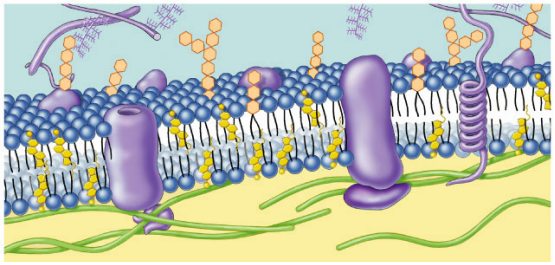
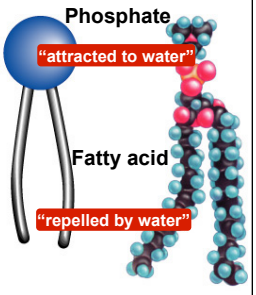
AP Biology

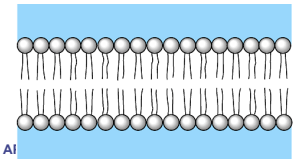
The Cell Membrane



Phospholipids

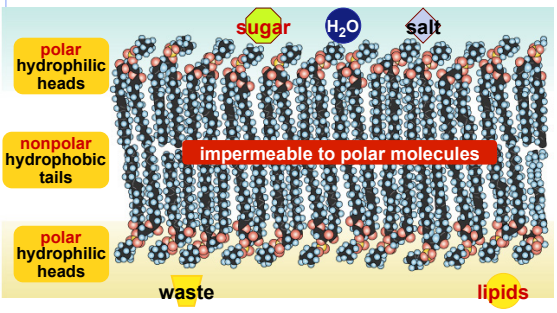
- Phosphate head
  - hydrophilic
- Fatty acid tails
  - hydrophobic
- Arranged as a bilayer





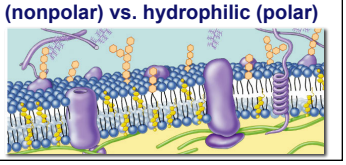
Arranged as a Phospholipid bilayer

- Serves as a cellular barrier / border



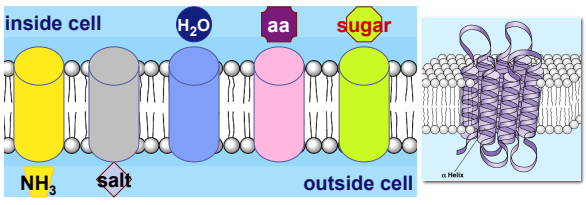
Cell membrane defines cell

- 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
    - hydrophobic (nonpolar) vs. hydrophilic (polar)



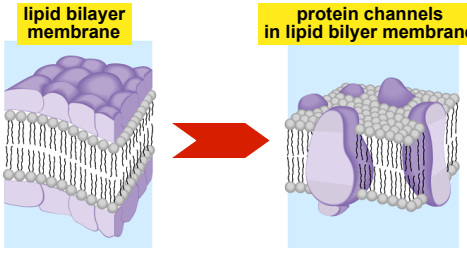
Permeability to polar molecules?

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



Cell membrane is more than lipids…

- Transmembrane proteins embedded in phospholipid bilayer
  - create semi-permeabe channels



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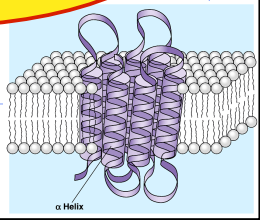
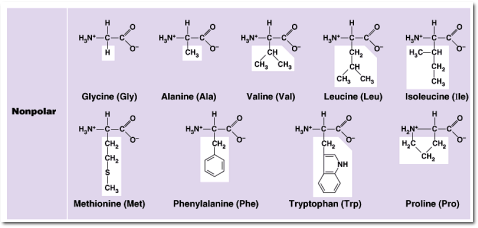
Why are proteins the perfect molecule to build structures in the cell membrane?



Classes of amino acids

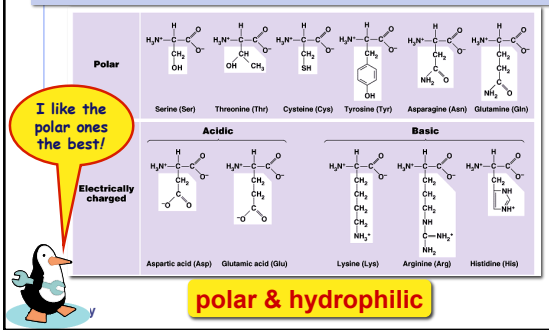
What do these amino acids have in common?



nonpolar & hydrophobic

Classes of amino acids

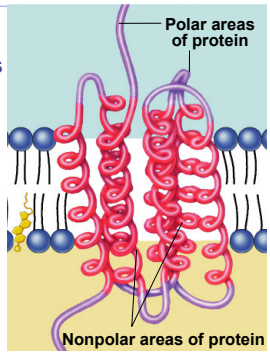
What do these amino acids have in common?



polar & hydrophilic

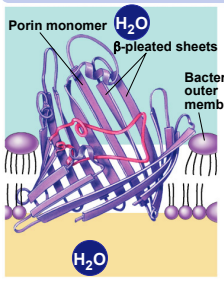
Proteins domains anchor molecule

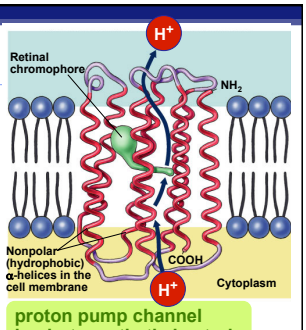
- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane in fluid
  - polar amino acids
    - hydrophilic
    - extend into extracellular fluid & into cytosol



Examples

aquaporin = water channel in bacteria

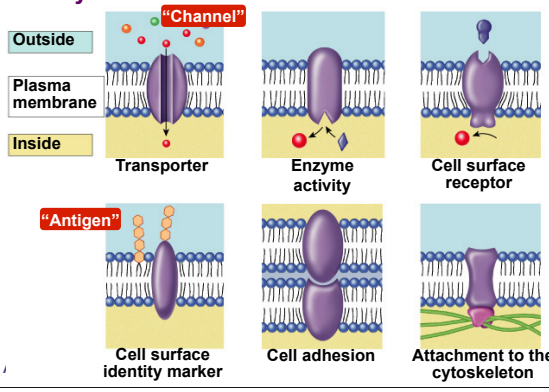




proton pump channel in photosynthetic bacteria

function through conformational change = protein changes shape

Many Functions of Membrane Proteins



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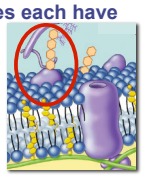
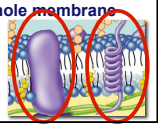
Membrane Proteins

- Proteins determine membrane's specific 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)





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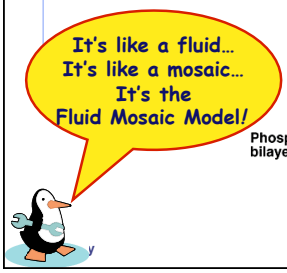
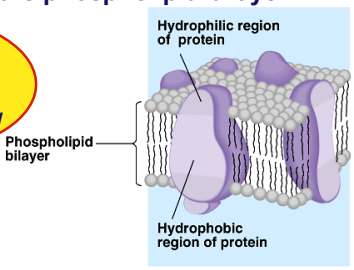
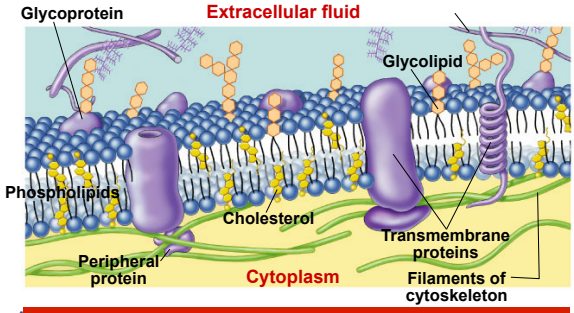
Cell membrane must be more than lipids…

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





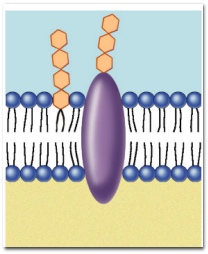
Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer



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

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



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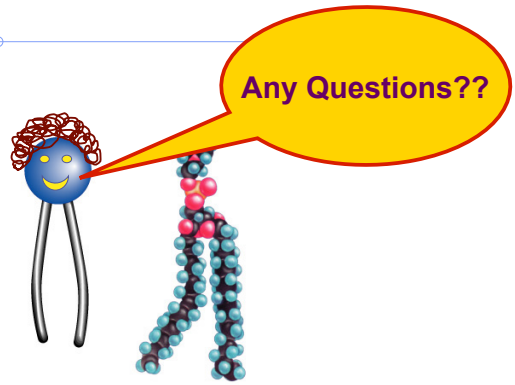

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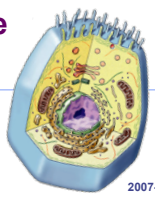
Movement across the Cell Membrane



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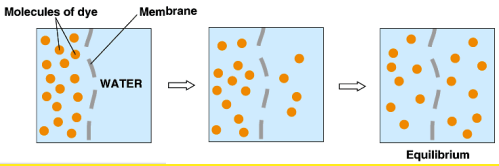
Diffusion

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

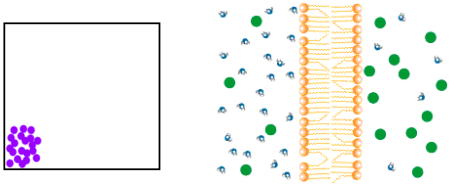


- Diffusion
  - movement from HIGH → LOW concentration

Simple Diffusion

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

movement of water

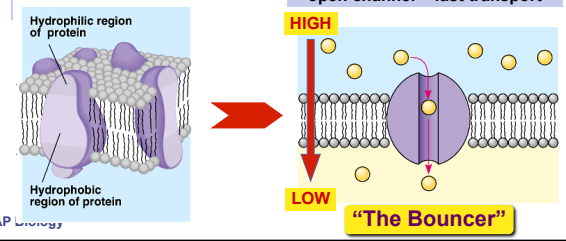


diffusion osmosis

Facilitated Diffusion

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

facilitated = with help
open channel = fast transport

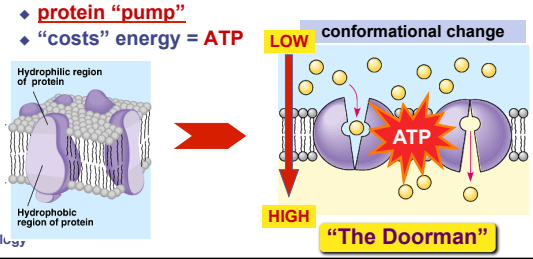


"The Bouncer"

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

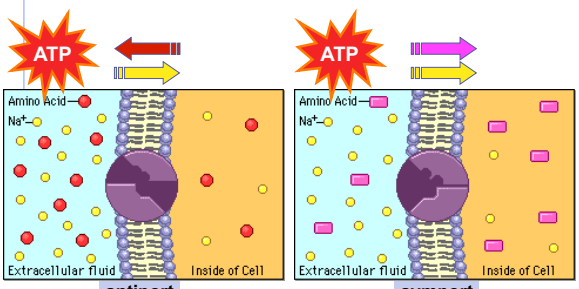
conformational change



"The Doorman"

Active transport

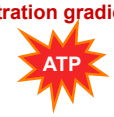
- Many models & mechanisms



antiport symport

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
  - diffusion *against* concentration gradient
    - LOW → HIGH
  - uses a protein pump
  - requires ATP



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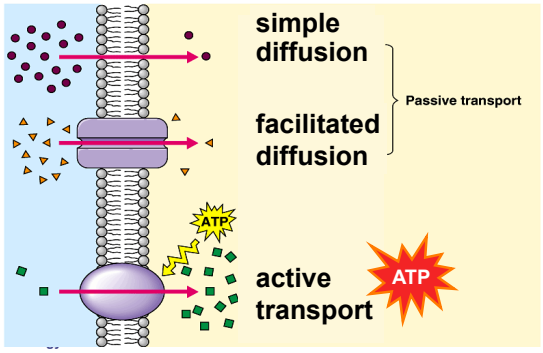
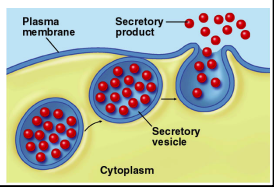
Transport summary



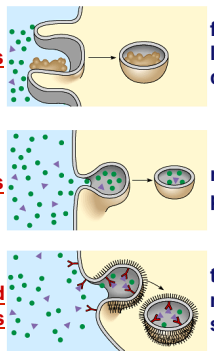
How about large molecules?

- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - endocytosis
    - phagocytosis = "cellular eating"
    - pinocytosis = "cellular drinking"
  - exocytosis



exocytosis

Endocytosis



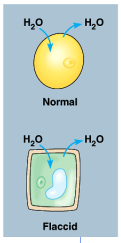
phagocytosis — fuse with lysosome for digestion

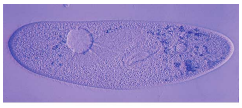
pinocytosis — non-specific process

receptor-mediated endocytosis — triggered by molecular signal

The Special Case of Water

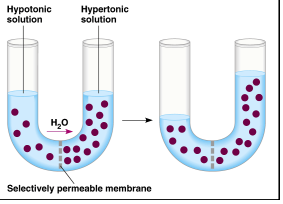
Movement of water across the cell membrane





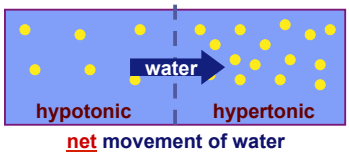
Osmosis is just diffusion of water

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



Concentration of water

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



net movement of water

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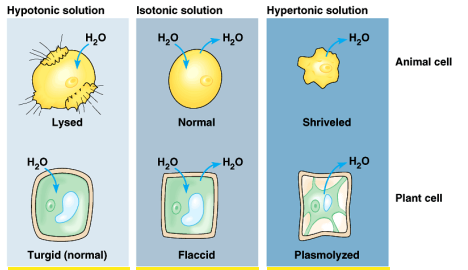
Managing water balance

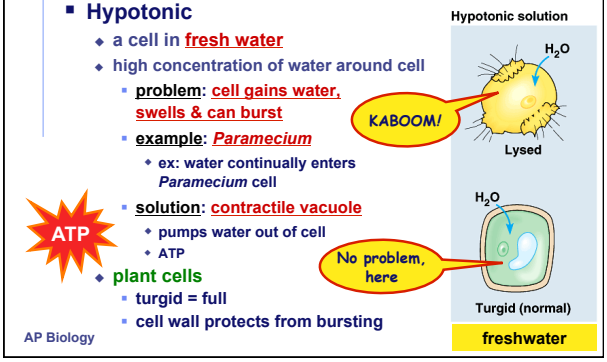
- Cell survival depends on balancing water uptake & loss



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



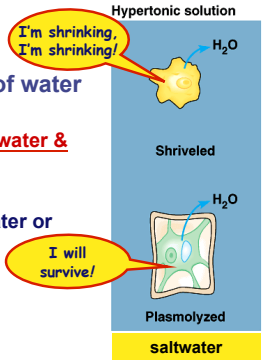
Pumping water out

- Contractile vacuole in *Paramecium*

2

Managing water balance

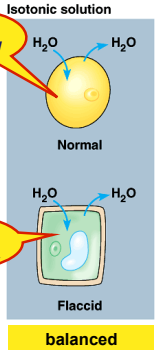
- Hypertonic
  - a cell in salt water
  - low concentration of water around cell
    - problem: cell loses water & can die
    - example: shellfish
    - solution: take up water or pump out salt
  - plant cells
    - plasmolysis = wilt
    - can recover



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

1991 | 2003

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

Peter Agre — John Hopkins

Roderick MacKinnon — Rockefeller

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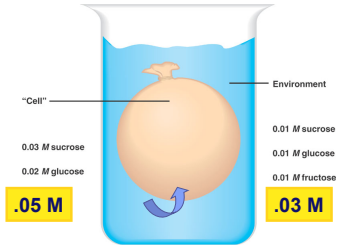
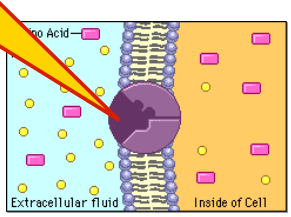
Do you understand Osmosis…



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

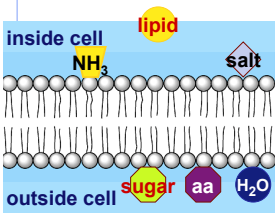
Any Questions??



Ghosts of Lectures Past (storage)

Diffusion through phospholipid bilayer

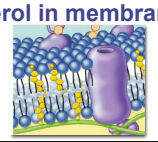
- What molecules can get through directly?
  - fats & other lipids

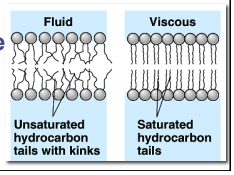


- What molecules can NOT get through directly?
  - polar molecules
    - H_2O
  - ions (charged)
    - salts, ammonia
  - large molecules
    - starches, proteins

Membrane fat composition varies

- Fat composition affects flexibility
  - membrane must be fluid & flexible
    - about as fluid as thick salad oil
  - % unsaturated fatty acids in phospholipids
    - keep membrane less viscous
    - cold-adapted organisms, like winter wheat
      - increase % in autumn
  - cholesterol in membrane



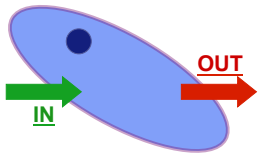


Diffusion across cell membrane

- Cell membrane is the boundary between inside & outside…
  - separates cell from its environment

Can it be an impenetrable boundary? NO!

IN
food
carbohydrates
sugars, proteins
amino acids
lipids
salts, O_2, H_2O



OUT
waste
ammonia
salts
CO_2
H_2O
products

cell needs materials in & products or waste out