditions
- *Pythium*
- *Phytophthora*
- *Aphanomyces*
- Seed rot and seedling necrosis
- Monocyclic disease cycle

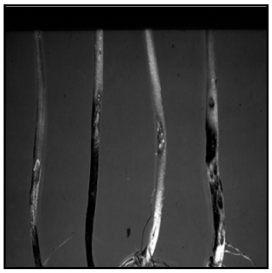
## Damping-off

- Term related to seed rot or seedling death
- Relates to disease caused by Pythium species
- Pythium most active in water saturated soils or potting media
- Pre- or Post- are prefixes related to status of seedling emergence

## Diseases caused by Oomycetes Damping-off

- Post-emergence damping-off
- Wet soil conditions
- *Pythium*
- *Phytophthora*
- *Aphanomyces*
- Seedling necrosis

## Diseases Caused by Oomycetes Concept of Primary & Secondary Symptoms



## Oomycetes: *Peronospora*, *Plasmopora*, *Phytophthora infestans*

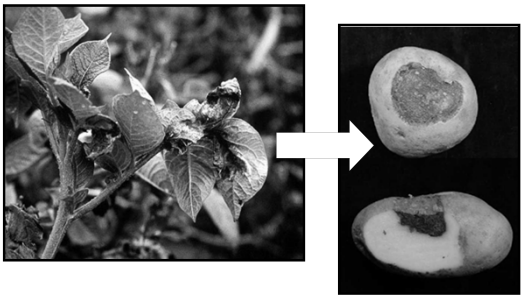
- **Obligate Biotrophs:**
  - ***Peronospora***
  - ***Plasmopora***
- **Facultative Biotrophs:**
  - ***Phytophthora infestans***
- **Cause leaf blights**

## Diseases Caused by Oomycetes Root rots

**Root rots**

- **Wet soil favors disease**
- **Monocyclic disease cycle**
- ***Phytophthora***
- ***Pythium***
- ***Aphanomyces***
- **Resistant cultivars**

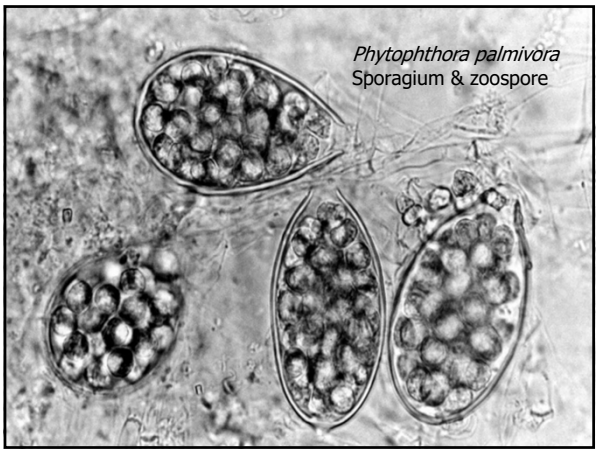
## Oomycetes: Leaf pathogens that also infect fruit or other forms of harvested product

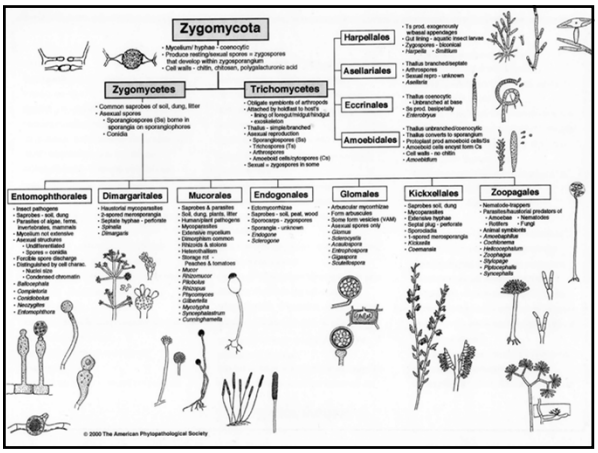


## Diseases Caused by Oomycetes Stem rots

- ***Phytophthora sojae***
- **Stem Lesion is common symptom**
- **Numerous resistance genes to pathogen**
- **Many races of pathogen**

## Diseases Caused by Oomycetes Durian Root and Crown Rot




## Diseases Caused by Oomycetes
## Diseases of leaves, stems & fruits

**Late Blight**

- ***Phytophthora infestans***
- **Potato & tomato**
- **Facultative biotroph**
- **Polycylic disease cycle**
- **Infect leaves, stems and tubers/fruit**

**Downy Mildews**

- **–** ***Peronospora***
- **–** ***Plasmopara***
- **Obligate biotrophs**
- **Polycyclic disease cycles**
- **Infect leaves and fruit**

## Zygomycetes

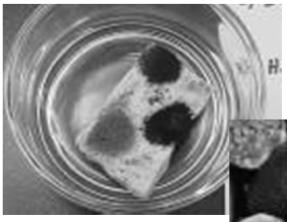
# Zygomycota

- **Sexual spore is a zygospore**
- **Hyphae are coenocytic**
- **Asexual sporangiospores, formed within a sporangium**
- **Trend is from many-spored to monospored sporangia**
- **Fast-growing saprophytes, some insect and plant pathogens**

## Zygomycetes

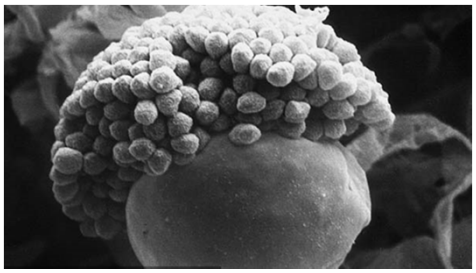
- ***Choanephora spp***
  - **Soft rot of squash, pepper, okra**
- ***Rhizopus spp.*** **and** ***Mucor spp.***
  - **Soft rot fruits, vegies, bulbs, corms**
- **Weak parasites**
- **Sexual resting spore = zygospore**
- **Sporangiospores = infectious spore, produced in sporangium**

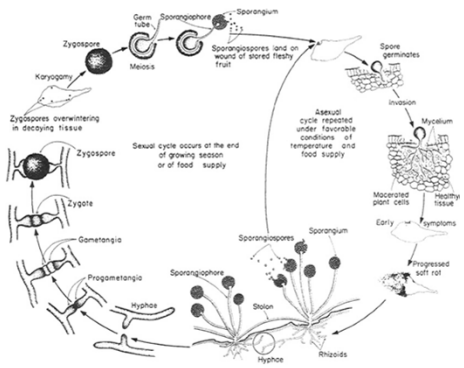
## *Rhizopus* spp.

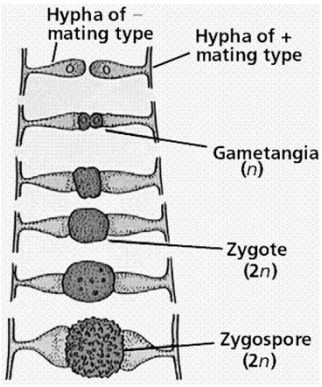


Rhizopus rot of strawberry

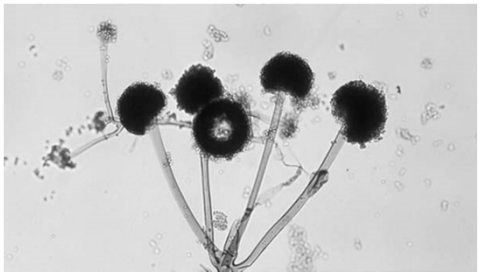
## Sporangium with Sporangiospores





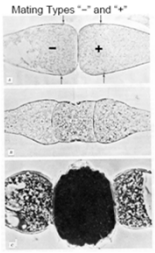

## Sporangia



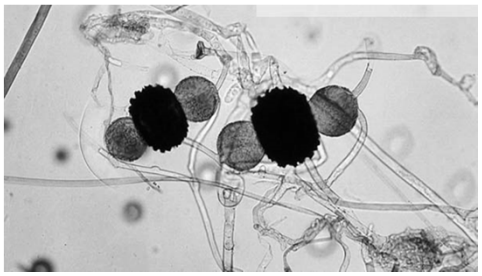
## True Fungi – Meiospores
## Zygomycetes

Zygosporangium between suspensors

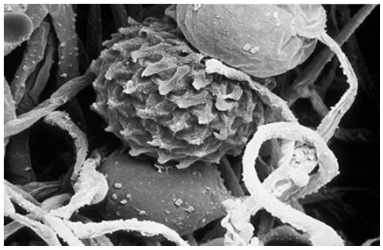
- Common cause of fruit storage rots
- Bread molds

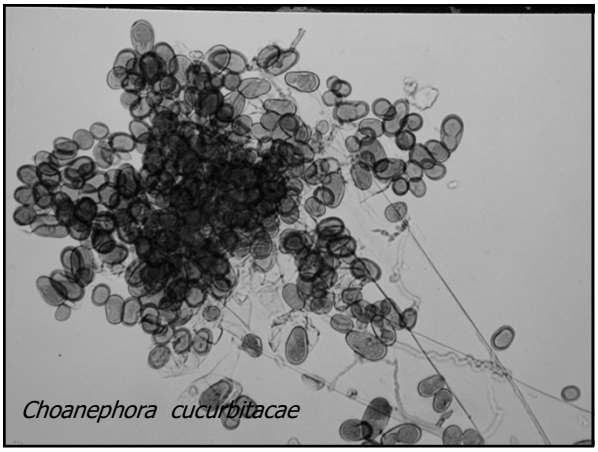


## Zygospore = zygosporangium



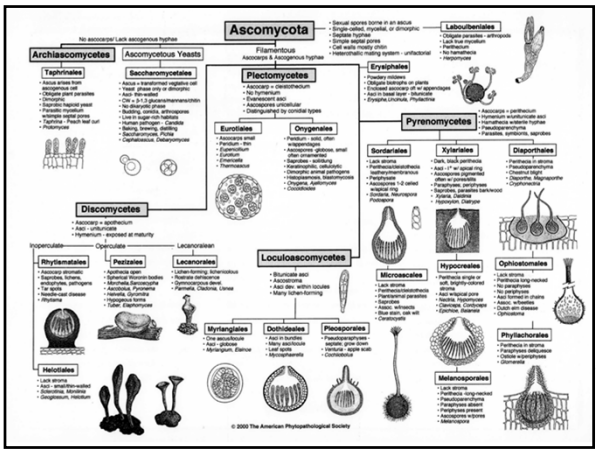

## Zygosporangium containing zygospore



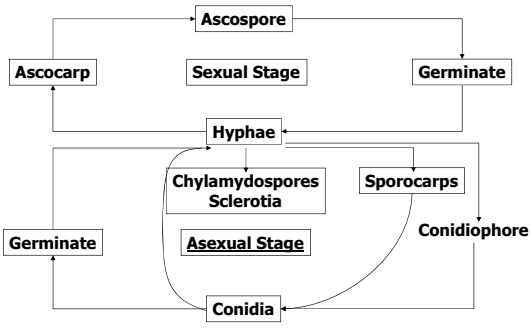



## Ascomycota

- **Sexual spores (ascospores) formed within an ascus**
- **Dikaryon restricted to ascoma**
- **Vegetative nuclei haploid, cells heterokaryotic**
- **Over 40,000 named species**

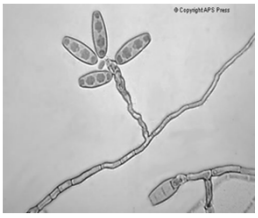



## Life Cycles of Ascomycete Fungi



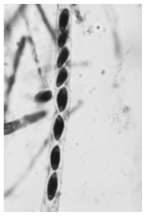

## Ascomycete Spores

•Asexual Spores



•Conidia

•Sexual Spores



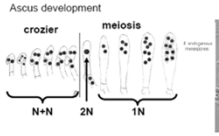
•Ascospore

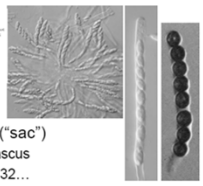
## Ascomata

- Naked asci
- Cleistothecia
- Perithecia
- Pseudothecia
- Apothecia

## True Fungi – Meiospores Ascomycetes

Ascus development

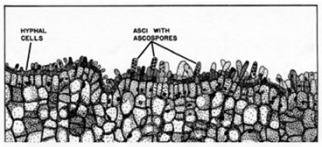


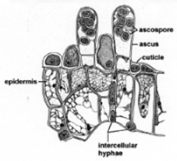



Ascospores borne in ascus ("sac")
- Usually 8 ascospores per ascus
- Or multiples of 8: 4, 8, 16, 32…

- Asci are borne in characteristic ascomata (fruiting structures)

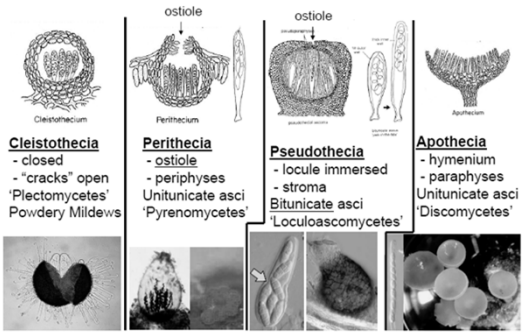
## Ascomycetes: 'Hemiascomycetes' asci not borne in ascomata




Naked Asci
contain ascospores on leaf surface
*e.g. Taphrina deformans*
"The Yeasts"
Saccharomycotina, Taphrinomycetes, etc.

## Ascomycetes: Four Ascomata




## Powdery Mildews

- **Obligate biotrophs (parasites):**

**Haustorium (a): specialized structure of fungus which penetrates epidermal cells and absorbs nutrients**

**Effect on Host: Reduces photosynthesis; infected cells act as "nutrient sink" – organic and inorganic compounds rerouted to infected cells – translocation patterns of plant disrupted.**

**Physiological changes in host: reduced photosynthesis, increased respiration and transpiration**

## Diseases Caused by Ascomycetes

- **Powdery mildew**
  - **Host specific**
- **Leaf spots & blights**
  - **Fruit-grain rots**
- **Cankers**
  - **Usually woody hosts**
- **Anthracnose**
  - ***Colletotrichum***
- **Root & stem rots**
- **Vascular wilts**
  - **Host specific pathogens**
- **Fruit – grain rots**
  - **Field problems**
- **Post harvest diseases**
  - **Transit to storage**
  - **In storage**

## Powdery Mildews

- **Powdery mildew pathogens cause polycylic diseases**
  - **conidia**
- **Conidia germinate in absence of free water**
- **Cleistothecia form towards end of season**
  - **Overwinter stage**

## Powdery Mildews

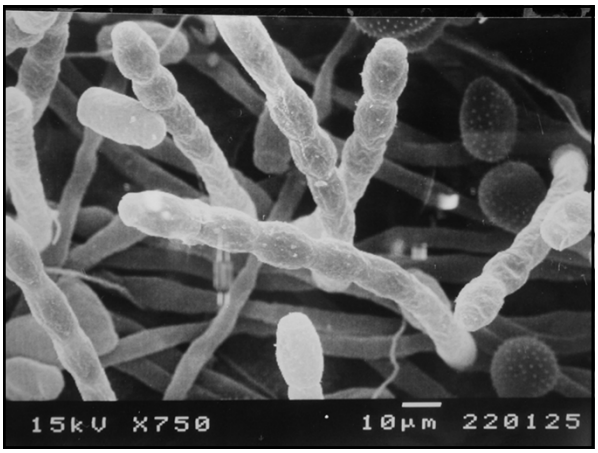
- **Pathogens: Species within the genera *Uncinula, Phyllactinia, Sphaerotheca, Erysiphe (Blumeria), Podosphaera* and *Microsphaera*.**
- **Host Range: Cereals and Grasses: Barley, wheat, bluegrass**
- **Vegetables: Pea, cucumber, squash, "melons"**
- **Fruit: Apple, Grape, Peaches, Cherries**
- **Ornamentals: Roses, Crepe Myrtle, Zinnia, Rudebeckia, Lilac, Phlox, Viburum**
- **Trees: Oaks, elms, willows**

## Powdery Mildew Rose

- **Cause: *Sphaerotheca pannosa***

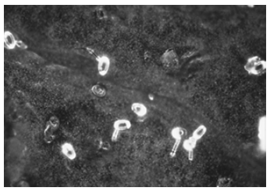
## Powdery Mildew Rose

- Signs of pathogen on stem

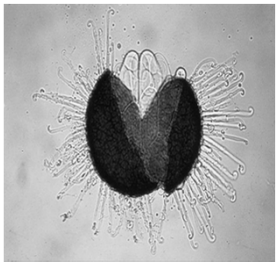



## Powdery Mildew Rose

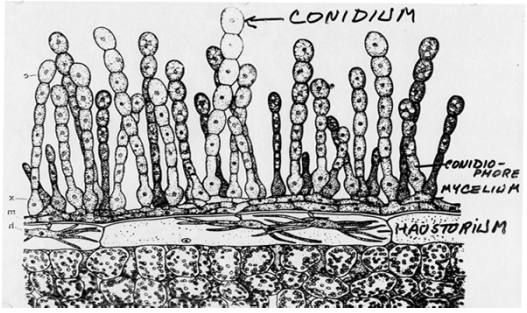
- Conidia of pathogen on leaf surface
- Note germ tubes emerging from conidia



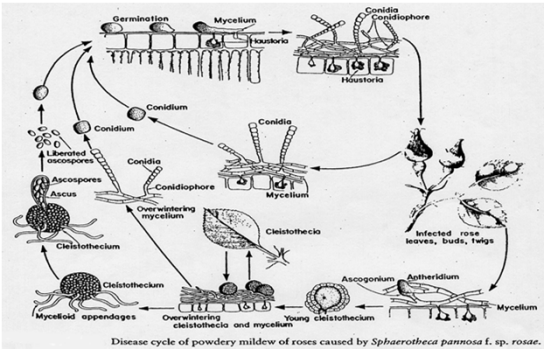
## Cleistothecia of Powdery Mildews



## Powdery Mildew Fungi




## Powdery Mildew Disease Cycle

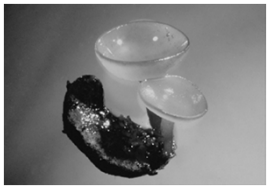



Disease cycle of powdery mildew of roses caused by *Sphaerotheca pannosa* f. sp. *rosae*.

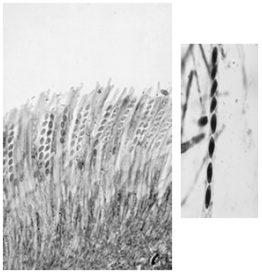
## White Mold
## *Sclerotinia sclerotiorum*

- ***Sclerotinia sclerotiorum***
  - Wide host range
- White Mold
  - Monocyclic disease
- Environmental factors
  - High humidity
  - Moderate air temperatures
- Host factors
  - Dense crop canopy

## Apothecium
## *Sclerotinia sclerotiorum*



2 apothecia emerging from a sclerotium



Asci with ascospores

## Source of Apothecia

- Frequently formed from sclerotia
- Sclerotia
  - Composed of hyphae
  - Hard pigmented cover = rind
  - Hyphae inside and protected by rind
  - Overwinter well

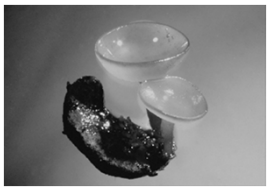
## White Mold
## *Sclerotinia sclerotiorum*

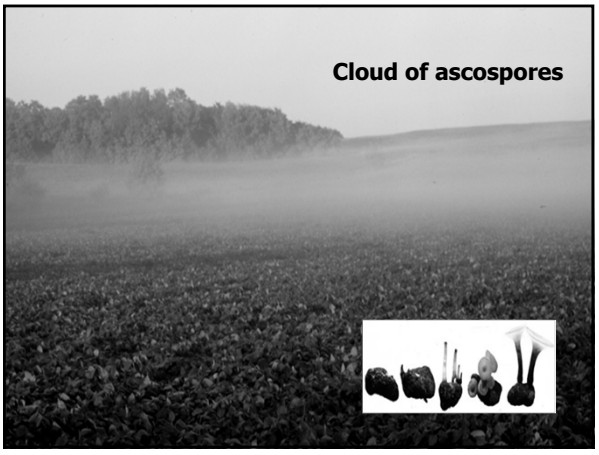
- Rapid changes in pressure within asci
- Ascospores are ejected from ascus
- Wind currents carry ascospores to host

## White Mold
## *Sclerotinia sclerotiorum*

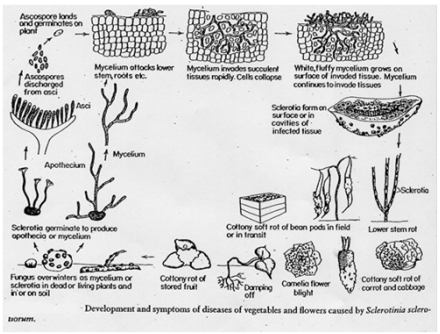
Factors that affect germination of sclerotia

- Water, temperature and light
- Crop canopy important
- Germinate by:
  - Apothecia
  - Mycelium





## White Mold Disease Cycle



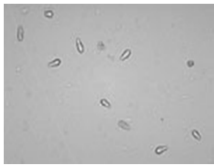
Development and symptoms of diseases of vegetables and flowers caused by *Sclerotinia sclerotiorum*.

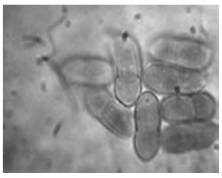
## Apple Scab

## White Mold on Soybean
## *Sclerotinia sclerotiorum*

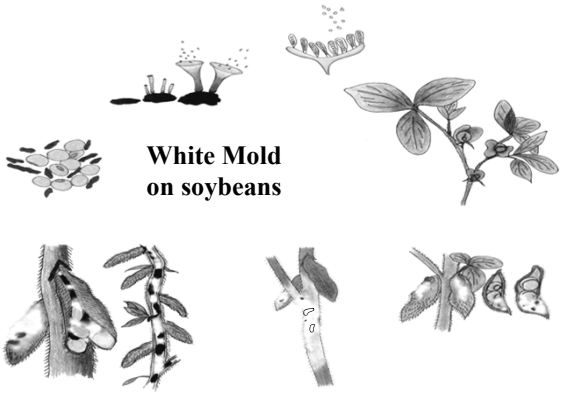
- **Symptoms**
  - **Necrosis**
  - **Wilt**
  - **Chlorosis**
- **Signs**
  - **Mycelium**
  - **Sclerotia**

## Apple Scab
## *Venturia inaequalis (Spilocaea pomi* syn*. spilocaea dendriticum)*

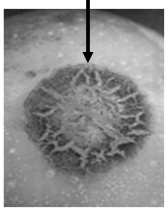


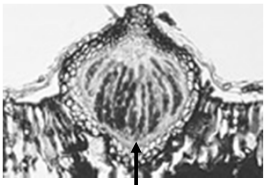


- **asexual spore**
- **sexual spore**

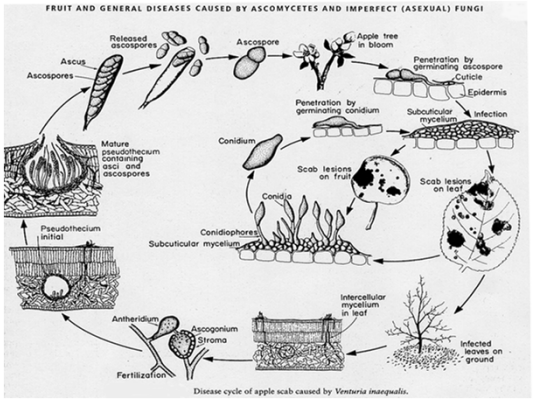


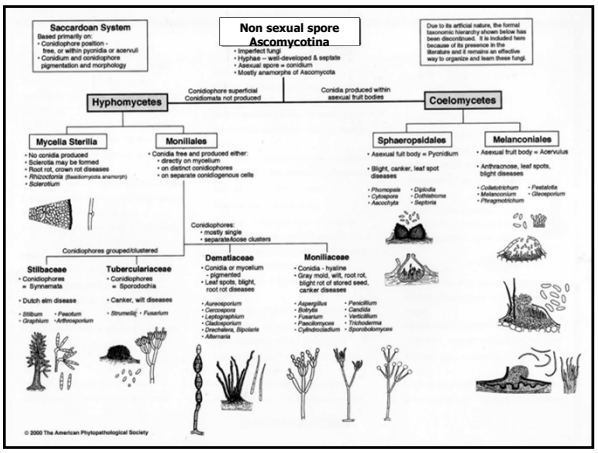

- **Sub-cuticular growth of hyphae**





- **Pseudothecium (specialized perithecium)**



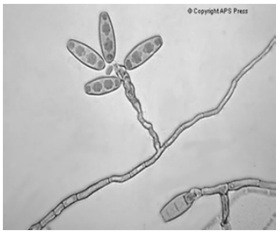



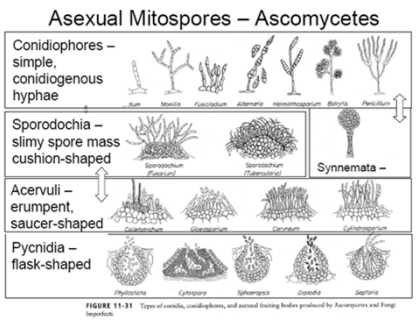

# Non sexual spore Ascomycotina

- **Most are Ascomycotina that lost sexual stage**
- **Various mechanisms generate genetic diversity**
- **Rely on conidia for dispersal**
- **Anamorph Class Hyphomycetes have exposed conidiophores**
- **Anamorph Class Coelomycetes have enclosed conidiophores**

# Non sexual spore Ascomycotina

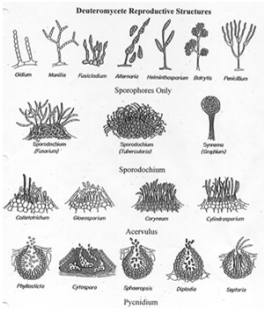
- **Asexual spores - mitosis**
- **Spores = conidia (singular = conidium)**
- **Borne on conidiophores**
- **Naked on hyphae**
- **Sporocarps (Sporodochium, acervulus, pycnidium)**



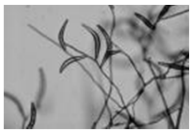

# Reproductive Structures of non sexual spore Ascomycetes

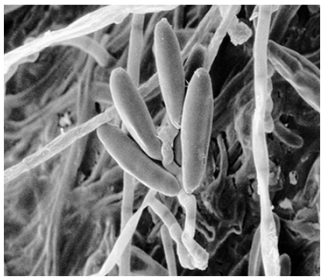
- **Conidia on conidiophores**
- **Sporodochium**
- **Synemma**
- **Acervulus**
- **Pycnidium**



## Non sexual spore Ascomycetes- Conidia

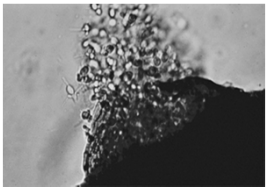
- Conidia borne on conidiophore
- *Bipolaris spp.*
- Pathogens of corn





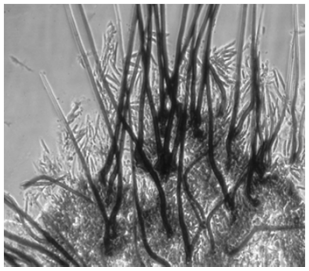
## Pycnidium

- Closed sporocarp
- Contains conidia
- Flask shaped



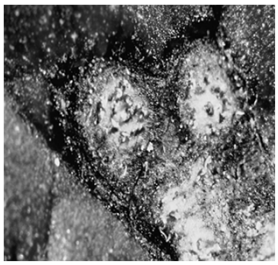
## Acervulus

- Open sporocarp
- Contains conidia
- Sterile hyphae - setae
- *Colletotrichum*

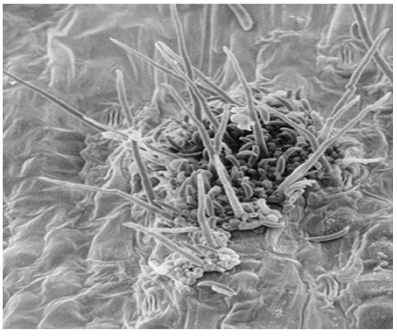


## Pycnidium

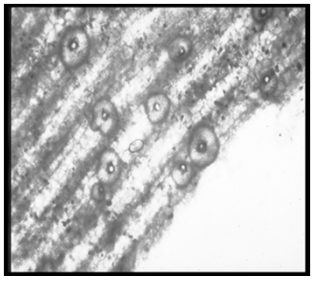
- Pycnidia of *Septoria* embedded in lesion
- Septoria species are common pathogens of vegetables

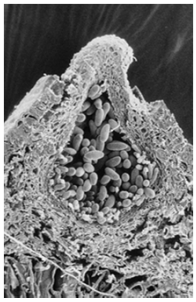


## Acervulus

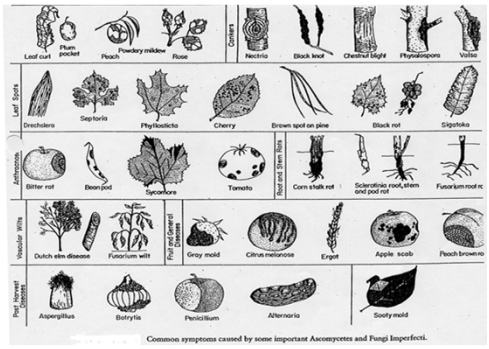


## Pycnidium

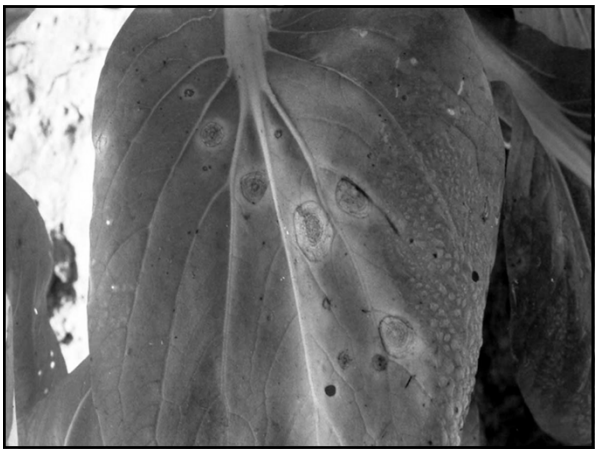


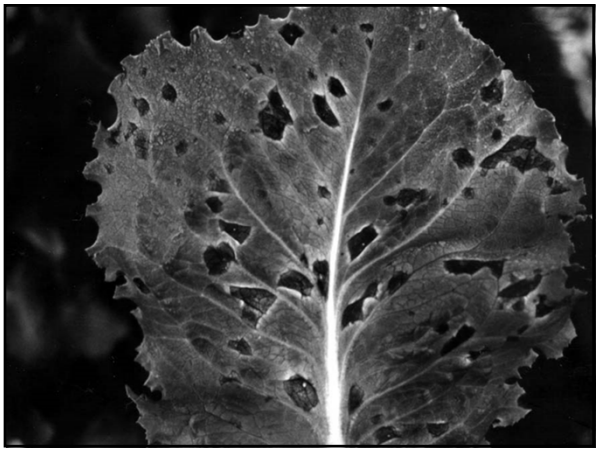


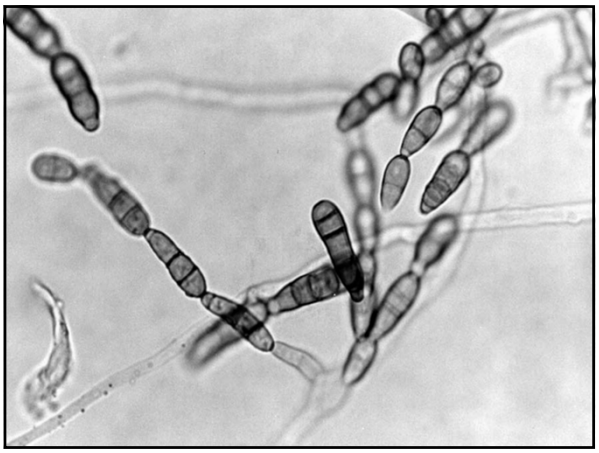
## Diseases Caused by Ascomycetes



Common symptoms caused by some important Ascomycetes and Fungi Imperfecti.



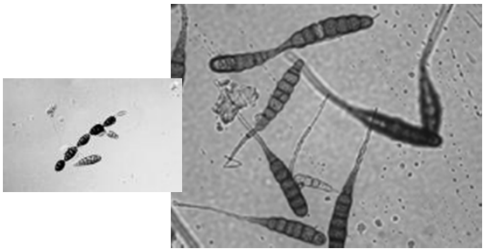


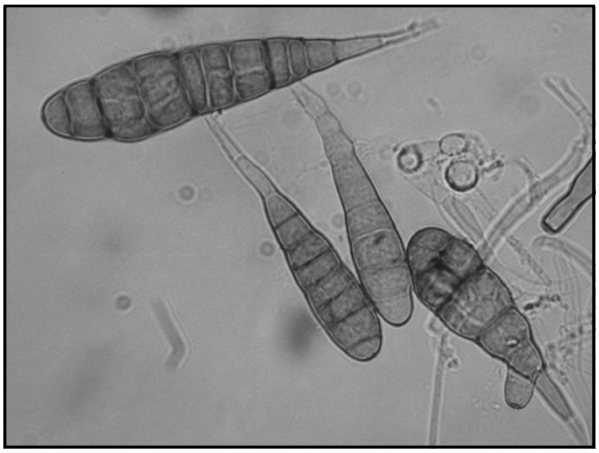


## Early Blight of Potato
## *Alternaria solani*

- **Target like lesions**
- **Causes premature decline of foliage**
- **Tubers infected**
- **Reason for multiple applications of fungicides**

## Conidia





## Early Blight *Alternaria solani*

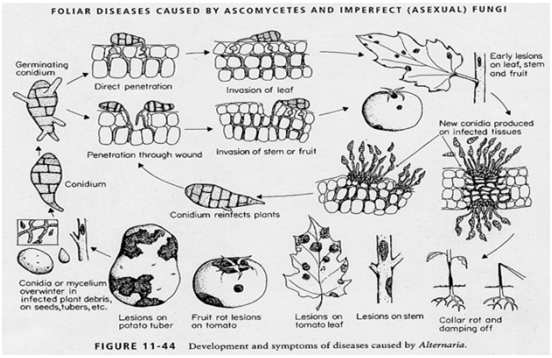
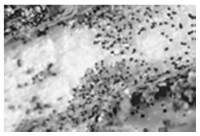
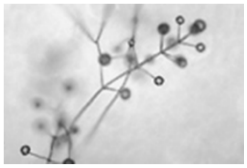


FIGURE 11-44 Development and symptoms of diseases caused by *Alternaria*.

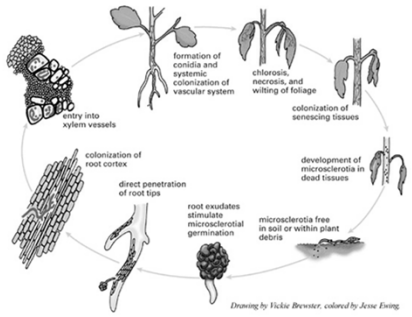
**Verticillium wilt**
*Verticillium dahliae*





Chilli anthracnose
(*Colletotrichum capsici* )

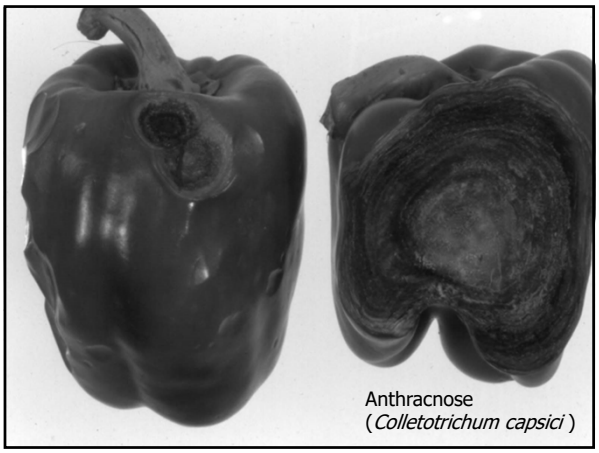
**Verticillium wilt**




ANTHRACNOSE
(*Colletotrichum circinans*)

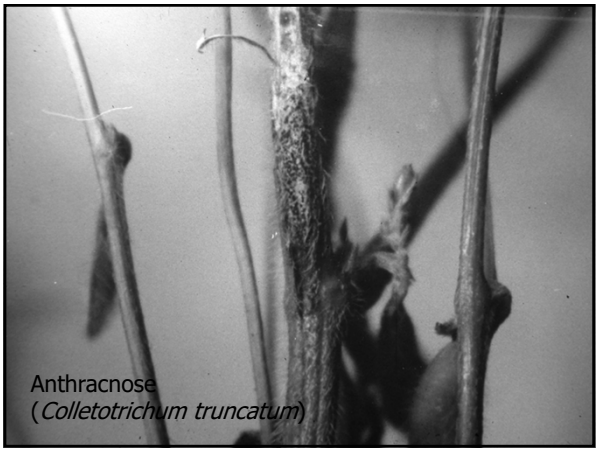
Anthracnose of Vegetable soybean (*Colletotrichum truncatum*)

Anthracnose
(*Colletotrichum gloeosporioides*)



Anthracnose
(*Colletotrichum capsici* )

**Root rot of chilli**
**(*Sclerotium rolfsii)***



Anthracnose
(*Colletotrichum truncatum*)

**Root rot of tomato**
**(*Sclerotium rolfsii)***

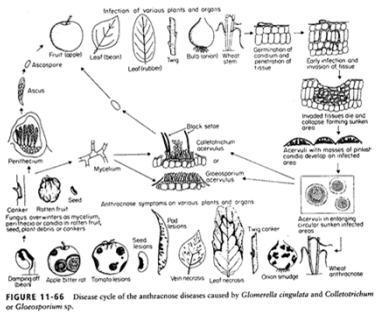



**FIGURE 11-66** Disease cycle of the anthracnose diseases caused by *Glomerella cingulata* and *Colletotrichum* or *Gloeosporium* sp.

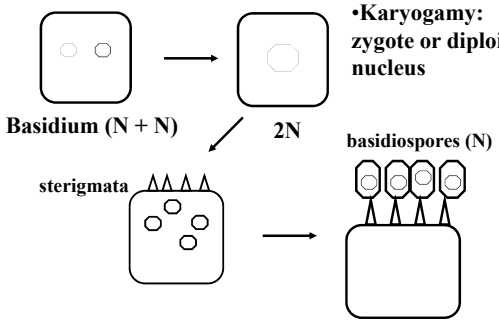
# Basidiomycotina

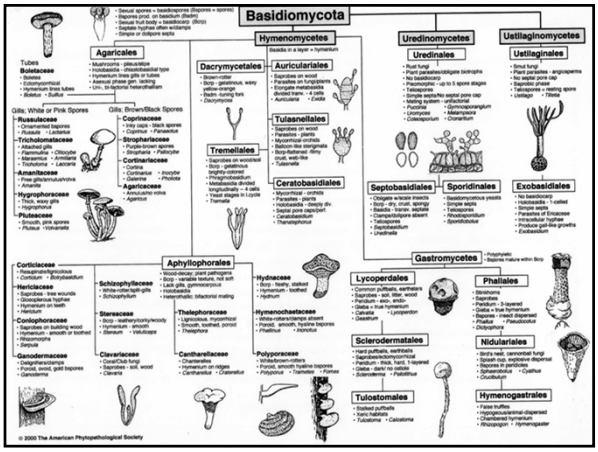
- **Sexual spore (basidiospore) formed on the basidium**
- **Vegetative nuclei are haploid, cells are dikaryotic**
- **Classification based on structure of the basidium:**
  - **septate or non-septate**

## Basidiomycetes

- **Sexual spores**
  - **Basidiospores, produced on the outside of a specialized, microscopic, spore-producing structure called the basidium**
- **Asexual spores**
  - **Various types of asexual spores formed by some basidiomycetes**
  - **Sometimes called conidia**

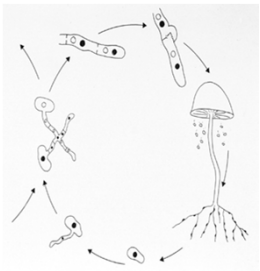
## Haploidization (N)



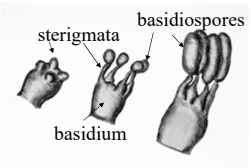

## Basidiomycetes: reestablish the dikaryotic condition (N + N)

- **Life cycle of a basidiomycete**
- **Dikaryon reestablished by fusion of (N) hyphae and migration of nuclei**
- **Anastomosis = fusion of hyphae**



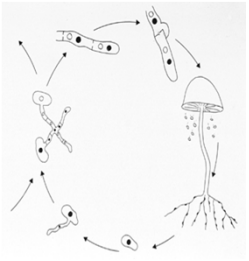
## Sexual Spore = Basidiospore

- **Product of meiosis**
- **Spores formed on sterigmata**
- **Sterigmata arise from basidium**



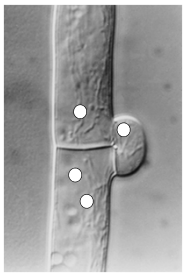

## Dikaryon Formation

- **Frequently identical N genotypes will not form dikaryon**
- **Mating types = genes control whether two hyphae will anastomose**
- **Ensures outcrossing**

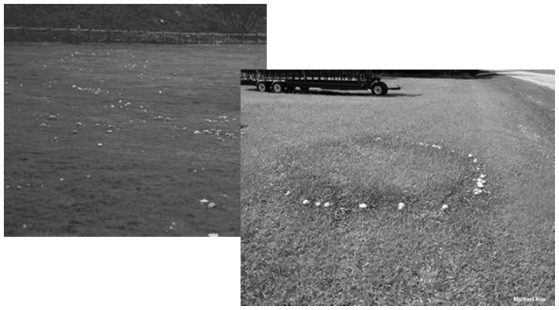


## How do Basidiomycetes maintain dikaryotic (N+N) status?

- Clamp connections: formed during the conjugate division of the nuclei in the tip of a growing hypha
  - Regulate movement of nuclei from cell to cell
- Dolipore septum prevents movement of nuclei from cell to cell



## Fairy Rings



## Members of Basidiomycetes

"Mushrooms"

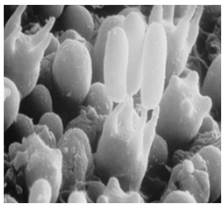
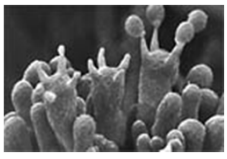


Basidiocarps: fruiting bodies that bear the basidia

## Basidiomycetes: diverse group of fungi and diseases

- Rusts
- Smuts
- Seed and seedling rots
- Leaf blights
- Root and stem rots
- Wood rots

## Basidiospores can be seen from gills of mushrooms

## Rusts

- Order: Uredinales
- ~ 5000 species
- Obligate parasites
- Destructive, esp. grain crops
- Historical famines
- Robigus and Robigalia: Roman Empire

## Economic Impact of Rusts

- Millions of dollars per year in crop loss
- Important pathogens:
  - *Cronartium ribicola*
    - white pine blister rust
  - *Endocronartium harknessii*
    - western gall rust
  - *Melampsora larici-populina*
    - poplar leaf rust
  - *Puccinia striiformis*
    - yellow rust
  - *Puccinia graminis* f. sp. *tritici*
    - black stem rust of wheat
  - *Hemelia vastatrix*
    - coffee rust
  - *Phakopsora pachyrizi*
    - soybean rust
    - Australia
  - *Puccinia pittieriana*
    - potato rust
    - potential problem

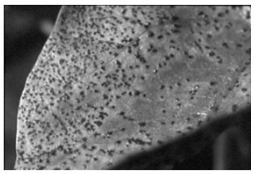
## Rust Reproduction

- Spore stages
  - Stage 0 = Spermatia(-um) / Spermogonia(-um)
  - Stage I = Aeciospore(s) / Aecia(-um)
  - Stage II = Uredospores / Uredia(-um)
  - Stage III = Teliospores / Telia (-um)
  - Stage IV = Basidiospores* / Basidia(-um)

*formerly pycniospores

## Signs/Symptoms

- Attack stems and leafs
- Leaf spots
- Numerous lesions
  - blisters or pustules
  - spores rupture epidermis



## Rust Reproduction

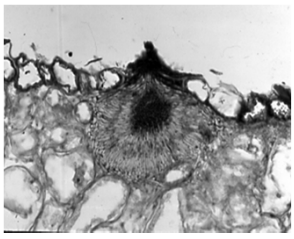
- **Up to five spore types**
- **All five = macrocyclic rust**
- **Less than five = microcyclic rust**
- **Macrocyclic**
  - **One host = autoecious**
  - **Two hosts = heteroecious**
    - **primary (telial) host = one host for stages II, III, IV**
    - **alternate (aecial) host = host for stages 0 and I**

## Rust Reproduction

- **Up to five spore types**
- **All five = macrocyclic rust**
- **Less than five = microcyclic rust**
- **Macrocyclic**
  - **One host = autoecious**
  - **Two hosts = heteroecious**

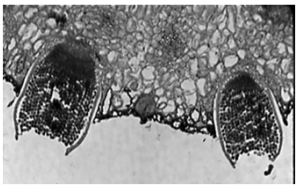
## Stage 0: Spermogonium

- **Spermogonium formed from infection by basidiospore (N)**
- **Spermatia formed**
- **Receptive hyphae formed**
- **Spermatia fuse with receptive hyphae of opposite type**
- **Dikaryon reestablished (N + N)**



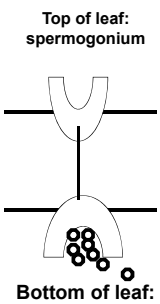
## Stage I: Aecium

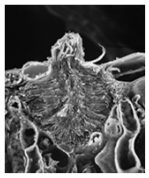
- Dikaryon hyphae from spermogonium migrate to tissue below to form aecium
- Aecia form on bottom leaf
- Aeciospores formed
- Disseminated to alternative host if heteroecious rust

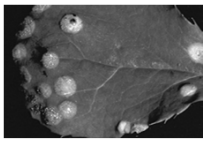


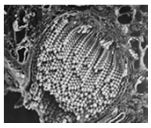
## Stage II: Uredium

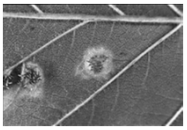
- Arises from dikaryotic mycelium from germinated aeciospores or urediospores
- Urediospores form in uredium
- Disseminated to same host: repeating stage
- Secondary inoculum
- Associated with polycyclic diseases



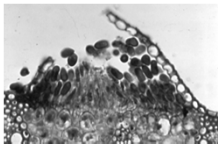









## Stage II: Uredium



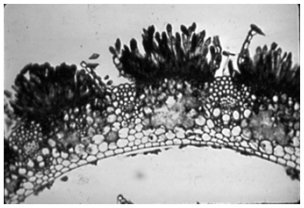
- Rupture of epidermis
- Repeating spore
- Rust color

## Aecium & Aeciospore Biological and Pathological Significance

- Captures dikaryotic state in a spore - aeciospore
- Aeciospores wind disseminated
- Disperse old and new genotypes of rust fungus
- Aeciospores serve as primary inoculum

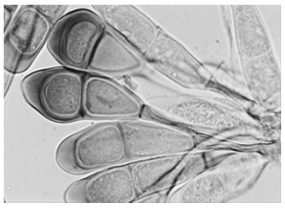
## Stage III: Telium

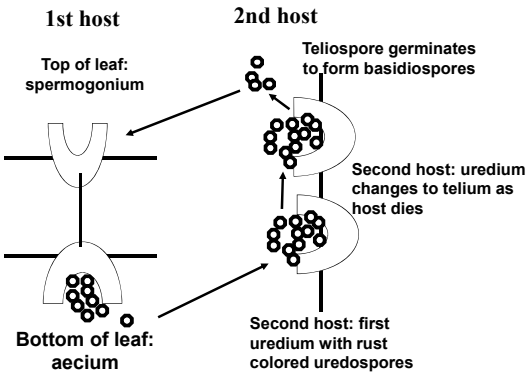
- Teliospores formed within telium
- Frequently uredium converts to telium
- Common to observe urediospores and teliospores in same pustule
- Teliospores form when host is near end of life cycle : overwintering spores



## Stage III: Telium

- **Survival structure**
- **Site of nuclear fusion**
- **(N+N) to 2N**
- **Meiosis**
- **Teliospores can not infect but germinate to form basidiospores (N)**



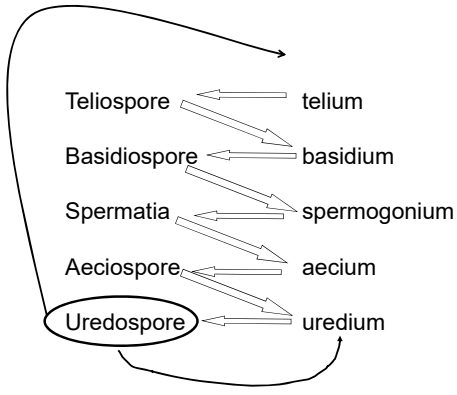



## Stage IV: Basidium

- **Basidium emerges from germinating teliospore**
- **Four haploid (N) basidiospores formed on basidium**
- **Basidiospores wind dispersed**
- **Disseminated to alternative host if heteroecious rust**

## Rust Reproductive Structures

| Spore | Sorus | Infect Host |
|---|---|---|
| Teliospore | telium | no |
| Basidiospore | basidium | yes |
| Spermatia* | spermogonium | no |
| Aeciospore | aecium | yes |
| Uredospore | uredium | yes |

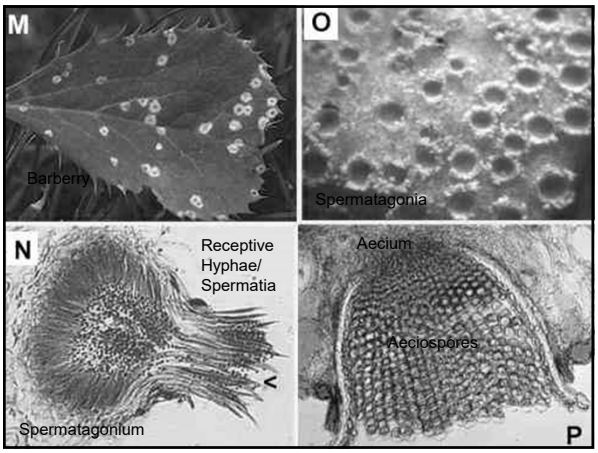



## Genus: *Puccinia*

- largest genus
- 3000 - 4000 species
- angiosperms
- heteroecious forms often have grasses as primary (uredinial/telial) hosts
- teliospores = 2 - celled
- *P. graminis* = stem rust
- *P. coronata* = crown rust of oats
- *P. sorghi* = common maize rust
- *P. polysora* = tropical maize rust
- *P. helianthi* = sunflower rust
- *P. antirrhini* = snapdragon rust
- *P. arachidis* = peanut rust

## *Puccinia graminis f. sp. tritici*

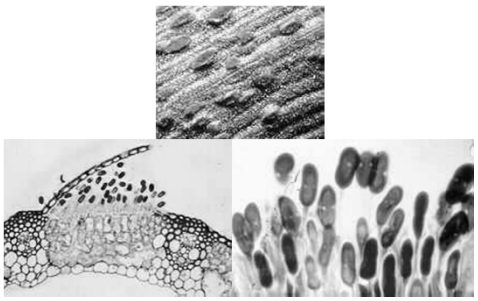
- **Stem rust of small grains**
- **2 hosts**
- **Uredium on grass**
- **Aecium on barberry**
- ***Puccinia graminis f.sp. hordei* (barley)**




## Barberry (*Berberis* spp.): Alternate Host to *Puccinia graminis*

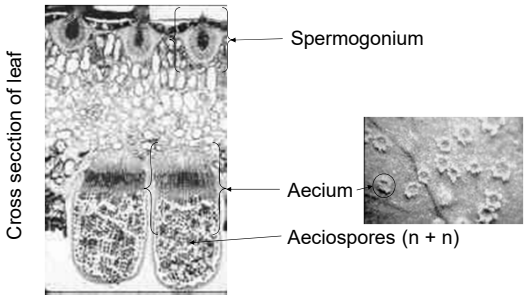
- **Barberry**
- **Common shrub**
- **Introduced from Europe**
- **Rust reproduction**
  - **Spermogonium**
  - **Aecium**

## Uredia/Urediospores of *Puccinia graminis*

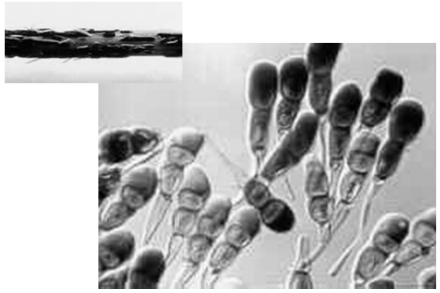


From: The Fifth Kingdom Online

## Barberry Infection

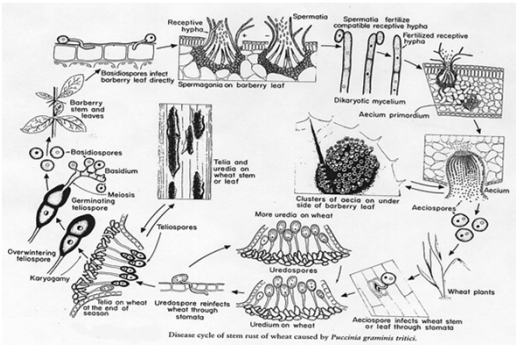



## Telia/2 - celled Teliospores of *Puccinia graminis*



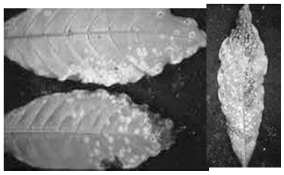
From: The Fifth Kingdom Online

## Stem Rust of Wheat



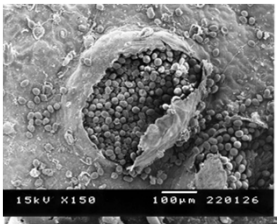

## Other Rusts

**Snapdragon rust**
***Puccinia antirrhini***

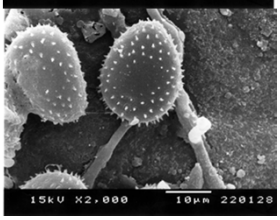


**Coffee rust**
***Hemelia vastatrix***

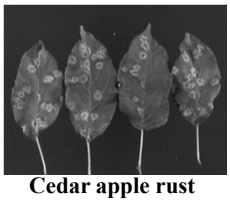
Pastule of
*Uromyces* sp.




Urediospore

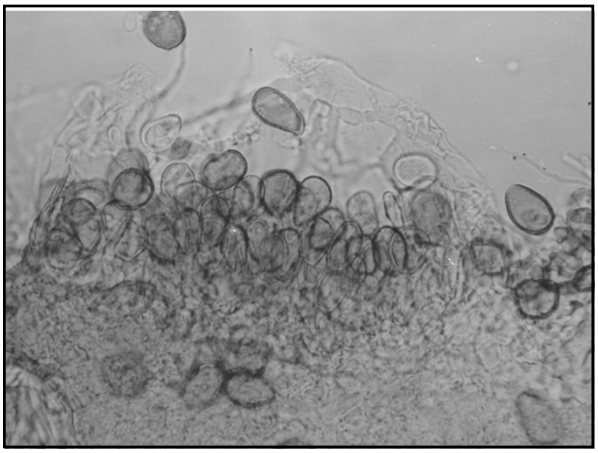



## Other Rusts



**Cedar apple rust**
***Gymnosporangium juniperi-virginianae***

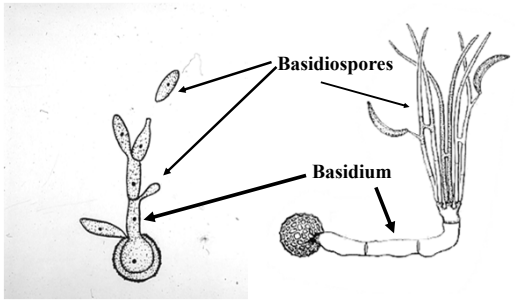
**Bean rust**
***Uromyces appendiculatus***



## Smut Fungi

- "Smut" from dark, dusty masses of teliospores produced in host tissue
- Economically important pathogens include:
  - *Ustilago maydis* (corn smut)
  - *Ustilago avenae* (loose smut of oats)
  - *Tilletia controversa* (dwarf bunt of wheat)
  - *Tillieta tritici* and *T. laevis* (common bunt)
  - *Tilletia indica* (Karnal bunt of wheat)
  - *Urocystis cepulae* (onion smut)
  - *Urocystis agropyri* (flag smut)

## Teliospore germination

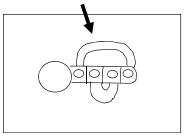


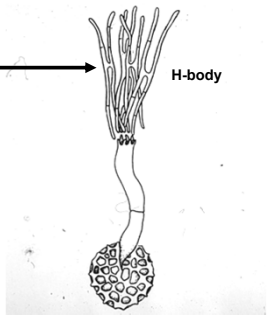

***Ustilago*-type** ***Tilletia*-type**

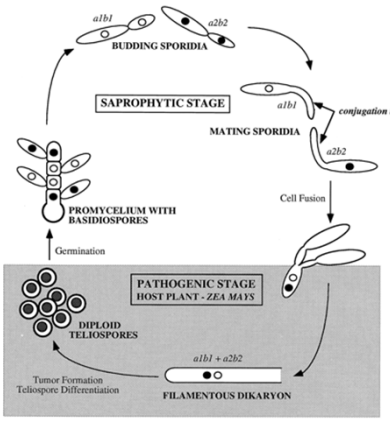
- 1200 species, 50 genera, infect > 4000 species of plants in 75 families of angiosperms
- Experimental organisms:
  - *Ustilago maydis*
  - *Microbotryum violaceum*

## Dikaryon formation

- Conjugation of primary or secondary basidiospores
- Conjugation of basidium cells

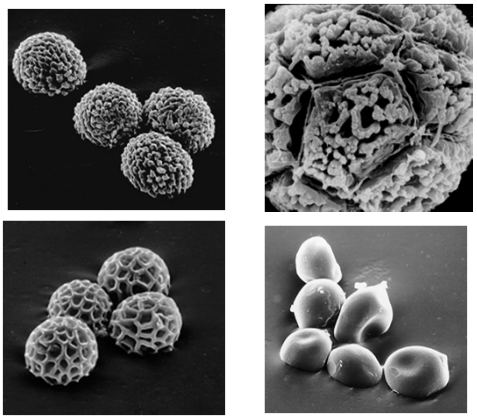





## Sori

- Composed of host and fungal tissues
- Teliospores are formed in sori
- Formed in host ovaries, stems, leaves, or roots depending on the smut taxon
- Characters of taxonomic importance include:
  - Thread-like structures (fungal)
  - Sterile cells
  - Columella (host)
  - Peridium (host or fungus)
    - Persistent = covered smut
    - Thin, breaking down to expose spores = loose smut

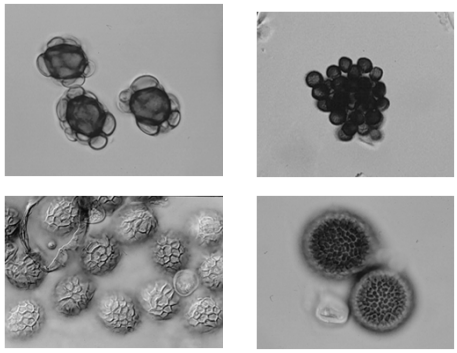


## Teliospores

- Formed singly or in spore balls
- Mostly globose, pigmented, with thick, ornamented walls
- Size ranges from 3.5 to 60 microns diam.
- Teliospore mass is usually dark
- Resistant structures, in some species can survive up to 10 years in soil, and 25 years or more under optimal conditions

## Smut Diseases

- Based on location of sorus in host:
  - Inflorescence smuts
  - Leaf smuts
  - Stem smuts
  - Root smuts



## Infection Types

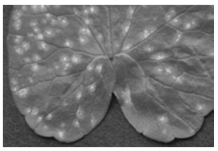
- Seedling infection
  - Systemic, initiated at seedling stage, mostly intercellular hyphae and sporulation in host ovary
- Embryo infection
  - Systemic, initiated through developing embryo; intercellular mycelium remains dormant in seed until infected seed germinates
- Shoot infection
  - Systemic, infection through shoots or young buds. May result in lack of floral development or aborted inflorescence.
- Local infection
  - Mycelium and sporulation restricted to region of infection, fungus is not systemic

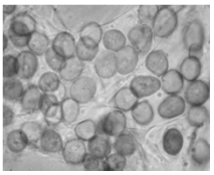
## Common types of smut diseases

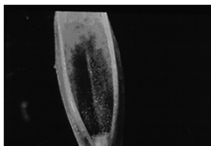
- Bunt
  - Ovary-infecting species of *Tilletia* that infect cereals
- Stinking Bunt
  - Diseases caused by *Tilletia* species that produce foetid (fishy) odor
- Partial Bunt
  - Only a portion of seed or inflorescences are bunted, only part of seed is replaced by sorus.
- Covered smut
  - Well-developed, persistent peridium surrounding sorus
- Loose smut
  - Thin, delicate peridium that ruptures easily to expose teliospores

## *Entyloma*

- Sori in vegetative organs of host
- Teliospores formed singly, permanently embedded in host tissue
- Teliospores with pale, smooth walls
- Tilletia-type germination (see Fig. 13)

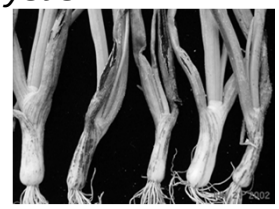


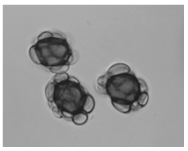




## *Urocystis*

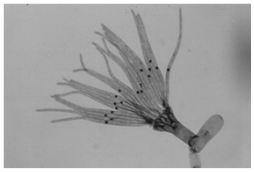
- Sori mostly in leaves, stems, forming streaks, swellings or galls
- Spore balls with pigmented teliospores surrounded by hyaline sterile cells
- Tilletia-type germination (see Fig. 18)





## *Tilletia*

- Sori usually in reproductive organs of host
- Teliospores formed singly, usually pigmented with ornamented walls
- Sterile cells present in sorus
- Teliospores with foetid odor due to production of trimethylamine
- Tilletia-type germination (also see Fig. 14)



## *Ustilago*

- Sori in reproductive organs or vegetative tissues of host
- Teliospores formed singly, usually pigmented with sculptured walls
- Sterile cells absent
- Ustilago-type germination (see Fig. 9)