Biology of Fungi, Lecture 4: Fungal Growth

Overview of the Hypha
◆ The hypha is a rigid tube containing cytoplasm
  ✓ Growth occurs at the tips of hyphae
  ✓ Behind the tip, the cell is aging

Apical Growth
◆ Fungi are unique in that growth occurs solely at the apical tip of a hypha
◆ Hyphal tip (apex) shows extreme plasticity
  ✓ Swell to form spores or yeast-like cells
  ✓ Taper to penetrate
  ✓ Give rise to complex structures
◆ Robertson in a series of experiments hypothesized that apical growth is the result of two independent processes:
  ✓ Continuous extension of a plastic, deformable tip
  ✓ Rigidification of wall behind the extending tip
◆ Such a response by hyphae is known as the “stop-swell-branch” sequence
◆ Wall assembly at the hyphal apex is very complex involving various components in both growth and maturation
  ✓ Chitin synthase - biosynthesis of chitin
    ● Chitin is formed in situ, not delivered by membrane-bound vesicles
    ● Chitin synthase is probably delivered by vesicles containing chitosomes which are inactive zymogens
    ● Chitin synthase becomes an integral membrane protein that must be activated by a protease (also probably delivered by vesicles)
    ● Chitin fibrils are synthesized to extrude from the outer face of the plasma membrane
    ● The synthesis of chitin is regulated by many mechanisms including a cytosolic inhibitor
Glucan synthase - produces \( \beta \)-1,3-glucan

- Probably delivered by vesicles and incorporated into the plasma membrane in a manner similar to that of chitin synthase
- Regulation differs - two subunit enzyme
  - Catalytic subunit on outside portion of membrane
  - GTP-binding protein subunit on inside of membrane
  - GTP binding stimulates the synthesis of glucan
- Modifications of glucans by the addition of side chains of \( \beta \)-1,3-glucan which progressively increase in the subapical hyphae regions during wall maturation

Mannoproteins are pre-formed in the endoplasmic reticulum-Golgi complex and delivered to the apex via vesicles; mainly a major component of yeast cell walls

Cross-linking and maturation - various linkages between wall components occur more regularly in the older parts of the wall; lysine may be involved in some linkages

Wall lytic enzymes - chitinase, glucanase

- May be involved in the “softening” of the wall at the apical tip, though some evidence suggests that it is the cytoskeleton that reinforces the hyphal tip
- Must be required for initiation of branching at subapical regions of the hypha

Steady-state model of wall growth

- Proposed by Wessels (1990)
- Newly-formed wall is viscoelastic
  - Wall polymers continually added to the tip
  - Flow outwards and backwards
  - Wall rigidifies progressively
  - Fits Robertson’s original hypothesis
  - Supported by Jackson and Heath (1990) experiments using actin inhibitors
- Explains release of enzymes by fungi
◆ Possible driving force behind apical growth
  ∗ Actin
  ∗ Microtubules
  ∗ Calcium ions
  ∗ More likely a combination of the above and other as yet unidentified factors

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