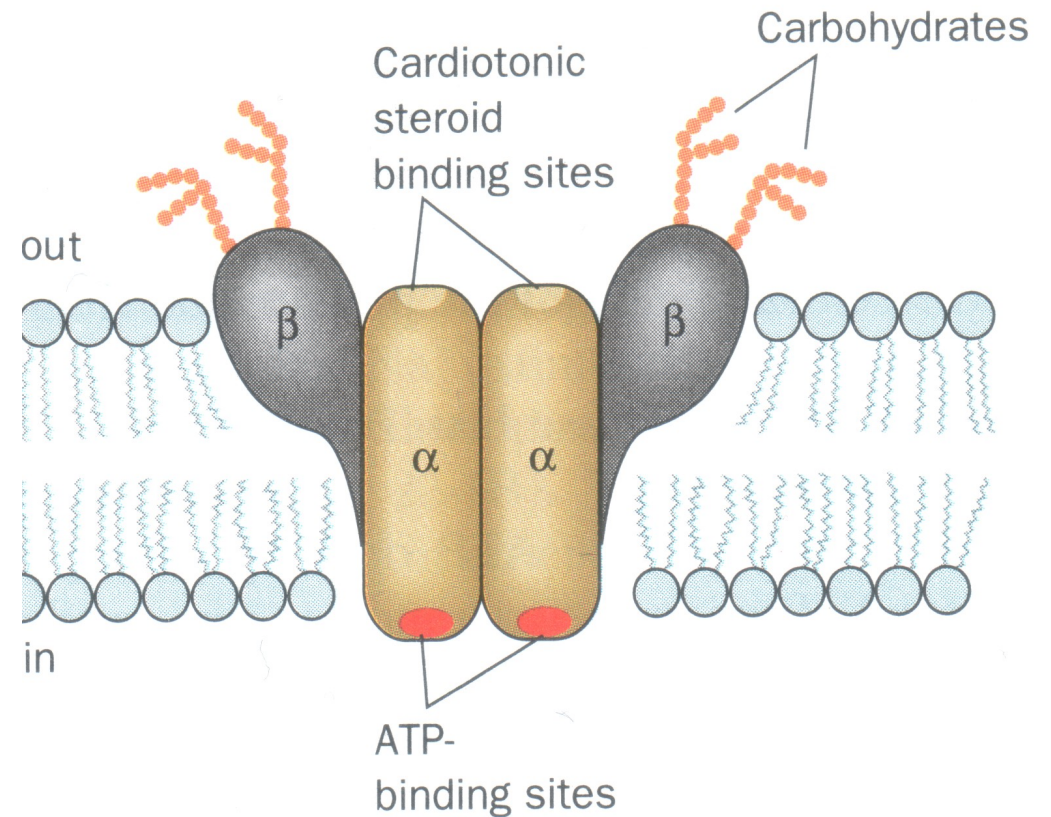


Chapter 20: Transport

**Voet & Voet:
Sections 20-1, 20-
2, 20-3a & 3d**



Transport

Membranes are impermeable to most ionic and polar compounds

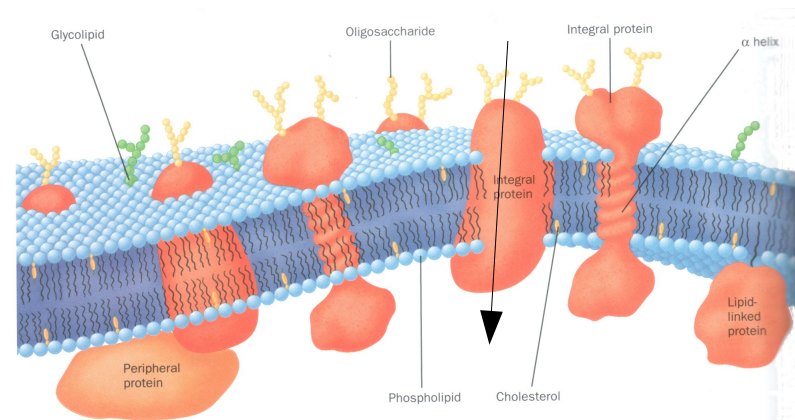
*these substances may only traverse the membrane through the action of specific **transport proteins***

- transport proteins mediate transmembrane movements of ions, metabolites and water
- transport proteins also responsible for all biological electrochemical phenomena including neurotransmission and oxidative phosphorylation

Applies to plasma membrane (separating cell and environment)

- also applies to boundaries and internal structures of eucaryotic organelles

Membrane with arrow
indicating transport via
transporter



Electrochemical Membrane Potentials

Electrochemical potential across a membrane has two components

(1) **Chemical potential**

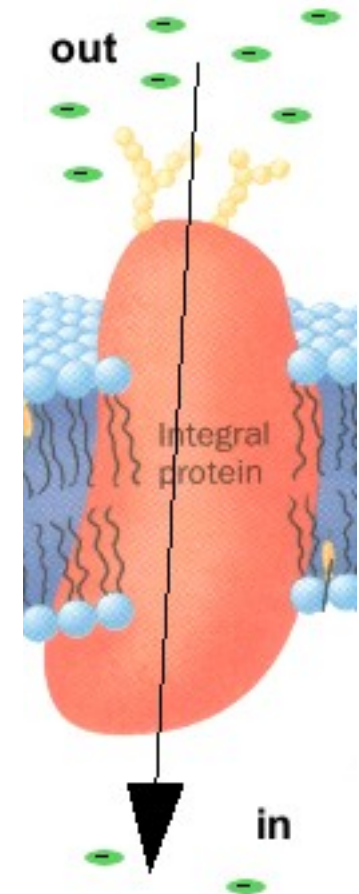
Depends upon the relative concentrations of **solute** on each side of the membrane ($[in]/[out]$)

(2) **Electrical potential**

Depends upon the relative concentrations of **ions** on each side of the membrane ($[in]/[out]$)

- the electric potential component of the **electrochemical potential** is only significant for ions

The potential is a result of the diffusion of solute from regions of high concentration to regions of low concentration



Transport Mechanisms

Mechanistic studies indicate there are two types of transport

Nonmediated – Simple diffusion controlled transport

Mediated – Transport through action of specific carrier proteins variously called *carriers, permeases, porters, translocases, translocators* and *transporters*

Two types of mediated transport

Passive or facilitated diffusion – concentration gradients drive transport

Active – energy is utilized to concentrate against a gradient (transport is from low concentration to high)

Four differences between mediated and nonmediated transport

- (1) Speed (orders of magnitude faster) and specificity
- (2) Saturation kinetics (similar to enzyme suggesting formation of complex)
- (3) Susceptibility to competitive inhibition
- (4) Susceptibility to chemical inactivation

Ionophores (Passive Mediated)

Ionophores have advanced our understanding of mediated transport

- **small organic compounds or oligopeptides that are antibiotics of bacterial origin**
- **disrupt vital concentration gradients through mediated transport of ions or compounds**

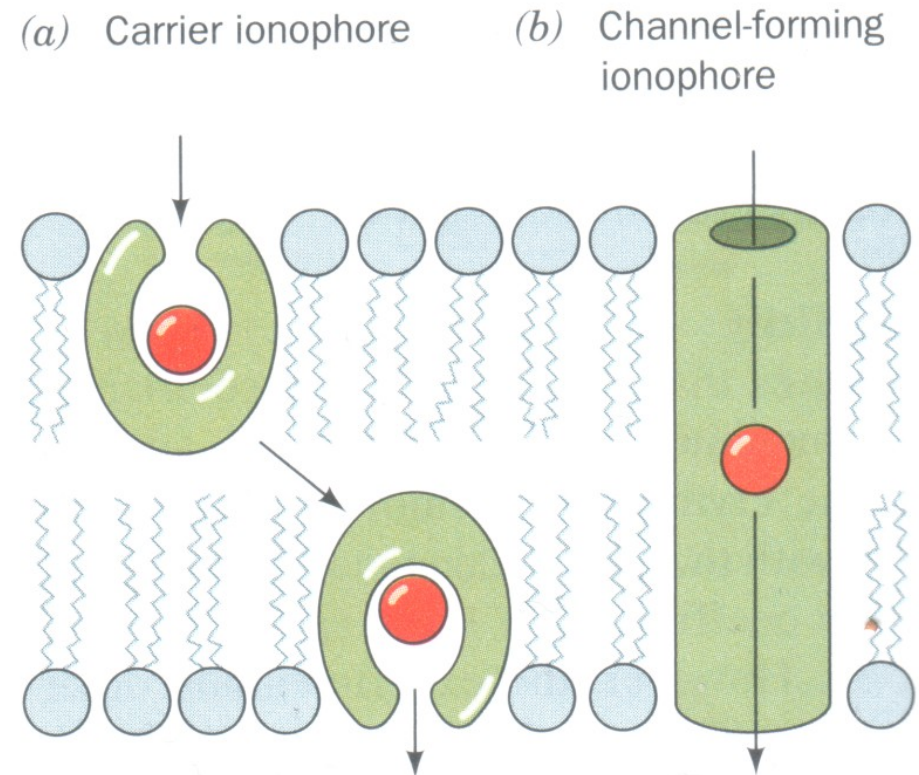
Two types of Ionophores

(1) **Carriers** (eg valinomycin)

bind selected solutes and diffuses through membrane with solute

(2) **Channel Formers** (eg gramicidin)

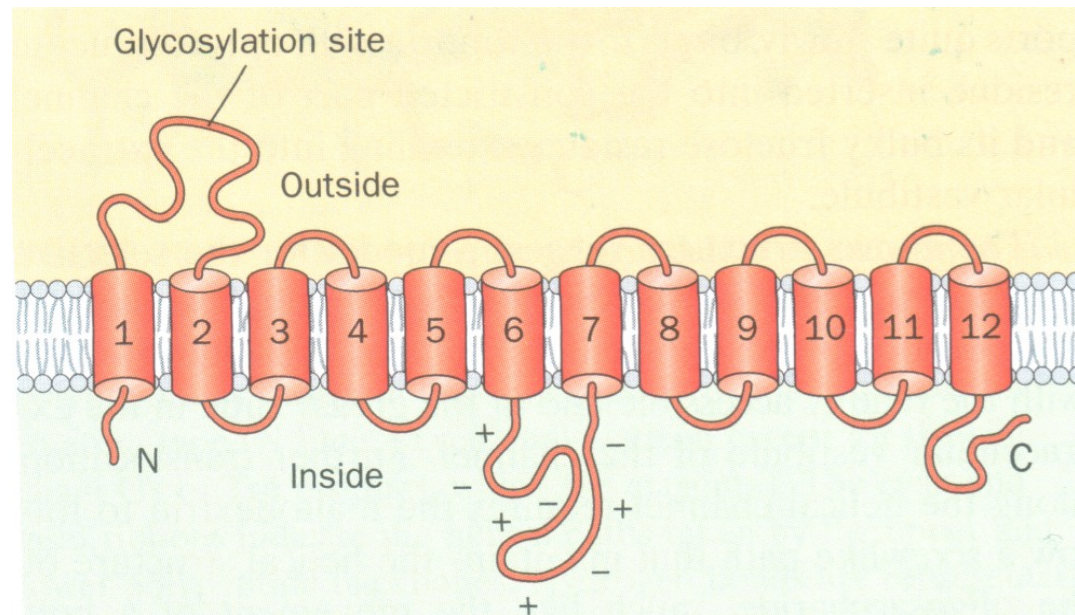
opens pore that allows selected solutes to pass through membrane



Glucose Transporter (Passive Mediated)

Glucose transporters are a conserved family of 4 closely related proteins with tissue specific distributions

- likely composed of 12 transmembrane helices thought to form a hydrophobic cylinder
- 5 helices are amphipathic (3,5,7,8,11) and form a hydrophilic channel that transports glucose



Glucose Transporter (Gated Transport)

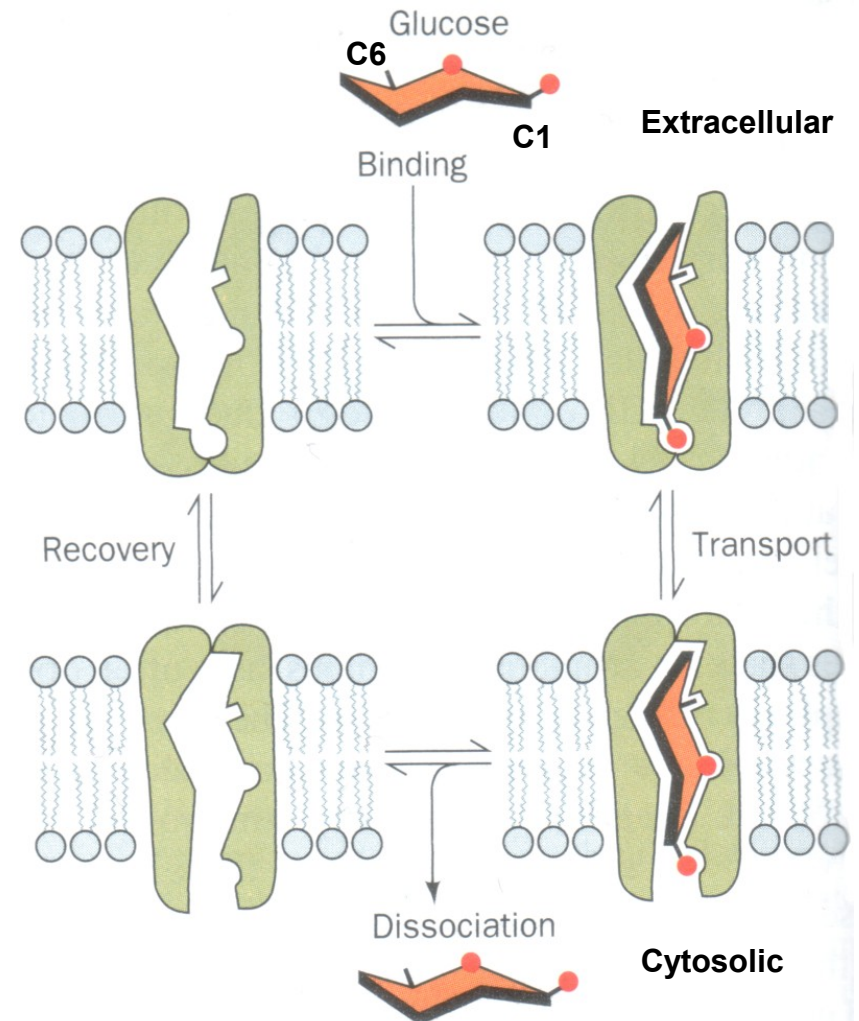
Binding sites on either side of membrane that differ

- 1-propylglucose binds to cytosolic but not extracellular site
- 6-propylglucose binds to extracellular but not cytosolic site

Transporter has two alternating conformations

- extracellular site requires contact with O1 and leaves O6 free
- cytosolic site requires contact with O6 and leaves O1 free

Behaves like a canal “gate”



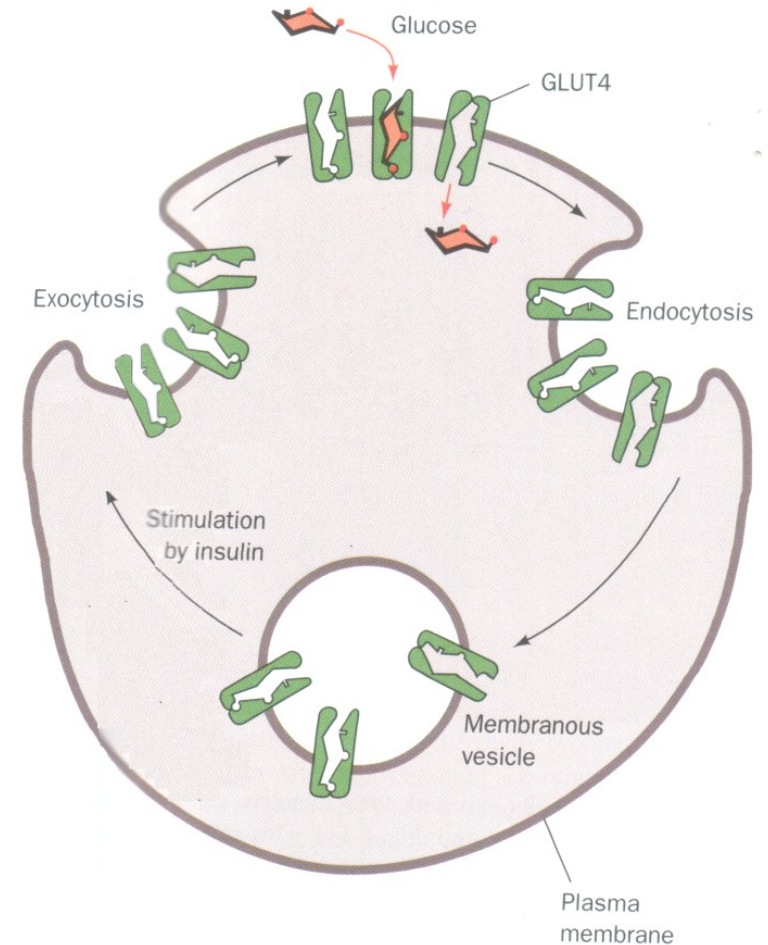
Glucose Transporter (Cellular Regulation)

Insulin stimulates a 6-12 fold increase in glucose uptake

- no change in binding affinity of transporter
- not affected by inhibitors of protein synthesis

Glucose Transporters are stored in intracellular vesicles

- insulin stimulates vesicles to fuse with plasma membrane – exocytosis
 - increases glucose transporter concentration on cell surface
- insulin withdrawal results in reverse process - endocytosis



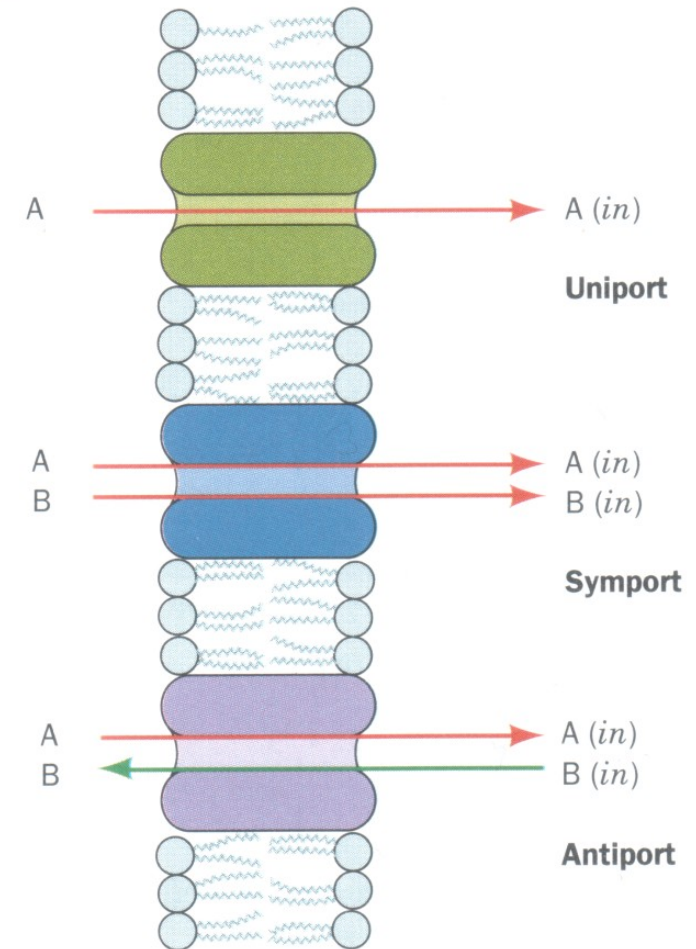
Active Transport

ATP driven active transport is categorized by the stoichiometry of the transport process

- **Uniport** – movement of a single molecule at a time
- **Symport** – simultaneous transport of two molecules in the same direction
- **Antiport** – simultaneous transport of two molecules in opposite directions

Active transport is further categorized by its electrical character

- **Electroneutral** transport does not change charge separation across the membrane
 - Symport of oppositely charged molecules OR Antiport of similarly charged molecules
- **Electrogenic** transport results in charge separation across the membrane



Na⁺-K⁺ ATPase

Large dimeric protein with $\alpha_2\beta_2$ quaternary structure

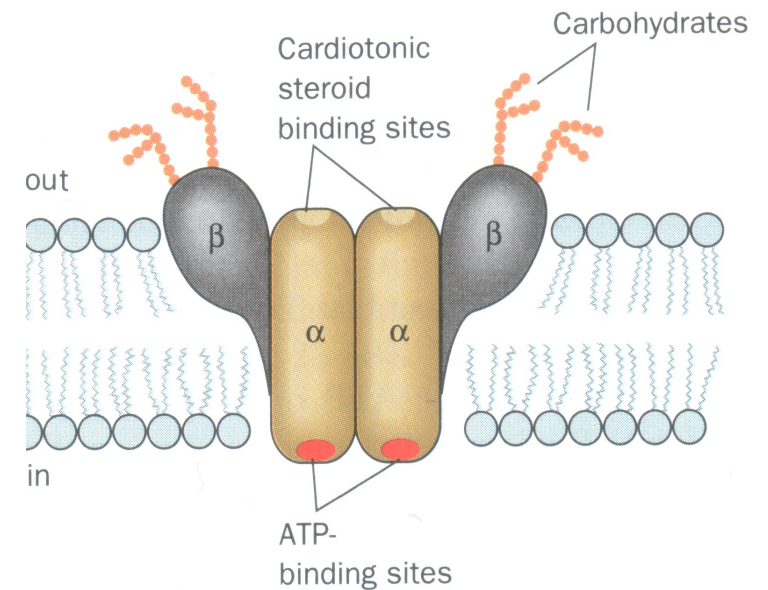
- α subunit spans membrane and transports ions

ATP driven pump that moves 3 Na⁺ out of the cell and 2 K⁺ into the cell

- electrogenic antiporter that maintains osmotic pressure in animal cells
- can require 30% of a cells ATP under normal conditions

Two major conformational states

- phosphorylation of protein at ATP binding site in the presence of bound Na⁺ triggers conformation change



Coupled Transport

Several active transport systems phosphorylate substrate during transport

- conserves energy as high energy bond is retained by substrate and subsequently utilized during metabolic processes
- glucose transport can be coupled with phosphorylation of O6

