GENERAL PRINCIPLES

Section I - Cell Transport

I. Cell Membranes

A. Composed of phospholipids

B. One hydrophilic phosphate head (water soluble) with two hydrophobic fatty acid tails (lipid soluble)

C. Hydrophobic tails face each other and form a lipid bilayer

D. Lipid soluble (non-polar) substances can cross cell membrane easily (simple diffusion) (Figure 1.1)

1. Steroids
2. Lipids
3. O_2, CO_2, and N_2
4. Numerous drugs and anesthetic gases

E. Water-soluble substances are repelled by the lipid bilayer (Figure 1.2).

1. Charged molecules (H_2O, Na^+, Cl^-, K^+, glucose)
2. Large particles (proteins)

II. Simple Diffusion (Figure 1.1)

A. No carrier/protein transporter

B. No energy required (passive)

C. Follows gradient

1. Driven by transmembrane concentration gradient (substances diffuse down their concentration gradient)

III. Carrier-Mediated Transport

A. Has carrier/protein transporter

B. Conducted via protein

1. Can be saturated → can reach a transport maximum (Tm)
2. Can experience competition

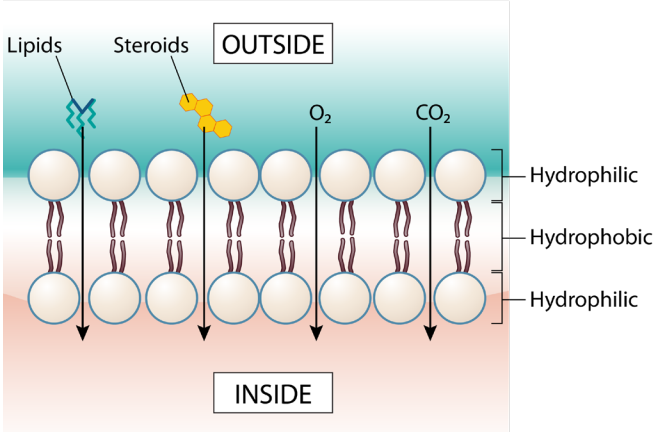


Figure 1.1 - Simple diffusion

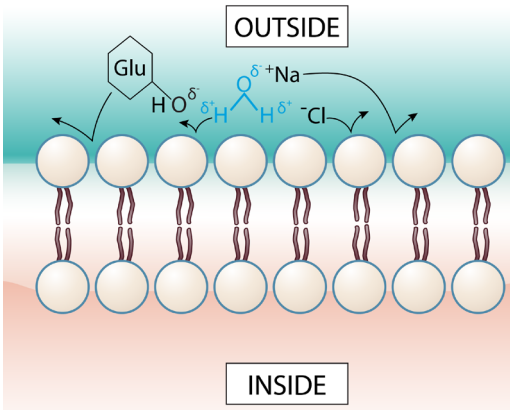


Figure 1.2 - Large and charged substances

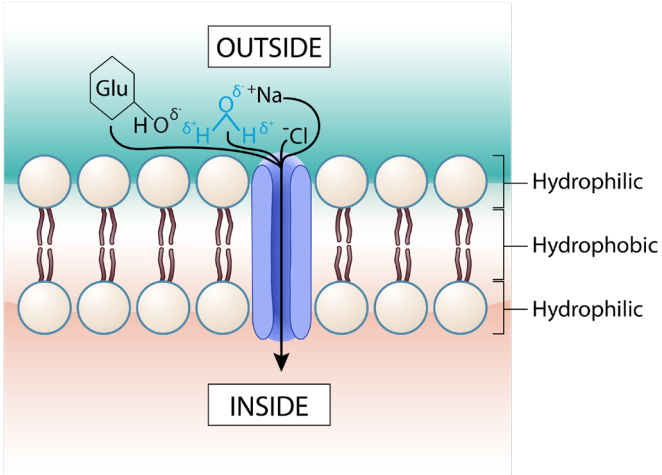


Figure 1.3 - Facilitated Diffusion

C. Types include:

1. Facilitated diffusion
2. Primary active transport
3. Secondary active transport

IV. Facilitated Diffusion (Figure 1.3)

A. Has carrier/protein transporter

B. No energy required (passive)

C. Follows gradient

1. Driven by transmembrane concentration gradient (substances diffuse down their concentration gradient)

D. Almost any substance that cannot enter via simple diffusion can use facilitated diffusion.

V. Primary Active Transport (Figure 1.4)

A. Has carrier/protein transporter

B. ATP energy required (active)

1. Examples end with, "ATPase" (Na^+/K^+-ATPase, H^+-ATPase, and Ca^{2+}-ATPase)

C. Moves against gradient

1. Transported substances move energetically uphill, against their electrochemical gradient.

VI. Secondary Active Transport (Figures 1.5 and 1.6)

A. Has carrier/protein transporter

B. ATP energy required (active)

1. ATP required indirectly, only to keep intracellular NA^+ low via the Na-K pump

C. Moves against gradient but follows Na^+ gradient created by primary active transport

D. Can be symporters or antiporters

1. Symporters include: Na^+-glucose cotransporter, Na^+-amino acid cotransporter
2. Antiporters include: Na^+-Ca^{2+} exchange and Na^+-H^+ exchange

VII. Receptor-Mediated Endocytosis (Figure 1.7)

A. Proteins on ligand bind to proteins on cell surface → cell membrane forms coated vesicle that is then ingested.

B. High yield examples include:

1. Iron in the serum (transferrin-iron complex stimulate endocytosis)
2. LDL stimulates LDLR
3. EGF stimulates EGFR

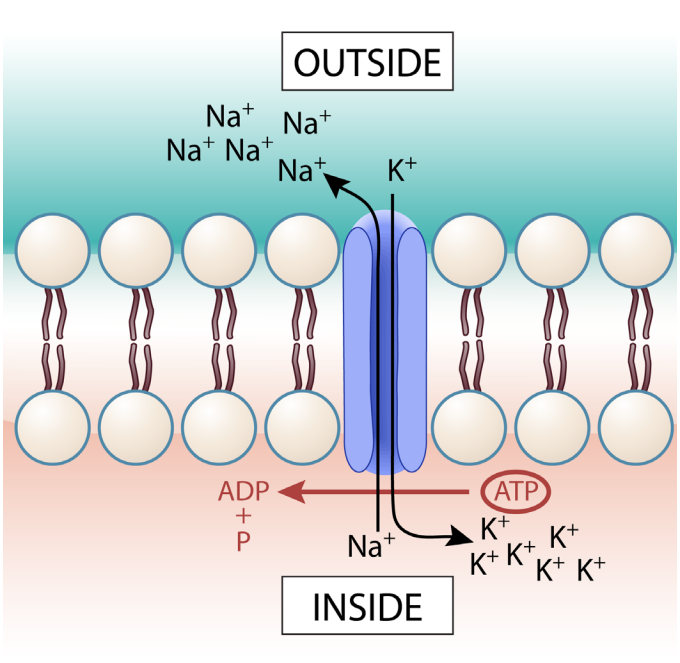


Figure 1.4 - Primary Active Transport

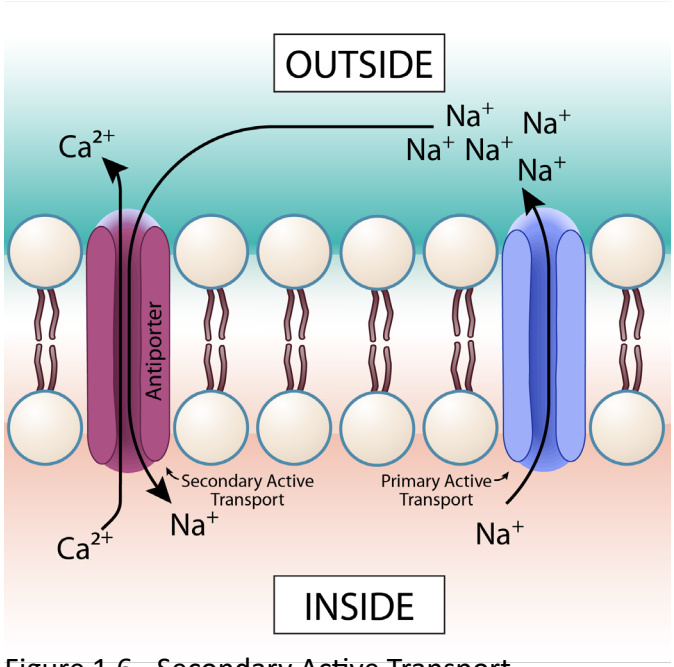


Figure 1.6 - Secondary Active Transport with Calcium

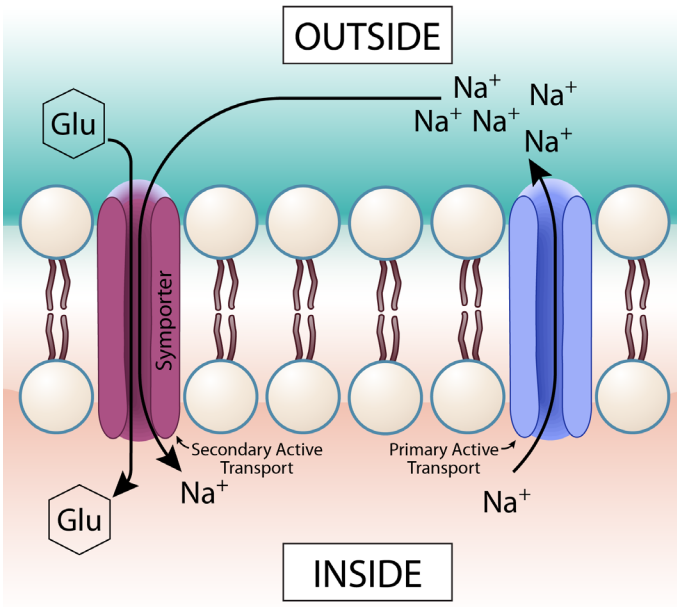


Figure 1.5 - Secondary Active Transport with Glucose

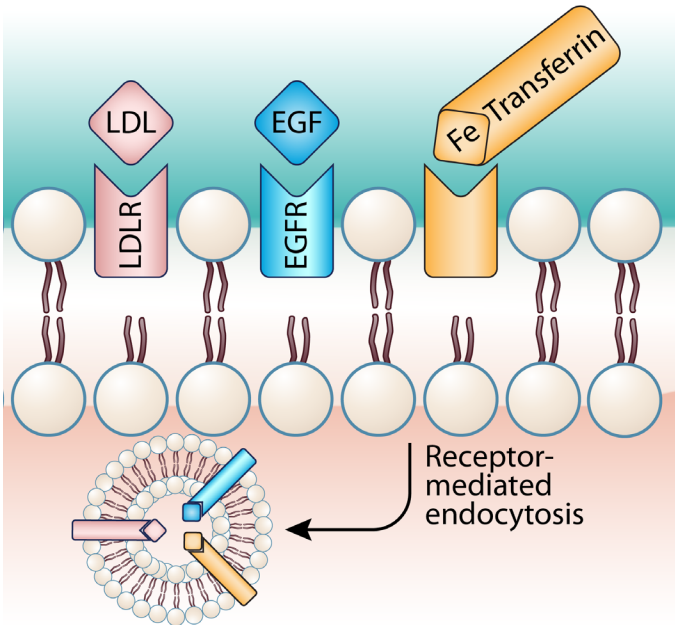
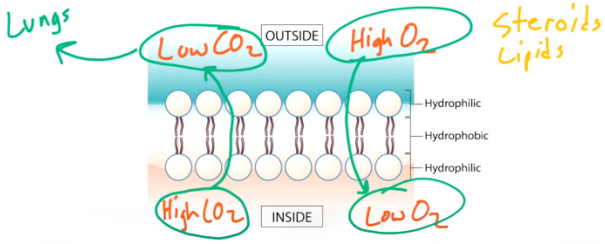


Figure 1.7 - Receptor-mediated Endocytosis

REVIEW QUESTIONS

1. Hemoglobin carries oxygen to the capillaries. How does oxygen leave the capillaries to enter the tissue?

   - **Oxygen can cross the membrane via simple diffusion due to concentration gradient**
   - **Oxygen is high in the capillaries and low in the cell, causing flow of oxygen from the blood into the tissues**
   - **CO_2 is high in the cell (waste product) and diffuses into the capillaries where it can be taken to the lungs and exhaled**



2. In an experimental setting, a cell does not have any protein transporters. The researcher notices that some substances can enter the cell and others cannot. Will glucose be able to enter the cell?

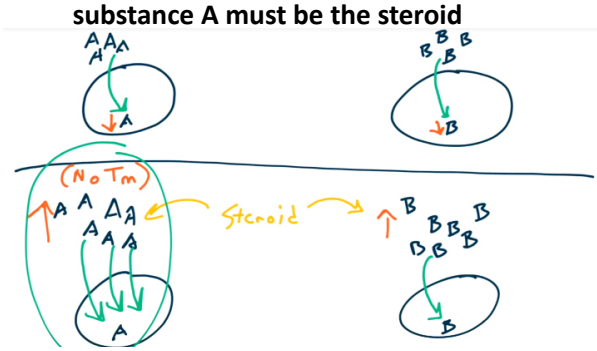
   - **Glucose is not small or lipid soluble**
   - **Glucose requires a protein transporter**

3. A researcher determines that glucose is high in the cell but is still brought into the cell against its concentration gradient. No ATP is used at the transporter glucose uses to enter the cell. What type of transport was used for this glucose?

   - **Glucose is not small or lipid soluble, so simple diffusion is not used**
   - **Facilitated diffusion always moves down a concentration gradient**
   - **Primary active transport requires direct action of ATP**
   - **Secondary active transport can move against a concentration gradient without the direct action of ATP**

4. Measurements are taken for transport of substance A and substance B across distinct and separate cell membranes. Throughout the experiment, both substances are kept low in their respective cells while concentration increases outside the cell. Transfer of substance A increases proportionally as the concentration gradient is increased. However, transfer of substance B does not increase even though its concentration gradient increased. One of the substances is a steroid hormone. Is the steroid likely to be substance A or B?

   - **Protein transporters can be saturated**
   - **The mechanism of transport of substance B was saturated → substance B must require a protein transporter**
   - **Substance A was not saturated → substance A must not require a protein transporter and diffuses freely across the membrane → substance A must be the steroid**



5. The LDLR is dysfunctional in a certain patient. What will happen to the intracellular level of LDL in the adipose tissue of this patient?

   - **Endocytosis of LDL requires LDLR function**
   - **Dysfunctional LDLR means decreased LDL in adipose, keeping it elevated in the serum**