Basidiomycota - Rusts

Rusts, Smuts (Bunts) and Yeast
(Two lectures)
3 Major Clades - Classes - of the Basidiomycota

- Agaricomycotina
  mushrooms, shelf fungi, jelly fungi, coral crusts, puffballs

- Ustilaginomycotina
  Smuts, bunts

- Puccinomycotina
  rusts, marine yeasts, crusts
### Three Classes of Basidiomycota

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agaricomycotina</strong></td>
<td>- n+n dolipore septum&lt;br&gt;- basidia single cell or septate, active &amp; passive basidiospore release&lt;br&gt;- basidiocarp present</td>
</tr>
<tr>
<td><strong>Ustilaginomycotina</strong></td>
<td>- n +n dolipore septum without pore cap&lt;br&gt;- basidia septate, passive basidiospore release&lt;br&gt;- teliospores</td>
</tr>
<tr>
<td><strong>Urediniomycotina</strong></td>
<td>- n+n simple dolipore septum with occlusions&lt;br&gt;- basidia sepatate, active basidiospore release&lt;br&gt;- teliospores</td>
</tr>
</tbody>
</table>
Rusts, Smuts and Bunts

Spore horns, composed of teliospores (n+n) form on the juniper trees in the spring.

Aeciospores (n+n) infect juniper. Mycelium (n+n) grows in the tree.

Teliospores (n+n) germinate to form basidia (2n) that form basidiospores (n) through meiosis.

Basidiospores (n) germinate and form spermatia. The spermatia (n) form dikaryotic aceia (n+n) on apple leaves.
Urediniomycotina:
   Uredinales - the Rusts; ~5000 species
   140-150 genera

Ustilagniomycotina:
   Ustilaginales - the Smuts and Bunts; ~1200 species
   ~50 genera

All are parasitic on plants, often causing great damage to cultivated crops, and in the case of rusts, forest trees

Heterothallic (less commonly Homothallic)

Obligate biotrophs – in that they are incapable of completing life cycle without a host plant
Urediniomycetes
Teliospore: site of karyogamy technically part of the basidium
teliospore germinates, gives rise to the basidium
basidium: site of meiosis & formation of sterigmata and basidiospores; karyogamy often occurs in teliospore

Basidium 4 celled, sterigmata, active basidiospore release
Rust spore germination and infection of host

Biotrophic, obligate plant parasites
Uredinales

Rust fungi may produce as many as five different spore-producing stages (0, I, II, III, IV) in their life cycles

Life cycle patterns of the Uredinales:
1. macrocylic forms- all five reproductive stages
2. demicyclic forms- the uredinial stage is absent
3. microcyclic forms- both aeciospores and urediniospores are absent; teliospore is the only binucleate spore produced

Heteroecious- two taxonomically different host plants in order to complete their life cycles.

Autoecious - completes its entire life cycle on a single host species
Examples of rusts with two hosts

*Puccinia graminis*
0 and I on barberry bushes (*Berberis vulgaris*: dicot)
II and III on various grasses (monocot)

*Cronartium ribicola*
0 and I on white pines (*Pinus monticola* gymnosperms)
II and III on currants & gooseberries (*Ribes sanguineum* angiosperms)

*Uredinopsis osmundae*
0 and I on the balsam fir (*Abies balsamea*: gymnosperm)
II and III on the cinnamon fern (*Osmunda cinnamomia*)
Coffee rust is the most economically important coffee disease in the world, and in monetary value, coffee is the most important agricultural product in international trad.

http://www.huffingtonpost.com/2013/03/25/coffee-rust-cenicafe_n_2935249.html

**Puccinia malvacearum Hollyhock Rust**

- **Homothallic**
- **Telium**
- **Autoecious** - entire life cycle completed on a single host species, short cycle, teliospores, basidiospores

**Teliospores**

**Basidium**
Puccinia graminis wheat rust

- spermagonium
- spermatia
- receptive hyphae
Stage 0: Spermagonia bearing spermatia (n) and receptive hyphae (n)

- fertilization of the receptive hyphae by spermatia initiates the dikaryon and the formation of aecia
Stage I: Aecia bearing aeciospores (n+n)

- aeciospores infect primary host
- e.g., aeciospores produced on alternate host (e.g., Barberry) infect primary host (e.g., grasses)
Stage II: Uredinia (j) bearing urediniospores (n+n)

- reinfect primary host
- amplifies disease within primary host
- uredinia can eventually develop into telia
Stage III: Telia bearing teliospores (n+n>2n)

- final stage on primary host
- overwinters as dikaryon
Stage IV Basidia bearing basidiospores (n)

- In the spring, teliospore germinates a promycelium.
- Diploid nucleus migrates into the promycelium and undergoes meiosis.
- Four haploid nuclei migrate into developing sterigmata and are incorporated into basidiospores.
- Basidiospores reinfect alternate host.
Wheat stem rust (\textit{Puccinia graminis} f. sp. \textit{tritici}) is historically the most damaging disease of wheat. The disease has the capacity to turn a healthy looking crop, only weeks away from harvest, into nothing more than a tangle of black stems and shriveled grains at harvest. Under suitable conditions, yield losses of 70% or more are possible. Wheat stem rust is highly mobile, spreading rapidly over large distances by wind or via accidental human transmission (infected clothing or plant material).

Each year urediniospores move northward via the “Puccinia Pathway.” (Copyright APS). Note: This is a figure from the upcoming book Hungry Planet to be published by APS.

Spread by urediniospores

Wheat stem rust (\textit{Puccinia graminis} f. sp. \textit{tritici}) is historically the most damaging disease of wheat. The disease has the capacity to turn a healthy looking crop, only weeks away from harvest, into nothing more than a tangle of black stems and shriveled grains at harvest. Under suitable conditions, yield losses of 70% or more are possible. Wheat stem rust is highly mobile, spreading rapidly over large distances by wind or via accidental human transmission (infected clothing or plant material).
Yield loss due to stripe rust in wheat cultivars with differing resistance/susceptibility to stripe rust, *Puccinia striiformis*.
Ustilaginales Smuts (Bunts)

- monokaryons nonpathogenic
- dikaryon pathogenic
- heterothallic; mating of compatible spores, etc.
- teliospores
Corn Smut

*Ustilago maydis*

It has a dimorphic life cycle with a yeast-like saprophytic phase B, switching to filamentous, pathogenic growth upon hyphal fusion C.

Plant tissue

Teliospores can be produced on leaves, stem, stamens, seeds.

Figure 5. Proposed life cycle of *U. maydis* emphasizing nuclear condition. A. Asexual haploid budding stage is saprobic. B. Compatible haploid cells mate in G2—note that solid and open nuclei represent two compatible mating types. C. Dikaryon is obligately parasitic and must infect maize plants. Mitotic cell division resumes within the plant, and the dikaryon is maintained via clamp connections until tumor enlargement commences. Fungal growth is mainly through cells (termed intracellular although the plant cell membrane is not breached). D. Karyogamy occurs when tumor enlargement begins, and most fungal growth is in between host cells. Tumor enlargement results from mitotic division of cells with diploid nuclei. E. At some point, sporulation is triggered and cells lay down thick ornamented walls. Some cells with diploid nuclei do not become spores. Teliospores arrest in early stages of meiosis, presumably after pachytene. F. Teliospores finish meiosis upon germination. Each haploid nucleus migrates into a cell that can reproduce mitotically by budding.
In Mexico's corn-loving culture, the quasi-mushroom also provides nutrition: high amounts of the essential amino acid lysine that's absent in corn, as well as lots of fiber and protein. Together, corn and huitlacoche make a complete protein meal.
Loose smut
*Ustilago nuda f.sp tritici*

Mycelium follows growing point of wheat plant

Mycelium invades the grain sites

Grain sites replaced by masses of teliospores

Teliospores land on flowers of healthy plants and infect developing grain

Mycelium invades part of embryo in seed

Mycelium invades young seedlings

*Ustilago nuda*

*Ustilago bullata*
Stinking Bunt
The spores have a fishy odor.

*Sorus of teliospores!*

Teliospores form from $n + n$ cells!

*Tilletia caries*

Conidia actively released via Buller droplet

The spores have a fishy odor.
Tilletia caries
Losses from common smuts are highly variable and rather difficult to measure, ranging from a trace up to 10 percent or more in localized areas. In rare cases, the loss in a particular field of sweet corn may approach 100 percent.

Smuts


Losses from common smuts are highly variable and rather difficult to measure, ranging from a trace up to 10 percent or more in localized areas. In rare cases, the loss in a particular field of sweet corn may approach 100 percent.