You Should Know...

- Ascomycetes - three groups
  - Archiascomycetes
  - Saccharomycetales
  - Filamentous ascomycetes
- Cleistothecial ascomycetes.
- Perithecial acomycetes.
- Apothecial ascomycetes.
- Plus examples of them all.
Fungus of the day - *Agaricus bisporus*

Taxonomy: Phylum (subphylum) Basidiomycota
Order - Agaricales
Family - Agariceae

Agaricales - the family for gilled mushrooms.

Agaricus means gilled mushroom.

Bisporus - two spores per basidium.

Most mushrooms have 4 haploid products of meiosis (basidiospores).

What makes *Agaricus* into *Agaricus*?

Typical member of Agaricales:

A cap - Pileus
A stalk - Stipe
A neck ring - Annulus
Gills - lamellae - pink
Basidiospores - chocolate brown
A. *bisporus* is the button mushroom that you buy at Dillon’s or eat on your pizza.

Most commonly cultivated - makes 90% of the mushroom production in the US (worth ca $800 million annually)

Per capita consumption ca 2.2 lbs per annum.

Globally only 40% of the mushroom production

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Cap color can be highly variable.

Button mushroom, crimini and Portobello are all the same species but names have been given to the strains helping distinguish between more mature and flavorful variants or different colored caps
Fungus of the day - *Agaricus bisporus*

*A. bisporus* is a secondary decomposer - other fungi and bacteria must do the initial work.

Composting of the substrate required for button mushroom beds.

The compost bed is made of wheat straw and horse poop, other ingredients may be added as well.

Composting beds make a selective medium to reduce competition.

Fungus of the day - *Agaricus bisporus*

Spawn is added to trays and incubated at ca 24°C

Phase I composting to modify substrate

*Agaricus bisporus* spawn

Phase II composting after partial sterilization - selective for bacterial decomposers
Fungus of the day -
*Agaricus bisporus*

And voilá - button mushrooms...

... turn into *Agaricus bisporus* basidiocarps...

*Agaricus bisporus* primordia...

Mushroom cultivation is among the top three biotechnology industries.

Mushrooms make a great dietary supplement, low fat, no cholesterol but a good source of protein and dietary fiber.

Quorn - mycoprotein as an example for fungal nutritional value

<table>
<thead>
<tr>
<th>Units</th>
<th>Quorn</th>
<th>Cheddar cheese</th>
<th>Raw chicken</th>
<th>Raw lean beef</th>
<th>Fresh cod</th>
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<tbody>
<tr>
<td>Protein g 100 g⁻¹</td>
<td>12.2</td>
<td>26.0</td>
<td>20.5</td>
<td>20.3</td>
<td>17.4</td>
</tr>
<tr>
<td>Dietary fibre g 100 g⁻¹</td>
<td>5.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total fats g 100 g⁻¹</td>
<td>2.9</td>
<td>33.5</td>
<td>4.3</td>
<td>4.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Fat ratio Polysaturated: saturated</td>
<td>2.5</td>
<td>0.2</td>
<td>0.5</td>
<td>0.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Cholesterol mg 100 g⁻¹</td>
<td>0</td>
<td>70</td>
<td>69</td>
<td>59</td>
<td>50</td>
</tr>
<tr>
<td>Energy kJ 100 g⁻¹</td>
<td>334</td>
<td>1697</td>
<td>506</td>
<td>514</td>
<td>318</td>
</tr>
</tbody>
</table>
A look forward...

- Basidiomycetes - defined.
- Generalized life.
- Holobasidiomycetes vs. heterobasidiomycetes

Reminder where we stand...

Ancestral traits
- Chitin
- Glycogen
- Posterior flagellum

Loss of phagotrophy
- Loss of flagella
- Chitin
- Glycogen
- Posterior flagellum
- Dikaryotic stage
  - Septate mycelium
- Basidiospores
  - Ascomycota
  - Basidiomycota
  - Zygomyctota
  - Chytridiomycota
- Animalia
- Basidiomycetes
  - Ascomycota
  - Basidiomycota
  - Zygomyctota
  - Chytridiomycota

Clamp connections
Dollipore septum
Septate mycelium
Loss of phagotrophy
Loss of flagella
Dikaryotic stage
Ascomycota
Basidiomycota
Zygomyctota
Chytridiomycota
Animalia
Basidium and basidiospores

General characteristics of basidiomycetes

As indicated by the phylum name, basidiomycetes share basidiospore production in basidia. An additional good character is the presence of the dolipore septum.

Dolipore septum

General characteristics of basidiomycetes

Dolipore septum seems like a complex devise to allow cytoplasmic streaming between the compartments (cells) in the hyphae.
Clamp connections

General characteristics of basidiomycetes

An additional oddity is the presence of the clamp connections.

Let’s take a look.

Clamp connections are the lumps that are typical to some basidiomycetes.

Formation of clamp connections

General characteristics of basidiomycetes

Clamp connections exist to ensure that the dikaryophase is maintained through cell divisions.

The binucleate cell produces a branch into which one of the nuclei migrates. The two parent nuclei go through a conjugate mitotic division. The sister nuclei separate as the septum develops between the branch as well as the new cell and the old and the new cells. The branch or the hook fuses with the old cell and delivers one of the sister nuclei.

This way, each cell maintains the vegetative binucleate dikaryophase.

Formation of clam connections and the nuclear behaviour during the cell division
Holo vs. heterobasidiomycetes

General characteristics of basidiomycetes

Basidia can take different shapes and forms.
There are two different types of basidia which were considered as major divisions within the basidiomycetes - holo- and heterobasidia. Holobasidiomycete basidium is a single, usually club-shaped cell with most often four sterigmata. Heterobasidiomycete basidium divided into often four cells.

Basidiomycetes - divided into 3 groups

With all these characteristics in mind, let’s look at the classification aspect of the basidiomycetes: three main groups within basidiomycota - hymenomycetes, smuts and rusts.
Basidiomycete Macrofungi

Basidium development

Basidiospores develop at the tips of sterigmata. The basidium develops from the terminal end of a binucleate, heterokaryotic hyphae - the dikaryon. The basidium enlarges and the two nuclei fuse (karyogamy). The zygote goes through meiotic divisions, the resulting four haploid nuclei meander into the sterigmata forming the basidiospore initials. It has been suggested that the enlarging vacuole in the basidium squeezes the cell contents into the basidiospores.

Basidiomycete Macrofungi

Basidiospore release

Basidiospores developed at the tips of sterigmata. Buller’s drop is somehow involved in the basidiospore discharge. How, we do not know. As a matter of fact we do not even know whether the droplet is membrane bound or just liquid adhering to the side of hilar appendix. The germinating basidiospores establish haploid mycelium which we call primary mycelium.

Theory:
Buller’s drop may be a CO₂ bubble which breaks the cell walls at hilar appendix. Same electric charge of sterigma and the spore repels the spore on its merry way.
Meisporic vs. mitosporic reproduction

Asexual reproduction may be of lesser importance in basidiomycetes than it is in ascomycetes (rusts and smuts are an exception to this rule).

Nonetheless, budding and mycelial fragmentation occur.

Some species may produce arthroconidia, which basically are hyphae fragmented into unicellular propagules.

Examples of arthroconidia production

Basidiomycete Macrofungi - life cycles

Although vegetative fragmentation is common, mitospores are fairly infrequent among the basidiomycetes

Vegetative dikaryophase or secondary mycelium dominant phase

Organized specialized tissues in the basidiocarp – tertiary mycelium

Anastomosis of compatible mycelia. Compatible mating types

Haplophase or primary mycelium

Spore germination
Basidiomycete Macrofungi

- Basidiomycetes do a great number of things. They do also have a great variety of means to get their spores “out there.”

*Tremella* - a jelly fungus - on a *Stereum* - a conk or a polypore

*Geastrum* - an earth star - is a common puff ball - also a member of Gasteromycetes

*Nidulariales* - the bird nest fungi - are also members of Gasteromycetes

*Calvatia gigantea* - an appropriately named Gasteromycete

*Auricularia auricula* another basidiomycetous jelly fungus

The typical basidiomycete bears its spores on the gills of a cap; *Amanita* sp.
Basidiomycete Macrofungi

They can form mutualistic symbiotic associations such as mycorrhizae, or live as saprobes on wood, soil, leaves, or dung.

_Galerina autumnalis_ - a saprotrophic agaric

_Russula amoenaolens_ - a brittle mushroom - and its mycorrhizae

Basidiomycete Macrofungi

There are also lichenized agarics, _Omphallina umbellifera_ being a good example of this.

Lichenized fungi are mainly ascomycetous - apothecial, perithecial, ascostromatal. Taken together this implies that the lichen symbiosis must be a very successful symbiosis.

_Omphallina umbellifera_ - a lichenized agaric
Summary

• *Agaricus* commercial growing.

• Basidiospore production and release.

• Clamp connections and their meaning.

• Different types of basidiomycetes.