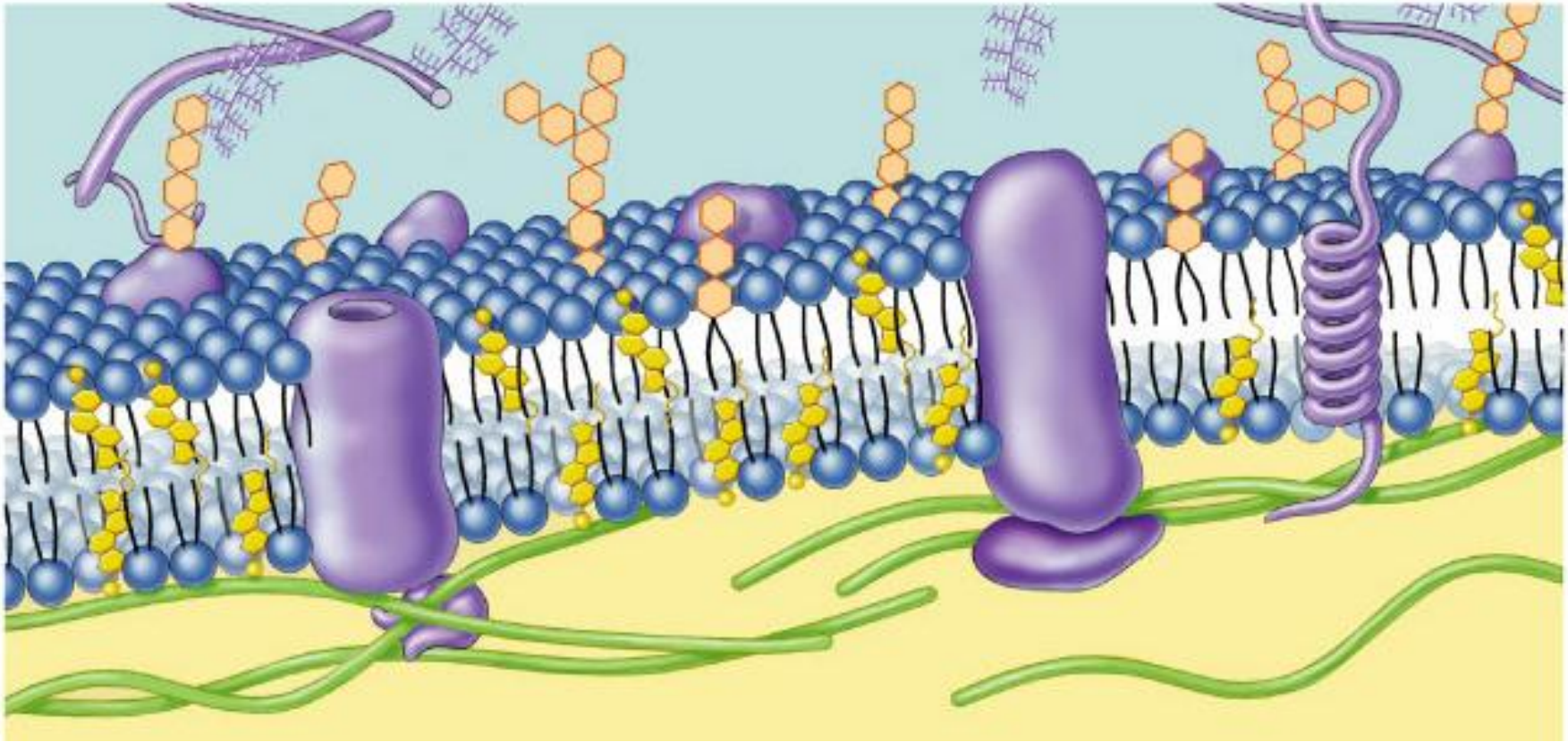
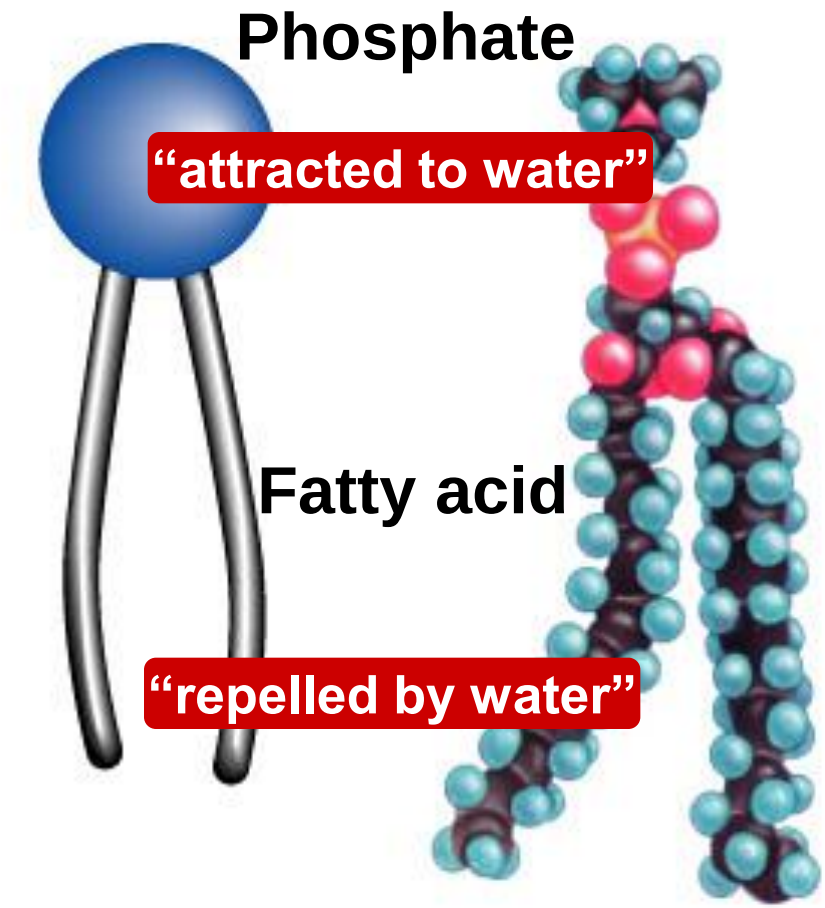
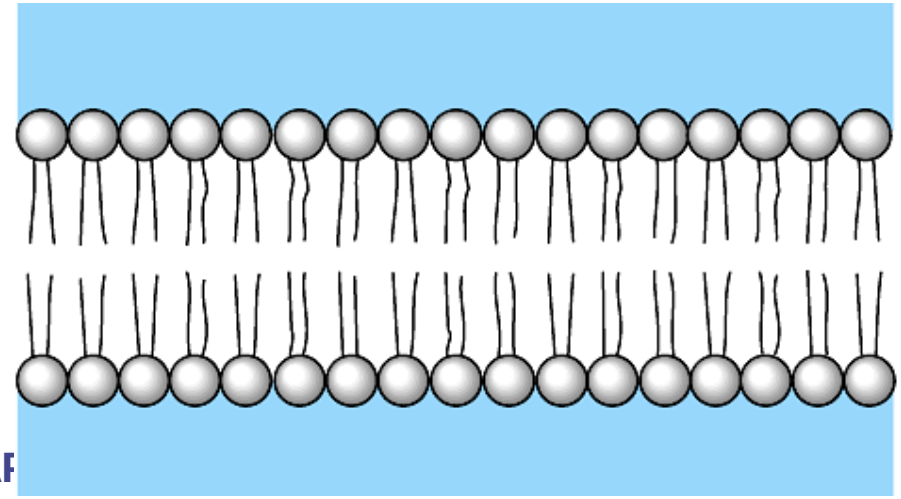
The Cell Membrane

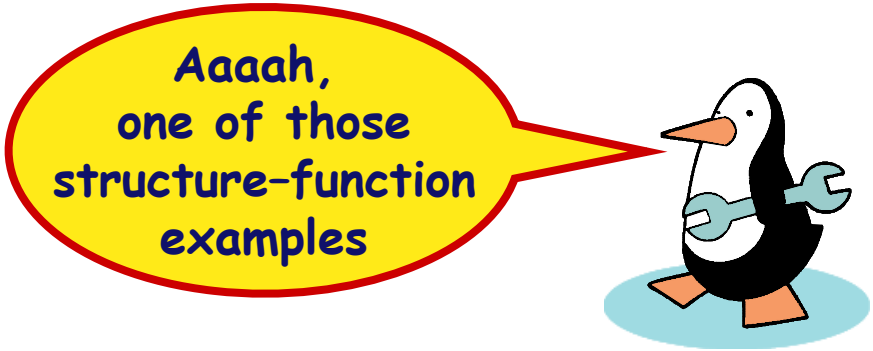


Phospholipids

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

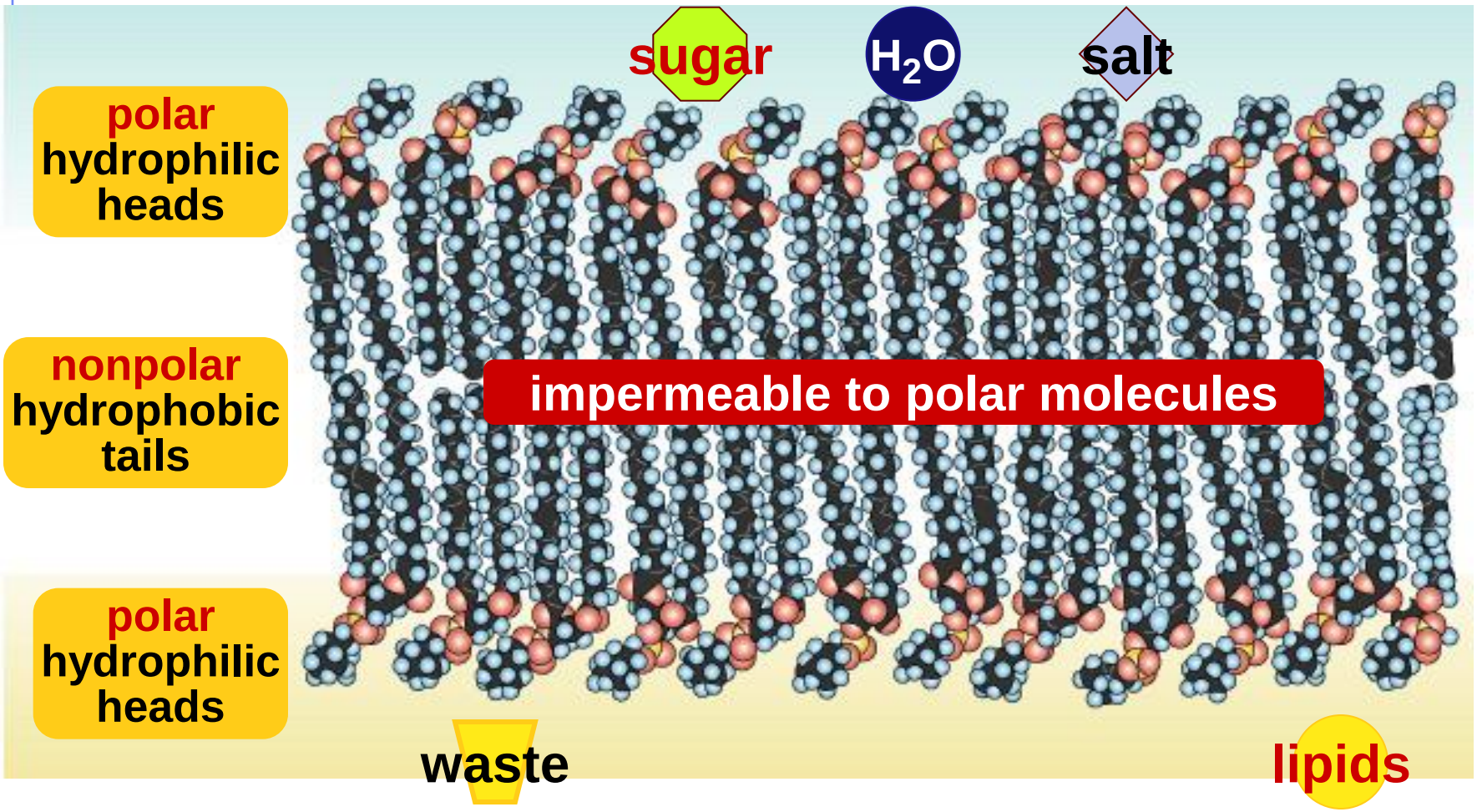






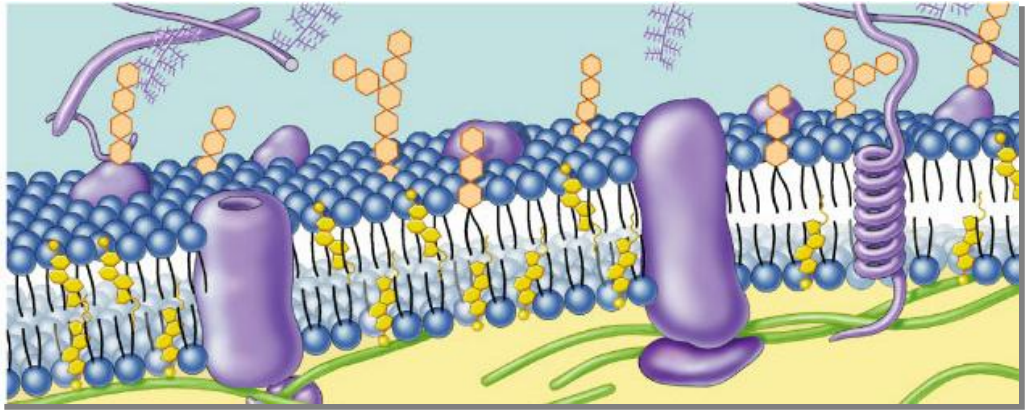
Arranged as a Phospholipid bilayer

- Serves as a cellular barrier / border



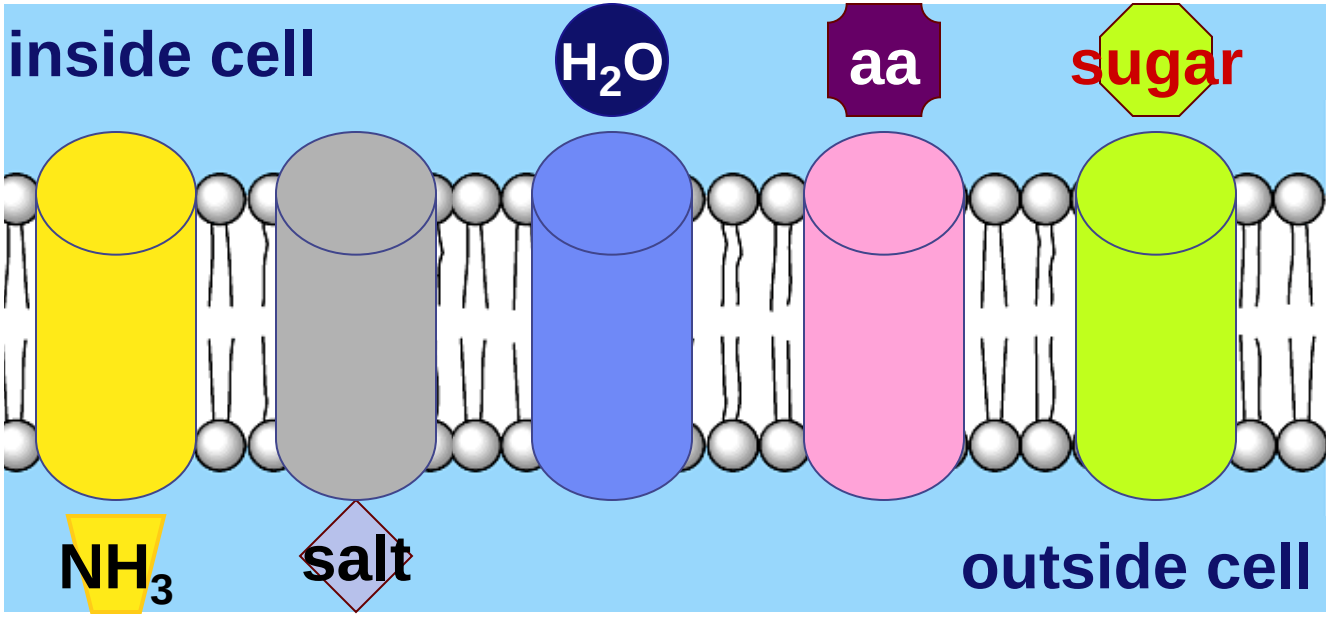
Cell membrane defines cell

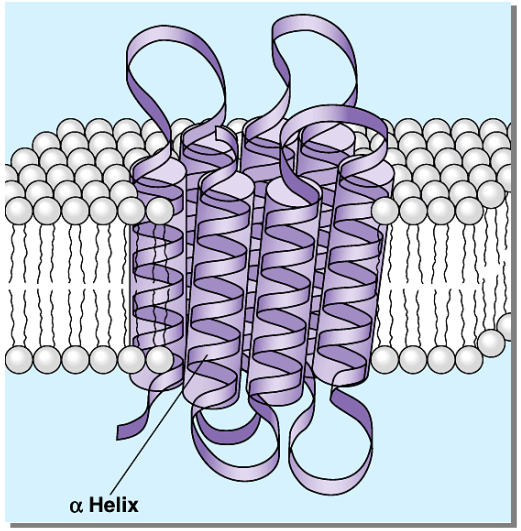
- Cell membrane separates living cell from aqueous environment
  - thin barrier = 8nm thick
- Controls traffic in & out of the cell
  - allows some substances to cross more easily than others
    - hydrophobic (nonpolar) vs. hydrophilic (polar)



Permeability to polar molecules?

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

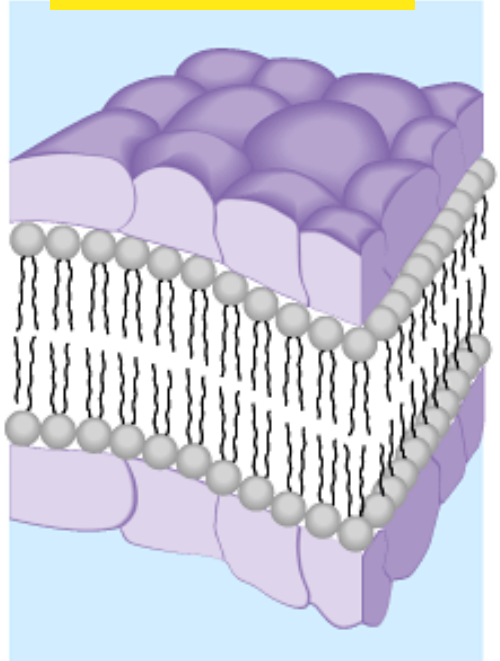




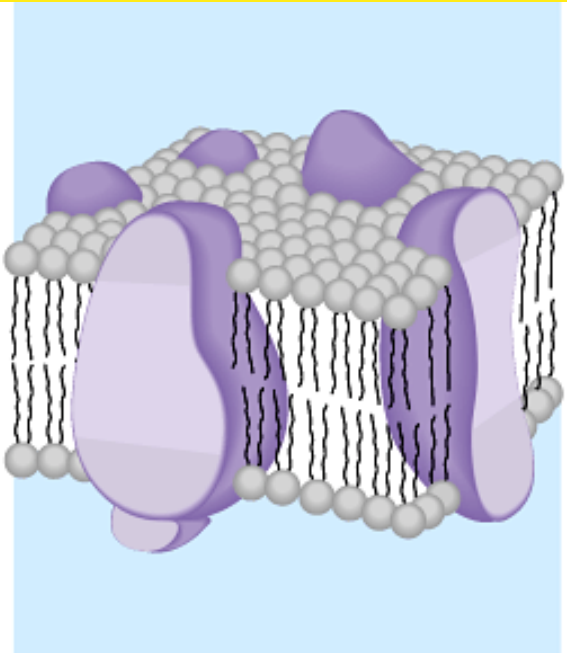
Cell membrane is more than lipids…

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

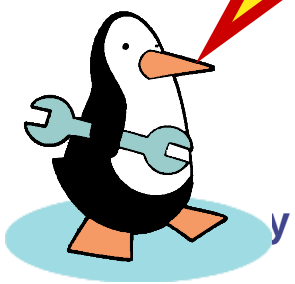
lipid bilayer membrane

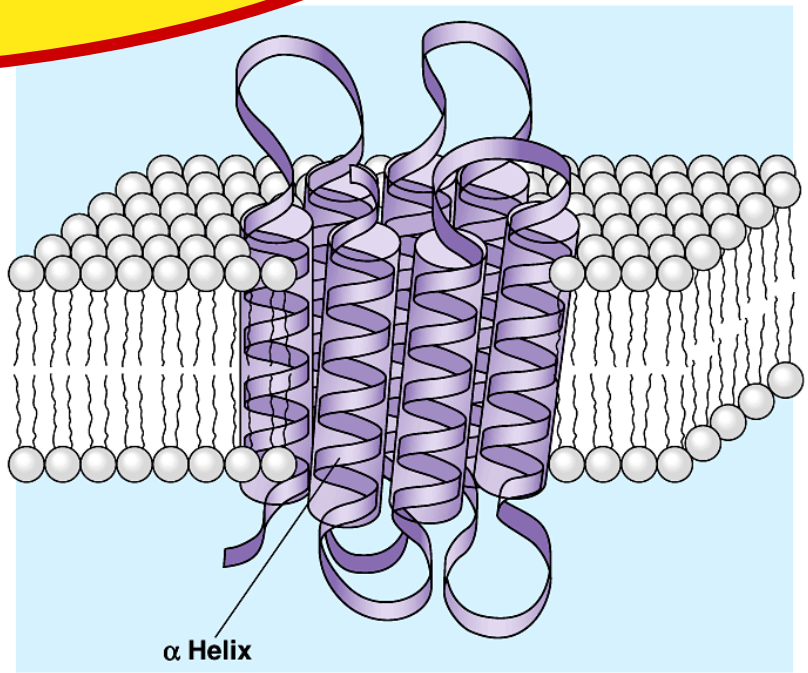


protein channels in lipid bilyer membrane



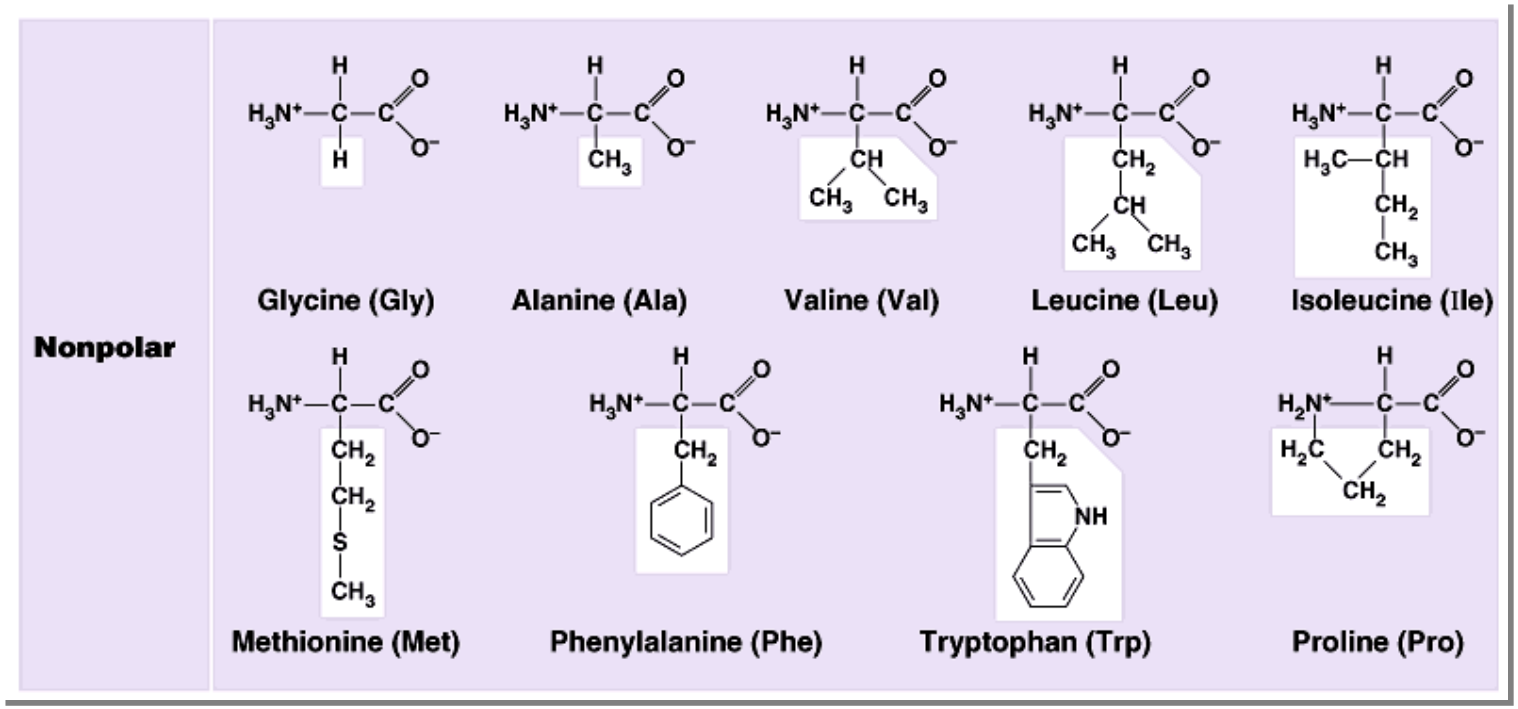
Why are
<u>proteins</u> the perfect
molecule to build structures
in the cell membrane?





Classes of amino acids

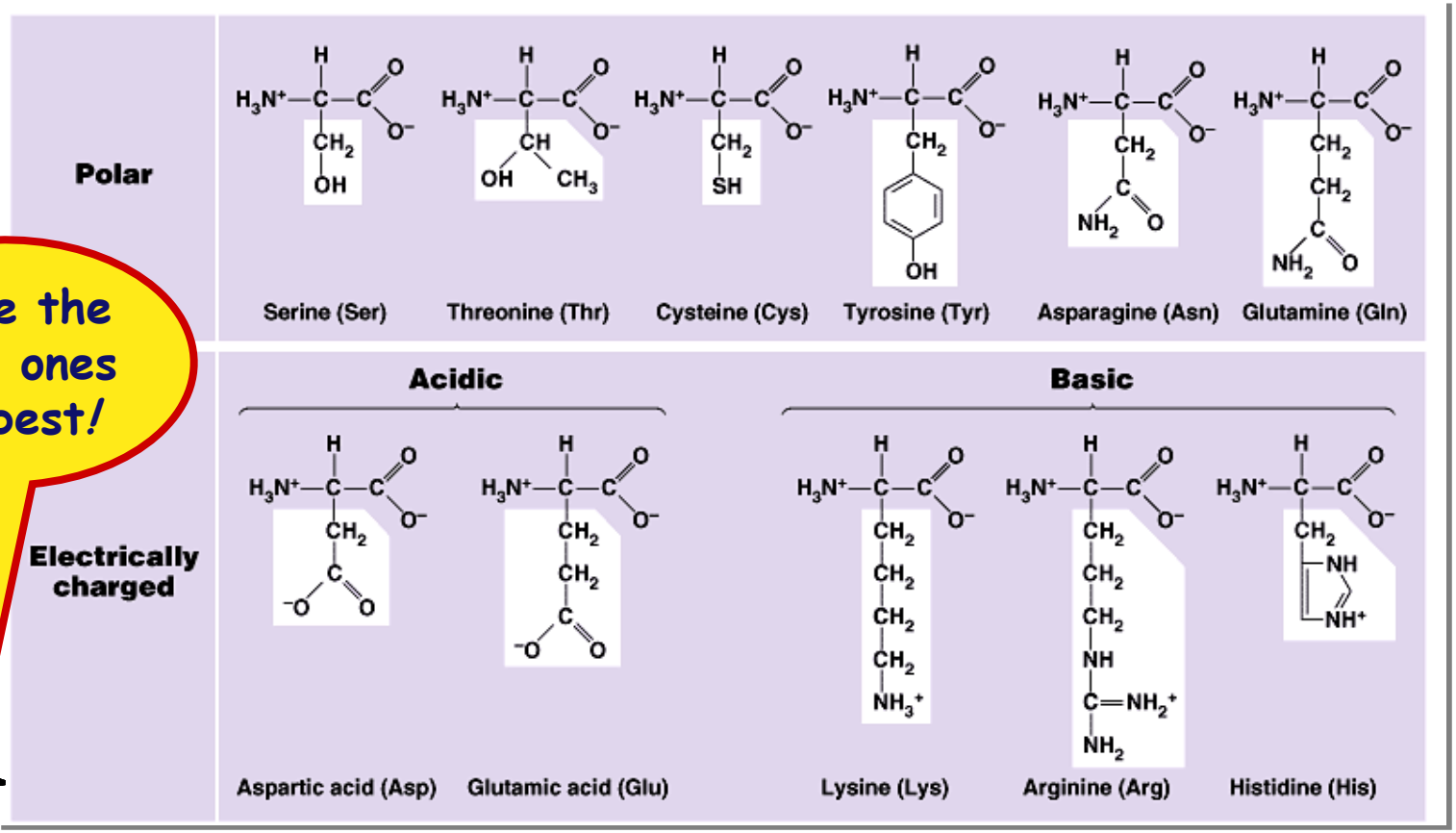
What do these amino acids have in common?

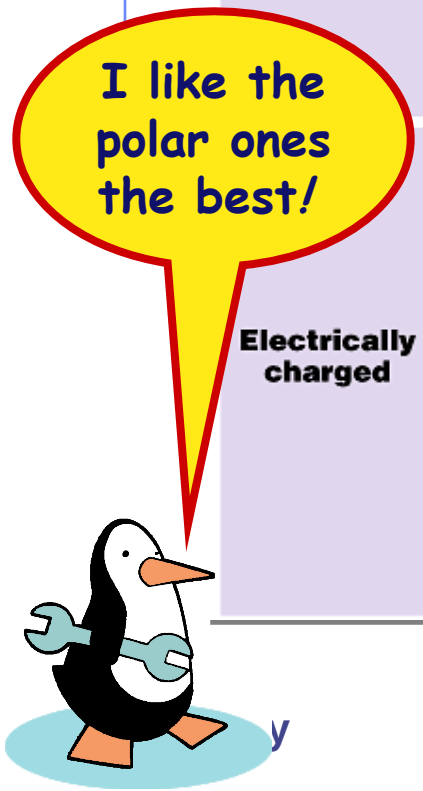


nonpolar & hydrophobic

Classes of amino acids

What do these amino acids have in common?

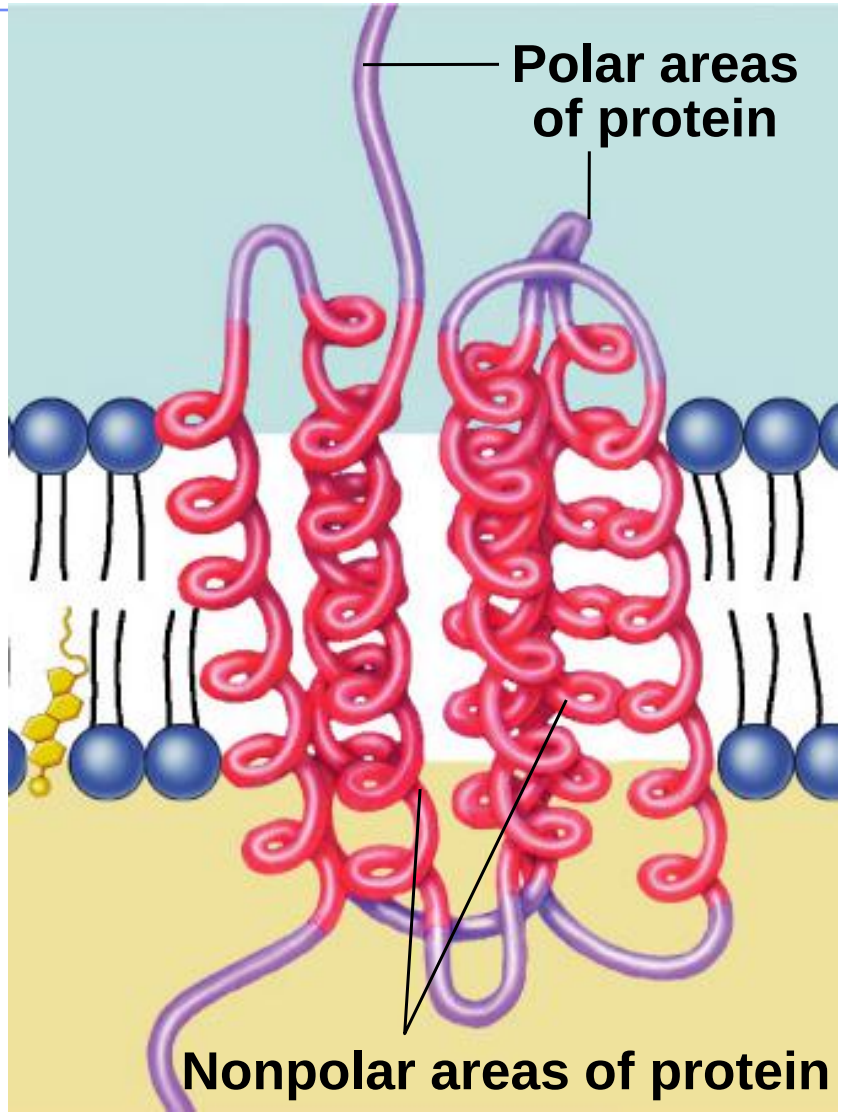




polar & hydrophilic

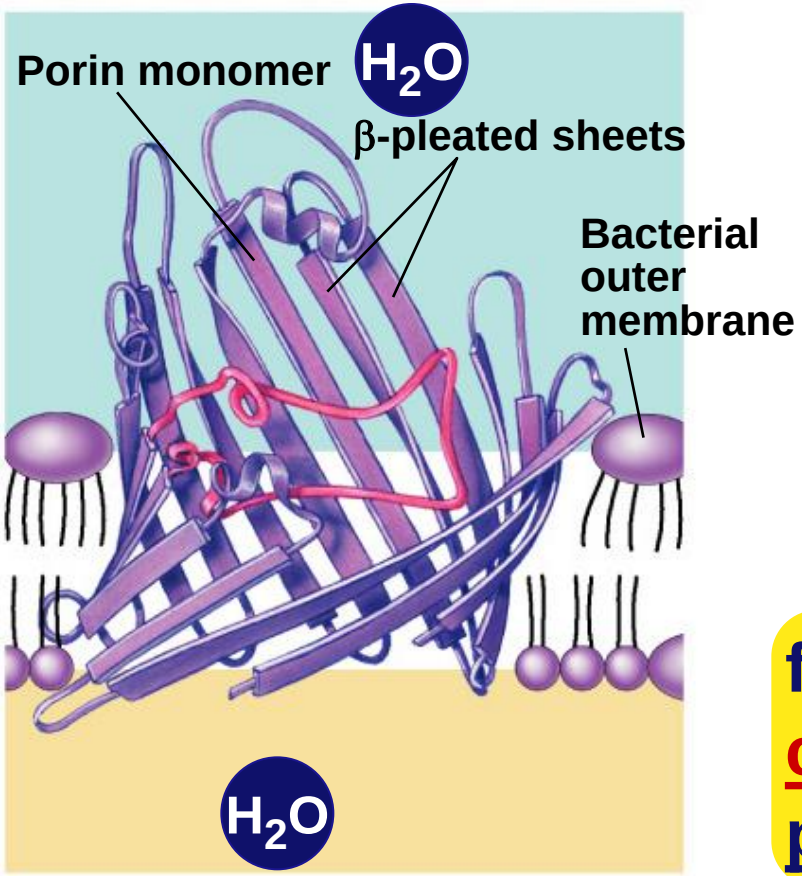
Proteins domains anchor molecule

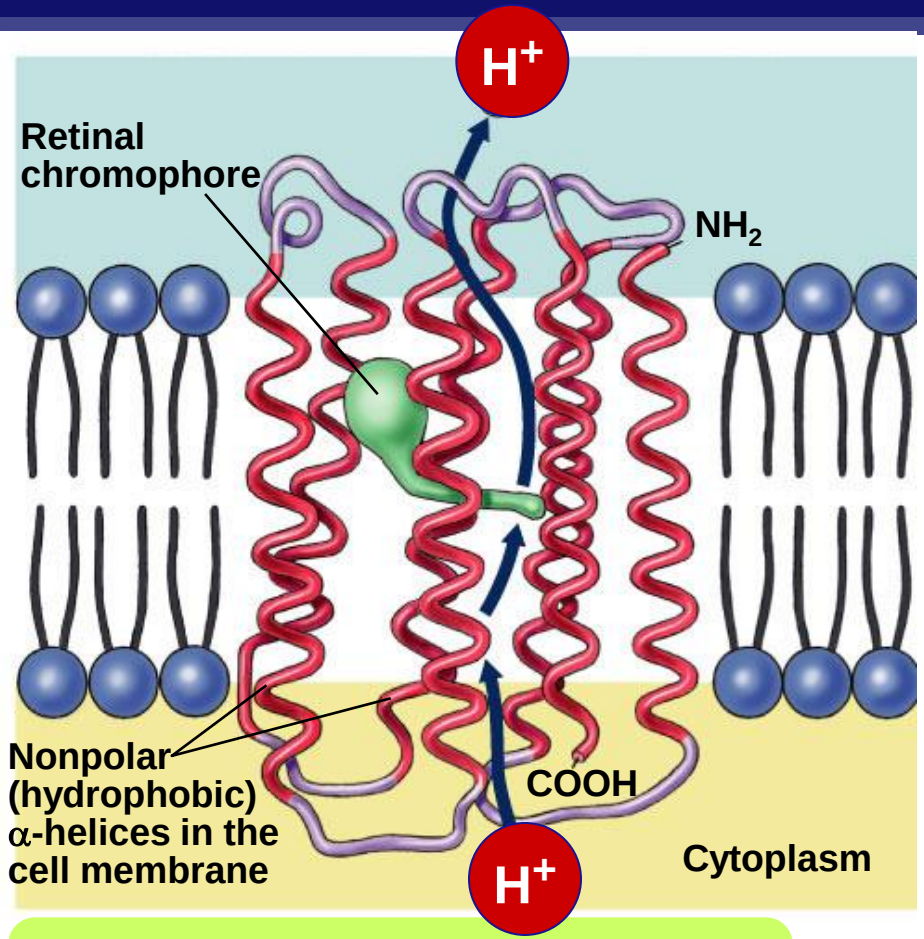
- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane in fluid
  - polar amino acids
    - hydrophilic
    - extend into extracellular fluid & into cytosol



Examples

aquaporin =
water channel in bacteria

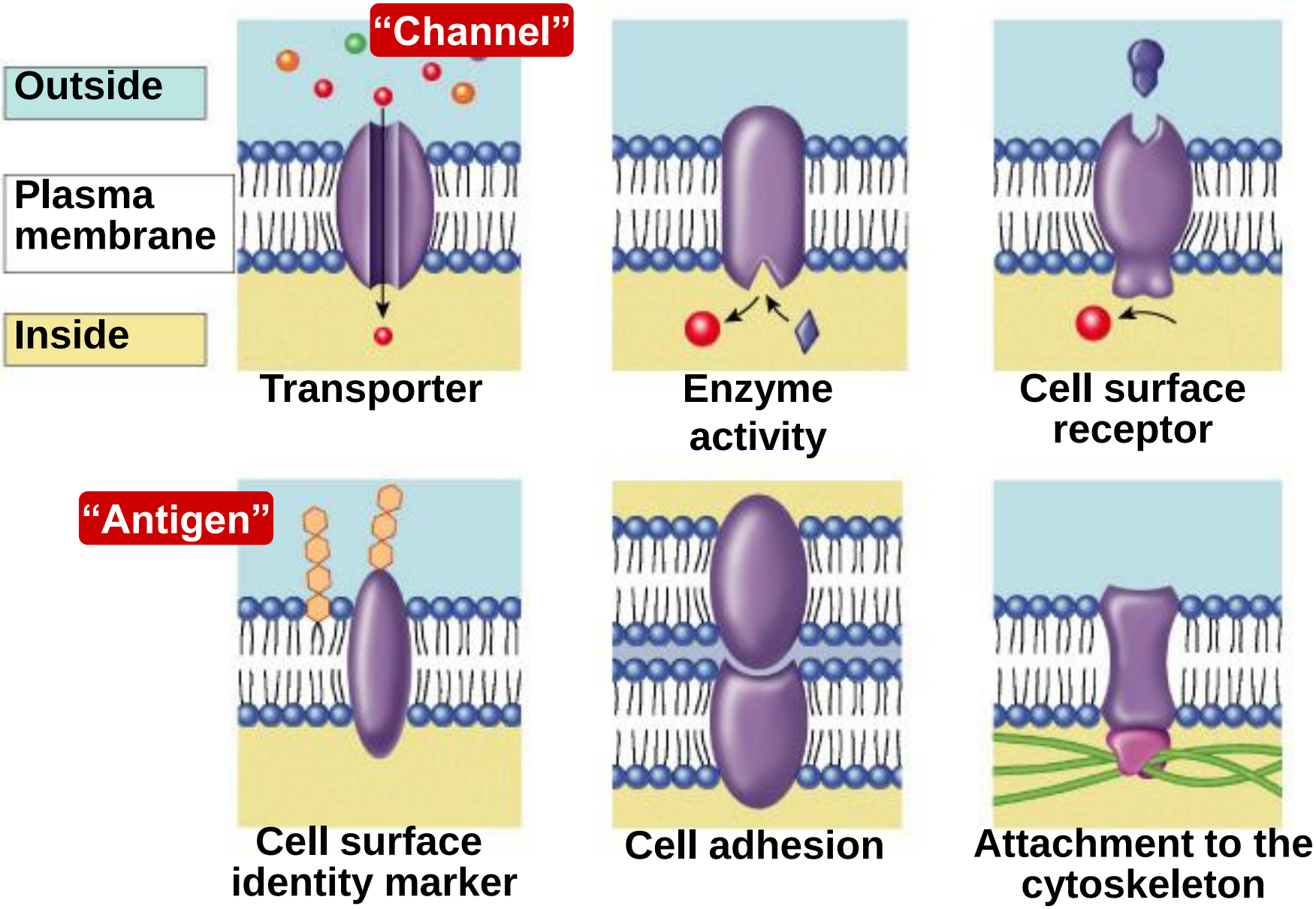




proton pump channel
in photosynthetic bacteria

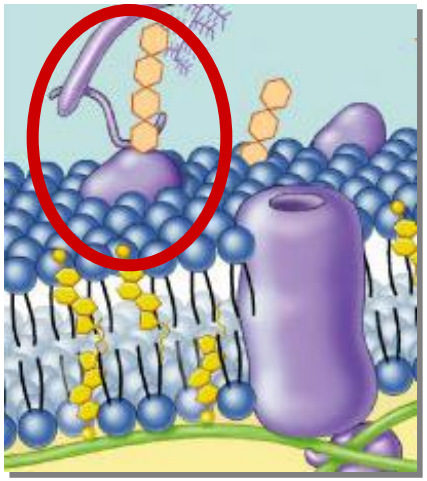
function through
<u>conformational</u> change =
<u>protein changes shape</u>

Many Functions of Membrane Proteins

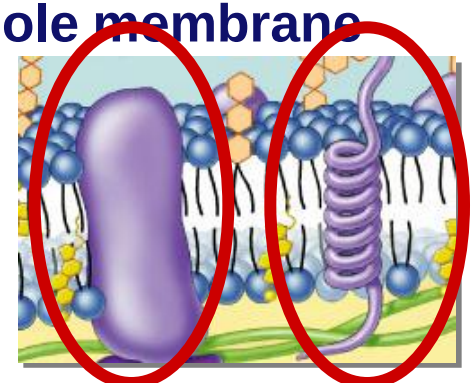


Membrane Proteins

- **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)**

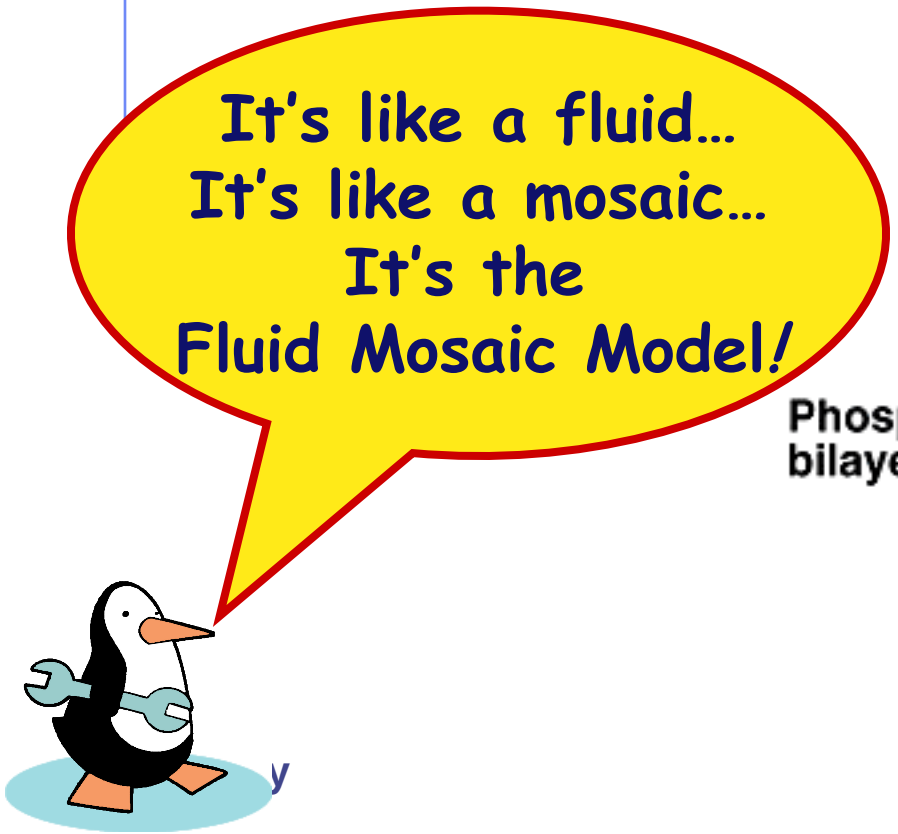


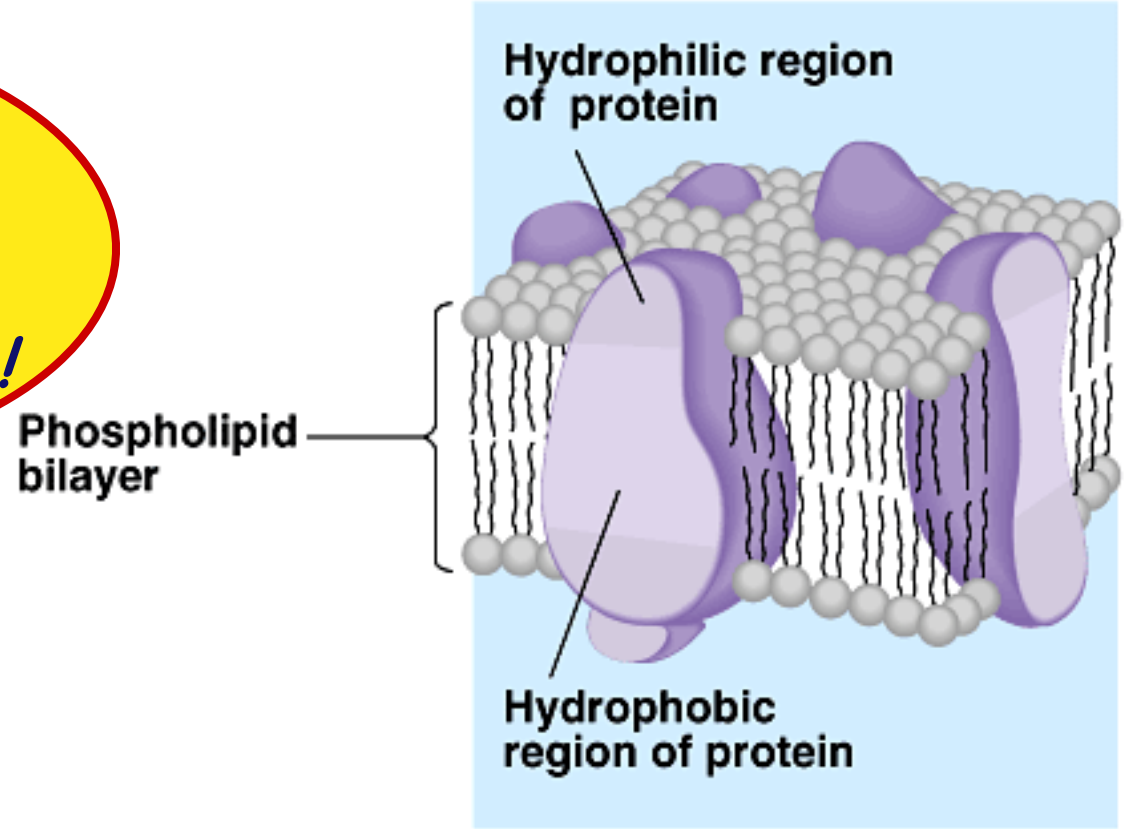
  - **integral proteins**
    - **penetrate lipid bilayer, usually across whole membrane**
    - **transmembrane protein**
    - **ex: transport proteins**
      - **channels, permeases (pumps)**



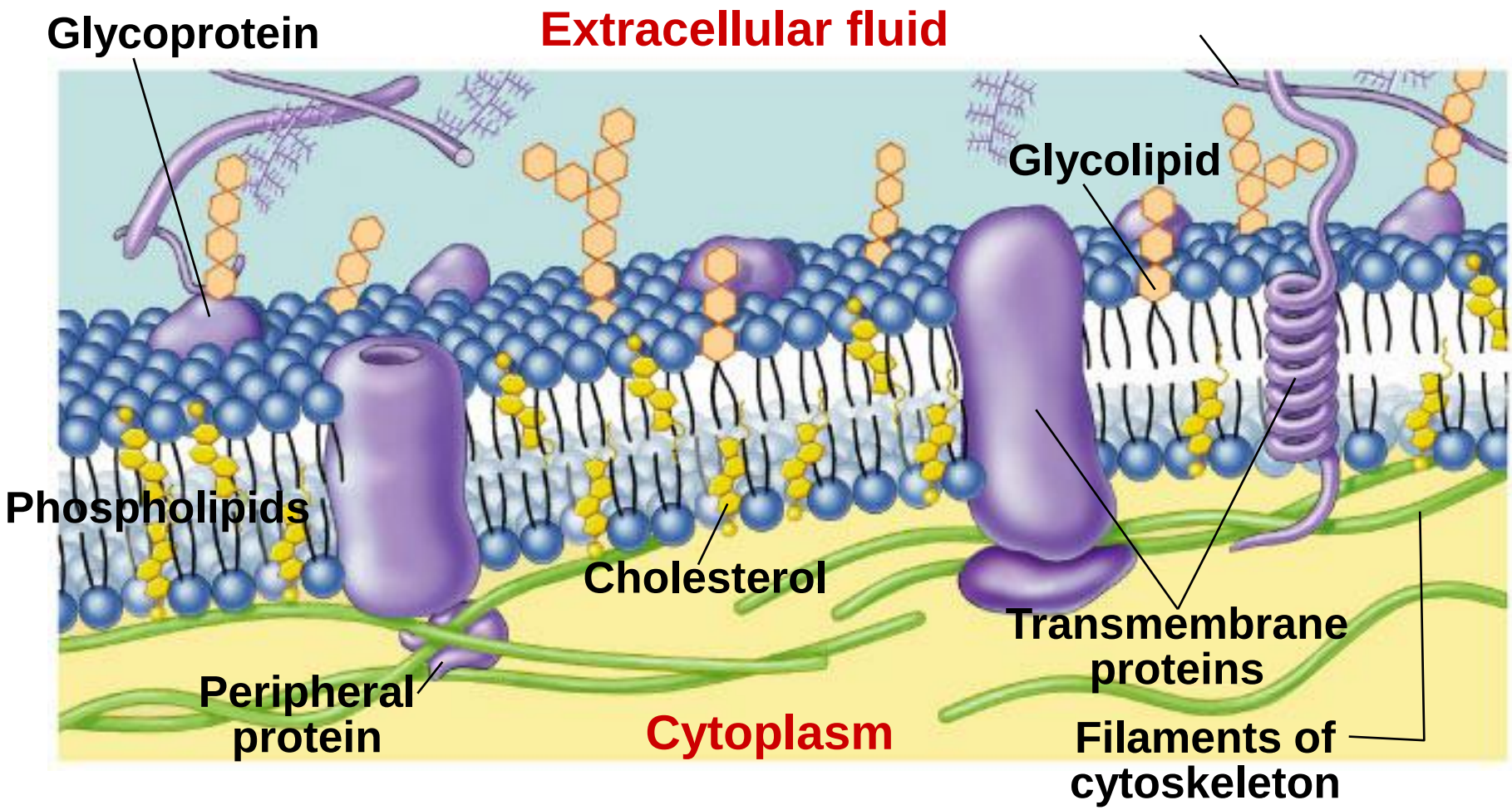
Cell membrane must be more than lipids…

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





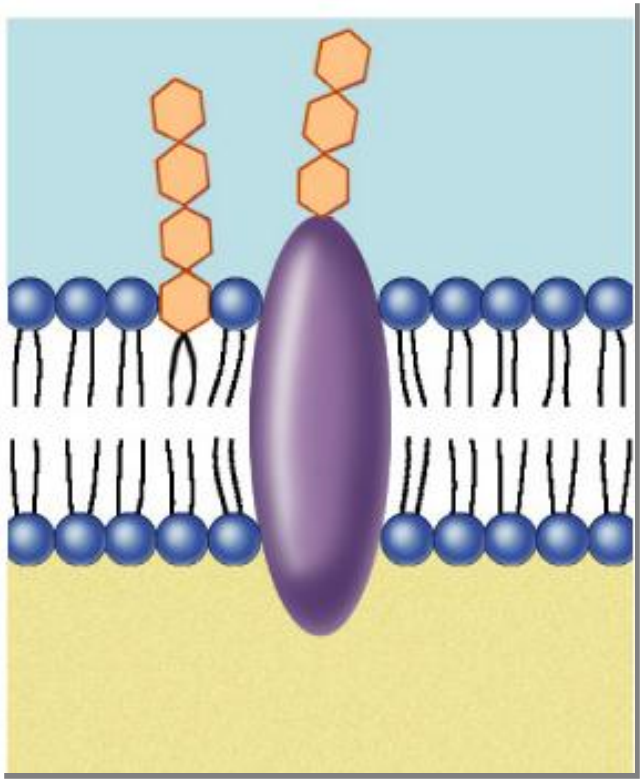
Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer

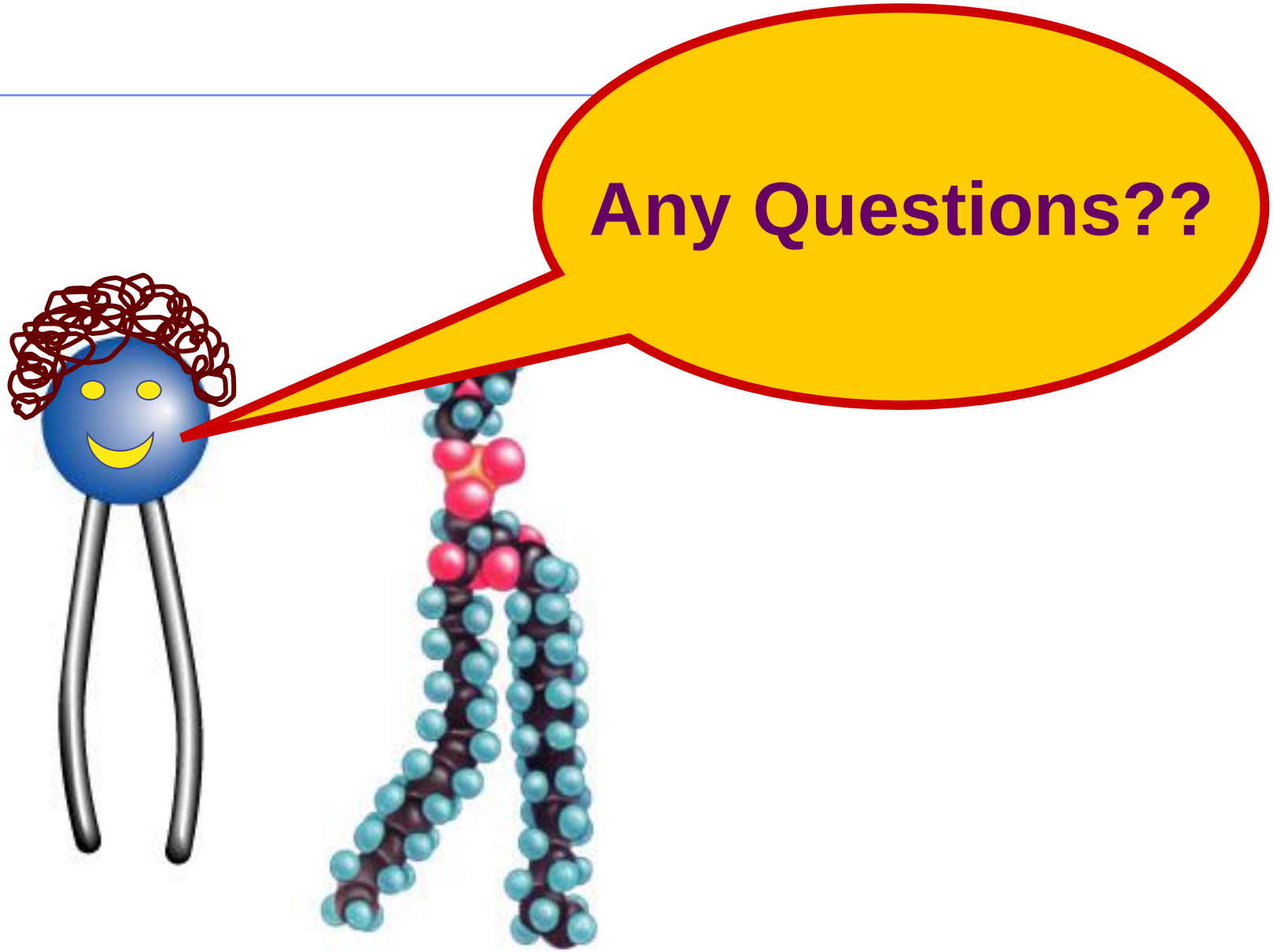


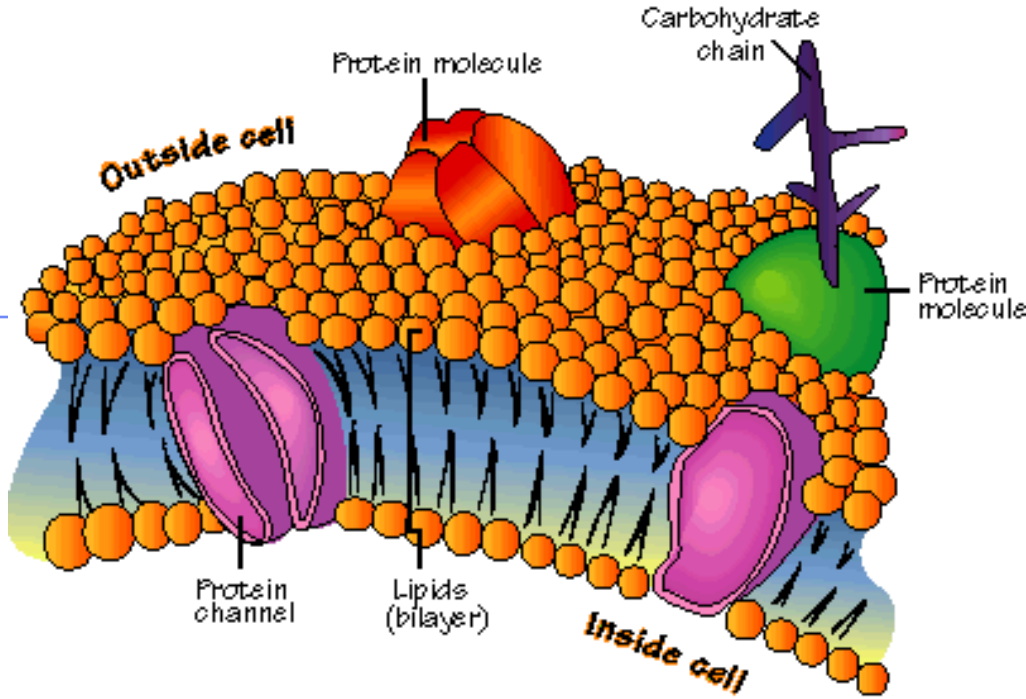
1972, S.J. Singer & G. Nicolson proposed Fluid Mosaic Model

Membrane carbohydrates

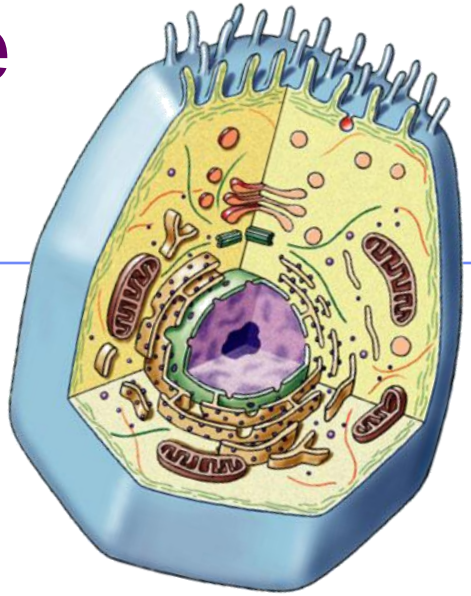
- Play a key role in cell-cell recognition
  - ability of a cell to distinguish one cell from another
    - antigens
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system




Any Questions??

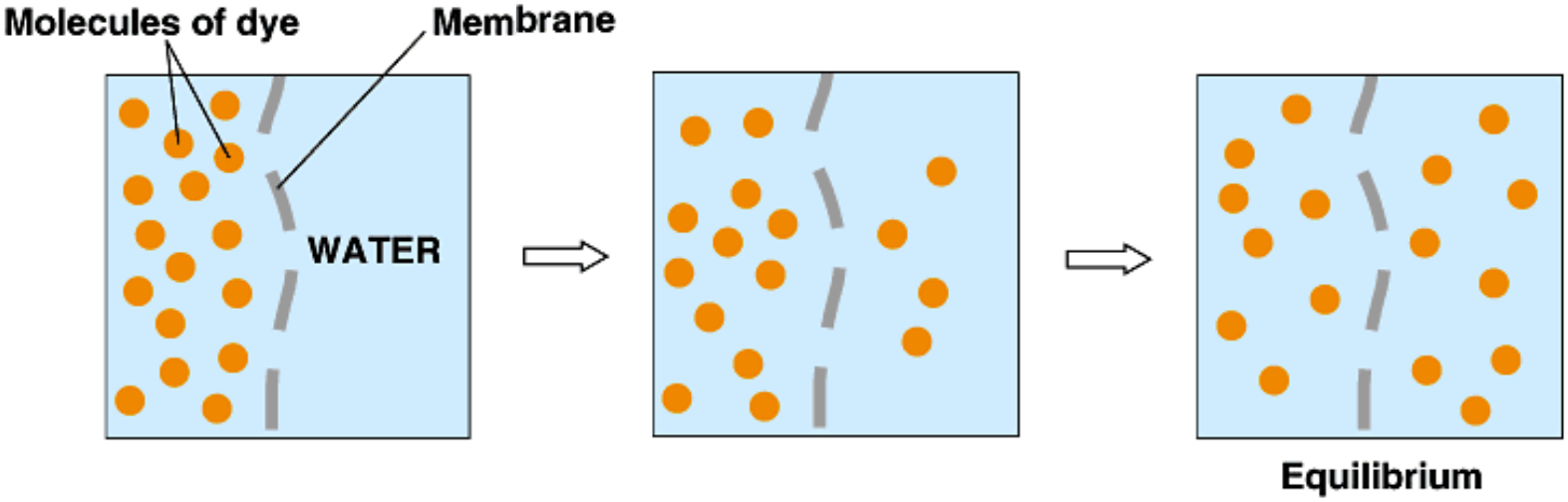


Movement across the Cell Membrane



Diffusion

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

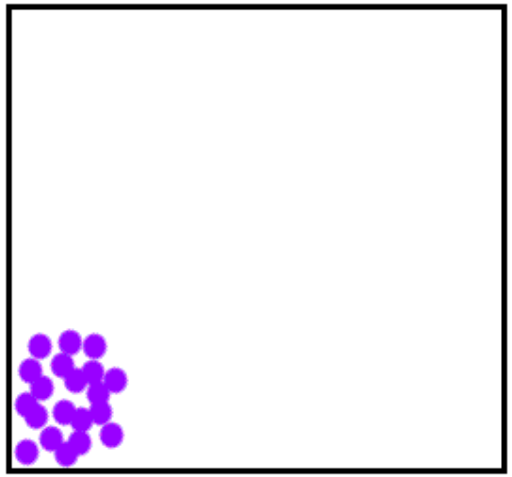


- **Diffusion**
  - movement from **HIGH → LOW** concentration

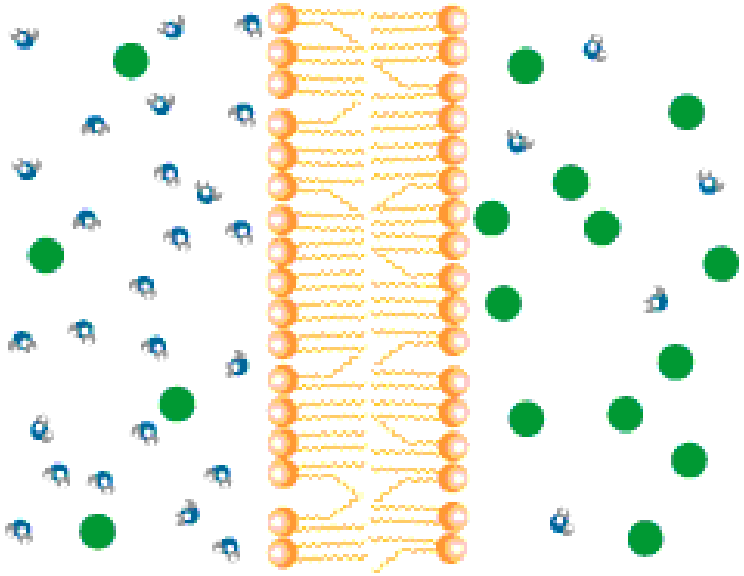
Simple Diffusion

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

movement of water



diffusion



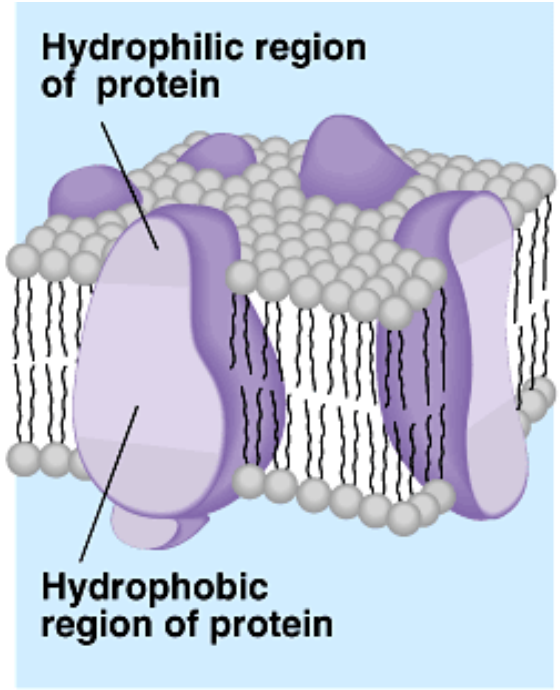
osmosis

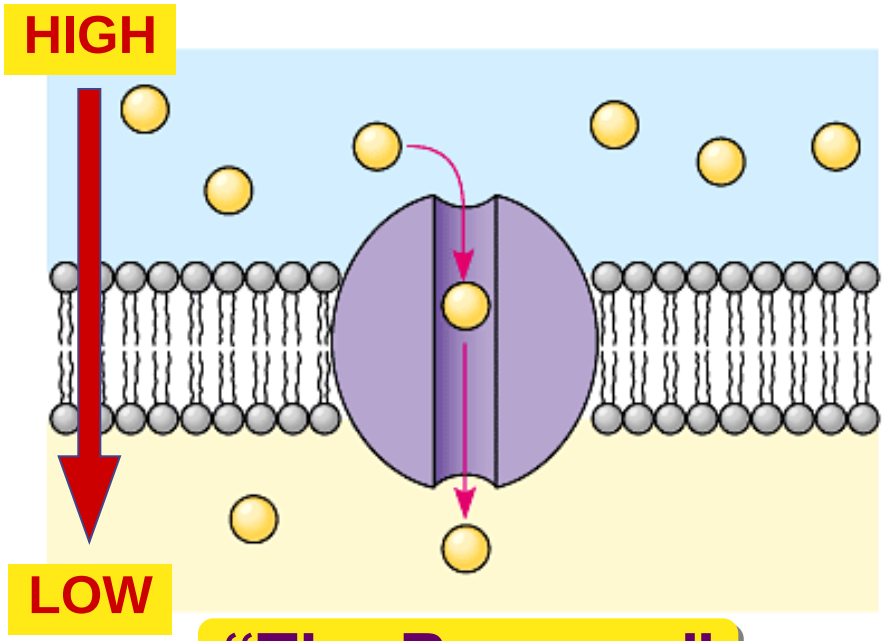
Facilitated Diffusion

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

facilitated = with help

open channel = fast transport

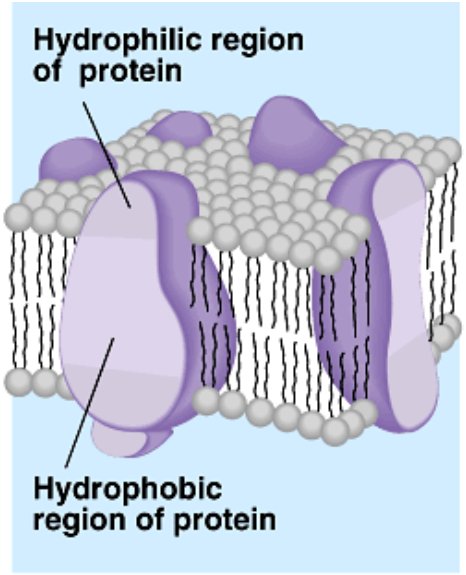


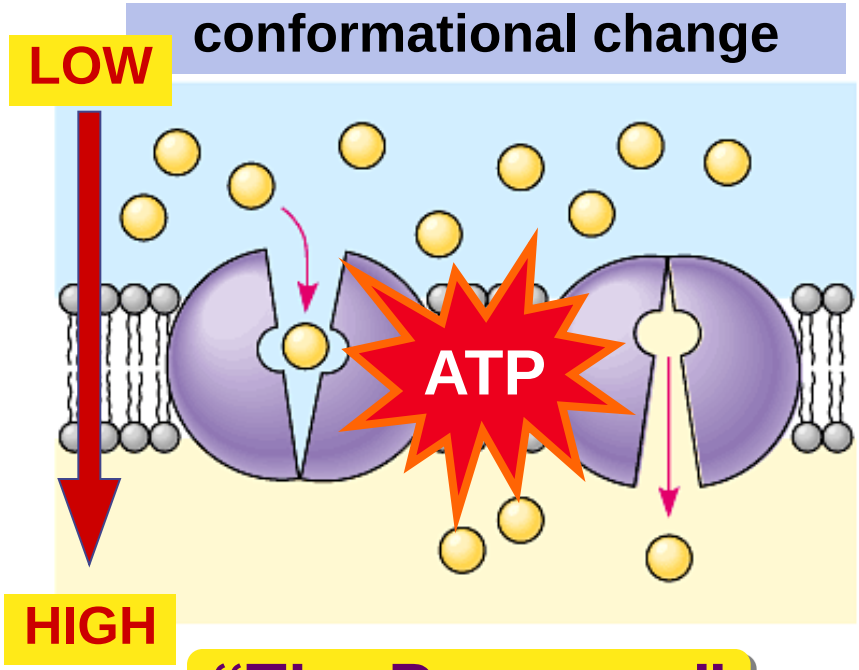


"The Bouncer"

Active Transport

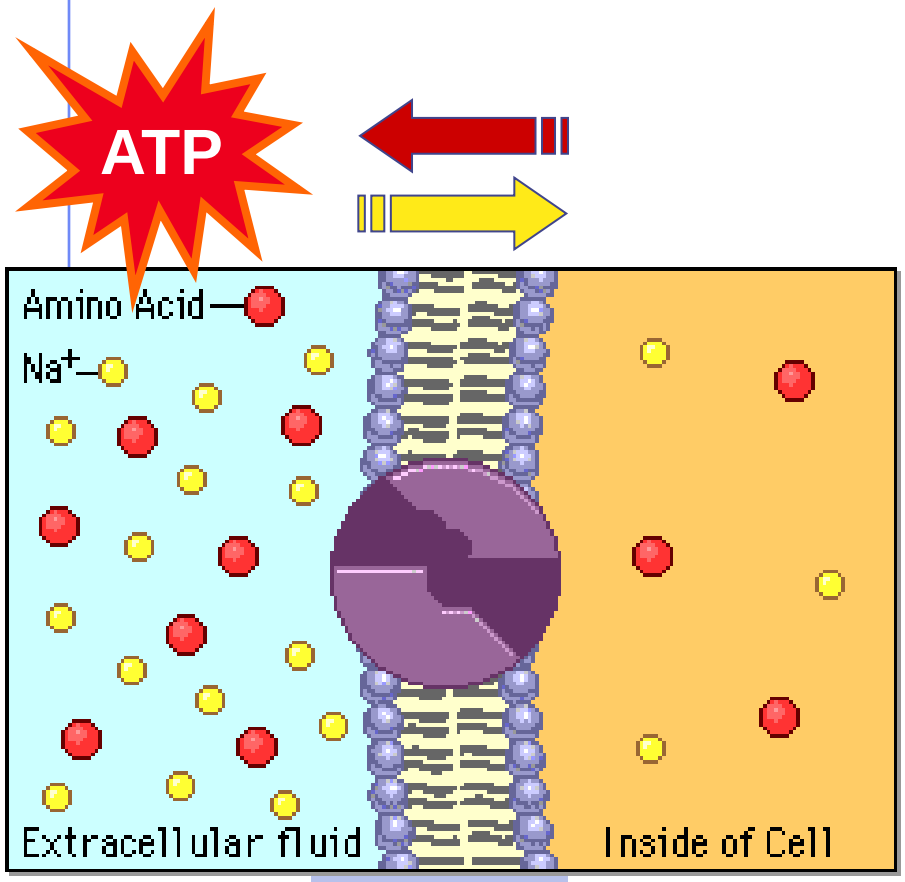
- Cells may need to move molecules ***against*** concentration gradient
  - conformational shape change transports solute from one side of membrane to other
  - **protein "pump"**
  - "costs" energy = ATP



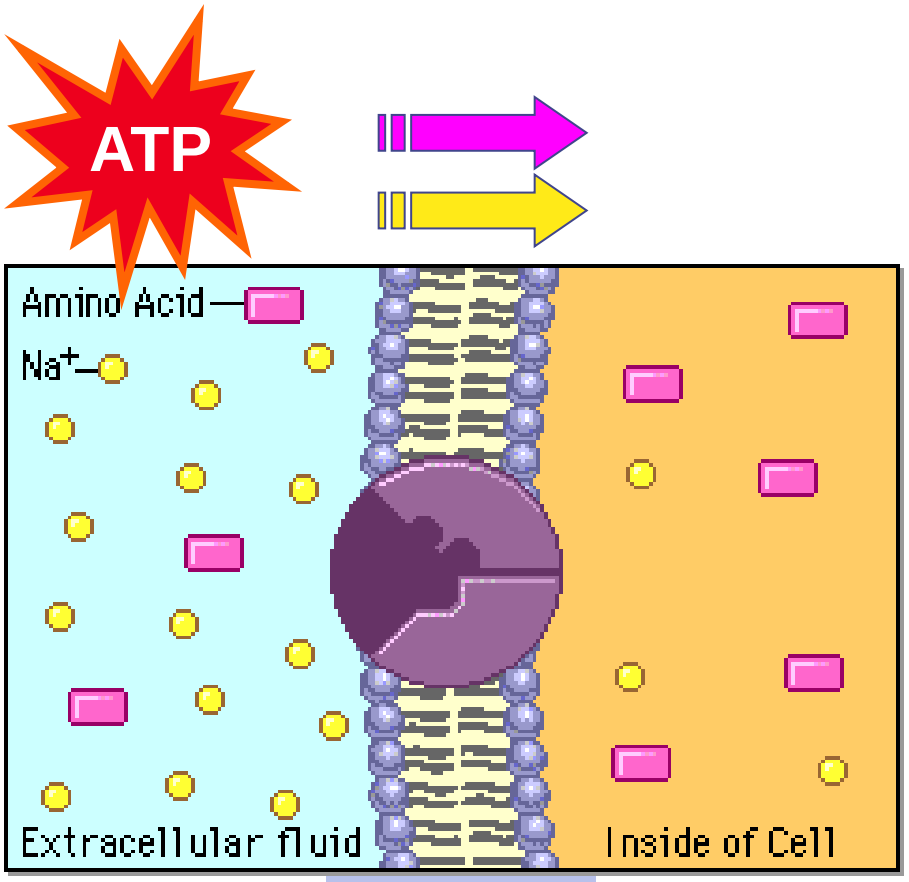


Active transport

- Many models & mechanisms



antiport

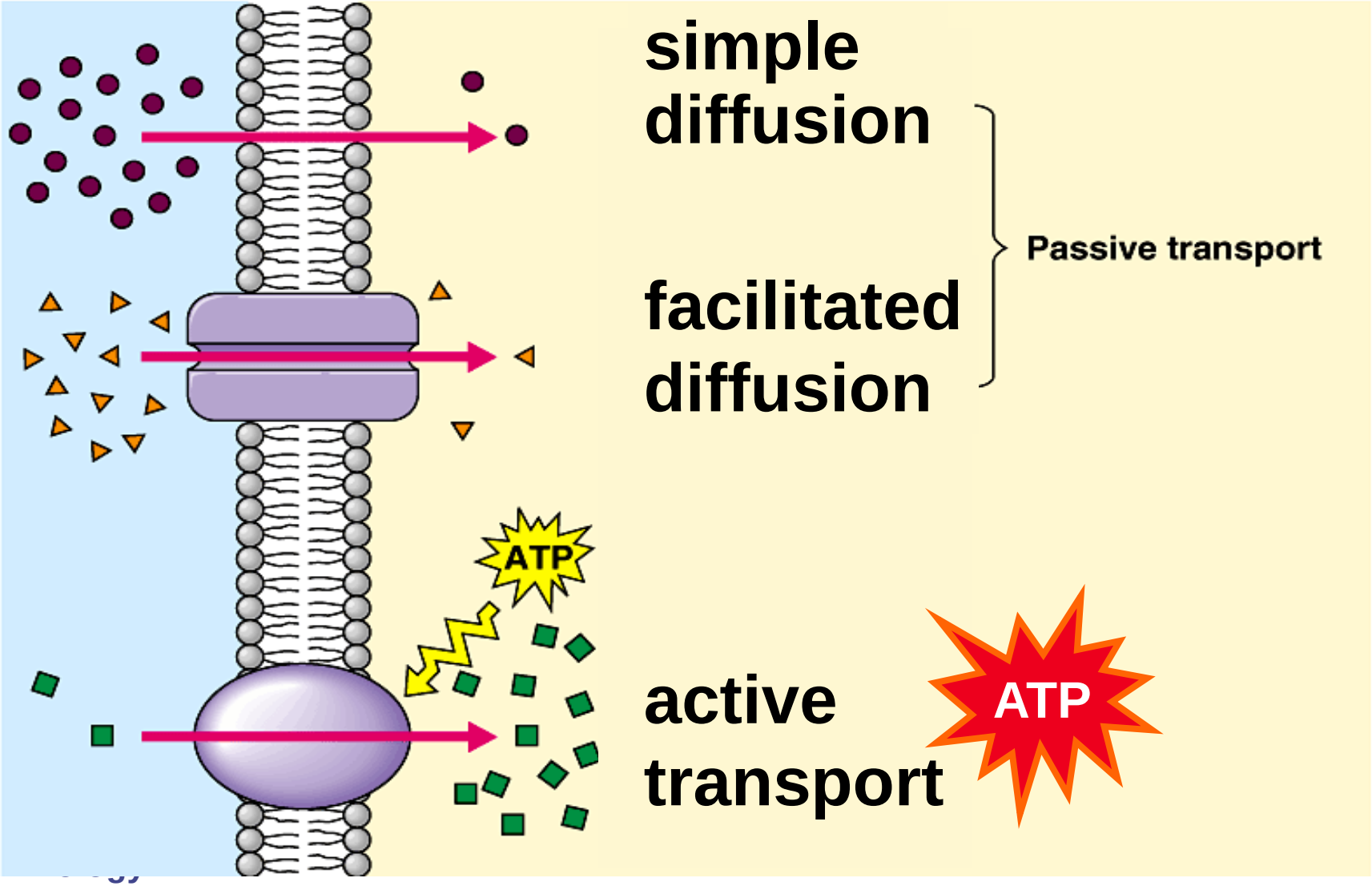


symport

Getting through cell membrane

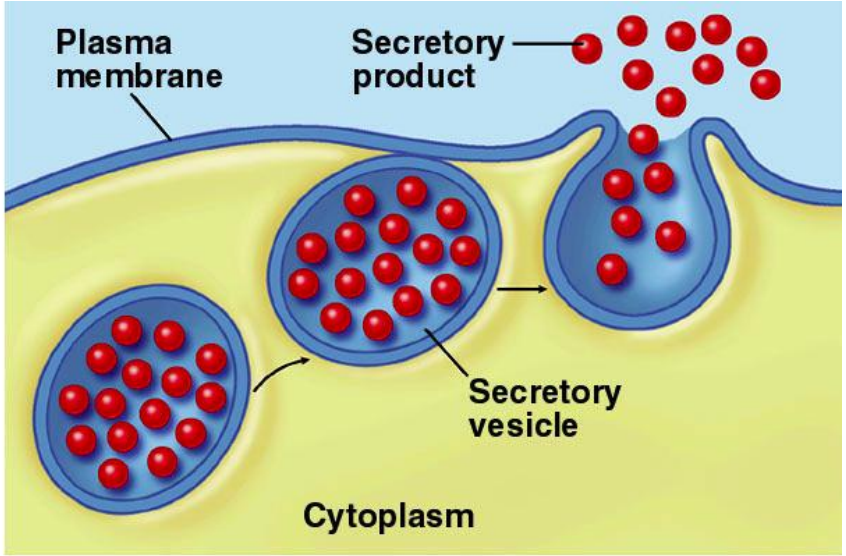
- **Passive Transport**
  - **Simple diffusion**
    - diffusion of nonpolar, hydrophobic molecules
      - lipids
      - HIGH → LOW concentration gradient
  - **Facilitated transport**
    - diffusion of polar, hydrophilic molecules
    - through a protein channel
      - HIGH → LOW concentration gradient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

Transport summary



How about large molecules?

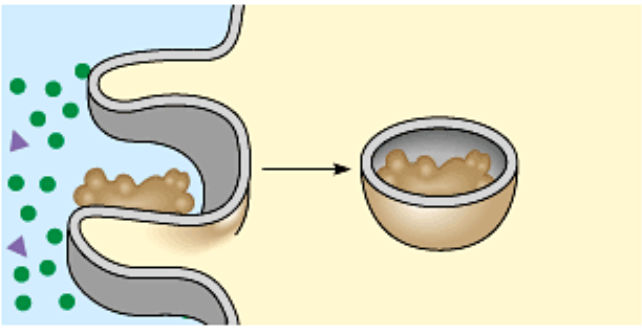
- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - endocytosis
    - phagocytosis = "cellular eating"
    - pinocytosis = "cellular drinking"
  - exocytosis



exocytosis

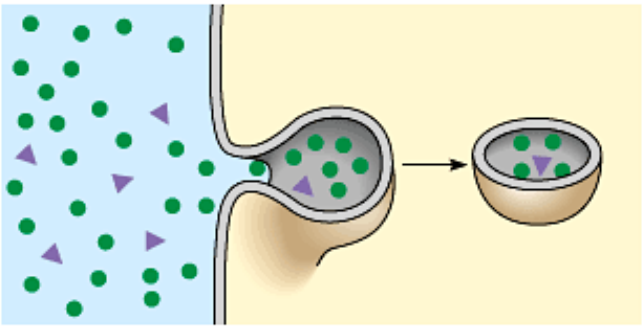
Endocytosis

phagocytosis



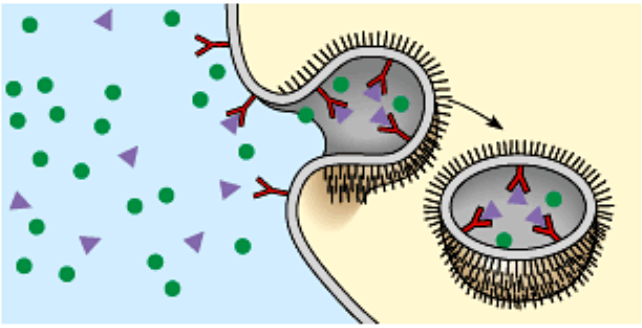
fuse with lysosome for digestion

pinocytosis



non-specific process

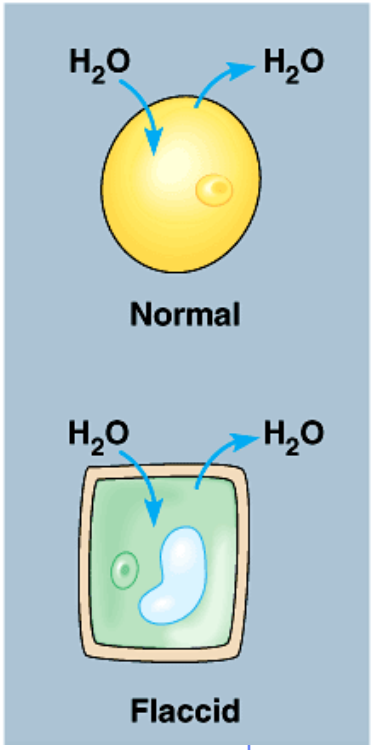
receptor-mediated endocytosis

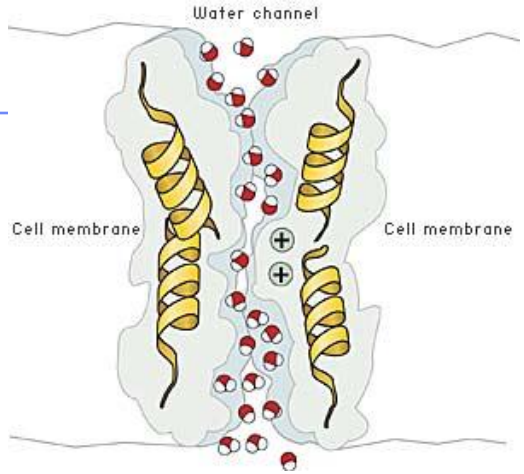


triggered by molecular signal

The Special Case of Water

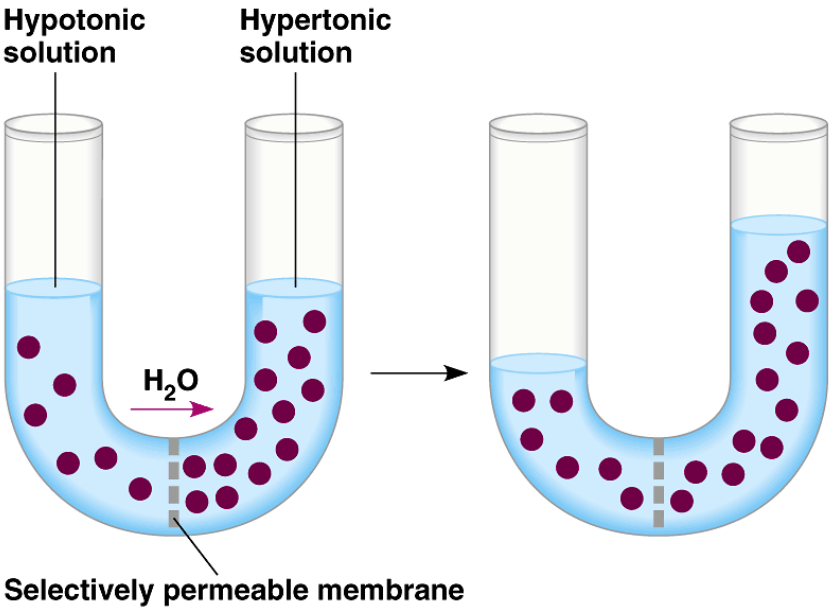
Movement of water across the cell membrane





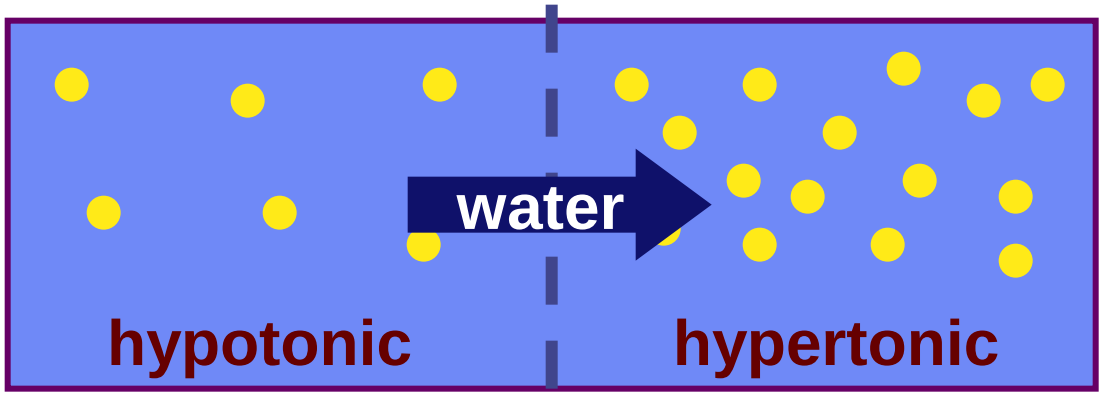
Osmosis is just diffusion of water

- 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

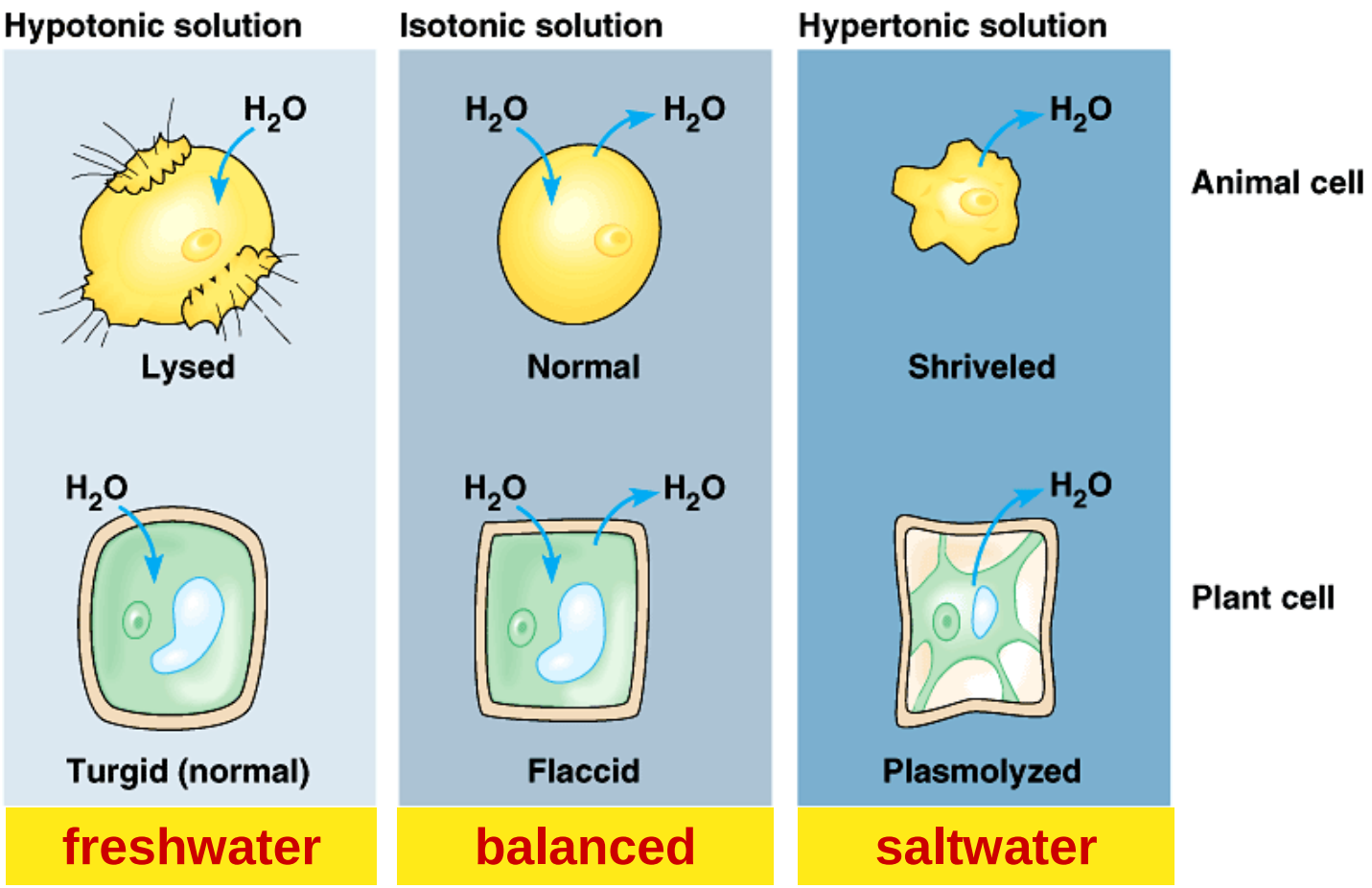
- Direction of osmosis is determined by comparing total solute concentrations
  - Hypertonic - more solute, less water
  - Hypotonic - less solute, more water
  - Isotonic - equal solute, equal water



net movement of water

Managing water balance

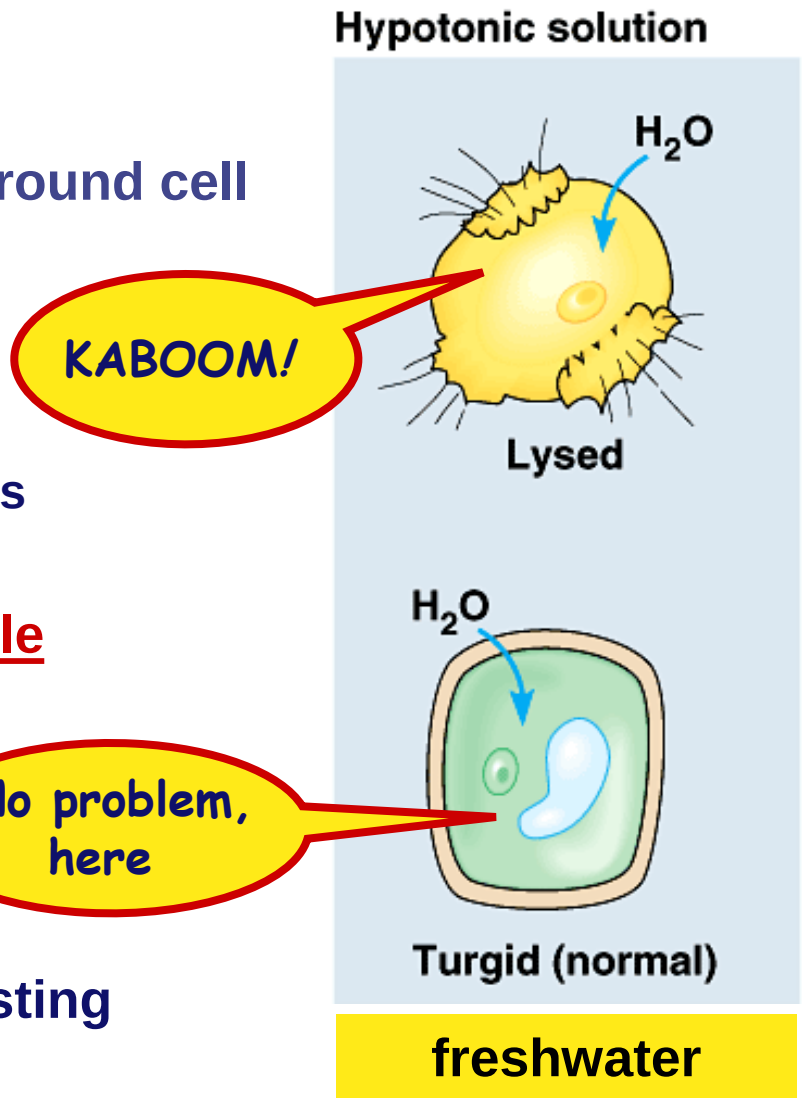
- Cell survival depends on balancing water uptake & loss



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

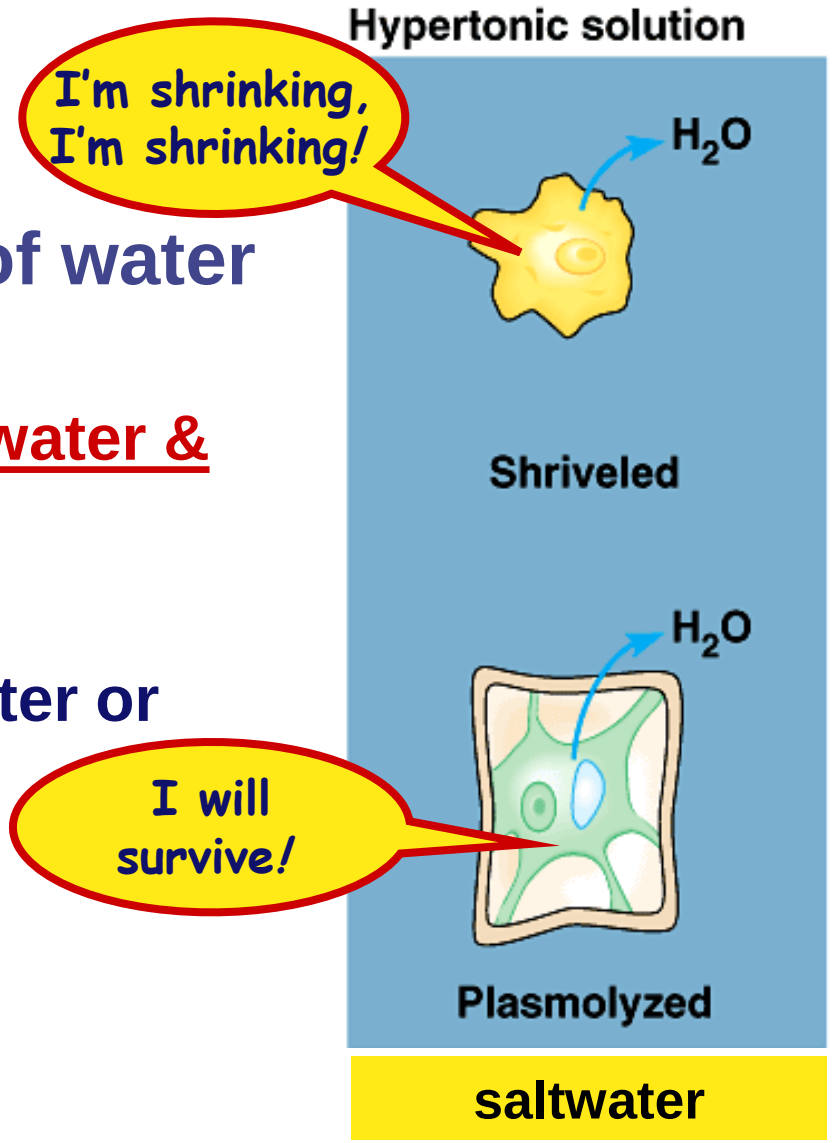


Pumping water out

- Contractile vacuole in *Paramecium*

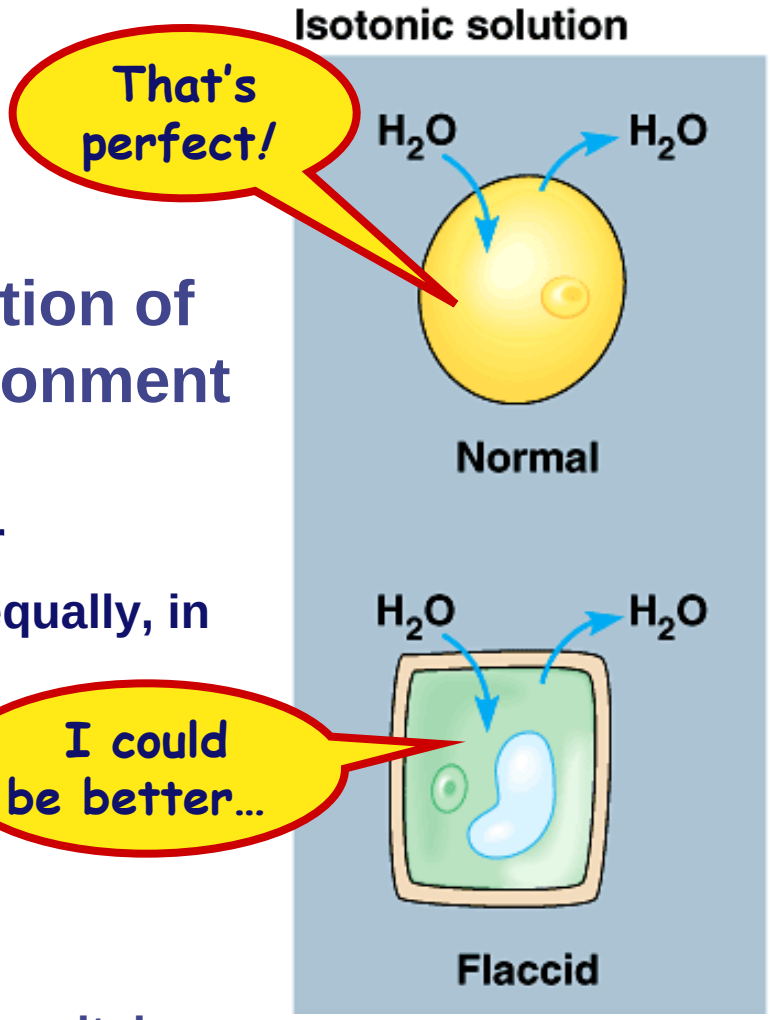
Managing water balance

- **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



Managing water balance

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

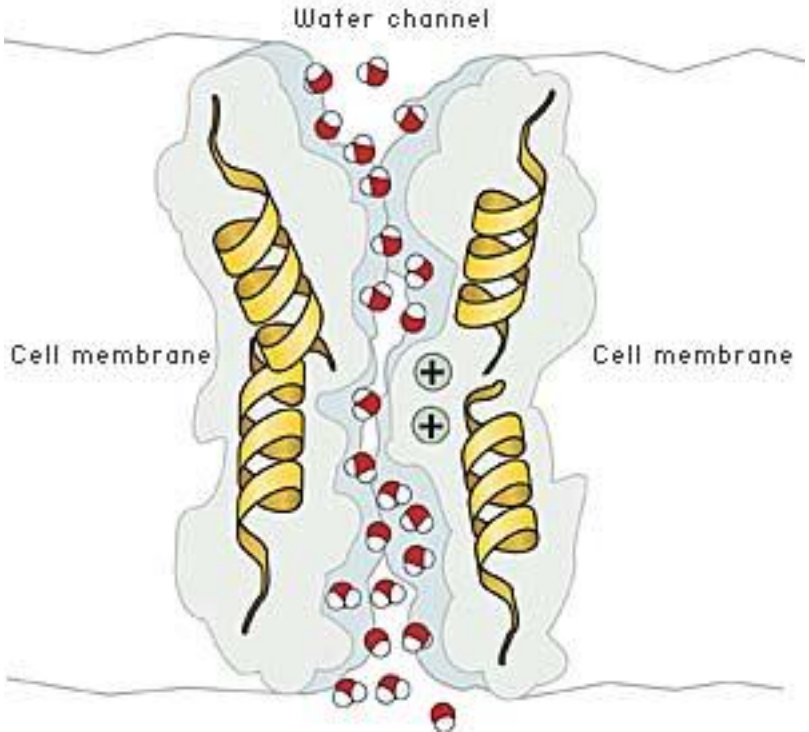


balanced

1991 | 2003

Aquaporins

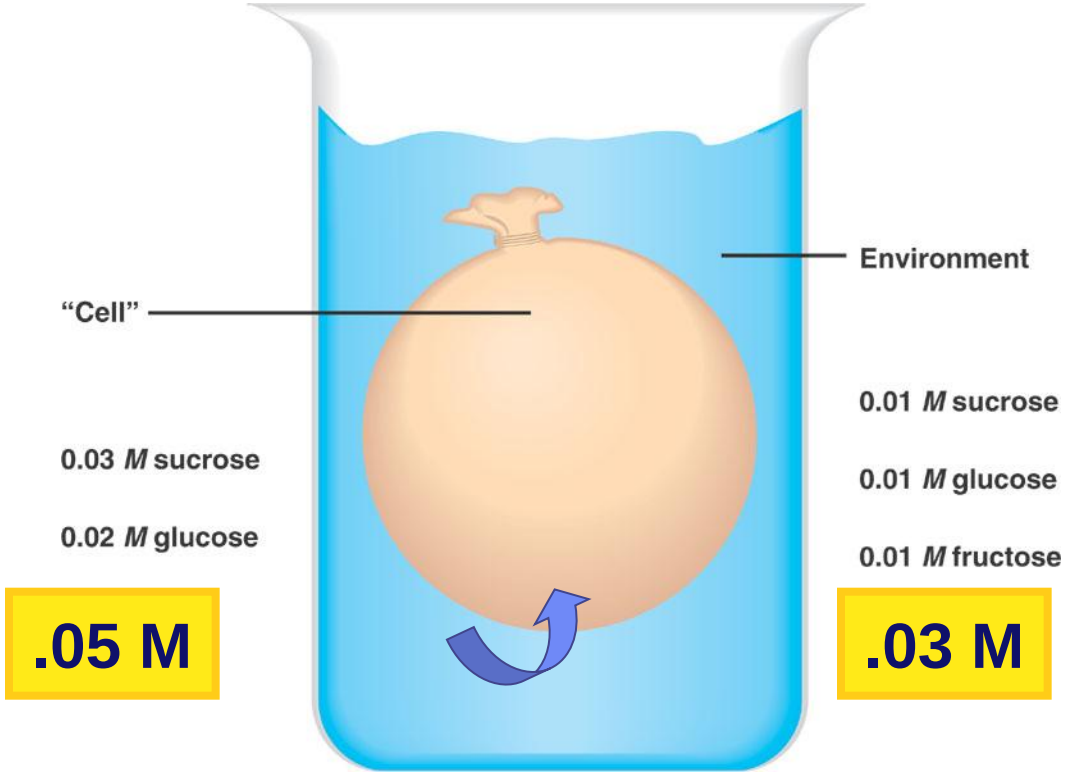
- Water moves <u>rapidly</u> into & out of cells
  - evidence that there were water channels
    - protein channels allowing flow of water across cell membrane



Peter Agre
John Hopkins

Roderick MacKinnon
Rockefeller

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??