- Chytrids in cattle rumen
  - Have a major role in degrading plant structural carbohydrates
  - Process these compounds through a mixed acid fermentation pathway, much like lactic acid bacteria
  - Mixed acid fermentation occurs in the cytoplasm producing ethanol and lactic acid (derived from pyruvate)
  - Some pyruvate goes to the hydrogenosome where ATP is produced as well as molecular hydrogen
  - Hydrogen is converted to methane

◆ Physiology of oxygen tolerance

∗ Inadvertant side product of metabolism are several types of highly reactive forms of oxygen

- O_2^-, superoxide anaion
- H_2O_2, hydrogen peroxide
- OH^-, hydroxyl radical

∗ These oxygen species damage cellular constituents

◆ Fungi and other organisms have evolved mechanisms to handle these destructive compounds

∗ Catalase – converts H_2O_2 to water and molecular oxygen

∗ Superoxide dismutase - converts O_2^- to water and molecular oxygen

- ∗ Do thermophilic fungi have a higher rate of metabolism as compared to mesophiles?
  - ● No difference in growth rate
  - ● Suggests that thermophiles have become specifically adapted to their high-temperature environment

Hydrogen Ion Affects

- ◆ Fungi grow over a broad range of pH
  - ∗ Range = 4.0 - 8.5
  - ∗ Some grow over broader range of 3.0 - 9.0
  - ∗ Most show a relatively broad pH range optimum of 5.0 - 7.0
- ◆ Also, special cases of acid-tolerant and acidophilic fungi as well as alkali-tolerant and alkalophilic fungi
- ◆ Fungi from extreme pH environments still possess cytosolic pH near 7.0
- ◆ Fungal cytosol has a great buffering capacity that functions by either
  - ∗ Pumping H^+ ions out;
  - ∗ Exchange of materials between cytoplasm and vacuoles; or
  - ∗ Interconversion of sugars and polyols
- ◆ Changes in the cytoplasmic pH can induce differentiation, e.g., zoospore induction in Phytophthora
- ◆ Fungi can alter their environmental pH which can help facilitate the acquisition of nutrients
- ◆ Small pH gradients can help direct fungal growth

Oxygen and Growth

- ◆ With respect to oxygen requirements, fungi can be either:
  - ∗ Obligate aerobes;
  - ∗ Facultative aerobes;
    - ● Fermentation - absence of oxygen
    - ● Anaerobic respiration - terminal electron acceptor other than oxygen
  - ∗ Obligately fermentative; or
    - ● Lack mitochondria or cytochromes
    - ● Growth occurs via fermentation regardless of the presence or absence of oxygen
  - ∗ Obligate anaerobes - cannot grow/survive in the presence of oxygen
    - ● Major group - Chytridiomycota
    - ● Live in a consortium of microbes within the rumen of cattle

Biology of Fungi, Lecture 7: Environmental Conditions for Growth and Tolerance

Concepts

- Fungal cultures in the laboratory does not always predict what happens to fungi growing in nature
- Fungi often can tolerate one suboptimal condition provided all others are at or near optimum
- Competition in nature can restrict what is observed to occur in the laboratory

Temperature

- Fungi can be categorized with regard to their response to temperature
- Four basic groups
  - Thermophilic: 20°C min., ~50°C max., 40-50°C optimum
  - Thermotolerant: can grow well within a wide range of temperatures
  - Mesophilic: commonly grow from 10-40°C; includes most fungi
  - Psychrophilic: growth optimum ≤16°C; 20°C max., ≤4°C minimum
- Physiological bases of temperature tolerance
  - Eukaryotic structural complexity alone restricts growth maximum to 60-65°C
  - Lower limits restricted by
    - Reduced rates of chemical reactions
    - Increased viscosity of cellular water
    - Concentration of substances, e.g., ions
  - Homeoviscous adaptation - changes in the fatty acid composition of the cell membrane due to temperature fluctuations
    - Ensures membrane fluidity
    - Unsaturated fatty acids increase with lower temperatures, e.g., psycrophilic fungi contain more unsaturated fatty acids in their membranes than mesophiles
  - Cytoplasmic composition changes to temperature fluctuations
    - Increases in polyols as temperature decreases
    - Trehalose increases as temperatures become lower providing membrane protection
  - Responses of fungi to increased temperatures
    - Enzymes and ribosomes of thermophiles are more heat stable
    - Heat-shock proteins act like chaperones