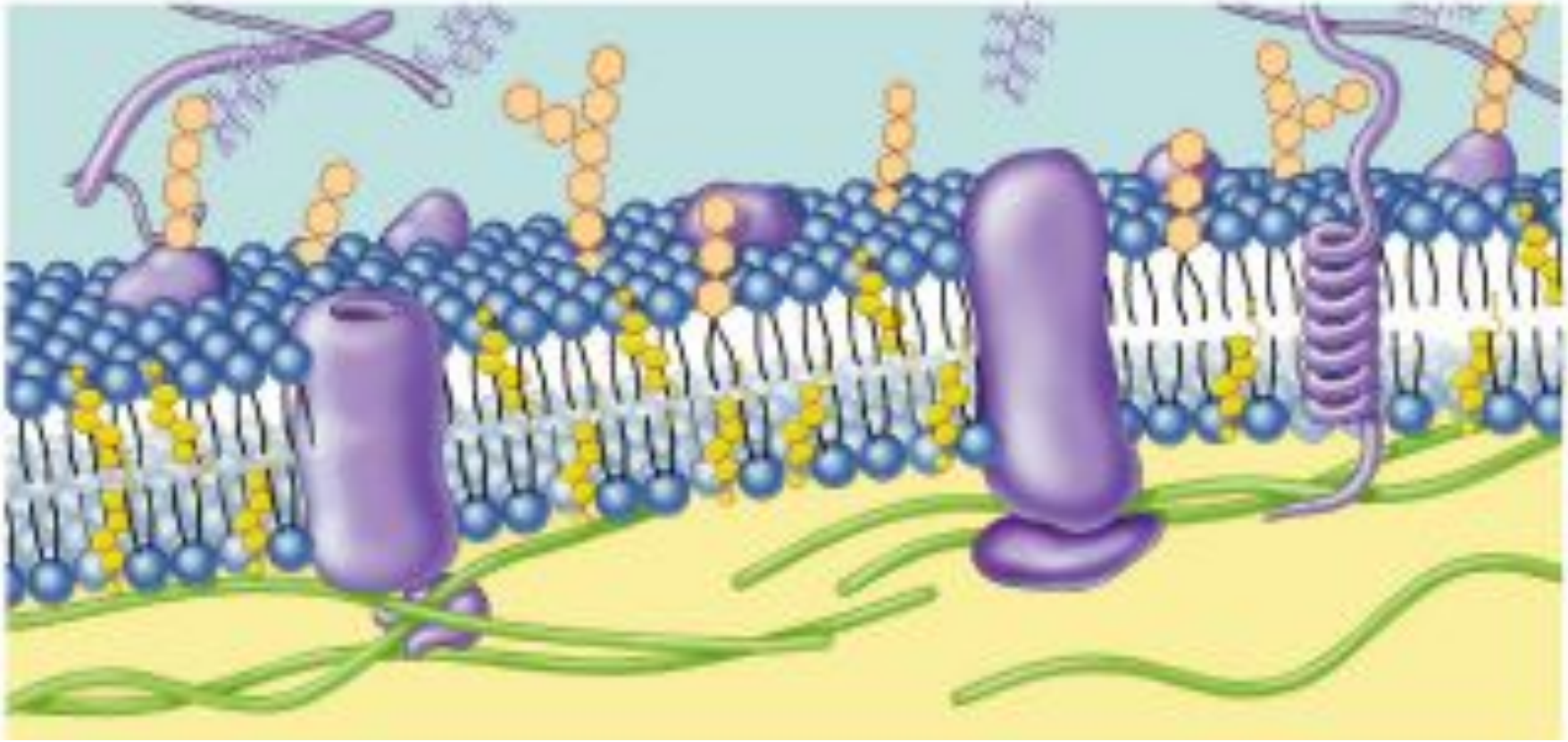
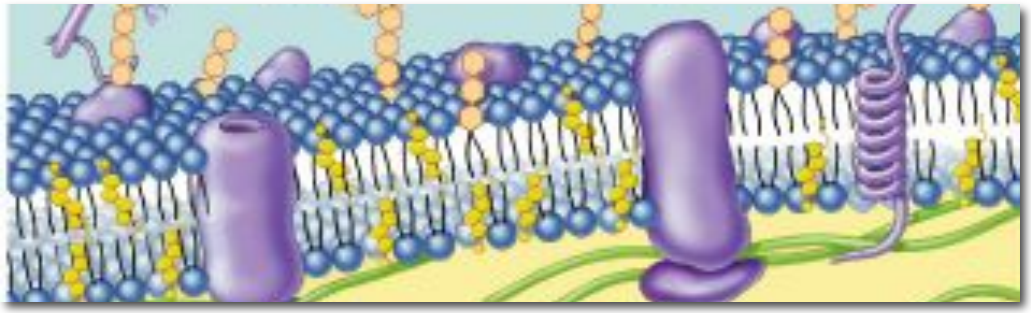
The Cell Membrane



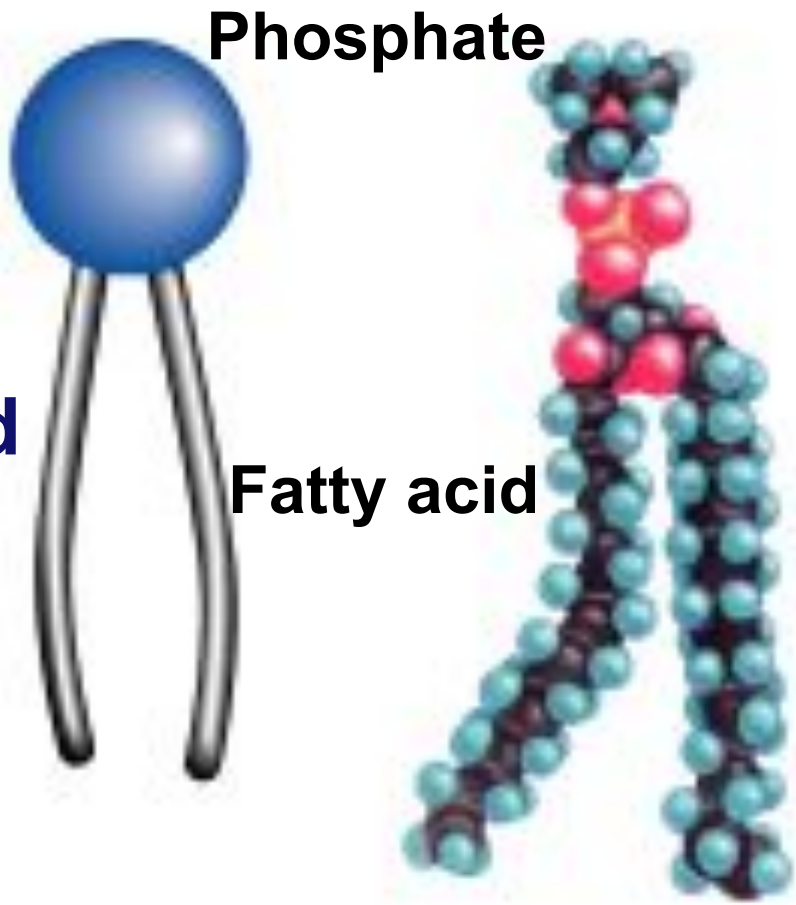
Overview

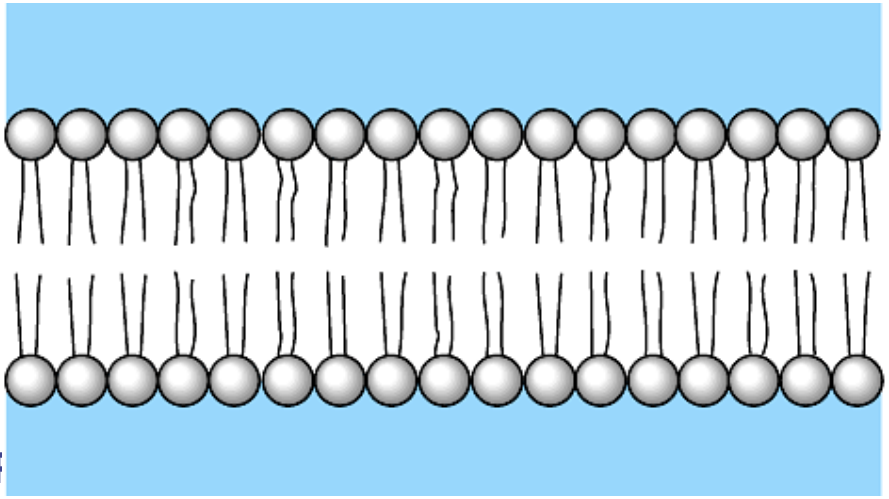
- Cell membrane separates living cell from nonliving surroundings
  - thin barrier = 8nm thick
- Controls traffic in & out of the cell
  - selectively permeable
  - allows some substances to cross more easily than others
    - hydrophobic vs hydrophilic
- Made of phospholipids, proteins & other macromolecules

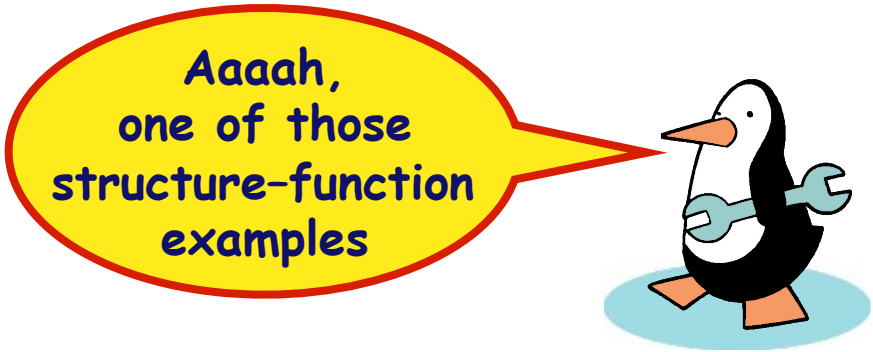


Phospholipids

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





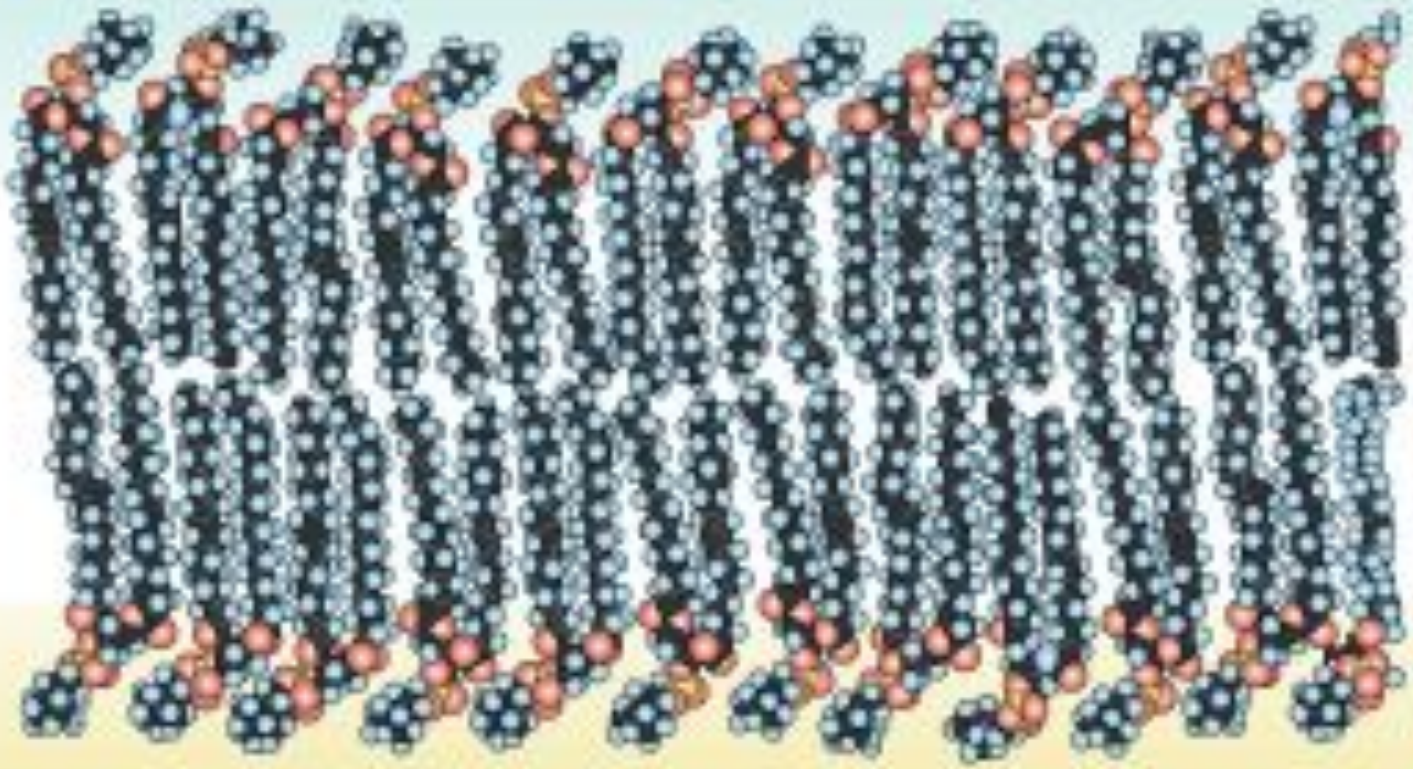


Phospholipid bilayer

polar
hydrophilic
heads

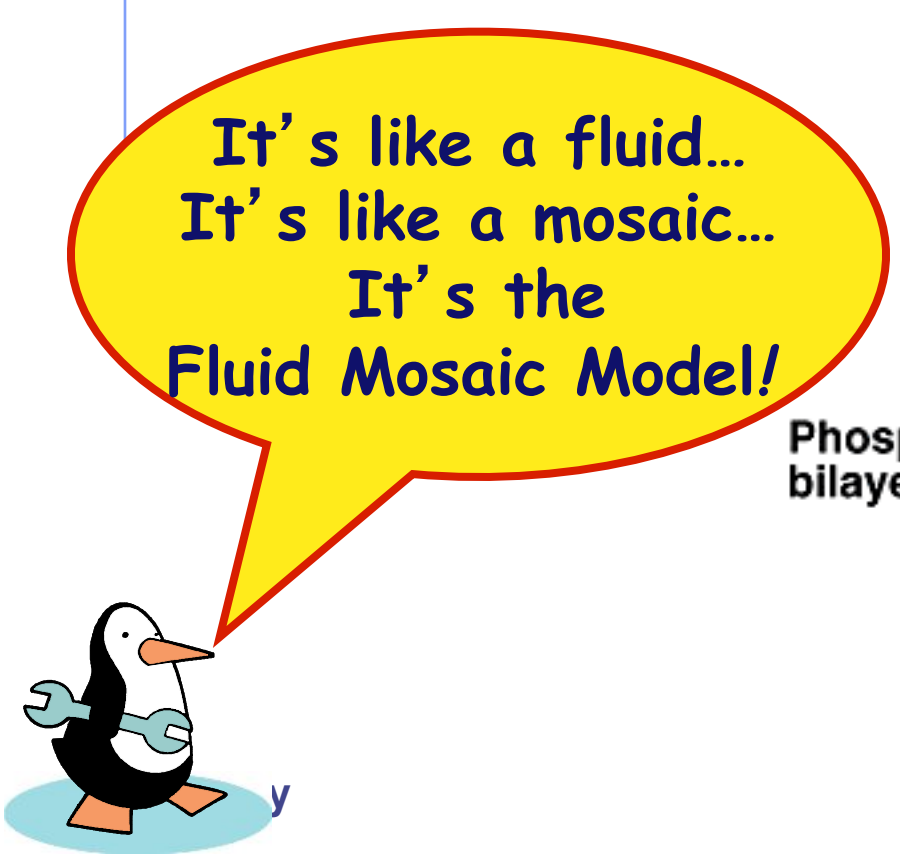
nonpolar
hydrophobic
tails

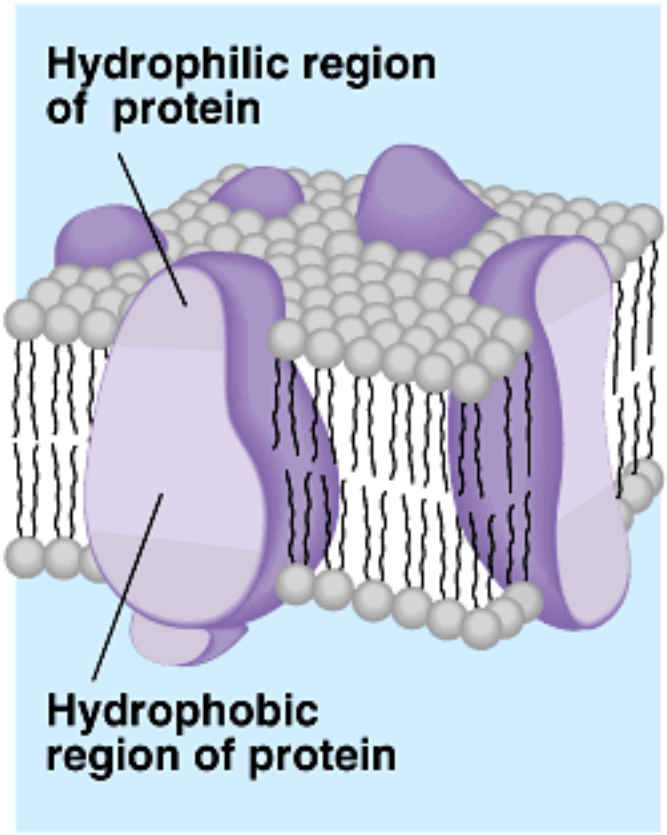
polar
hydrophilic
heads



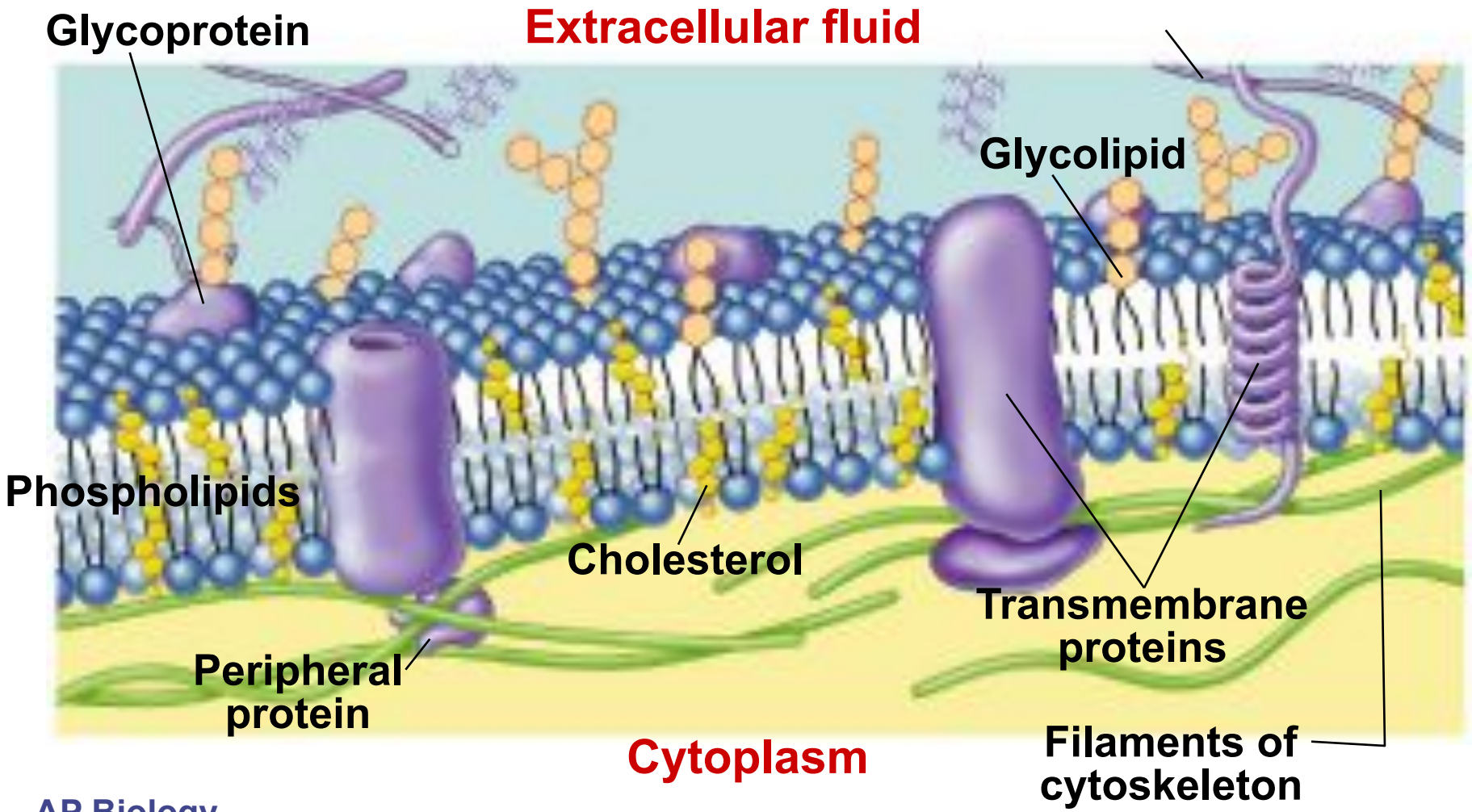
More than lipids…

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



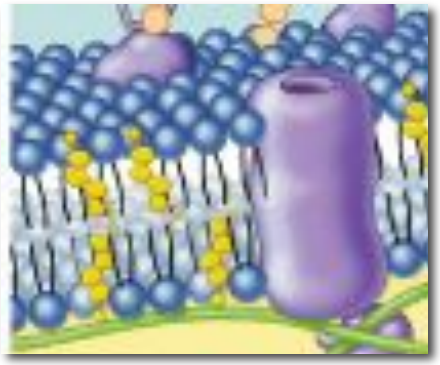


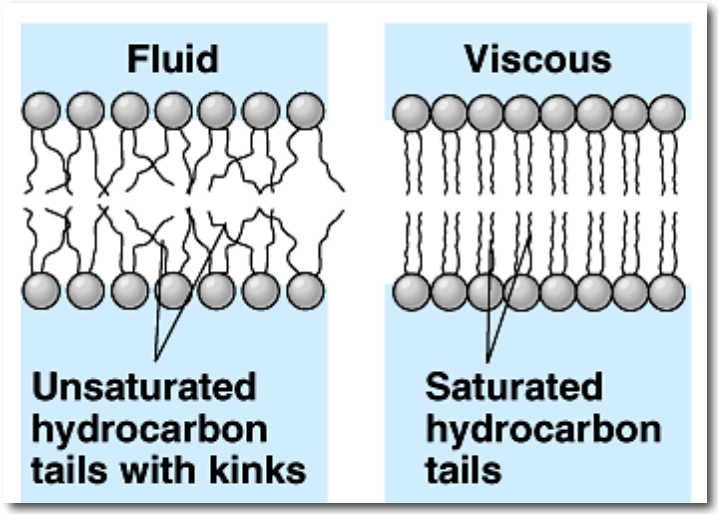
Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer



Membrane fat composition varies

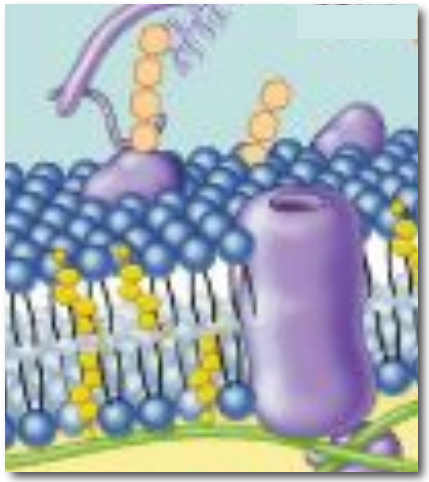
- Fat composition affects flexibility
  - membrane must be fluid & flexible
    - about as fluid as thick salad oil
  - % unsaturated fatty acids in phospholipids
    - keep membrane less viscous
    - cold-adapted organisms, like winter wheat
      - increase % in autumn
  - cholesterol in membrane



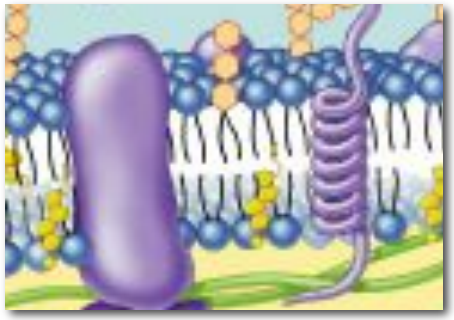


Membrane Proteins

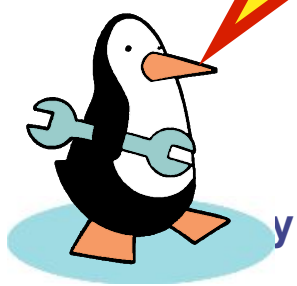
- Proteins determine membrane's specific functions
  - cell membrane & organelle membranes each have unique collections of proteins

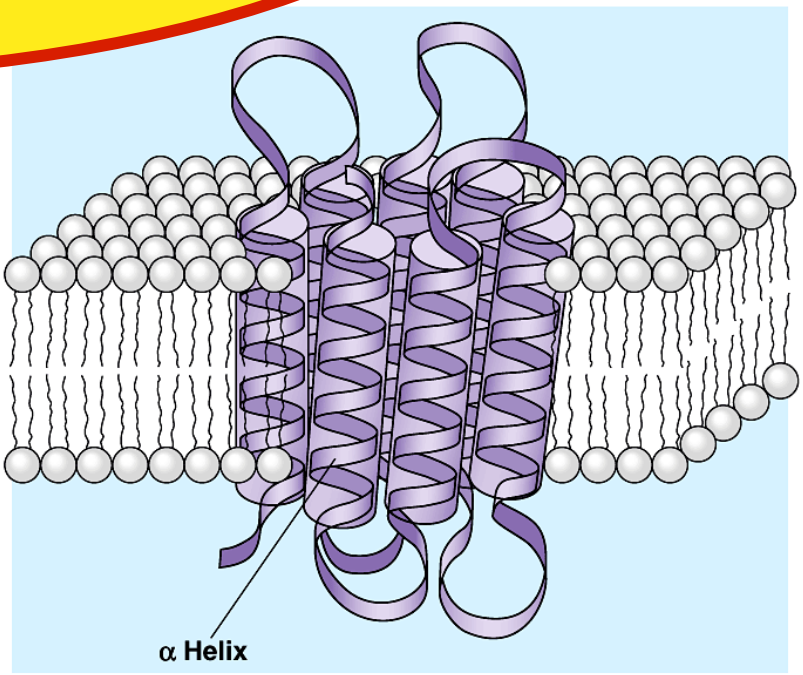


- Membrane proteins:
  - peripheral proteins
    - loosely bound to surface of membrane
    - cell surface identity marker (antigens)
  - integral proteins
    - penetrate lipid bilayer, usually across whole membrane
    - transmembrane protein
    - transport proteins
      - channels, permeases (pumps)



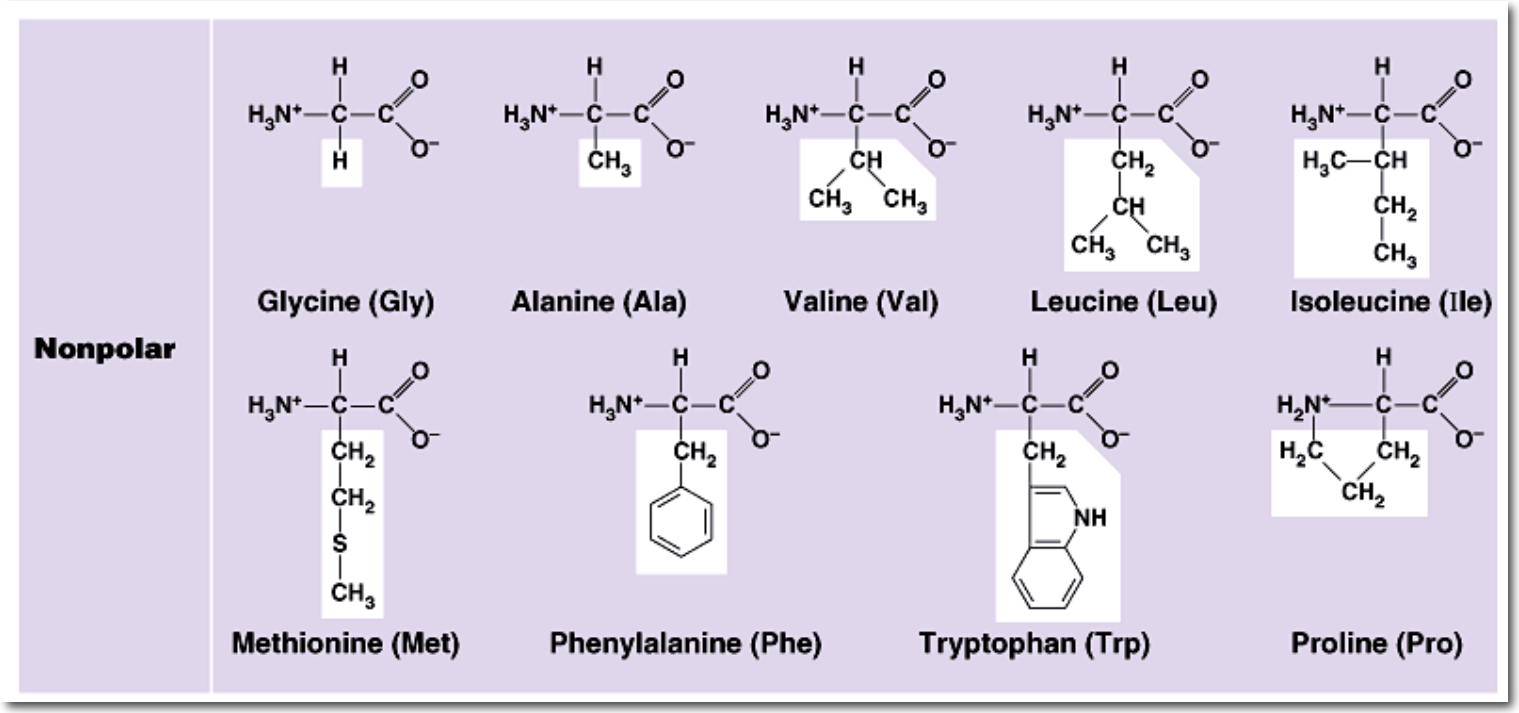
Why are proteins the perfect molecule to build structures in the cell membrane?





Classes of amino acids

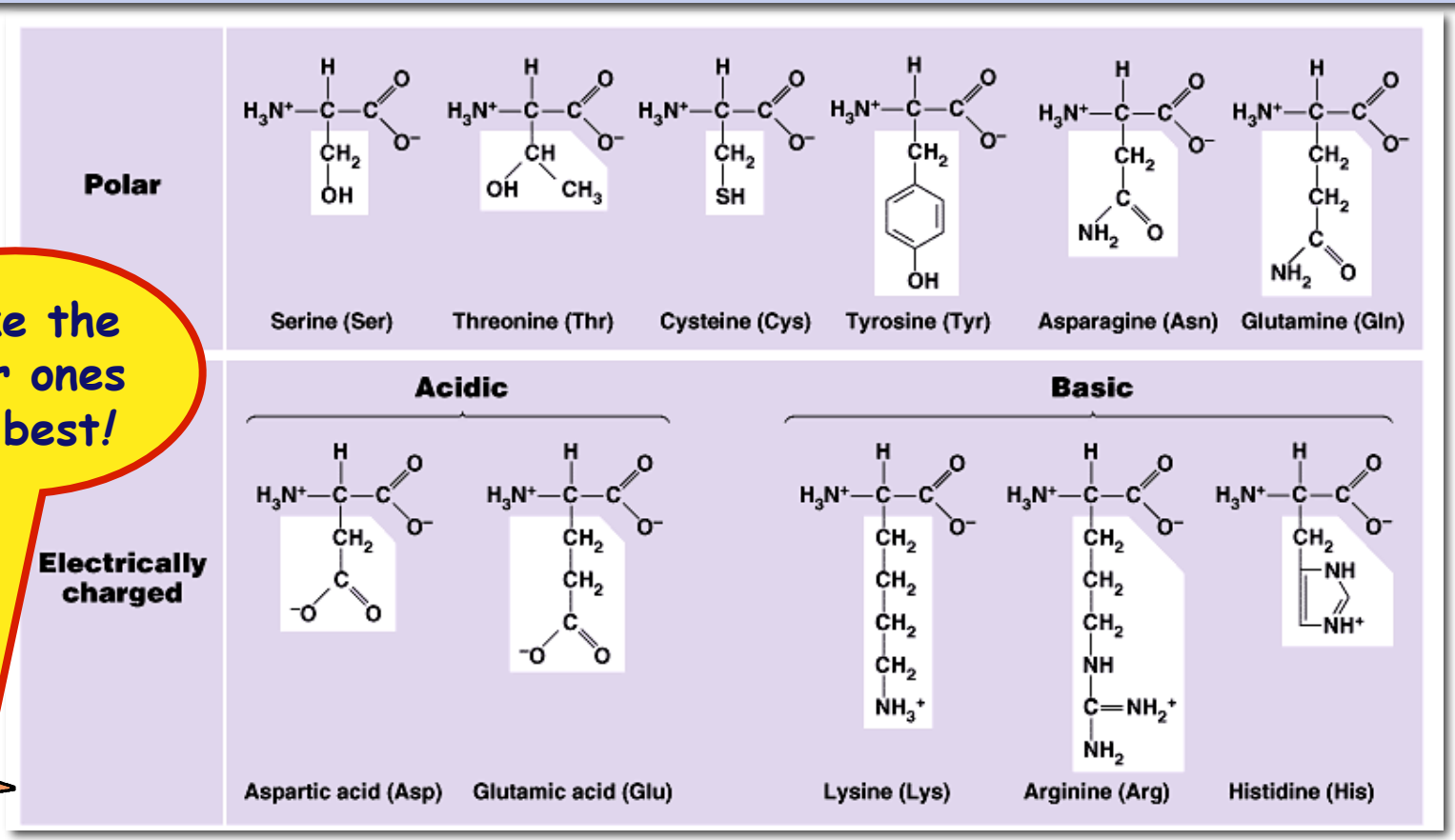
What do these amino acids have in common?



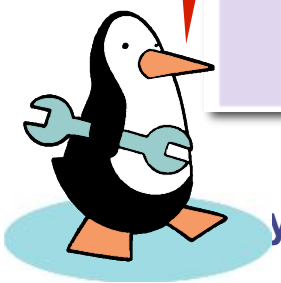
nonpolar & hydrophobic

Classes of amino acids

What do these amino acids have in common?



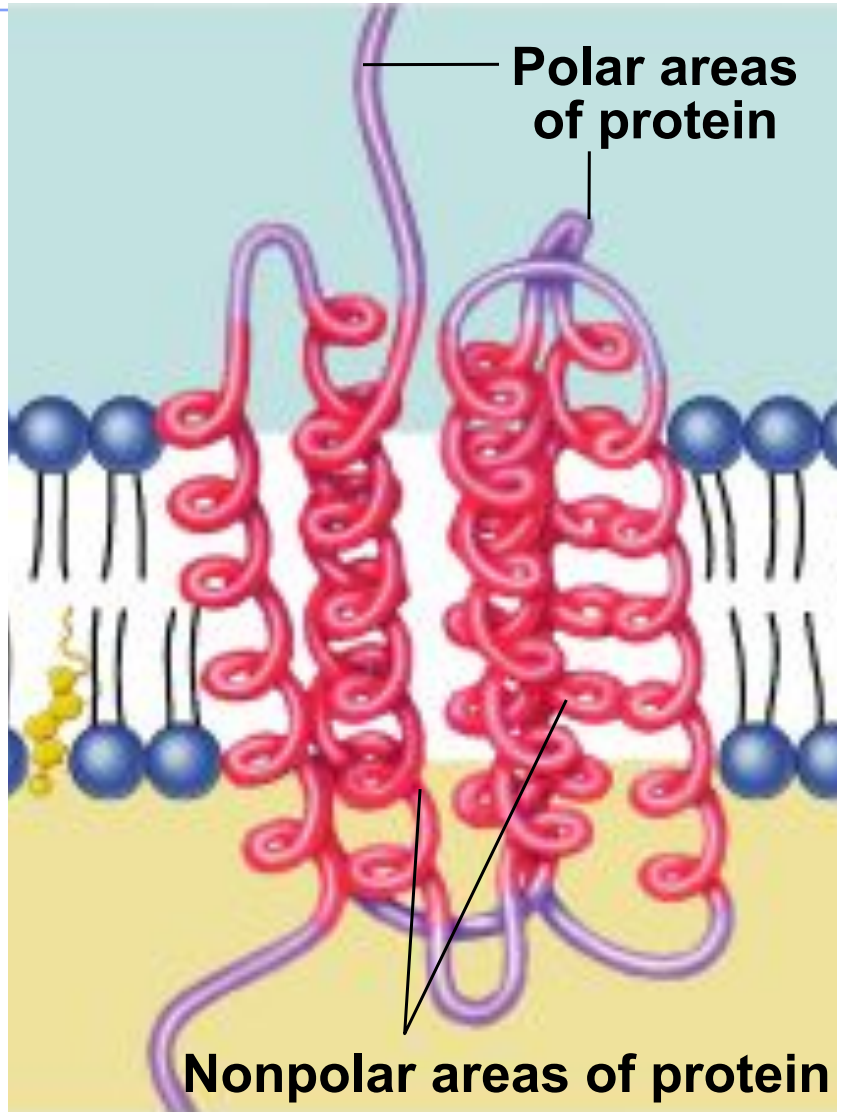
I like the polar ones the best!



polar & hydrophilic

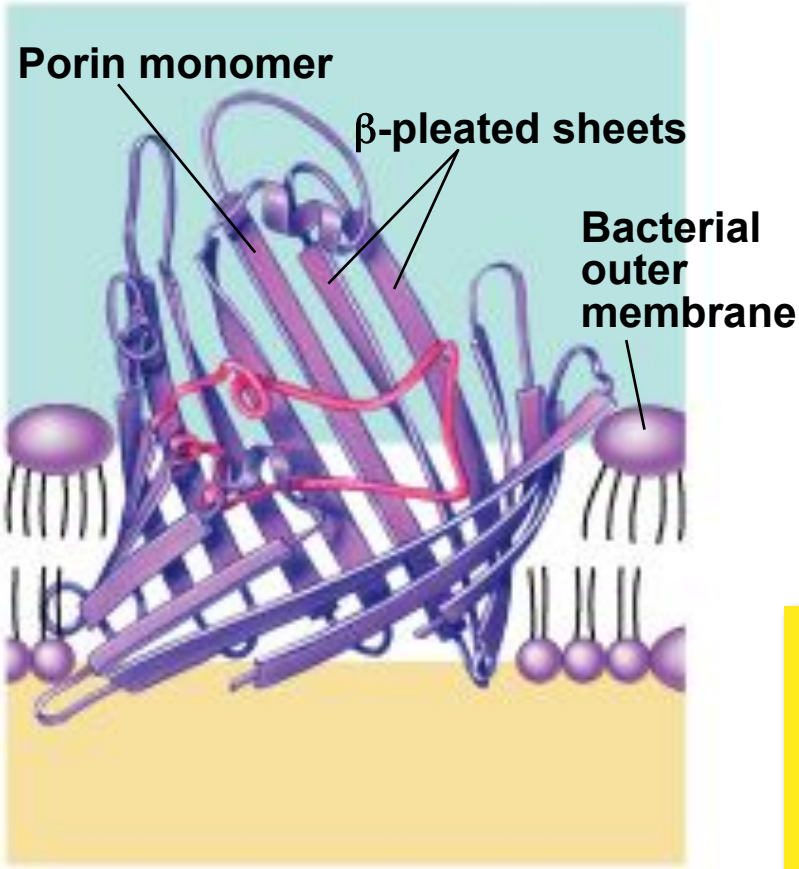
Proteins domains anchor molecule

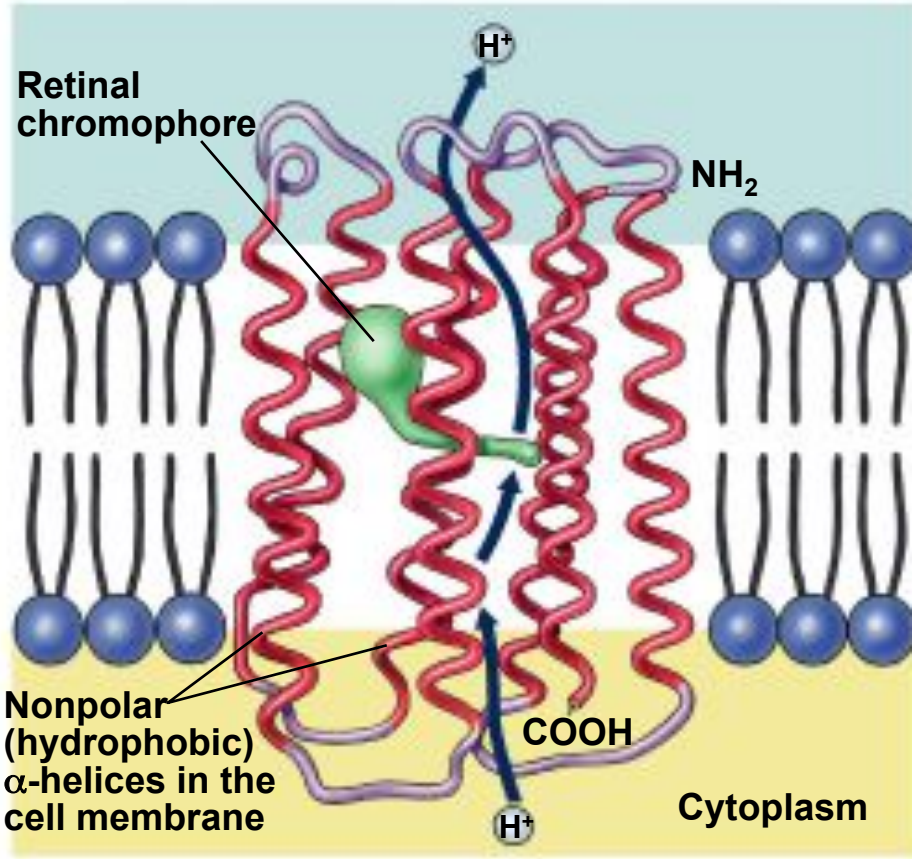
- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane
  - polar amino acids
    - hydrophilic
    - extend into extracellular fluid & into cytosol



Examples

water channel in bacteria

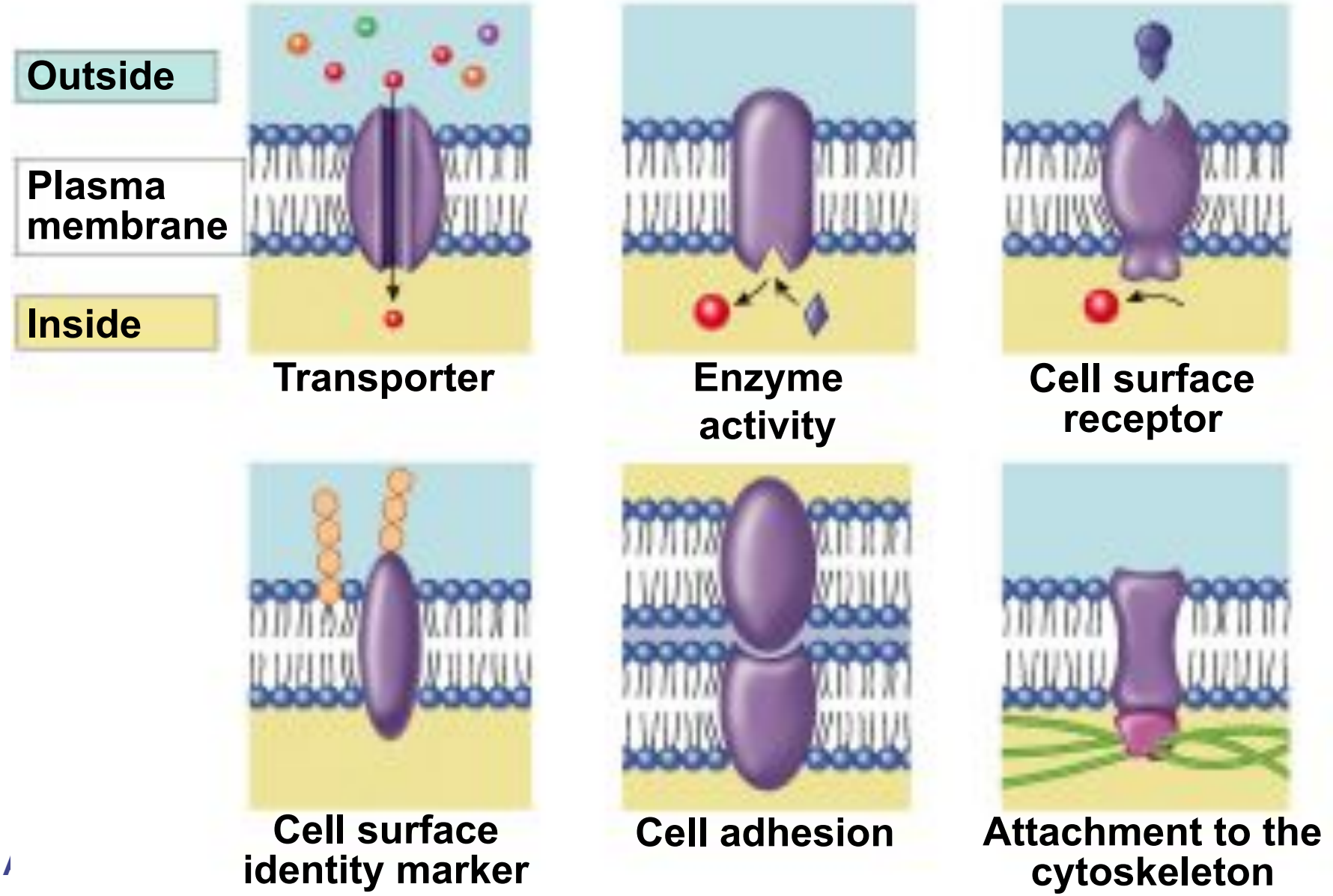




proton pump channel in photosynthetic bacteria

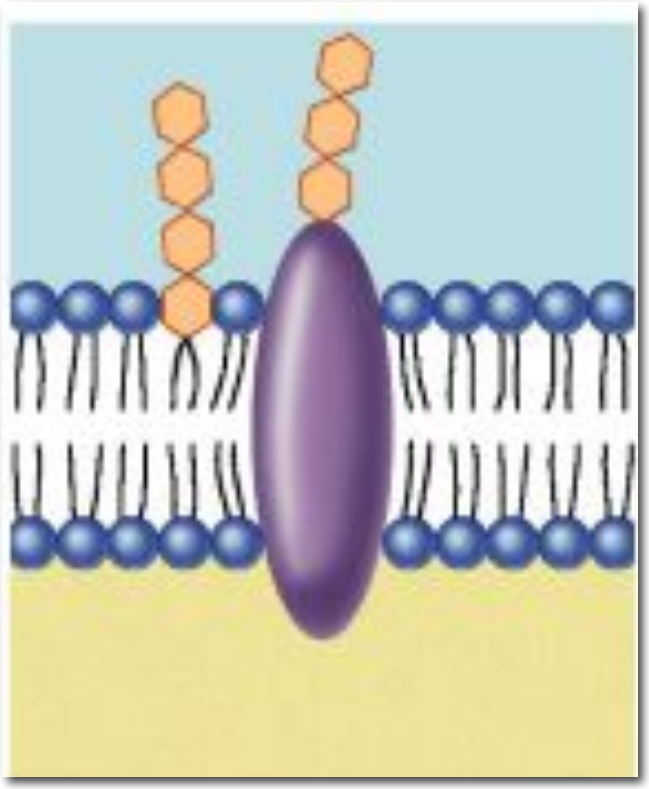
function through conformational change = shape change

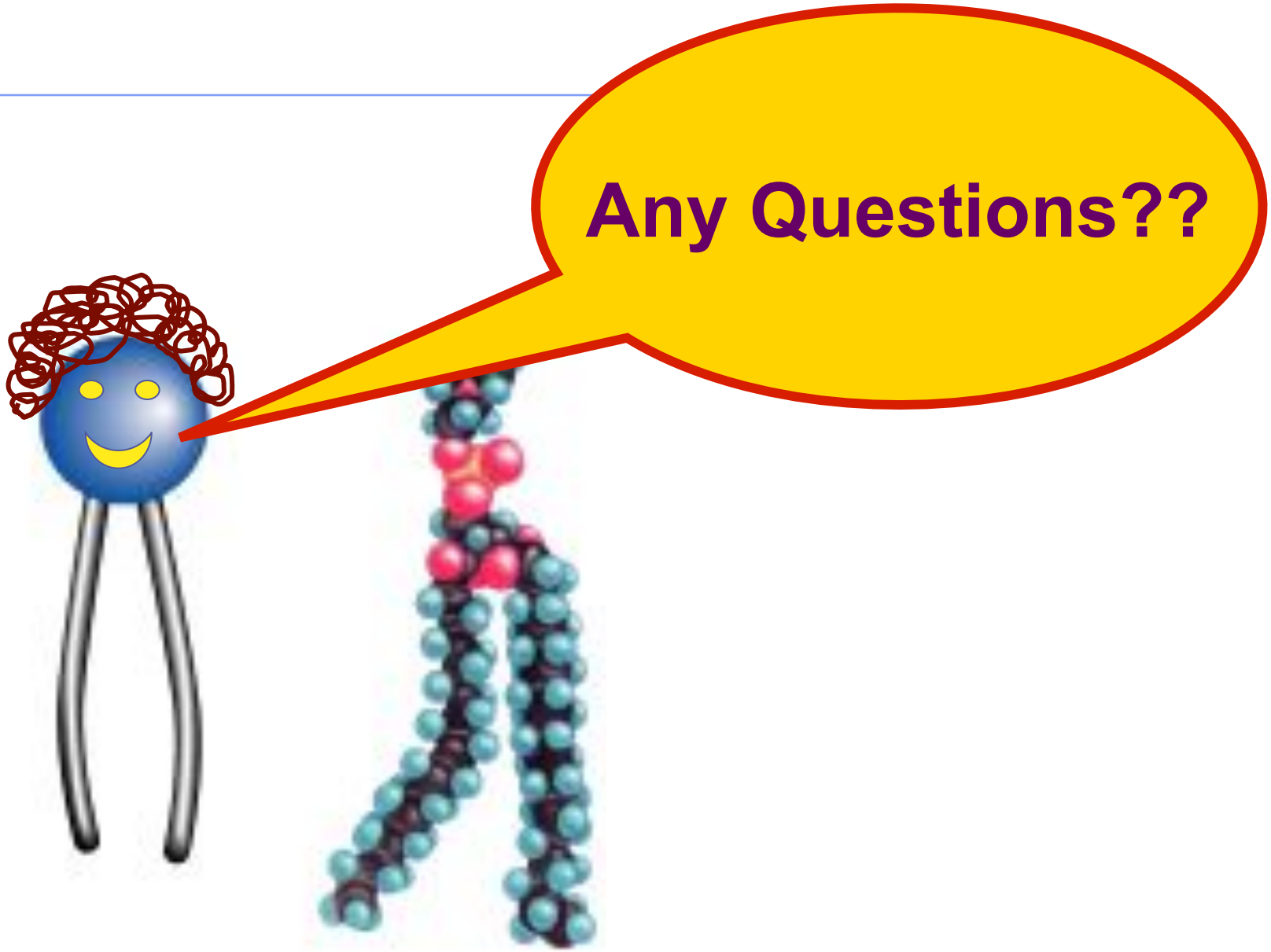
Many Functions of Membrane Proteins

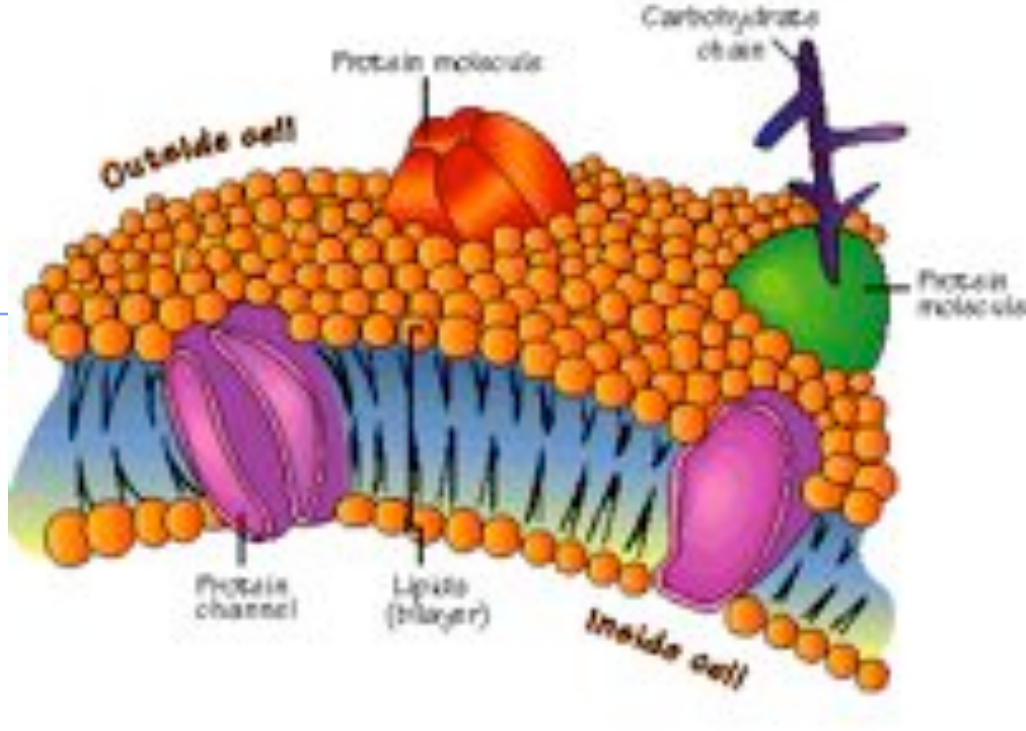


Membrane carbohydrates

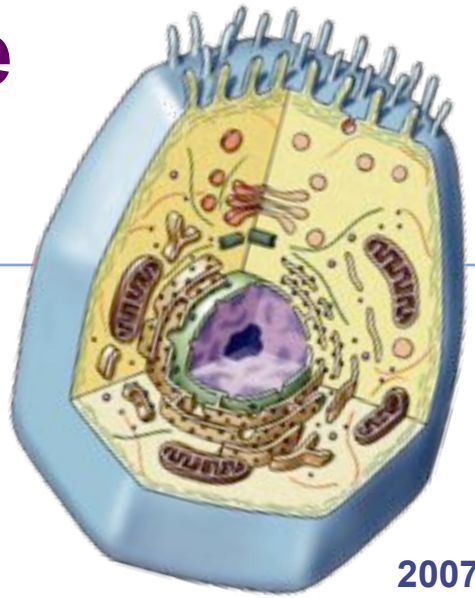
- Play a key role in cell-cell recognition
  - ability of a cell to distinguish one cell from another
    - antigens
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system




Any Questions??

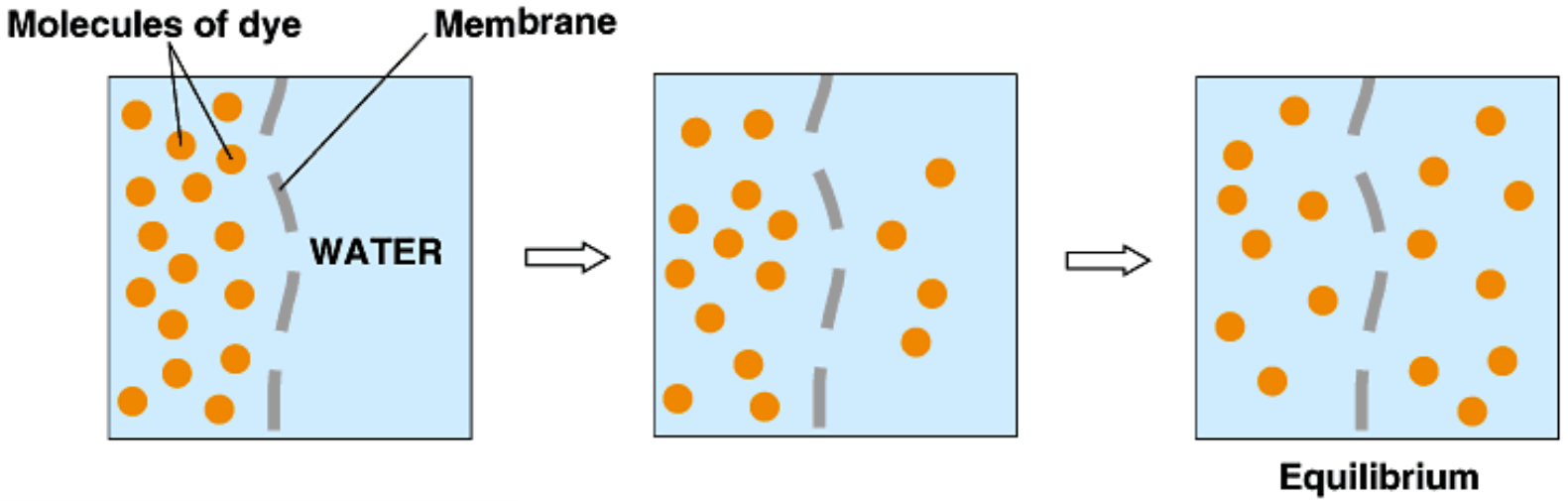


Movement across the Cell Membrane



Diffusion

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

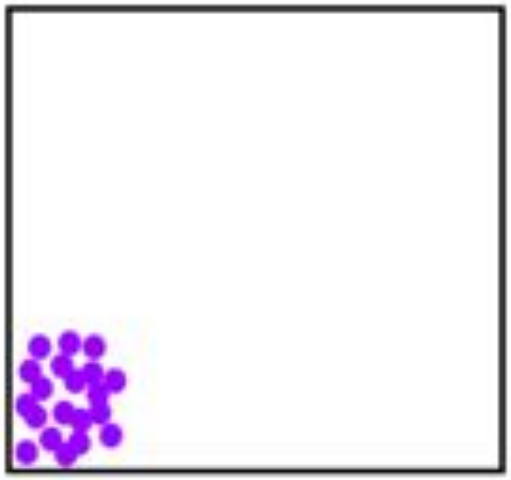


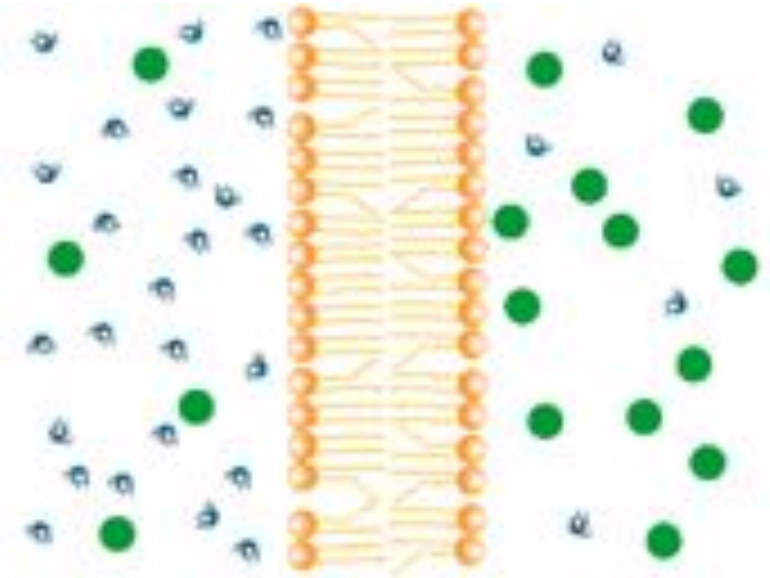
- **Diffusion**
  - movement from high → low concentration

Diffusion

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

movement of water





diffusion

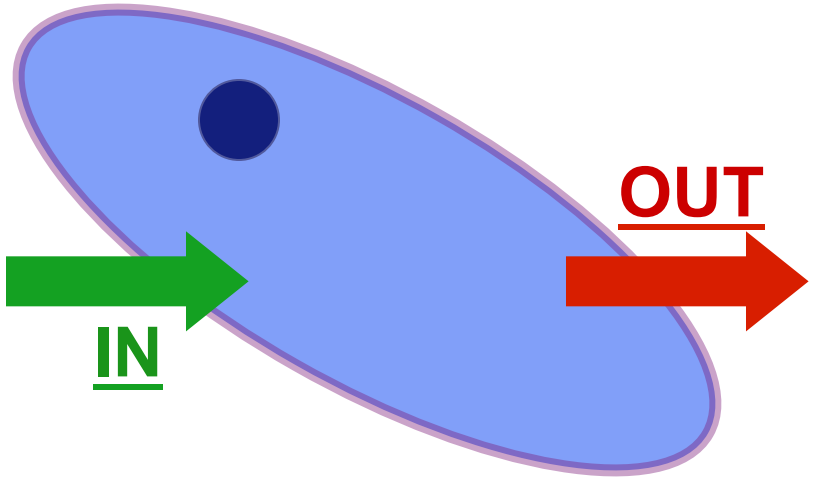
osmosis

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

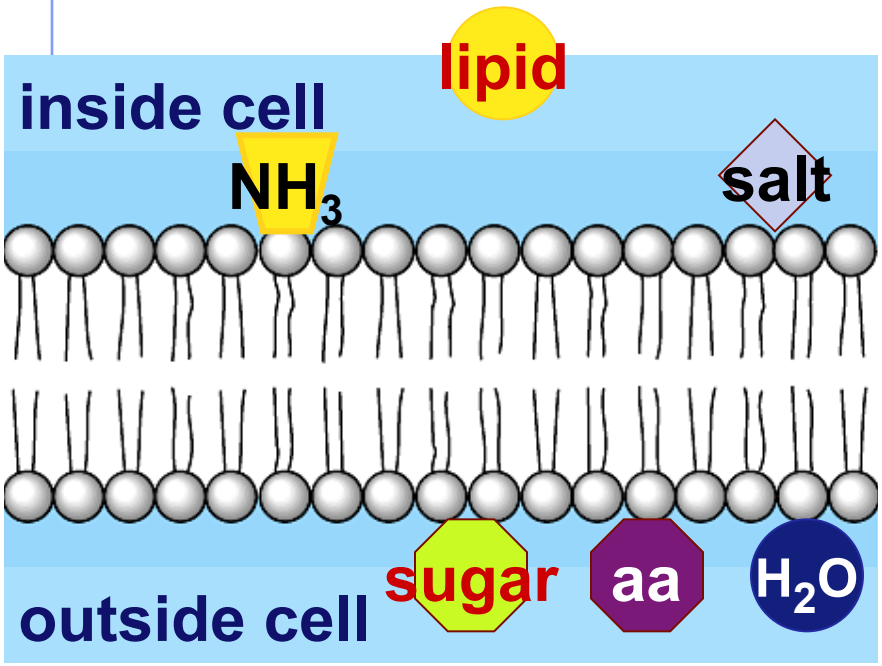


OUT
waste
ammonia
salts
CO_2
H_2O
products

cell needs materials in & products or waste out

Diffusion through phospholipid bilayer

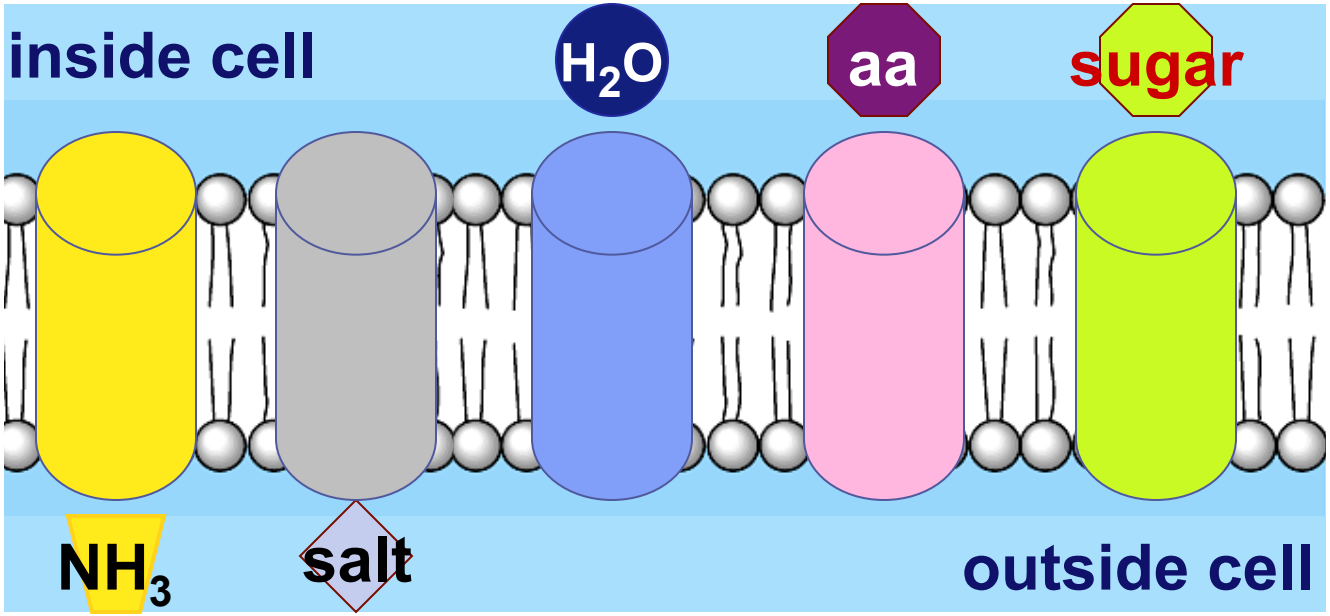
- What molecules can get through directly?
  - fats & other lipids

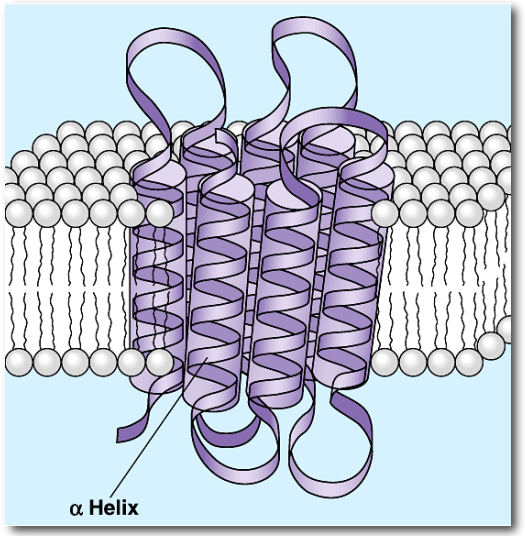


- What molecules can NOT get through directly?
  - polar molecules
    - H_2O
  - ions
    - salts, ammonia
  - large molecules
    - starches, proteins

Channels through cell membrane

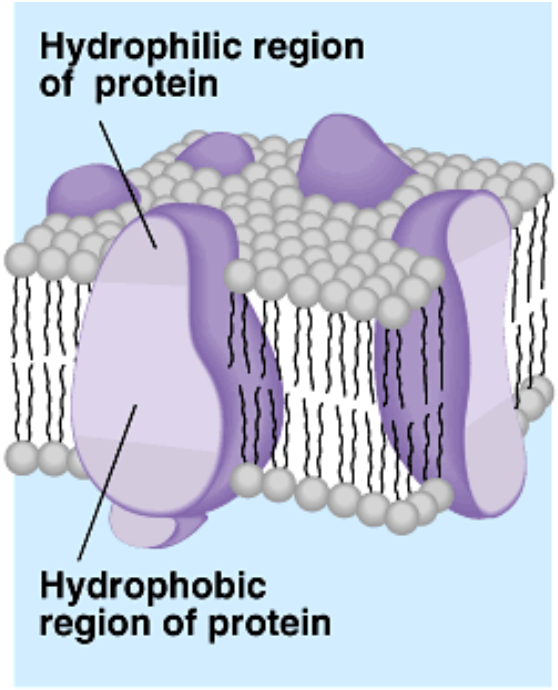
- Membrane becomes semi-permeable with protein channels
  - specific channels allow specific material across cell membrane





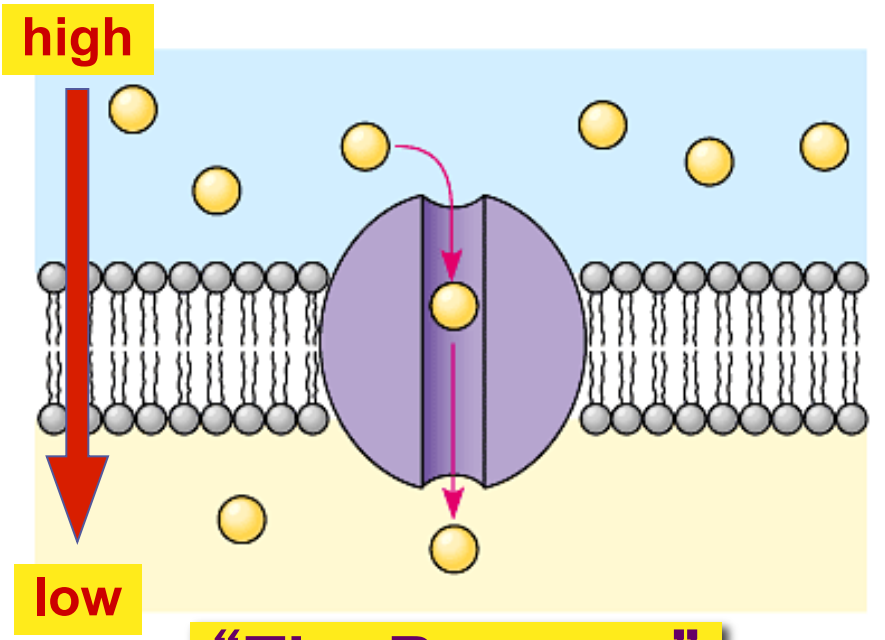
Facilitated Diffusion

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



facilitated = with help

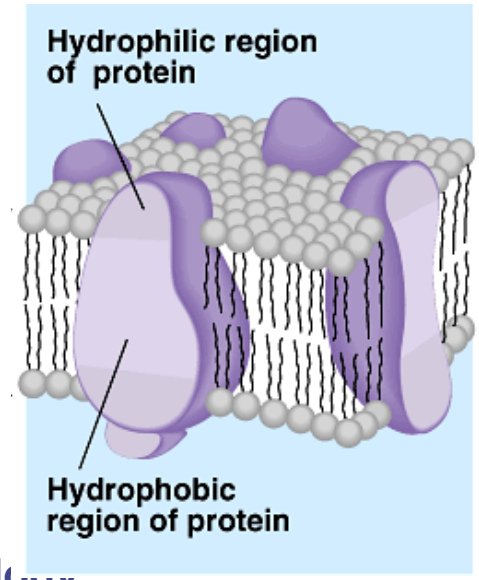
open channel = fast transport

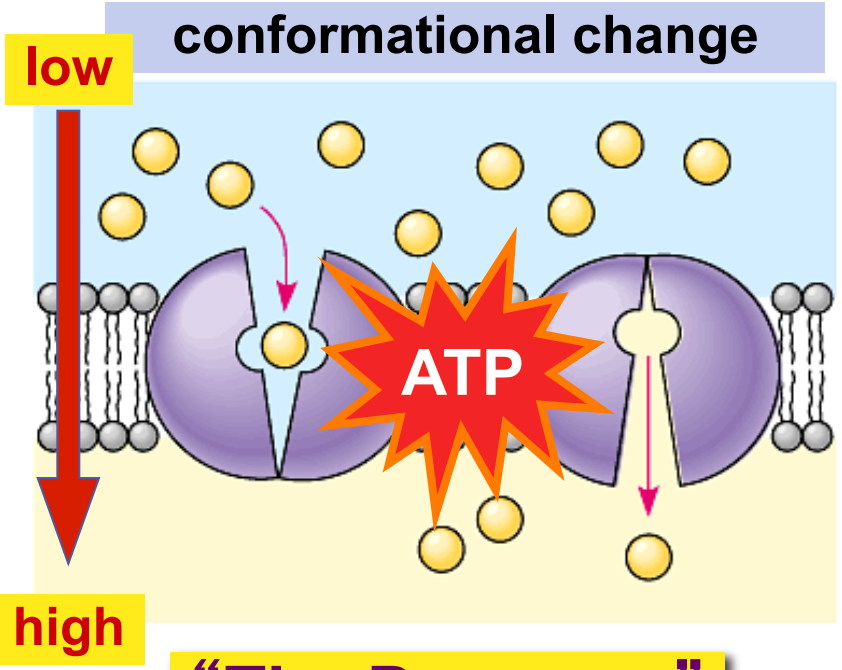


"The Bouncer"

Active Transport

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

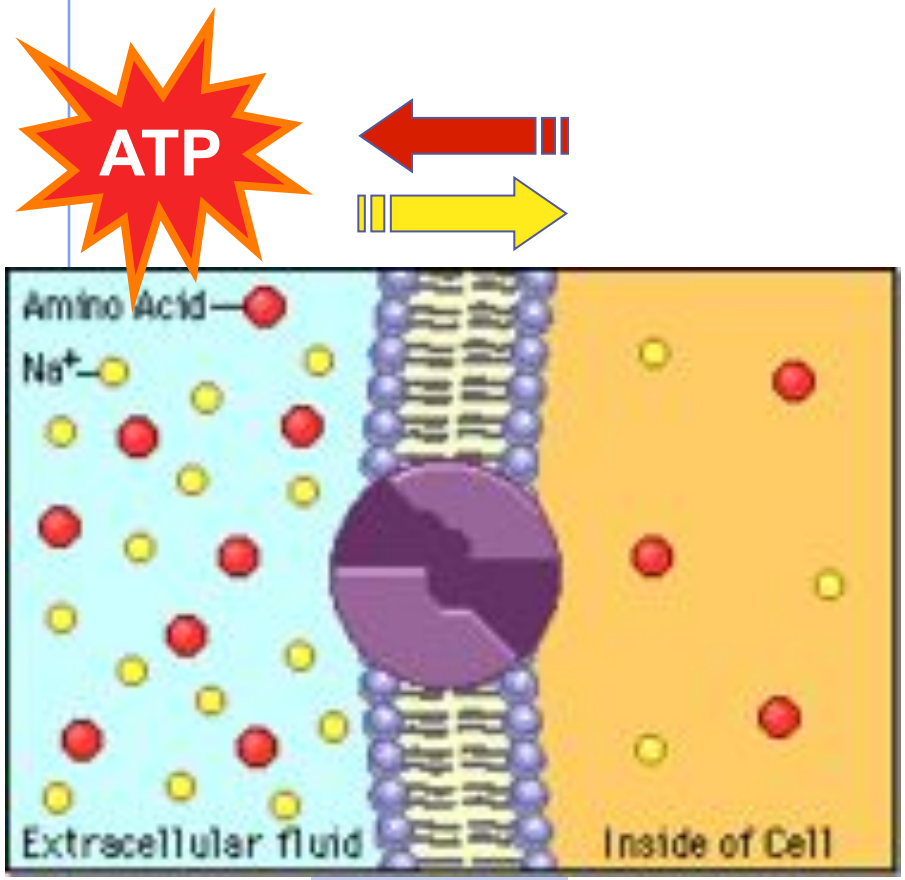




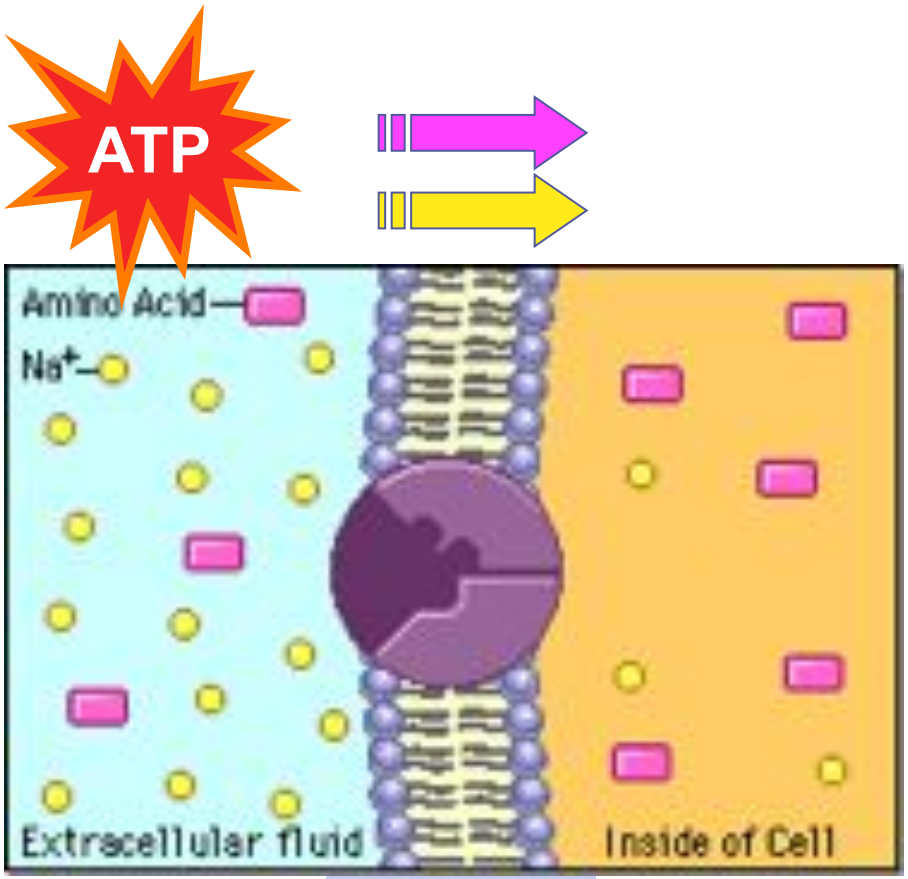
"The Doorman"

Active transport

- Many models & mechanisms



antiport

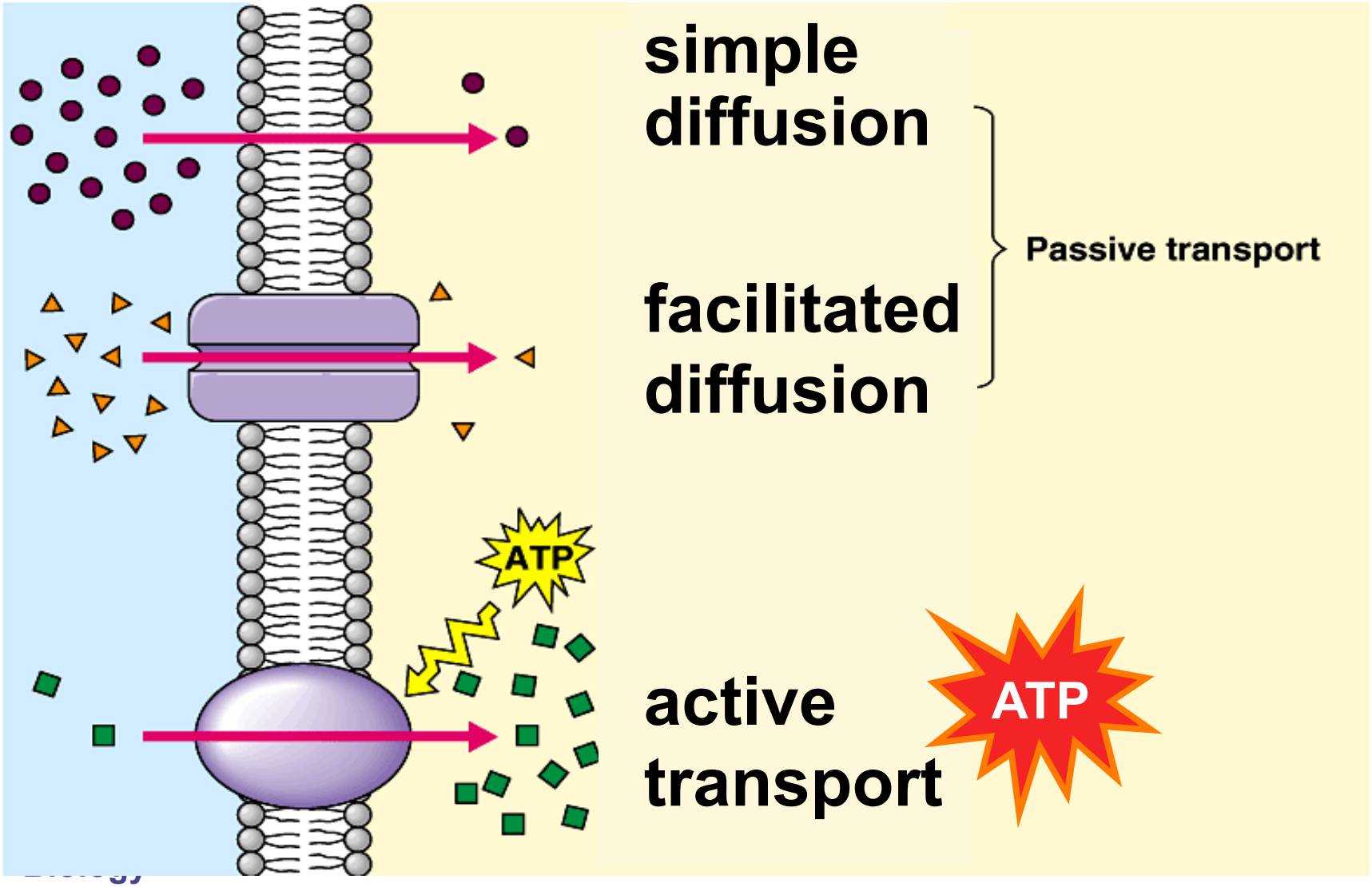


symport

Getting through cell membrane

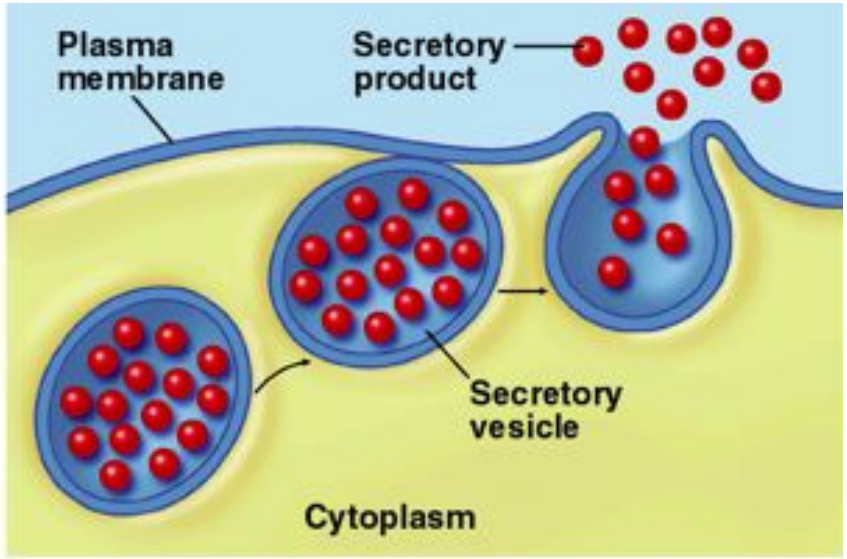
- **Passive Transport**
  - **Simple diffusion**
    - diffusion of nonpolar, hydrophobic molecules
      - lipids
      - high → low concentration gradient
  - **Facilitated transport**
    - diffusion of polar, hydrophilic molecules
    - through a protein channel
      - high → low concentration gradient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

Transport summary



How about large molecules?

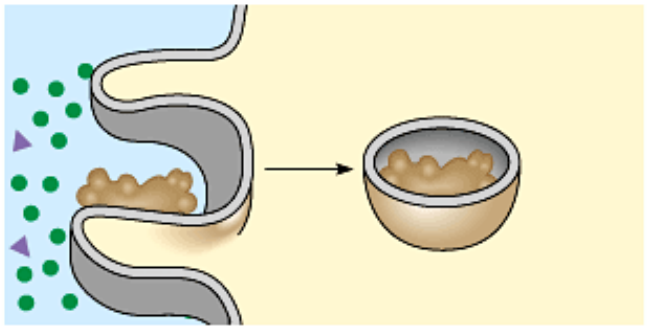
- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - endocytosis
    - phagocytosis = "cellular eating"
    - pinocytosis = "cellular drinking"
  - exocytosis



exocytosis

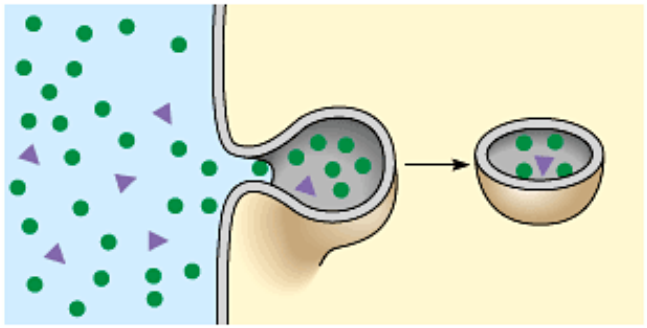
Endocytosis

phagocytosis



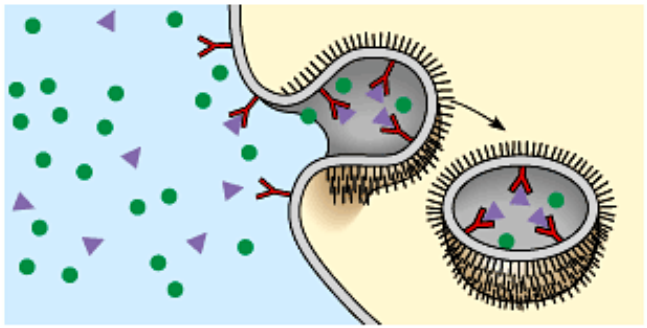
fuse with lysosome for digestion

pinocytosis



non-specific process

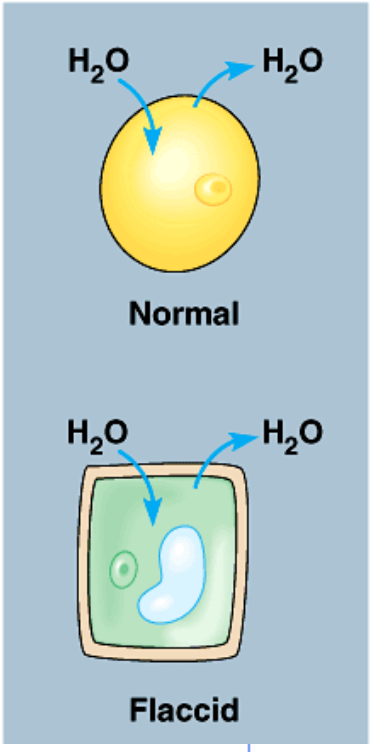
receptor-mediated endocytosis

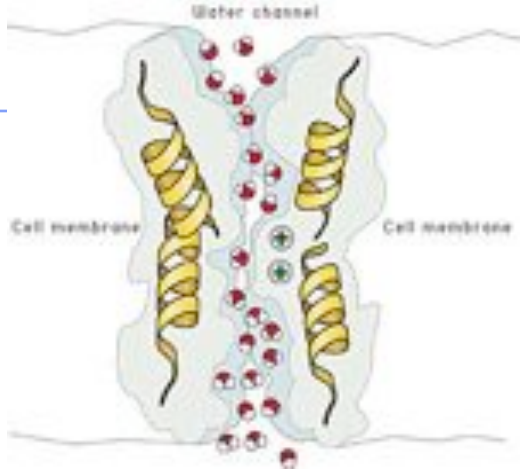


triggered by molecular signal

The Special Case of Water

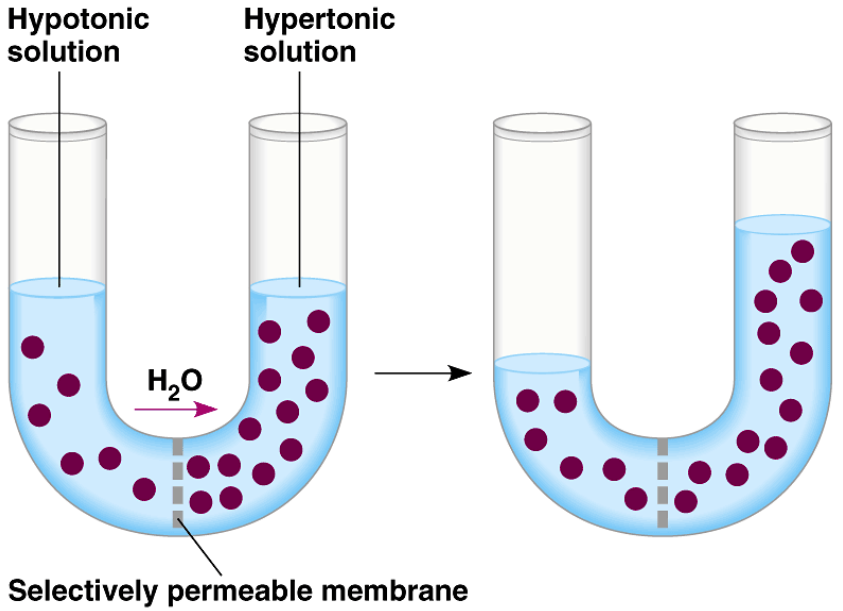
Movement of water across the cell membrane





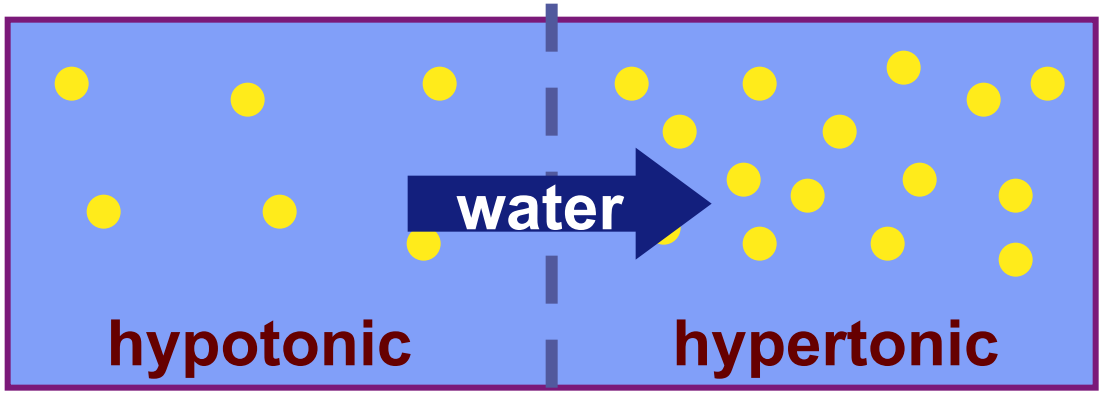
Osmosis is diffusion of water

- 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

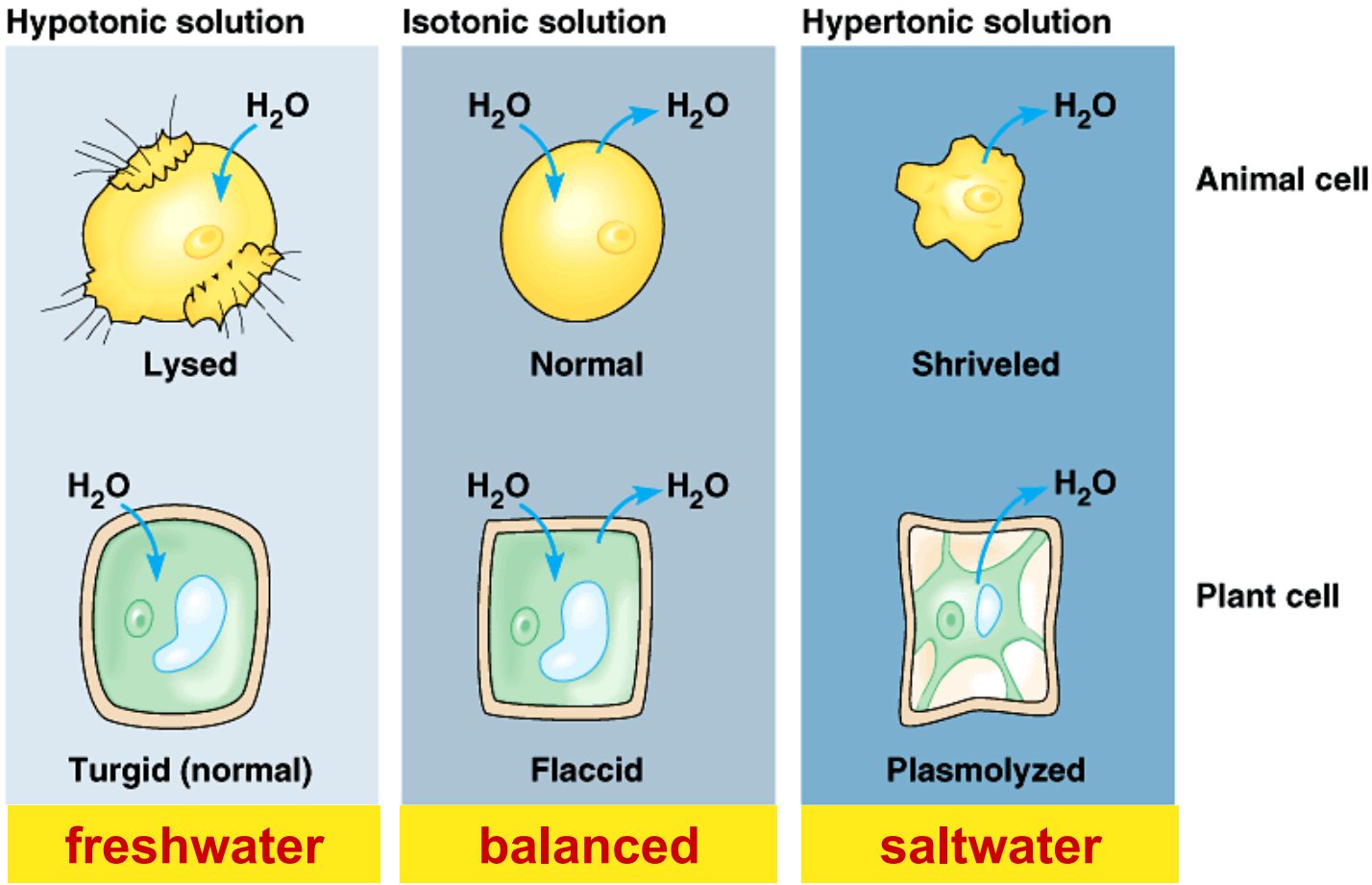
- Direction of osmosis is determined by comparing total solute concentrations
  - **Hypertonic** - more solute, less water
  - **Hypotonic** - less solute, more water
  - **Isotonic** - equal solute, equal water



net movement of water

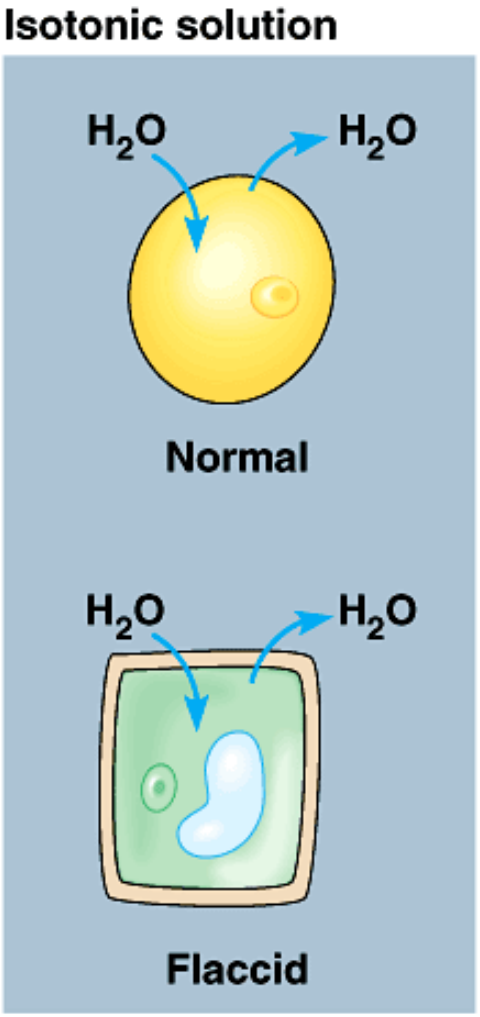
Managing water balance

- Cell survival depends on balancing water uptake & loss



Managing water balance

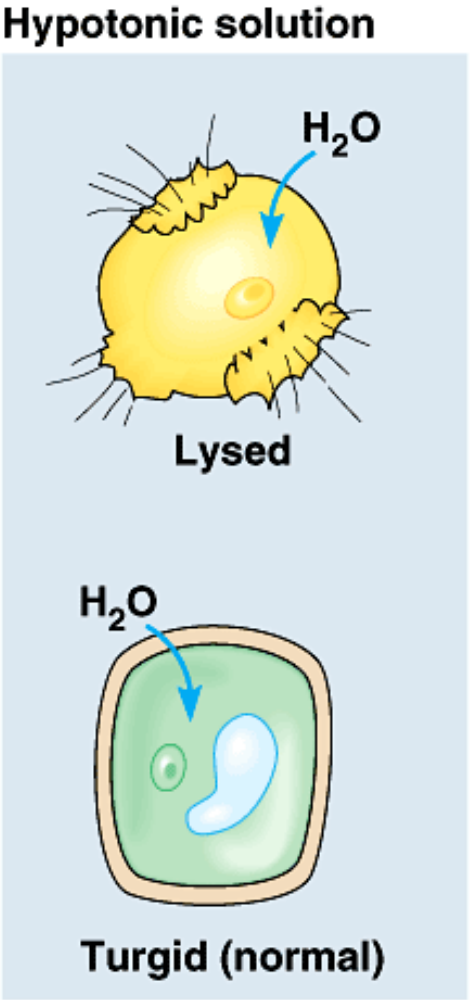
- Isotonic
  - animal cell immersed in mild salt solution
    - example: blood cells in blood plasma
    - problem: none
      - no net movement of water
        - flows across membrane equally, in both directions
      - volume of cell is stable



balanced

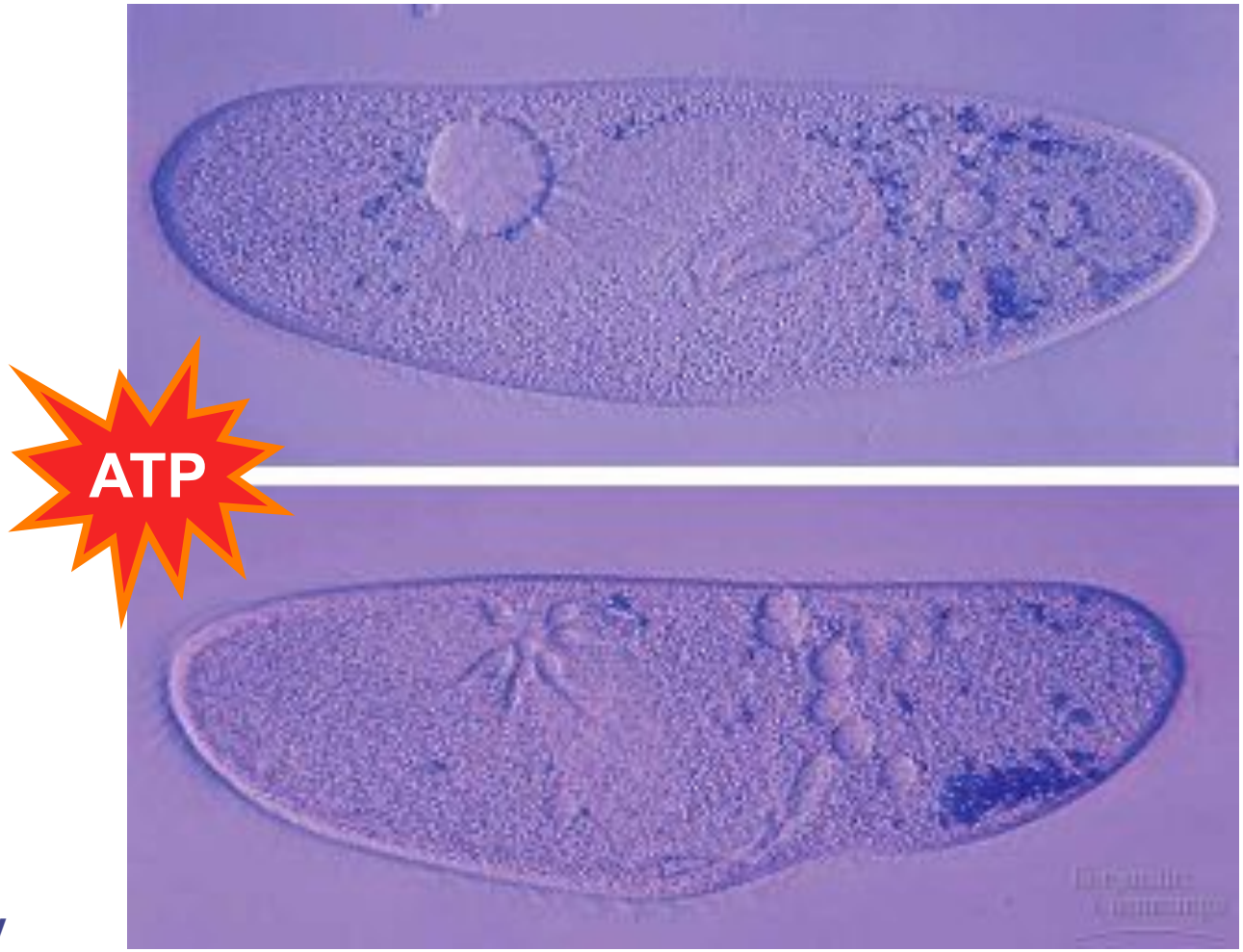
Managing water balance

- **Hypotonic**
  - a cell in **fresh water**
    - **example**: ***Paramecium***
    - **problem**: **gains water**, swells & can burst
      - water continually enters *Paramecium* cell
    - **solution**: **contractile vacuole**
      - pumps water out of cell
      - ATP
  - **plant cells**
    - turgid



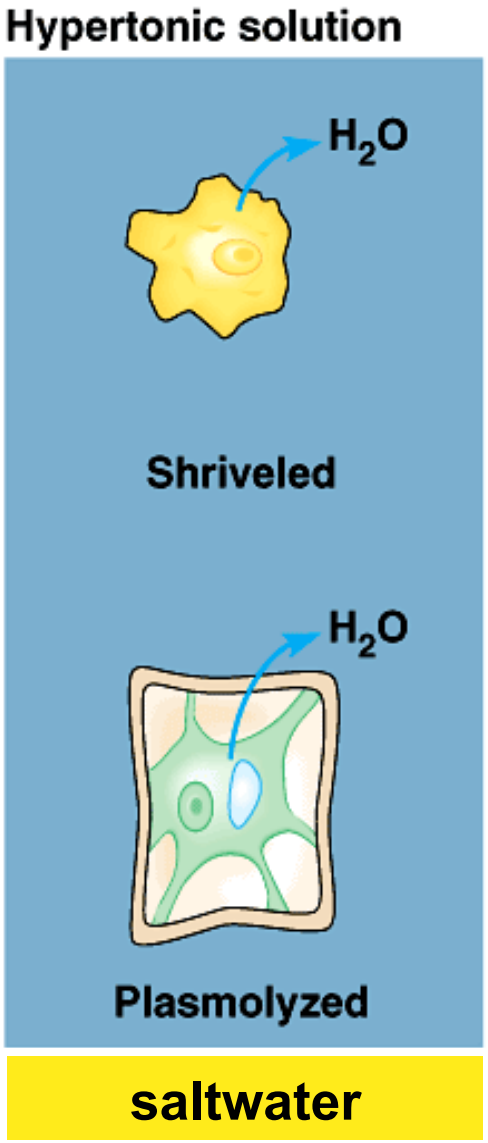
Water regulation

- Contractile vacuole in *Paramecium*



Managing water balance

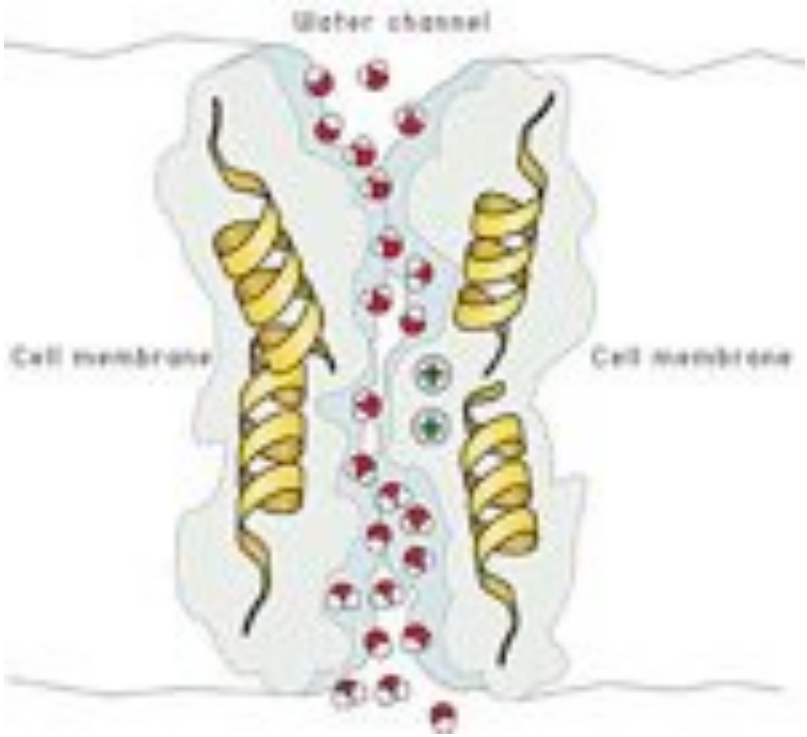
- Hypertonic
  - a cell in salt water
    - example: shellfish
    - problem: lose water & die
    - solution: take up water or pump out salt
  - plant cells
    - plasmolysis = wilt



1991 | 2003

Aquaporins

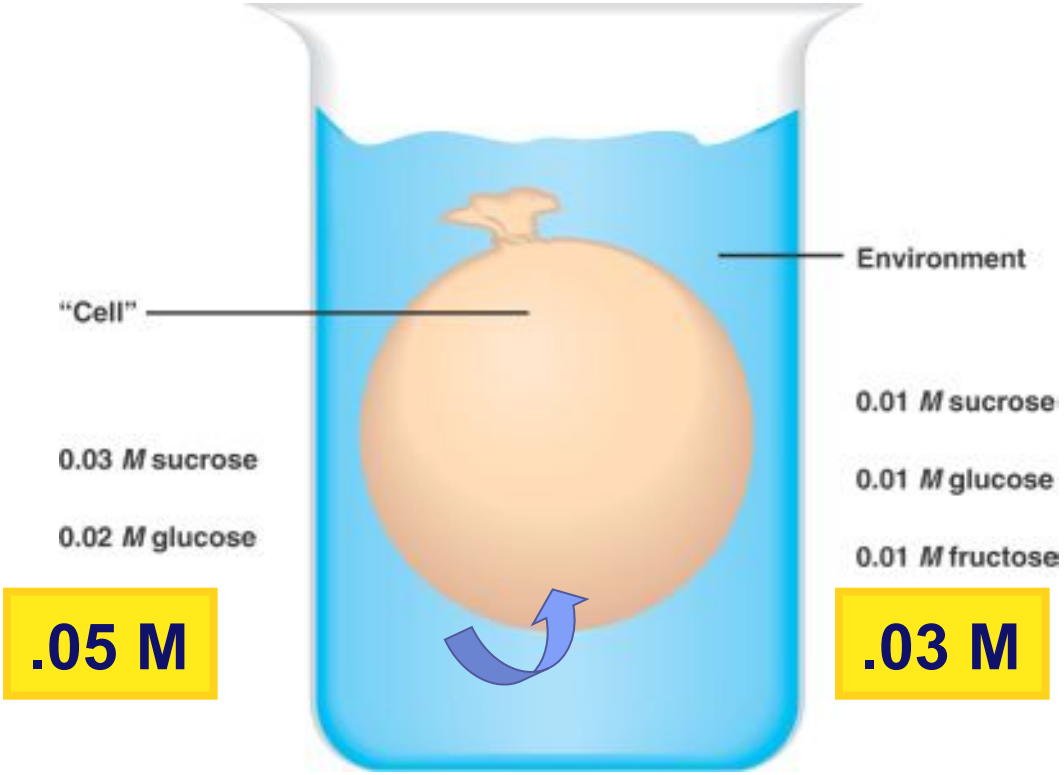
- Water moves rapidly into & out of cells
  - evidence that there were water channels



Peter Agre
John Hopkins

Roderick MacKinnon
Rockefeller

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??