Lecture 5

January-12-11
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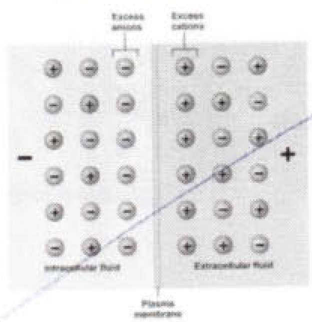
Biology 2A03
Lecture 5

Transport Mechanisms II

1

Separation of Charge Across a Membrane



- Separation of charge = potential energy

-Electrical forces
- Opposite charges attract
- Like charges repel

-Membrane potential is: negative (always relative to inside)
- Electrical driving force on cations - into cell
- Electrical driving force on anions - out of cell

-Magnitude of electrical driving force depends on:
- size of membrane potential
- valence of ion

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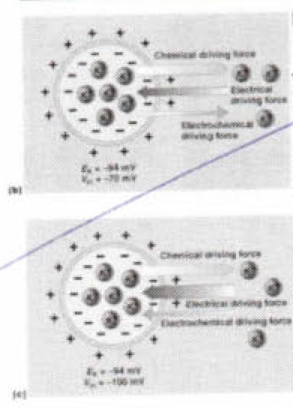
Fig 4.2

Electrochemical Driving Forces

Chemical driving forces due to concentration difference

Electrical driving forces due to charge of molecule



Direction of ion movement depends on balance between Chemical and electrical driving forces

If equal the electrochemical force is 0

For this example:
Chemical > electrical = outward force

Chemical < electrical = Inward force

E_k= equilibrium potential for K-reflects the chemical driving force

Different from membrane potential

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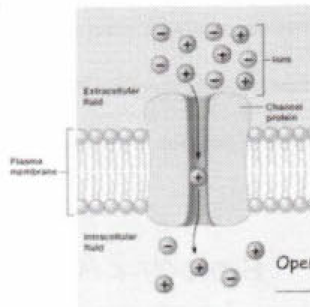
Fig 4-5

Protein forming an aqueous pore spanning the lipid bilayer of the cell membrane which when open allows certain solutes to transverse the membrane.

Channel Protein

Membranes can be selective by how many channels it has and what types of channels it has



Selective for type of ion
-due to size and the charged and polar surfaces of the protein subunits of the channels

Electrically Attract or repel particular ions

Consist of polypeptides Surrounded by a central core

Opening of the pore can be regulated (eg. Membrane potential regulates voltage-gated channels)

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Fig 4-13

2b) Facilitated Diffusion (actually a mediated transport)

Mvmt of specific mol'cs across cell membranes thru protein channels

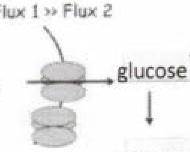
Net flux of molecules across membranes is From high to low concentration or downhill movement → no NRG req'd

Not coupled with ATP hydrolysis to move molecules in the opposite direction (i.e. low to high concentration)

Phosphorylation always keeps con'c of glucose low so that there is always a greater con'c outside cell

G6P is the first step of Kreb's cycle - so it doesn't flow out

Flux 1 >> Flux 2



Glucose transporter (GLUT)

ECF = glucose 6.6mM

glucose ICF = 1.0mM

Glucose-6-phosphate

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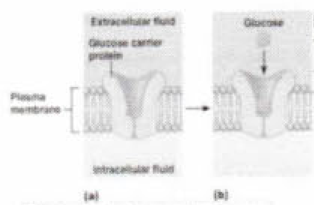
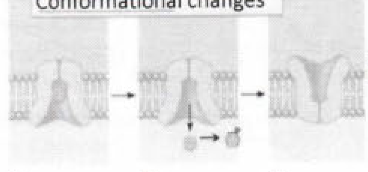
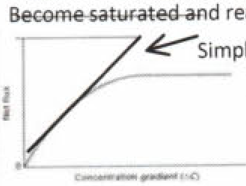


Differs from simple diffusion in that it involves Selective membrane transporters for large polar or charged molecules

Bind substrates and undergo Conformational changes



Mediated transport can also Become saturated and reach maximal flux



Simple diffusion will increase and cannot become saturated

Fig 4-11
Fig 4-12

Directly uses NRG to transport molcs across a membrane (also called direct active transport).

2c) Primary active transport

Direct use of ATP to power movement of molecules against an electrochemical gradient or uphill

Covalent modulation of transporter (via phosphorylation by ATP) increases the affinity of the solute binding site

alteration of a protein's shape and function by covalent bonding of chem. grps to it.

Dephosphorylation occurs by conformational change of the transporter and decreases the affinity of the binding site.

an essential process of removing (P) grps from an organic compd (as ATP) by hydrolysis

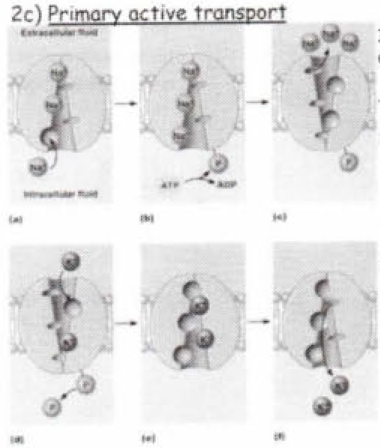
Examples include: Na^+ / K^+-ATPase, Ca^{2+}-ATPase, H^+-ATPase, H^+/K^+-ATPase

Intracellular K^+ = 140mM, extracellular K^+ = 4 mM

Inward movement of K+ uphill and requires active transport

See Table 4.1

2c) Primary active transport



Intracellular Na^+ = 15 mM
extracellular Na^+ = 145 mM

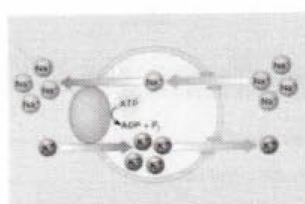
Outward movement of Na+ uphill and requires active transport

Intracellular K^+ = 140 mM
extracellular K^+ = 4 mM

Inward movement of K+ uphill and requires active transport

Exists in almost every cell

Fig 4-14



Membranes are "leaky" to ions

(sodium is constantly leaking in, potassium is constantly leaking out

Ion pumping to maintain proper gradients produces heat as a byproduct

Up to 50% heat production in some cases

Endotherms have leakier membranes than ectotherms

This results in a metabolic rate that is 10x that of a similar sized ectotherm

(Mouse has leakier membrane than frog, and mouse has metabolic rate 10x that of a frog

∴ Endotherms allow for ionic X4 much easier

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There is no direct coupling of ATP; instead, the electrochem. potential diff created by pumping ions out of the cell is used

2b) Secondary active transport

Uses [ion] gradient across membrane as energy source

As ion moves down its concentration gradient it provides energy for the uphill transport of another solute

Usually Na+ whose binding changes the affinity of the transporter for solute via allosteric modulation

allosteric modulation: sodium is going to bind to a different binding site

Def'n of Allosteric Modulation: the regulation of an enzyme or other protein by binding an effector mol'c at the protein's allosteric site (that is, a site other than the protein's active site.)

Primary active transport is needed to maintain the Na+ gradient that provides energy for secondary transport

the simultaneous or sequential passive transfer of mol'cs or ions across biological membranes in a fixed ratio

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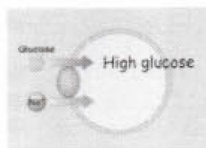
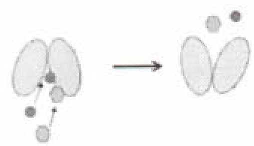
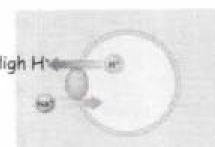


(a) Cotransport

This example is of cotransport (~~in the same direction)~~ - also called symport



Na+ binding increases the affinity for solute binding



(b) Countertransport

Can also occur in opposite directions = countertransport or anti-transport

The transport of 2 chemical species across a membrane in opposite directions

~~Osmosis~~

~~Water diffusion: although water is polar it has high permeability in membranes due to its small size~~

~~Flux can be increased by ____________~~

~~H_2O concentration depends on ____________~~

~~Total [solute] in solution determines ______~~

~~1 mole of dissolved particles = ____________~~

~~e.g. 1M of glucose in solution = ____________~~
~~but 1M of NaCl = ____________~~

~~The higher the osmolarity of a solution the ____________~~

~~Osmosis in the direction of ____________~~

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