Factors Affecting Transport Direction

- Passive + Active Transport
  - Spontaneous movement occurs from high → low energy / high → low concentration (passive)
    - ↳ to move in the opposite direction requires an input of energy (active transport) → mediated by transport proteins (pumps)
- Driving forces on molecules: any difference in energy across a membrane
  - ↳ Chemical forces: Concentration Gradients (ΔC) difference in concentration on either side of the membrane
    - down → passive, up → active
    - Magnitude of the force $\propto \Delta C$
  - ↳ Electrical forces: due to membrane potential → difference in electric potential (ΔV) across the membrane
    - Intracellular fluid has excess anions (-), causing a net negative charge; Extracellular fluid has positive charge from cations (+)
    - Sign of membrane potential is the sign of the net charge inside the cell relative to the outside
    - to determine direction of the electrical force, valence (charge of the ion) * sign of membrane potential
      - ↳ cations are attracted by the negative charge inside the cell → inward-directed force (opposite for anions)
    - Magnitude of the electrical force depends on the size of the membrane potential + quantity of charge carried by the ion → increases as these factors get larger
  - ↳ Electrochemical force: total force acting on the ion
    - equilibrium potential: hypothetical value for the membrane potential where electrical force is equal and opposite to the chemical force → electrochemical force = Ø
    - Determining direction: need to know ion's equilibrium potential and cell membrane potential
      1) identify direction of chemical + electrical forces (if they are the same, no further analysis is needed)

2) compare sizes of the equilibrium + membrane potential (if the same, the ion is at equilibrium)

3) if EP > MP, the chemical force is larger, and the electrochemical force acts in the same way (+ vice versa)

- when ions move passively, they move down their electrochemical gradient

Passive Transport

- **Flux**: number of molecules that cross a membrane in given length of time (mas | second)
- **Simple Diffusion**: movement of molecules due to their own thermal motion

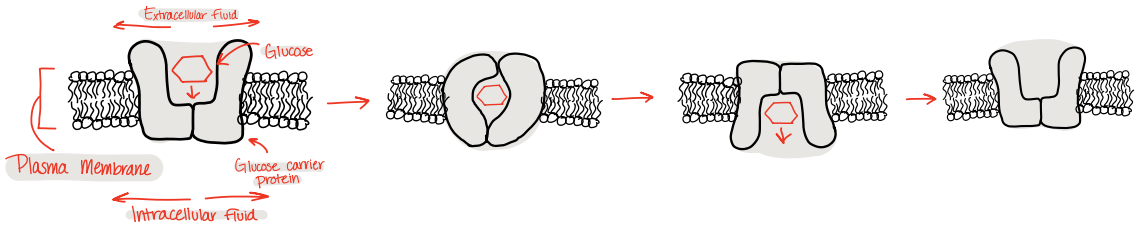
↳ Factors affecting rates of Diffusion

- magnitude of the driving force: net flux ∝ magnitude ∝ rate ∝ size of concentration gradient
- membrane surface area: rate of transport ∝ surface area
- membrane permeability: in passive transport : permeability ∝ rate of transport
  - factors influencing permeability of cell membranes
    - ↳ lipid solubility of diffusing substance: hydrophobic (nonpolar) substances are most lipid soluble, hydrophillic (polar / ionized) least soluble. lipid soluble ∝ membranes permeability to that substance
    - ↳ size + shape of diffusing molecules: larger + irregular molecules move slower (lower permeability)
    - ↳ Temperature ∝ movement of molecules
    - ↳ Membrane thickness: inversely proportional to permeability

- **Facilitated Diffusion**: crossing by way of transport proteins → mediated transport

- carriers in facilitated diffusion: commonly monosaccharides + amino acids

↳ molecule enters the binding site on the carrier. Carrier changes shape to move molecule across the membrane



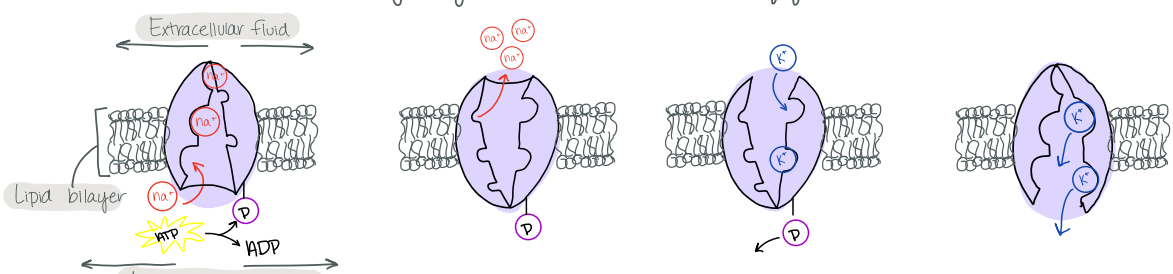
↳ Net flux depends on the frequency of binding / based on the affinity of the binding site and the concentration

barrier of solute across the membrane)

- Factors affecting rate of facilitated diffusion: transport rate of individual carriers, number of carriers in the membrane, magnitude of the concentration
  - when concentration on one side of the gradient increases (other is constant) the net flux increases rapidly then levels off b/c carrier proteins become 100% saturated
    - ↳ cells can regulate the rate by changing number of carriers that are present in the membrane
- Diffusion through channels → channels transport molecules through a passageway / pore
  - most water diffuses through aquaporins
  - ion channels: binding sites for ions in the pore (both sides are accessible at the same time)
    - ↳ ions move down an electrochemical gradient; when a channel has binding sites, it is generally slower and channels can be saturated

Active Transport

- Active transporters can harness energy to drive the transport of molecules in a preferred direction
- Primary active transport: uses ATP or other chemical energy source directly to transport substances (involve proteins called pumps)
  - ATPases: the membrane proteins in active transport also function as enzymes by harnessing ATP by catalyzing ATP hydrolysis
  - Sodium-potassium pump: transports Na^+ and K^+ ions opposite eachother across the membrane (both ions moving against their electrochemical gradients) → in each cycle of the pump, one ATP molecule is hydrolyzed to provide energy



Intracellular fluid

- Secondary active transport: powered by a concentration gradient or electrochemical gradient created before by a primary active transport. A transport protein couples the flow of one substance to that of another
  - ↳ cotransport: both in the same direction (ex: sodium-linked glucose transport)
  - ↳ countertransport: opposite directions (ex: sodium-proton exchange)

Osmosis

↳ Passive transport of water across membranes

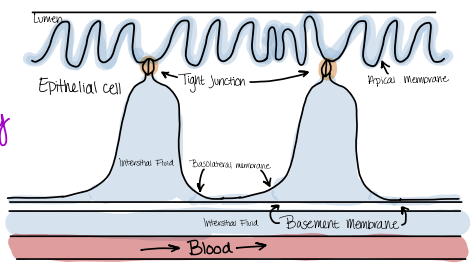
- Normal total solute concentration in intracellular fluid is 300 millimolar
- Hemolysis: red blood cells in pure water → swell + burst → release hemoglobin into the water
  - due to the lower concentration of water inside cells
- Osmolarity: total solute particle concentration of a solution → solution containing 1 mole of solute is at a concentration of 1 osmolar (depends on the total concentration of all solute particles)
  - iso-osmotic (same osmolarity), hyperosmotic > hypo-osmotic
- Osmotic Pressure: measure of its solute concentration in units of pressure
  - ↳ osmolarity $\propto$ osmotic pressure
  - when water moves by osmosis from low solute concentration → high, it is flowing up an osmotic pressure gradient ($\Delta\pi$) (→ does not violate gradient rules b/c water is moving down a chemical gradient → its own concentration gradient)
- Tonicity: a function of concentration outside a cell relative to inside, determining the behavior of a cell placed in the solution
  - ↳ isotonic (doesn't alter cell volume), hypertonic (solution that causes a cell to shrink), hypotonic (→ causes growth)

Transport Within Membranes

- **Endocytosis**: molecules in ECF enter the cell through endosomes (vesicles) from the PM
  - **phagocytosis**: membrane extends around matter to form a phagosome in the cytoplasm → phagosome fuses w/ lysosome membrane to form a phagolysosome → exposes mater to degradative enzymes that breakdown particle
  - **pinocytosis**: Plasma membrane develops an indentation to form an endosome containing ECF
  - **receptor-mediated endocytosis**: receptor proteins) on the PM bind w/ particles in ECF, triggering endocytosis → membrane indents (coated pit) where it's lined with clathrin (proteins) → forms a vesicle that pinches off PM and enters the cell → protein coat leaves + cathrin molecules are recycled → uncoated vesicle fuses w/ lysosome to form an endolysosome → breaks down particles
- **Exocytosis**: molecules in cells are packaged into secretory vesicles that fuse to the PM and are then released into ECF
  - Function: add components into the PM, recycle receptors removed from the PM by endocytosis, secrete specific substances out of the cell and into ECF

Epithelial Transport

- In epithelial tissue, cell membranes transport materials across cells
- apical membrane: faces lumen of a body cavity
- basolateral membrane: rests on basement membrane, faces internal environment, in contact w/ interstitial fluid, exchanges materials w/ blood
- **Epithelial solute transport**: Primary active transport by ATPases generates electrochemical gradients used by membranes producing bidirectional movement of solutes



- **Epithelial Water Transport**: epithelium creates osmotic gradient by actively transporting solute to make concentration higher outside of the cell → creates an osmotic gradient, passively transporting water from the lumen into interstitial fluid

- **Transcytosis:** large molecule is taken into the cell by endocytosis then fuses w/ PM to release its content by exocytosis