Lectures 5 and 6: Microbial Nutrition and Growth

* A large amount of the material related to Microbial Nutrition and Growth is application-based and will be covered in detail in lab 5 and 6. Please use the crossword puzzle at the end of these lectures as a review of this material.

Why is it important for microorganisms to be able to transport molecules into and out of the cell?

LeuTAA is a bacterial Na+/Cl- transporter that is a homologue of human transporters that uptake biogenic amines such as dopamine. Protein Databank 2A65.
I. Uptake of nutrients by the cell
   A. 1. Small molecules such as ... from a region of higher concentration to one of lower concentration. is necessary.
   2. ... depends on the size of the concentration gradient ((Fig 6.3 (8th ed.) or 3.10 (9th ed.)).

B. 1. Mediated by either ... proteins that allow a molecule to cross from a region of ... This can eliminate a difference in concentration but cannot create one. output.
2. Carriers
   a. Show and accommodate one solute at a time.
   b. The rate of transport increases more rapidly and sooner with a carrier, but the carrier can become (Fig 6.3 (8th ed.) or 3.10 (9th ed.)).
Simple, passive diffusion and channels vs. carriers
AN ANALOGY
3. Carrier mechanism:

The solute molecule binds to the outside of the carrier causing a

The molecule is transferred to the interior of the cell.

*Since this process is concentration dependent, it is
4. In order to maintain a concentration gradient that is amenable to transport, many cells immediately the transported molecule into something else or eukaryotic cells may it to another compartment.

5. Examples:
   a. Carriers: Certain K⁺ uptake systems
   b. Channels: and in many bacteria.
   *Facilitated diffusion is observed much more often in than in prokaryotic systems. Why?

Aquaglyceroporin -a facilitator found across the inner membrane of *Escherichia coli*

*Biophys. J.* 2008, 94, 832-839
image available at http://www.edam.uhp-nancy.fr/ABF/applications.html
C. - can accumulate molecules against a concentration gradient ( ).

a. - The linked transport of two substances in the

The of E. coli is a symport.
b. The linked transport of two substances in directions.

The \textit{of E. coli} is an antiport.

\begin{itemize}
  \item \textbf{H}^+
  \item \textbf{Na}^+
\end{itemize}
2. Transport systems that use ATP = TP binding assette ( ) transport systems.
   - Utilizes a binding protein that is located outside the membrane to deliver the molecule to the transporter.

*E. coli* uses ABC transporters to bring in a variety of...
*E. coli* uses ABC transporters to bring in a variety of **sugars and amino acids**.
D.

-A molecule is chemically altered during its passage through the transporter (e.g. in the phosphotransferase system, sugars are phosphorylated as they enter the cell).

**Phosphoenolpyruvate: glucose phosphotransferase**

![Diagram showing the process of phosphorylation in the phosphotransferase system]

- **EP** transfers a phosphoryl group to **EIIB**.
- **EIIB** transfers a phosphoryl group to **EI**.
- **EI** transfers a phosphoryl group to **HPr**.
- **HPr** transfers a phosphoryl group to **EIIB**.
- **EIIB** transfers a phosphoryl group to **EI**.
- **EI** transfers a phosphoryl group to **HPr**.
- **HPr** transfers a phosphoryl group to another enzyme.

A high energy molecule called phosphoenolpyruvate to an enzyme called **El**.
II. Protein Secretion (prokaryotes)

The Sec-Dependent Pathway (General Secretion Pathway)

1. Proteins to be secreted this way are synthesized with a signal peptide at their amino terminus.

2. The signal peptide is recognized by Sec machinery.

[Diagram of protein secretion with labels for SecA, SecB, SecYEG, signal peptide, hydrolyzes ATP, and keeps the secretory protein from before it can be transported.]
III. Principles of Bacterial Growth

A. An increase in the number of cells in a population.

B. Cells often reproduce by

BACTERIAL CYTOKINESIS

Cell wall
Plasma membrane
chromosome

As a bacterial cell readies for division, it becomes larger (and increases in volume). The chromosome and plasmids

A begins to form and expands through the entire cell, creating two separate compartments

Two separate daughter cells are formed. Depending on the species the cells may stay associated (diplo arrangement)
The increase in the cell #s is
The number of cells after n divisions =
- For example after the third cycle of divisions and the number of cells =
It is often desirable to calculate the number of cells in a population that originated from more than a single cell:
C. \( t \) = the time it takes for a population to double in number.

- Many bacteria
- *Escherichia coli* - (under certain environmental conditions)
- *Mycobacterium leprae* - 10 to 30 days

(See also table 7.3 (8th) or 7.29 (9th))

Sample situation:
10 cells of a microorganism land on your ham sandwich. It sits in a warm room for 4 hours before you eat it for lunch. If this microorganism has a doubling time of 20 min., how many microorganisms do you eat?

\[
\text{# of divisions} = N_f = N_0 \times 2^n
\]

\[N_f = \]
IV. Bacterial Growth in Laboratory conditions
A. In lab, we grow organisms in tubes, flasks or on plates. In these systems nutrients are and waste products are not These are called . Growth in these conditions (particularly a shaken culture) is described by a growth curve.
B. The Growth Curve

Check out the YouTube Channel!
in response to population density, depletion of nutrients and buildup of waste products.

- Cells synthesize antibiotics and macromolecules that make them resistant to environmental factors called (starvation proteins).

- Total number of viable cells
- Secondary metabolites continue to be produced.

Total number of culturable cells

Log of # of viable cells

- Main objective -
- Amino acids, nucleotides and other macromolecules are rapidly synthesized and called

A few cells are still able to multiply.

* There is current debate as to whether cells actually simply starve to death in this phase. Some argue that cells may be viable but dormant, others argue that some cells may undergo programmed cell death to allow the population as a whole to survive.

* Enzymes, ribosomes, nucleic acids and ATP needed for replication

* Length depends upon the and the identity of the
During which stage of growth do you think that a bacterium would be most susceptible to antibiotics?

a. Lag phase  
b. Log phase  
c. Stationary phase  
d. Death phase
How is growth in nature often different than growth in a closed system?
C. Toxic derivatives of oxygen (O₂)
   1. Oxygen can be naturally converted into two toxic forms:
      a. 
      b. *Cause damage to cell membranes, DNA and proteins.*
   2. Some organisms are equipped with enzymes that can superoxide and hydrogen peroxide.

\[
2O_2^- + 2H^+ \rightarrow O_2 + H_2O_2
\]

\[
2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2
\]

*Most strict anaerobes lack these enzymes*