**Phylum: Glomeromycota**
- Formerly classified with Zygomycota.
- Recently erected into its own phylum.
- Say more about this group when we cover symbiosis in last lecture.

**Phylum: Ascomycota**
- Very difficult phylum to define.
- **Asci** (sing. **ascus**) and **ascospores** produced during sexual reproduction.
- **Mycelium septate.**
  - Thallus may also be **yeast:**
  - Unicellular fungi that reproduce asexually by **budding** or **fission.**
- **Fission:** Mitosis and cell division.
- Some species are **dimorphic:** Having yeast and mycelium produced during life cycle.
- Yeast and yeast-like fungi are believed to be ancestral morphology.
Phylum: Ascomycota
Many different classification of Ascomycota. Will divide phylum into three groups:
- **Class - Archiascomycetes**: Yeast and yeast-like fungi. Polyphyletic
- **Class - Saccharomycetes**: Budding yeast. Believed to be monophyletic and not closely related to Archiascomycetes.
- **Filamentous Ascomycetes**: Mycelium and ascocarp produced during life cycle.

Phylum: Ascomycota
Separation of Archiascomycetes from Saccharomycetales based mostly on rDNA analysis.
Archiascomycetes is believed to be the earliest evolved group, with the filamentous Ascomycetes and Saccharomycetes being derived sister groups.

Phylum: Ascomycota
Three ascus types:
- **Protunicate**

Phylum: Ascomycota
Three ascus types (Continued):
- **Bitunicate**
  - **Endoascus**
- **Unitunicate**
- **Exoascus**

Phylum: Ascomycota
Archiascomycetes include yeast that reproduce asexually by budding and fission, as well as dimorphic species.
- **Schizosaccharomyces octosporus** is example of fission yeast.
- **Taphrina deformans** is example of dimorphic species.
**Schizosaccharomyces octosporus**

- Life cycle of a fission yeast.
- Zygotic life cycle
- Asci and ascospores are borne naked.
- Species homothallic.

**Taphrina deforman**

- Cause of Peach Leaf Curl.
- Asci and ascospores borne on leaf surface, at site of deformities.
**Taphrina deforman**

- Asci and ascospores of *Taphrina deforman*.

**Higher Magnification.**

- Ascospore → Ascus → Stalk cell

**Taphrina deforman**

- Saprobiic in yeast stage.
- Mycelial stage is obligate parasite.

**Taphrina deforman**

- Parasitic, dikaryotic mycelium forms when yeast cell comes in contact with host.

**Taphrina deforman**

- Development of *Taphrina* ascus:
  - Karyogamy
  - Mitosis of zygote nucleus
  - Unequal cell division
  - Stalk cell

**Taphrina deforman**

- Longitudinal section of *Taphrina* infection on young peach leaves.

- Ascogenous cell → Cuticle
- Dikaryotic mycelium growing between host cells of leaf
- Epidermis
- Palisade parenchyma

**Taphrina deforman**

- Saprobiic yeast phase
- Parasitic mycelium phase
**Taphrina deforman**

Development of *Taphrina* ascus (Continued):

- Meiosis has occurred
- Mitosis and ascospore formation

**Phylum: Ascomycota**

- Saccharomycetes represents a monophyletic group of fungi:
  - *Dipodascopsis uninucleatus* is a yeast-like species with short hyphal growth.
  - *Saccharomyces cerevisiae* is the Brewer's Yeast of commerce.

**Dipodascopsis uninucleatus**

- Once thought to be link in origin of Ascomycota from Zygomycota.
- Species has short hyphal growth and is homothallic.
- Not a yeast!

**Summary of life cycle:**

- Plasmogamy occurs when cell wall between gametangia dissolves.
- Followed by karyogamy and meiosis.

**Dipodascopsis uninucleatus**

- Ascospores germinate to produce limited, hyphal growth.
- Adjacent cells function as gametangia.
**Dipodascopsis uninucleatus**

- Ascus elongates, followed by many mitotic divisions.
- Results in ascus with hundreds of ascospores instead of the typical eight.

**Saccharomyces cerevisiae**

- Yeast cell budding:

**Saccharomyces cerevisiae**

- Ascus with four ascospores:

**Filamentous Ascomycetes**

- Introduction:
  - Mycelium always septate, but septa incomplete, with pore in center.
  - Pore in septa often blocked in older hyphae with *woronin bodies*.

**Filamentous Ascomycetes**

- Introduction (continued):
  - Historically, classification of this group has been based on the type of ascocarp produced.
  - Molecular analyses has demonstrated this to be an artificial form of classification, but is still the most convenient means of classifying filamentous ascomycetes.
Filamentous Ascomycetes

Introduction (continued):
- Asci and ascospores borne in an ascocarp.
- Four types of ascocarps associated with four informal categories of ascomycetes:
  - Cleistothecium - Plectomycetes
  - Perithecium - Pyrenomycetes
  - Apothecium - Discomycetes
  - Ascostroma - Loculoascomycetes

Cleistothecium:
- Ascocarp is entirely closed.
- Asci do not form a hymenium.
- Usually member of Plectomycetes.

Perithecia:
- Commonly flask-shaped.
- Hymenium formed.
- Sterile filaments present: Paraphyses, periphyses and pseudoparaphyses present or absent.
- Pyrenomycetes.

Apothecium:
- An ascocarp that has its hymenium entirely open at maturity.
- Paraphyses typically present.
- Discomycetes.

Ascostroma:
- Cavity in a stroma where asci and ascospores are borne.
- Loculoascomycetes.

Ascocarp Development
- Will use the development of Peziza as representative of ascocarp (apothecium) development.
- Start at germination of ascospores to produce monokaryon.
- Monokaryons self sterile and cross fertile, i.e. heterothallic.
Monokaryon Strains

Each monokaryon have both ascogonia (female gametangia) and antheridia (male gametangia).

Ascocarp Development

Ascocarp formed by tightly interwoven mycelium.

Peziza apothecium

Antheridal nuclei transported to the ascogonium through the trichogyne.

The trichogyne is a tubular growth originating from the ascogonium.

A1 and A2 nuclei pair off in ascogonium. A1 and A2 nuclei undergo synchronous mitotic divisions. Ascogenous hyphae (dikaryon) form from ascogonium.

Ascogenous hypha

Ascogenous hyphae (dikaryon) form from ascogonium.
Ascus Formation

Ascocarp Development

**Crozier Proliferation:**
- Apical and stalk cells fuse.
- New crozier proliferates.
- Crozier proliferation occurs repeatedly.

Ascocarp Development

**Ascogonium** forms asci, ascospores and paraphyses: hymenium.

Ascocarp Development

**Development of ascus and ascospores from new crozier:**

Ascocarp Development

At same time ascus is developing, ascocarp is forming.

Monokaryotic mycelium develops from stalk cell produce ascocarp.

L-Sect. - Mature Apothecium