

Cell Physiology

Part 3 – Membrane Transport

Membrane Transport

- Key to maintaining homeostasis
 - Homeostasis does not mean equilibrium!
 - Recall what happens if ions are allowed to reach equilibrium across the cell membrane
 - Homeostasis of the internal environment involves movement of materials across the cell membrane (between fluid compartments)
 - Motive force may be
 - Gradients (passive & active)
 - Cellular Energy (active)

9-08-09 Agenda

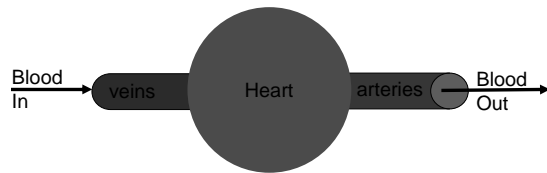
- Review Membrane Potentials
- Membrane Transport
 - Passive
 - Active
- Summary of Membrane Function

Membrane Transport

- Key Concept!
 - **Gradients**
 - Any situation where something is higher in one area and lower in another area
 - may be a:
 - pressure gradient (liquid or gas)
 - concentration gradient (chemical)
 - may occur within a compartment
 - Bulk Flow
 - may occur between compartments
 - Simple Diffusion
 - Facilitated Diffusion (utilizes channel proteins or carrier proteins)
 - Osmosis
 - may be established by using energy!

Membrane Transport **Bulk Flow**

- Bulk Flow
 - Movement within a compartment due to a pressure gradient
 - Pressure moves blood within plasma
 - Pressure moves air within respiratory tract



Is energy required?

Membrane Transport

- Passive Movement
 - Requires?
 - Types:
 - Simple Diffusion
 - Osmosis
 - Facilitated Diffusion

Membrane Transport **Simple Diffusion**

- Defined:
 - The movement of substances other than water from areas of high concentration to areas of low concentration
 - Area of high to area of low defines a gradient
 - The movement of substances other than water down its gradient
- What causes this movement?

Membrane Transport **Simple Diffusion**

- Molecular motion – the inherent kinetic energy of molecules due to sub atomic forces and collisions with other molecules

[Link to Motion Applet](#)

- The main factors that influence molecules moving across a cell membrane are
 - Size
 - Lipid solubility
 - Gradient Size
 - Temperature
 - Distance to diffuse

} molecular characteristics

} extrinsic diffusion factors

Membrane Transport

Simple Diffusion

Seven good things to know about diffusion:

1. it's passive,
2. movement occurs down a gradient,
3. movement occurs until concentration reaches equilibrium*,
4. occurs in an open system or across a membrane that is at least selectively permeable,

Rates of diffusion are determined by

5. Distance,
6. Temperature,
7. Molecular size.

**equilibrium will vary depending on other forces acting on it*

Membrane Transport

Simple Diffusion

- Phospholipid Bilayers & Diffusion
 - lipophilic molecules v hydrophilic molecules
 - Lipophilic molecules can move by simple diffusion
 - Hydrophilic molecules require facilitation!
 - Rate of diffusion across depends on
 1. Ability of molecules to get through the inner hydrophobic section of the membrane
 - Lipids, steroids, and small lipophilic molecules
 - Water – slowly and depends on cholesterol content of the cell membrane
 2. The surface area available for diffusion
 3. The thickness of the cell membrane

Membrane Transport

Simple Diffusion

Fick's law of diffusion wraps it all up nicely!

$$\text{Rate of diffusion } \propto \frac{\text{Surface area} \times \text{concentration gradient} \times \text{membrane permeability}}{\text{membrane thickness}}$$

(is approximately)

Membrane permeability is the most difficult as membrane permeability changes with lipid solubility and the size/characteristics of the molecule diffusing across!

Membrane Transport

Osmosis

- Defined:
 - The movement of water from an area of low solute concentration to an area of high solute concentration or....
 - The movement of water from an area of high water concentration to an area of low water concentration
- this ONLY concerns the movement of water

Membrane Transport **Osmosis**

- When will water move?
 1. When a gradient is established AND
 2. There is a pathway
- obligatory vs. facultative water movement

Membrane Transport **Osmosis**

- osmosis related health issue:
 - Why can eating a bag of salty chips (every day) cause a change in blood pressure?

Membrane Transport

Facilitated Diffusion

- Facilitated Diffusion:
 - Movement of charged or lipophobic molecules down their concentration gradients AIDED by
 - SLC (solute carriers) superfamily transporter proteins
 1. water filled
 - » fast but limited in transport ability
 2. carrier proteins
 - » slower but can transport larger molecules
 - Is still a passive process
 - No ATP required
 - Stops once its equilibrium is reached

Membrane Transport

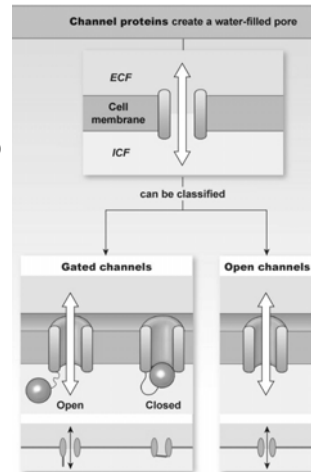
Facilitated Diffusion

1. Water filled channel proteins
 - Aquaporins (membrane protein)
 - Allow passage of water
 - Ion channels
 - Specific to size, charge
 - Specificity determined by
 - Diameter of pore
 - Electrical charge of amino acids in the channel

Membrane Transport

Facilitated Diffusion

- May be open or gated channels
 - Open channels are open most of the time or have no gates
 - Gated channels spend most time in the closed configuration and are
 - Chemically gated
 - Voltage gated
 - Mechanically gated
 - Light gated



Membrane Transport

Facilitated Diffusion

2. Carrier Proteins

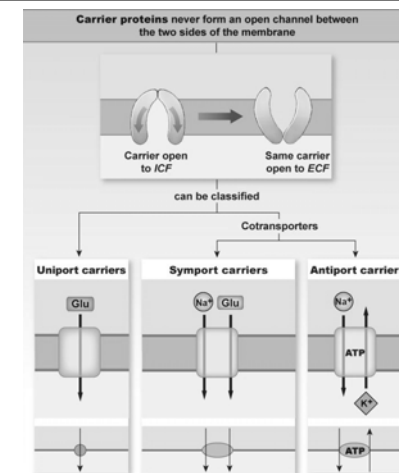
- Do not form channels that are open to both the ECF and ICF
- Move larger molecules across the membrane
- Operate as
 - Uniports⁽¹⁾
 - Example Glucose & Amino Acids
 - Cotransporters^{(1), (2)}

1-not all carrier proteins operate in a passive mode
2-typically operate as secondary active transporters

Membrane Transport

Facilitated Diffusion

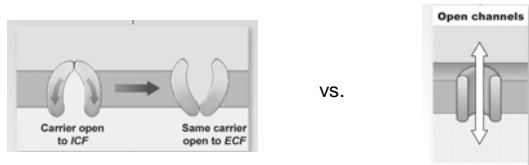
- Uniport Carrier Proteins
 - Transport one type of molecule & only in one direction
- Cotransport Carrier Proteins
 - Transport more than one type in
 - Symports
 - the same direction
 - Antiports
 - the opposite direction
 - Requires ATP (NOT USED IN FACILITATED DIFFUSION)



Membrane Transport

Facilitated Diffusion

- Movement using carrier proteins requires conformational change upon binding of molecules
 - This is why they are slow(er)
 - 1,000 to 1×10^6 molecules/sec compared to channels which are a factor of 10 faster!



Membrane Transport

Active Transport

- Energy is used to transport molecules against their gradient in Primary Active Transport
 - ATP provides the energy (*Table 5-2*)
 - Na^+/K^+ ATPase & H^+/K^+ ATPase (anion ports)
 - Ca^{2+} ATPase & H^+ ATPase (uniports)
- The potential energy created by the gradient may be utilized to operate protein carriers in Secondary Active Transport
 - $[\text{Na}^+]$ gradient (established by primary active transport) is used to cotransport (*Table 5-3*)
 - Na^+ , K^+ , Cl^- , Ca^{2+} , glucose, bile salts, choline, neurotransmitters

Membrane Transport

- Review Membrane Potentials
- **Membrane Transport**
 - Passive
 - **Active**
- Summary of Membrane Function

Membrane Transport

Active Transport

- Primary Active Transport Carrier Proteins also function as enzymes
 - ATP binds to the active site
 - One phosphate bond is broken
 - Phosphate is attached to the carrier protein
 - Induces a conformational change
 - Phosphate is released after transporter function has occurred, returning carrier protein to its original conformation
- Remember that because these are proteins they operate on the three protein assumptions of
 - Specificity
 - Competition
 - Saturation

Membrane Transport

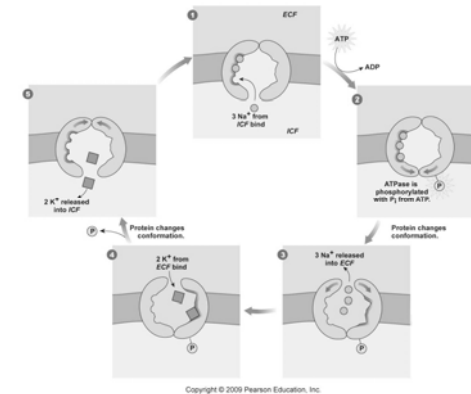
Active Transport

- Active Transport also involves Vesicular Transport
 - Phagocytosis
 - Endocytosis
 - Pinocytosis
 - Receptor Mediated Endocytosis
 - Potocytosis
 - Exocytosis
 - Combined actions include transcytosis
 - Transports across epithelium in a vessicle

Membrane Transport

Active Transport

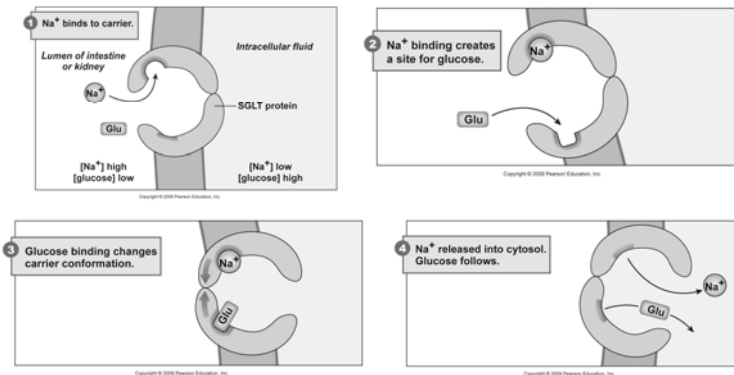
Example: Primary Active Transport



Membrane Transport

Active Transport

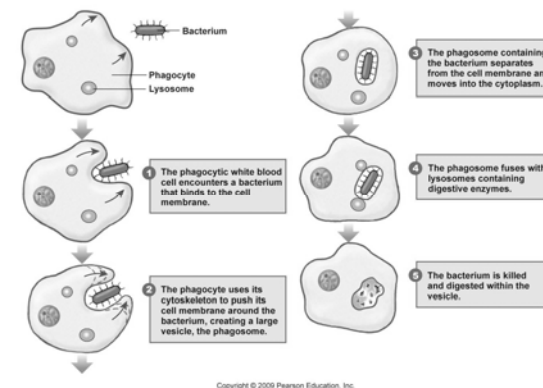
Example: Secondary Active Transport



Membrane Transport

Active Transport

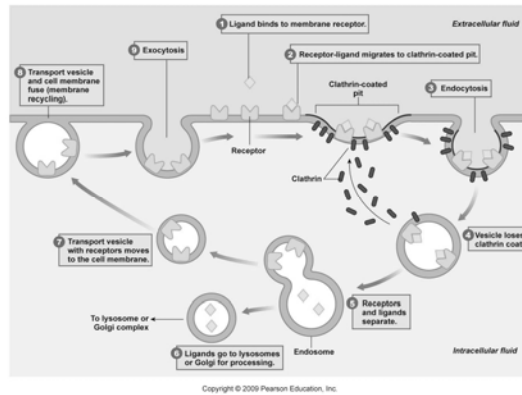
Phagocytosis



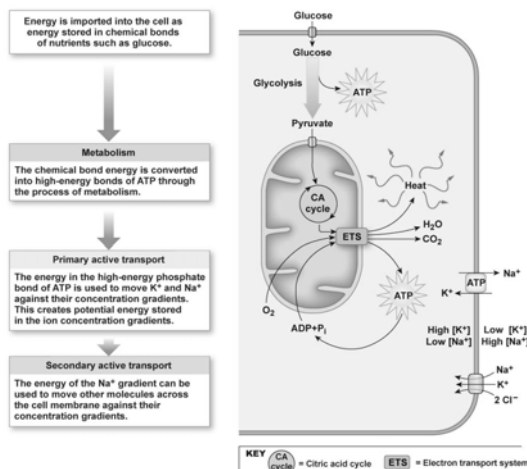
Membrane Transport

Active Transport

Receptor Mediated Endocytosis & Exocytosis



Membrane Transport



Membrane Transport

- Integrated Concept
 - Using membrane transport properties in more than one process... the link between glucose, ATP and membrane potential

Membrane Transport

- Integrated Concept: Transepithelial transport

