Membrane Transport Processes

Membrane Transport

Diffusion

- Molecules diffuse from high to low concentration
- Movement is random for each individual molecule
- The amount of substance moving per time is flow
- Flux is equal to flow/area
    - Flux depends on the concentration gradient (Fick's Law of Diffusion)
- Diffusion is greater for lighter substances

$$Flux\ (j) = D\frac{(C_1 - C_2)}{s}$$
$$Flow = j \times A$$

Body Fluids

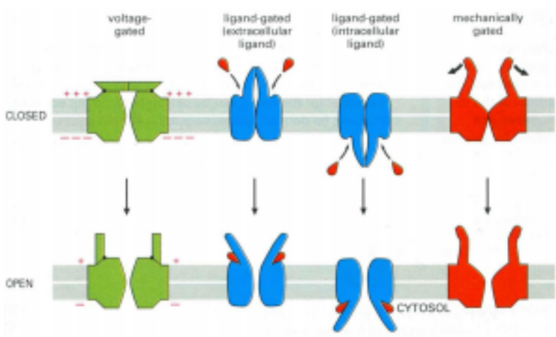
- 1/3 of total body water is extracellular fluid
- 2/3 of total body water is intracellular fluid
- Lipid bilayer divides intra and extracellular spaces
- Large and/or charged solutes cannot move through the cell membrane

Vesicle Transport

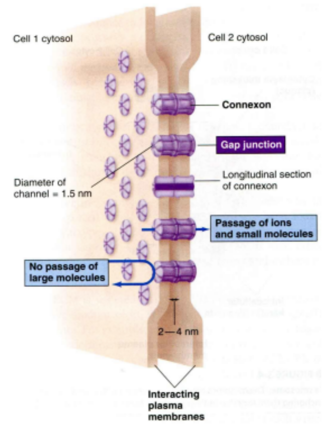
- Endocytosis
    - Pinocytosis – cell drinking
    - Phagocytosis – cell eating
- Binds to a receptor protein on cell surface
- Examples include:
    - Exocytosis of neurotransmitters from nerves
    - Phagocytosis of bacteria by macrophages

Channels

- Small polar molecules use protein channels
- Channels are transmembrane proteins that form a water filled pore
- Channels are often selective
    - Sodium channels will not allow potassium through
- Channels are often gated
    - Pores are ungated channels
    - Voltage Gated Channels
        - Nerves and muscle cells
    - Ligand gated channels
        - Opened by
        - neurotransmitters
    - Mechanically gated channels
        - Touch and hearing

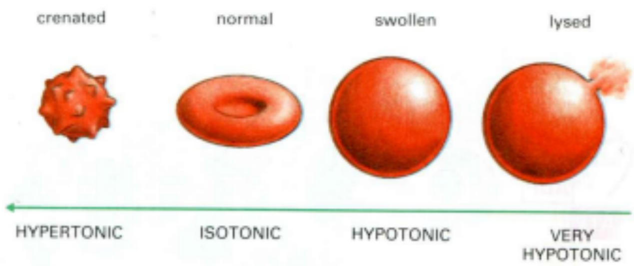


- Gap junctions are pores between cells
    - Formed from transmembrane protein connexon



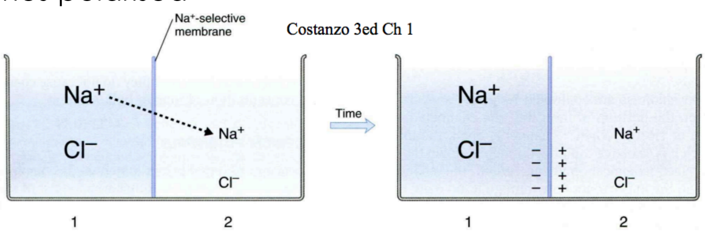
Osmosis

- Almost all cells have aquaporins water channels to allow water to diffuse
- Osmotic pressure differences drive water in
    - Pressure increases until pressure drives water back out
- Hyperosmotic cells shrink – hypertonic
- Hypoosmotic cells swells – hypotonic
- 150mM NaCl is isotonic
- Tonicity is a change in cell volume by osmosis



Membrane Potential

- When ions are found on either side of the membrane, the membrane becomes polarised



Costanzo 3ed Ch 1

- Concentration gradients have chemical potential energy
- Voltage generates electrical potential energy
- Nernst Equation gives membrane potential at equilibrium
    - Assumes only one ion is permeable

$$V = -\frac{RT}{zF}\ln\left(\frac{[X_{out}]}{[X_{in}]}\right)$$

- Capacitance is the relationship between charge and voltage

$$q = CV \qquad q = zFn$$

$$n = \frac{q}{zF}$$

- Real cells are permeable to many ions and the Goldman Equation is used
- For positive ions the equation is in/out
- For negative ions the equation is out/in
- An example is shown below for K^+, Na^+ and Cl^-

$$V = -\frac{RT}{F}\ln\frac{P_K[K^+_{IN}] + P_{Na}[Na^+_{IN}] + P_{Cl}[Cl^-_{OUT}]}{P_K[K^+_{OUT}] + P_{Na}[Na^+_{OUT}] + P_{Cl}[Cl^-_{IN}]}$$

- Only relative permeability is required
- As permeability to one ion increases, the membrane potential moves closer to the Nernst Equilibrium
- At rest, most cells are much more permeable to potassium than sodium

Nerve Action Potential

- Membrane goes from -70mV to +30mV in 1 msec
    - Caused by the opening of Na^+ channels
- Move towards 0mV is known as depolarisation or hyperpolarisation

Flow of Ions

- Flow is the movement of ions
- Flux is flow/area
- Can relate this to current:

$$j = \frac{i}{zFA}$$

- No current will flow at the equilibrium voltage
- Current is given as the flow of positive charges
- Conductance is how easy charges can move

Transport Proteins

Pores and Channels

- The cell membrane is permeable to lipid soluble molecules
- Pores and channels increase permeability
- Pores are non-gated channels

Carriers

- Carriers bind to the solute and change their conformation
- Opens to other side of membrane and releases solute
- Rate is limited by the speed of each carrier and the number of carriers

- This process is known as facilitated diffusion
- Carrier mediated transport shows a saturation and will have a maximum transport rate (J_{MAX})