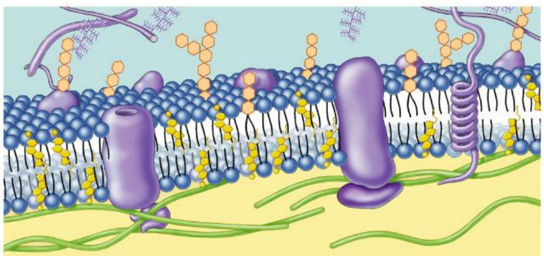
Cell Transport

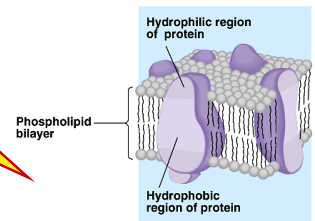


2007-2008

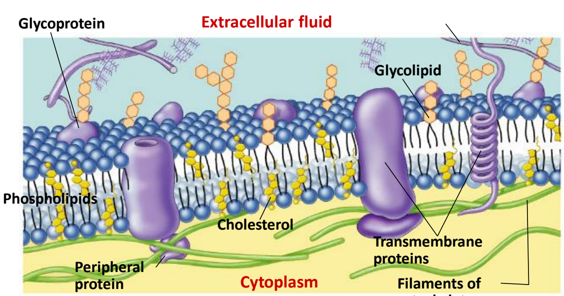
Cell membrane must be more than lipids…

- In 1972, S.J. Singer & G. Nicolson proposed that membrane proteins are inserted into the phospholipid bilayer

It's like a fluid…
It's like a mosaic…
It's the
Fluid Mosaic Model!



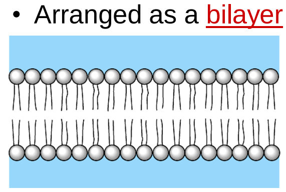
Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer

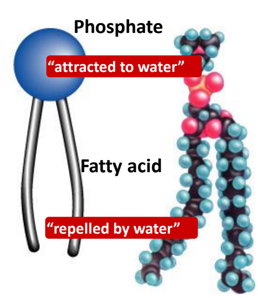


1972, S.J. Singer & G. Nicolson proposed Fluid Mosaic Model

Phospholipids

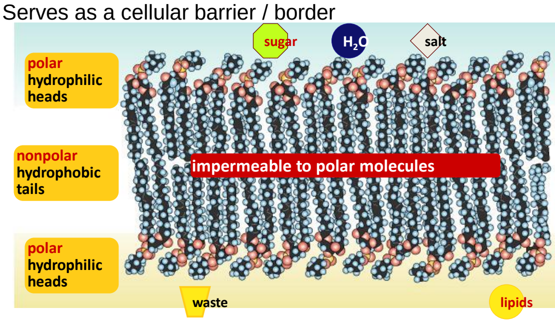
- Phosphate head
  - hydrophilic
- Fatty acid tails
  - hydrophobic
- Arranged as a bilayer





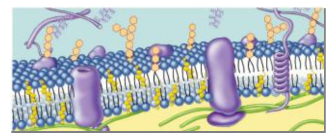
Arranged as a Phospholipid bilayer

- Serves as a cellular barrier / border



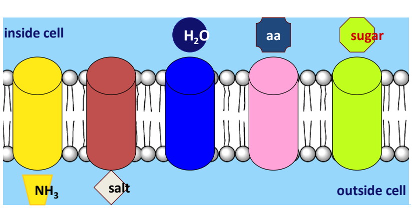
Cell membrane defines cell

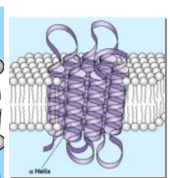
- Cell membrane separates living cell from aqueous environment
  - thin barrier = 8nm thick
- Controls traffic in & out of the cell
  - allows some substances to cross more easily than others



Permeability to polar molecules?

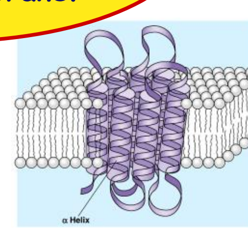
- Membrane becomes semi-permeable via protein channels
  - specific channels allow specific material across cell membrane





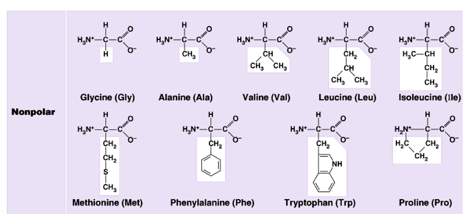
Why are proteins the perfect molecule to build structures in the cell membrane?

2007-2008



Classes of amino acids

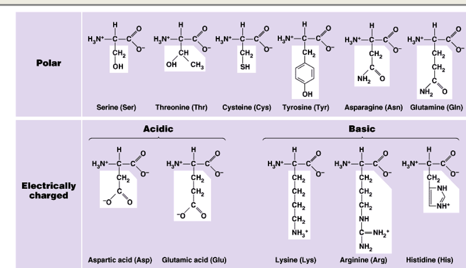
What do these amino acids have in common?



nonpolar & hydrophobic

Classes of amino acids

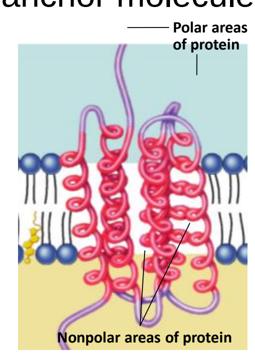
What do these amino acids have in common?



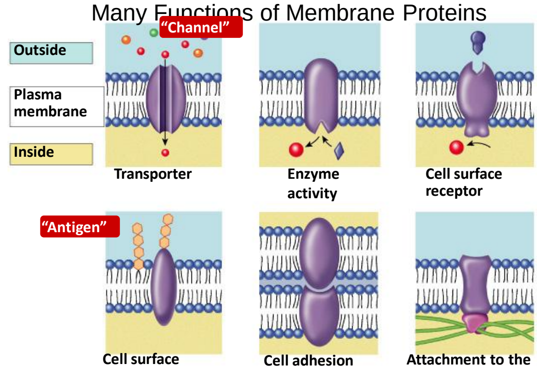
polar & hydrophilic

Proteins domains anchor molecule

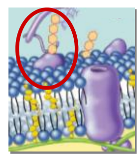
- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane in fluid
  - polar amino acids
    - hydrophilic
    - extend into extracellular fluid & into cytosol



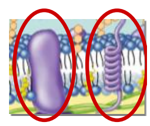
Many Functions of Membrane Proteins



Membrane Proteins

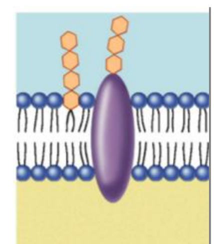


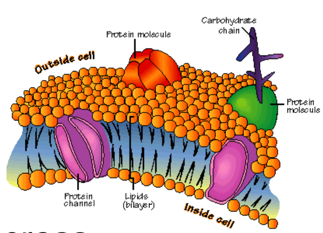
- Proteins determine membrane's functions
  - cell membrane & organelle membranes each have unique collections of proteins
- Classes of membrane proteins:
  - peripheral proteins
    - loosely bound to surface of membrane
    - ex: cell surface identity marker (antigens)
  - integral proteins
    - penetrate lipid bilayer, usually across whole membrane
    - transmembrane protein
    - ex: transport proteins
      - channels, permeases (pumps)



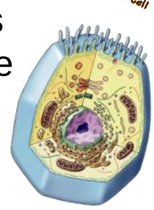
Membrane carbohydrates

- Play a key role in cell-cell recognition
  - ability of a cell to distinguish one cell from another
    - antigens
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system





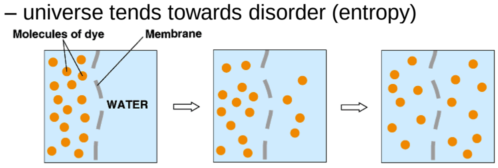
Movement across the Cell Membrane



2007-2008

Diffusion

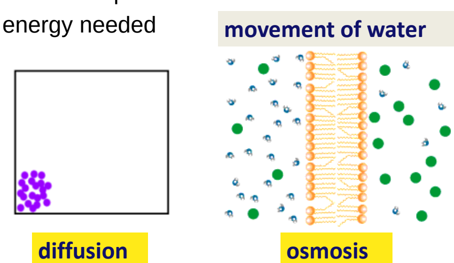
- 2nd Law of Thermodynamics governs biological systems
  - universe tends towards disorder (entropy)



- **Diffusion**
  - **movement from HIGH → LOW concentration**

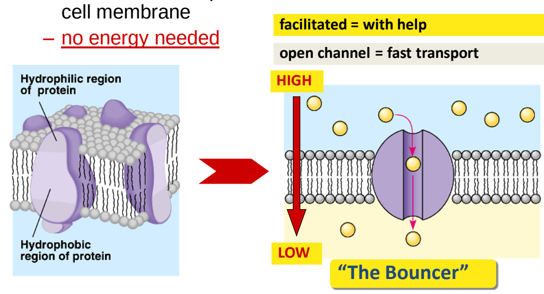
Simple Diffusion

- Move from HIGH to LOW concentration
  - "passive transport"
  - no energy needed



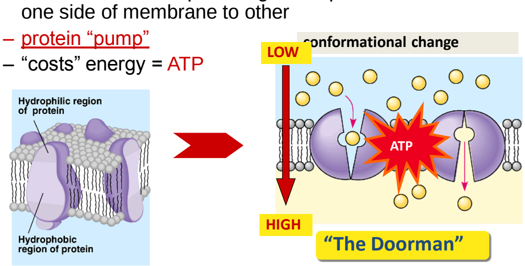
Facilitated Diffusion

- Diffusion through protein channels
  - channels move specific molecules across cell membrane
  - no energy needed



Active Transport

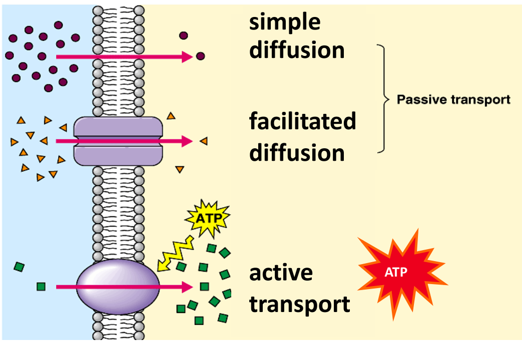
- Cells may need to move molecules *against* concentration gradient
  - conformational shape change transports solute from one side of membrane to other
  - protein "pump"
  - "costs" energy = ATP



Getting through cell membrane

- Passive Transport
  - Simple diffusion
    - diffusion of nonpolar, hydrophobic molecules
      - lipids
      - HIGH → LOW concentration gradient
  - Facilitated transport
    - diffusion of polar, hydrophilic molecules
    - through a protein channel
      - HIGH → LOW concentration gradient
- Active transport
  - *against* concentration gradient
    - LOW → HIGH
  - uses a protein pump
  - requires ATP

Transport summary



Proteins domains anchor molecule

- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane in fluid
  - polar amino acids
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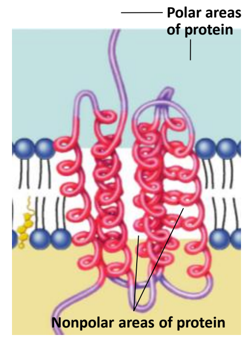
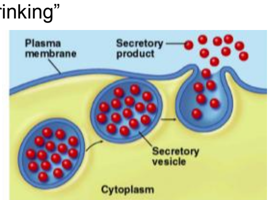
    - extend into extracellular fluid & into cytosol



How about large molecules?

- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - endocytosis
    - phagocytosis = “cellular eating”
    - pinocytosis = “cellular drinking”
  - Exocytosis
    - Substances leaving the cell
      - Secreted proteins

exocytosis

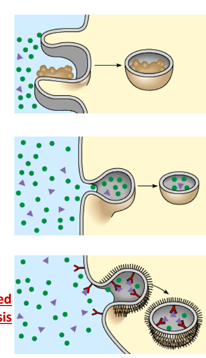


Endocytosis

phagocytosis

pinocytosis

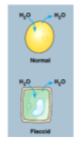
receptor-mediated
endocytosis



fuse with lysosome
for digestion

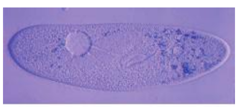
non-specific
process

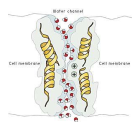
triggered by
molecular signal



The Special Case of Water

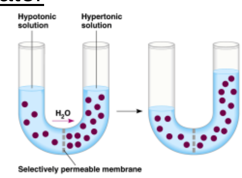
Movement of water across the cell membrane





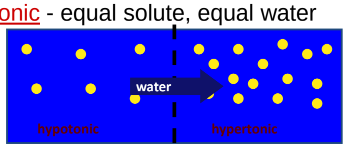
Osmosis is just diffusion of water

- Water is very important to life, so we talk about water separately
- Diffusion of water from *HIGH concentration* of <u>water</u> to *LOW concentration* of <u>water</u>
  - across a semi-permeable membrane



Concentration of water

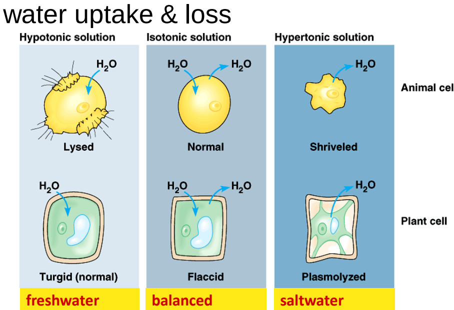
- Direction of osmosis is determined by comparing total <u>solute</u> concentrations
  - <u>Hypertonic</u> - more solute, less water
  - <u>Hypotonic</u> - less solute, more water
  - <u>Isotonic</u> - equal solute, equal water



<u>net</u> movement of water

Managing water balance

- Cell survival depends on balancing water uptake & loss

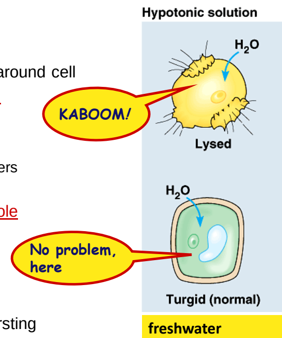


1

Managing water balance

- Hypotonic
  - a cell in fresh water
  - high concentration of water around cell
    - problem: cell gains water, swells & can burst
    - example: *Paramecium*
      - ex: water continually enters *Paramecium* cell
    - solution: contractile vacuole
      - pumps water out of cell
      - ATP
  - plant cells
    - turgid = full
    - cell wall protects from bursting

ATP



Pumping water out

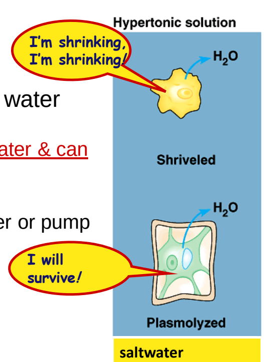
- Contractile vacuole in *Paramecium*

ATP

2

Managing water balance

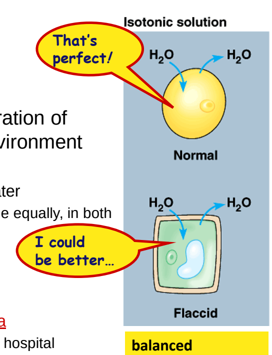
- Hypertonic
  - a cell in salt water
  - low concentration of water around cell
    - problem: cell loses water & can die
    - example: shellfish
    - solution: take up water or pump out salt
  - plant cells
    - plasmolysis = wilt
    - can recover



3

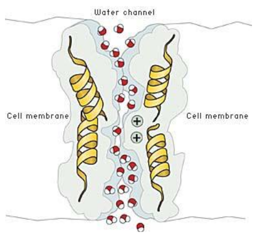
Managing water balance

- Isotonic
  - animal cell immersed in mild salt solution
  - no difference in concentration of water between cell & environment
    - problem: none
      - no net movement of water
        - » flows across membrane equally, in both directions
      - cell in equilibrium
      - volume of cell is stable
    - example: blood cells in blood plasma
      - slightly salty IV solution in hospital

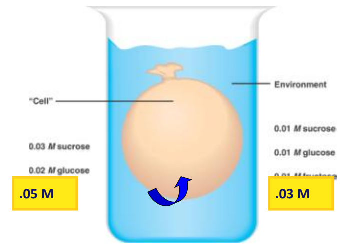


Aquaporins

- Water moves rapidly into & out of cells
  - protein channels allowing flow of water across cell membrane



Do you understand Osmosis…



Cell (compared to beaker) → hypertonic or hypotonic
Beaker (compared to cell) → hypertonic or hypotonic
Which way does the water flow? → in or out of cell

Do you understand Osmosis…

p. 141 #6 – Draw It!

Some Principles Described

- Water moves spontaneously only from places of *higher water potential* to places of *lower water potential*
- Between points of equal water potential, there is no net water movement
- The zero point of the water potential scale is defined as the state of Pure Water (no solutes) at normal pressure and elevation where, $\Psi_w = 0$

Definition of Ψ_w

$$\Psi_w = \Psi_P + \Psi_S$$

Where,

Ψ_P = pressure potential
- represents the pressure in addition to atmospheric pressure

Ψ_S = osmotic or solute potential
- represents the effect of dissolved solutes on water potential; addition of solutes will always lower the water potential

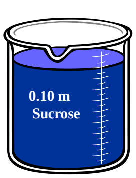
Some Principles Described

- Water potential values are always negative
  - for example, all plant cells contain solutes which will always lower the water potential
- Ψ_w is increased by an increase in pressure potential (Ψ_P)
- Ψ_w is decreased by addition of solutes which lowers the solute potential (Ψ_S)

Example

To illustrate the effect that solutes have on water potential, let's calculate the water potential of a 0.10 molar (m) solution of sucrose.

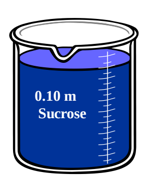
- The pressure potential (Ψ_P) of this solution is equal to zero because the beaker is open to atmospheric pressure and *no excess pressure* is being applied.
- The solute potential (Ψ_S) of the solution, is -0.244 MegaPascals.



$$\Psi_P = 0 \text{ MPa}$$

$$\Psi_S = -0.244 \text{ MPa}$$

When we plug these values into our equation and solve, we find that the water potential of the 0.10 m solution of sucrose is - 0.244 MPa.



$$\Psi_w = \Psi_P + \Psi_S$$

$$\Psi_w = 0 \text{ MPa} + (-0.244 \text{ MPa})$$

$$\Psi_w = -0.244 \text{ MPa}$$

So, by adding the solute sucrose to pure water we have lowered the water potential of that pure water.

$$\Psi_{w\ (Pure\ H_2 0)} = 0\ \text{MPa}$$

$$\Psi_{w\ (0.10\ m\ Sucrose)} = -\ 0.244\ \text{MPa}$$