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

- Inadvertent side product of metabolism are several types of highly reactive forms of oxygen
  - O$_2^-$, superoxide anaion
  - H$_2$O$_2$, 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$_2$O$_2$ 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., psychrophilic 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