# فسيولوجيا الأحياء الدقيقة
# Microbial Physiology

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مكتب ٢ ب ٤٥

## Bacterial Growth & Environmental Effects
## L9

# Upper and Lower Temperature Limits

- **What determines the upper limit for survival and growth?**

  Different mutations of a conserved enzyme (β - Galactosidase) from *E. coli*, it has been shown that mutations generally affect the thermal stability of the enzyme, rather than the catalytic activity (amino acid chain for structure).

- **Lower temperature limits:**

- Temperature create a change in the conformation state (folding) of proteins by affecting H-bonding.
- Proteins tend to become more sensitive to inhibition as temperature decreases (regulatory process).
- Assembly processes can also be affected (the assembly of the ribosome).

# Lethal Effects of Temperature

- Bacteria can be killed by exposure to high temperature, freezing, or sudden chilling.
- If kept above 0ºC, but below their minimum growth temperature, bacteria suffer a loss of viability due to the simple absence of growth.
- The bacterial cell's intrinsic ability to survive, the physiological state, and the protective elements of the media all affect the rate of destruction.
- Bacteria are also at risk to freeze killing. The rate at which the cell is frozen greatly affects the number of cells that can survive (ice crystals formation)- **immediate effects** (at the time of freezing) and **storage effects** (slow loss of viability).

# Lethal Effects of Temperature

- Compounds in the media are much more protective against the cold than they can protect against heat.
- Glycerol is used in the lab to help store frozen stocks of cells. Others include milk proteins, meat extract, sucrose, glucose and lactose.
- **Ice making Bacteria:** The effect of freeze killing is actually caused by ice formation, not the low temperature.
  - However, some bacteria can initiate ice formation.
  - Most ice formation particles (Nucleating particles) are not effective above -5$^{o}$ C.
  - Some bacteria produce cell wall proteins (INA) that can cause nucleation at this temperature.

# Why is this physiologically important?

- Ice-nucleating bacteria are epiphytes (grow on the surface of leaves).
- The production of these proteins may have two effects:
  - Increasing the formation of dew on the surface, providing the cells with water.
  - Causing localised destruction of plant cells, providing the cell with nutrients.

- Possible industrial use of these bacteria:
  - Replacing native bacteria with mutant strains that do not produce INA proteins will stop frost formation on nights that the temperature does not drop too low.
  - Seeding clouds may induce rain.
  - Seeding snow machines to aid in snow production at higher temperatures.

# Osmotic Pressure Effects

- Differences in solute concentrations between the interior and exterior of the cell produce an osmotic pressure.
- Water molecules will move into or out of the cell to equalize this pressure.
- Potentially dangerous for the cell.
- In dilute environments, water tends to flow into the cell, forcing the cell size to increase, and possibly burst.
- In concentrated solutions, water will move out of the cell, cause the cell to shrink or plasmolyze .
- Bacterial cells have a high internal osmotic pressure, and are able to maintain a constant turgor pressure (pushing the plasma membrane against the cell wall).

# Osmotic Pressure Effects

- How does the cell maintain its turgor pressure, and what effect can a changing environment have on a cell?
- With an increase in external osmotic pressure, the cell responds by increasing internal concentration of a few solutes.
- The uptake of K+ is controlled by turgor pressure.
- Increasing external osmotic pressure = decreases the cell's turgor pressure.
- K+ is then pumped into the cell (along with a compatible counter ion).
- K+ is increased or decreased by transport mechanisms.

- **What happens if K+ is not available?**
- Synthesis of certain amino acids (glutamate) can be used to counteract outside osmotic pressure .
- High osmotic pressure will eventually inhibit most enzyme activity, causing the cell to then plasmolyze.

# pH

- Bacteria are able to grow over a range of pH values.
- The descriptions of bacteria define which pH environments it prefers, the internal pH of the cell is kept constant.
  - *Thiobacillus ferooxidans* grows at a pH of around 2, but maintains an internal pH of around 6.5.
  - *Bacillus alkalophilus* survives up to a pH of around 10.5, but its internal pH is around 9.
- Changes in external pH do not change the internal pH by much, allowing the enzymes to remain active.

- **How the cell maintains its internal pH?**
- If the cell is in an environment that has a pH lower than its internal pH, protons will be harder to bring back into the cell, reducing its available potential energy source (PMF).

# pH

- The PMF of a cell is derived by the electrochemical potential of the membrane.
- A difference in pH, as well as a difference in membrane potential drives the cell ATPases to produce energy in the form of ATP.

- **How does the cell maintain its PMF if the pH is low?**
- By the use of proton/K+ or proton/Na+ antiport systems. As protons are moved out of the cell, a greater membrane potential is formed, allowing protons to then be used to drive ATPases.

- If the cell is an alkaline environment, a more complex system is involved.
- To counteract the alkaline environment, K+ is pumped out while protons are pumped in.

# pH

- The maintenance of cell growth is a complex interaction between proton pumping, cation-proton exchange, and the transport of K+ into the cell.
- It may also involve the synthesis of compatible solutes like glutamate.

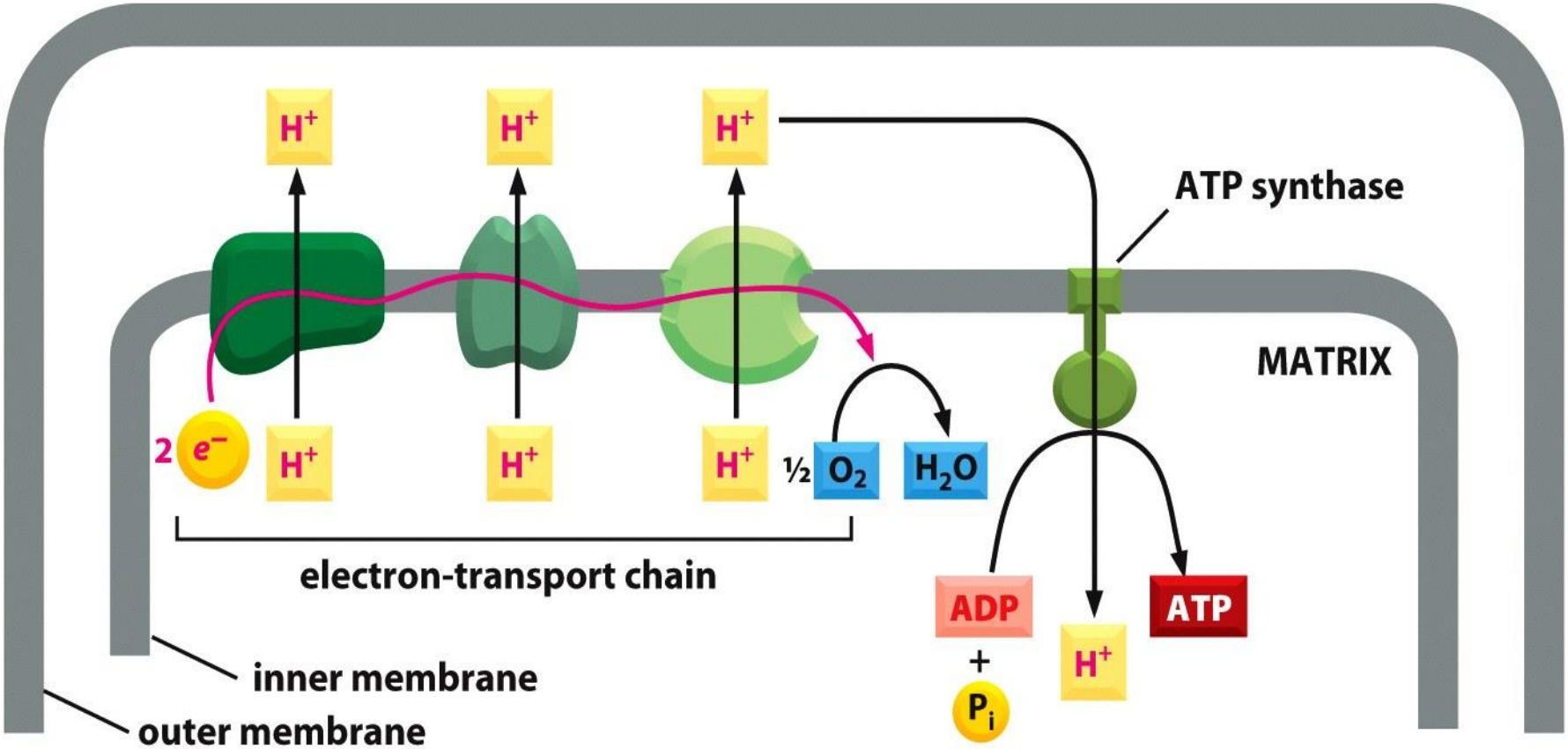


Figure 14-11 Essential Cell Biology 3/e (© Garland Science 2010)

# QUESTIONS??