**Biology of Fungi**

**Fungal Growth and Development**

**Spore Germination**

- Some general features
  - Some spores have a fixed point of germination termed the germ pore
  - Other spores swell (non-polar growth) prior to a germ-tube emergence from a localized point; subsequent wall growth is focused at this point

**Spore Germination (cont.)**

- Images showing different stages of spore germination.
Spore Germination (cont.)

- Some germinating spores exhibit different types of tropism, i.e., a directional growth response to an external stimulus, e.g.,
  - Negative autotropism - germ tubes emerge from a point on the spore furthest away from a touching spore
  - Positive tropism - germination towards an external stimulus

Spore Germination (cont.)

- Hyphal tips show tropism to a variety of substances
  - Nutrients
  - Cysteine and other amino acids
  - Volatile metabolites
  - Sex pheromones

Mold-Yeast Dimorphism

- Some fungi have the ability to alternate between a mold form and a that of a yeast form - dimorphic fungi
- Several pathogens of humans exhibit dimorphism
  - Candida albicans
  - Histoplasma capsulatum

Mold-Yeast Dimorphism (cont.)

- Dimorphism occurs in response to environmental factors, of which no one common factor regulates the morphological switch in all dimorphic fungi [Table 5.1, Deacon]
  - e.g., Histoplasma capsulatum - mold at 25°C, yeast at 37°C
  - e.g., Mucor rouxii - mold with oxygen, yeast in the absence of oxygen

Mold-Yeast Dimorphism (cont.)

- What is clear is that there is a change in polarity in terms of growth, thereby making study of the cell cycle a significant focal point
- To help identify the control of dimorphic growth, the mold and yeast phases of a fungus are compared - typically differences in biochemistry, physiology, and gene expression are noted

Mold-Yeast Dimorphism (cont.)

- Two fundamental questions on the observed differences:
  - Are the differences the cause of dimorphism?
  - Did the dimorphic switch cause the differences?
Mold-Yeast Dimorphism (cont.)

- Examples of differences:
  - Cell wall composition

<table>
<thead>
<tr>
<th>Organism</th>
<th>Mold Phase</th>
<th>Yeast Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucor roux</td>
<td>More mannan</td>
<td>More mannan</td>
</tr>
<tr>
<td>Paracoccidioides brasiliensis</td>
<td>More β-1,3-glucan</td>
<td>More β-1,3-glucan</td>
</tr>
<tr>
<td>Candida albicans</td>
<td>More chitin</td>
<td>More chitin</td>
</tr>
<tr>
<td>Mucor mucedo</td>
<td>More chitin</td>
<td>More chitin</td>
</tr>
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<td>More chitin</td>
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</tr>
</tbody>
</table>

- Cellular signaling and regulatory factors
  - Calcium, calcium-binding proteins, cAMP, pH, and protein phosphorylation have all been shown to fluctuate depending upon the growth form of a dimorphic fungus
  - Not clear is some or all or any directly impact the changes in cell morphology

- Gene expression differences
  - Measurement of mRNA production
  - Again, no clear cut answer as to an obligatory role of a gene in dimorphism

Asexual Reproduction

- Two fundamentally different processes lead to the development of two distinct types of mitosores:
  - Sporangiospores
  - Conidia


Asexual Reproduction (cont.)

- Sporangiospores
  - Formed by the cleavage of protoplasm within a multinucleate sporangium

Sporangiospores likened of Mucor roux. Source: www.biosci.ualberta.ca/~cmares/Blamey/Photos/Mucor/sporangiospore.htm

Asexual Reproduction (cont.)

- Several mechanisms
  - Large number of cleavage vesicles migrate around nuclei, then fuse to form the membrane of the spores
  - Central vacuole forms "arms" that fuse with the membrane of the sporangium to delimit the individual spores
Asexual Reproduction (cont.)

- Flagellar apparatus in motile spores (e.g., *Phytophthora*)
  - Separate flagellar vesicle is separate, but fuses with the spore membrane after enclosing the nucleus presenting itself on the outside

- Motile zoospores being released from spore of *Phytophthora*. Source: Deacon, 2006

Asexual Reproduction (cont.)

- Conidia
  - Formed in various manners, but always external to the hypha or conidiophore
  - Two basic types of conidial development:
    - Blastic - swelling or budding of hyphae
    - Thallic - fragmentation of hyphae

Asexual Reproduction (cont.)

- Regulation of conidiation
  - Traditionally difficult to study due to fact that cell growth is not synchronous across a colony
  - Solved via the culture of *Aspergillus niger* using a chemostat
  - In *A. niger*, three different nutritionally-related phases were uncovered
    - Initiation of conidiophore (switch from vegetative to sporulation) - nitrogen-limited, carbon-rich media
    - Development of conidiophore - requires nitrogen and citrate (or similar Krebs cycle intermediate)
    - Phialide formation - nitrogen and glucose required

Asexual Reproduction (cont.)

- Whole process occurs on agar medium in a 1-2 mm zone located a few mm behind the leading edge of a hyphal colony
- Presumably, in an asynchronous agar culture, physiological changes bringing about conidia formation is co-ordinated
- Genetics of sporulation studied in *A. nidulans* leading to the discovery of three gene groups:
  - Switch from somatic growth to sporulation
  - Regulation of sporulation development
  - Secondary aspects (e.g., spore color)
Asexual Reproduction (cont.)

- Some fungi require light to trigger sporulation
  - Near-UV light - 1 hour exposure can induce system
  - Blue light - represses sporulation (e.g., Botrytis cinerea)

Diagram of the effect of near-UV light on conidial formation
*Botrytis.* Source: Deacon, 2006

Asexual Reproduction (cont.)

- Role of hydrophobins
  - Hydrophobins are secreted proteins that are unique to fungi
  - Soluble in water, except at water/air interface where they form a film that surrounds a hypha extending outwards, making it hydrophobic in nature and leading to different interactions among the hyphae performing various functions

Hydrophobin rodlets. Source: [www.biomade.nl/AmphipathicProteins.htm](http://www.biomade.nl/AmphipathicProteins.htm)