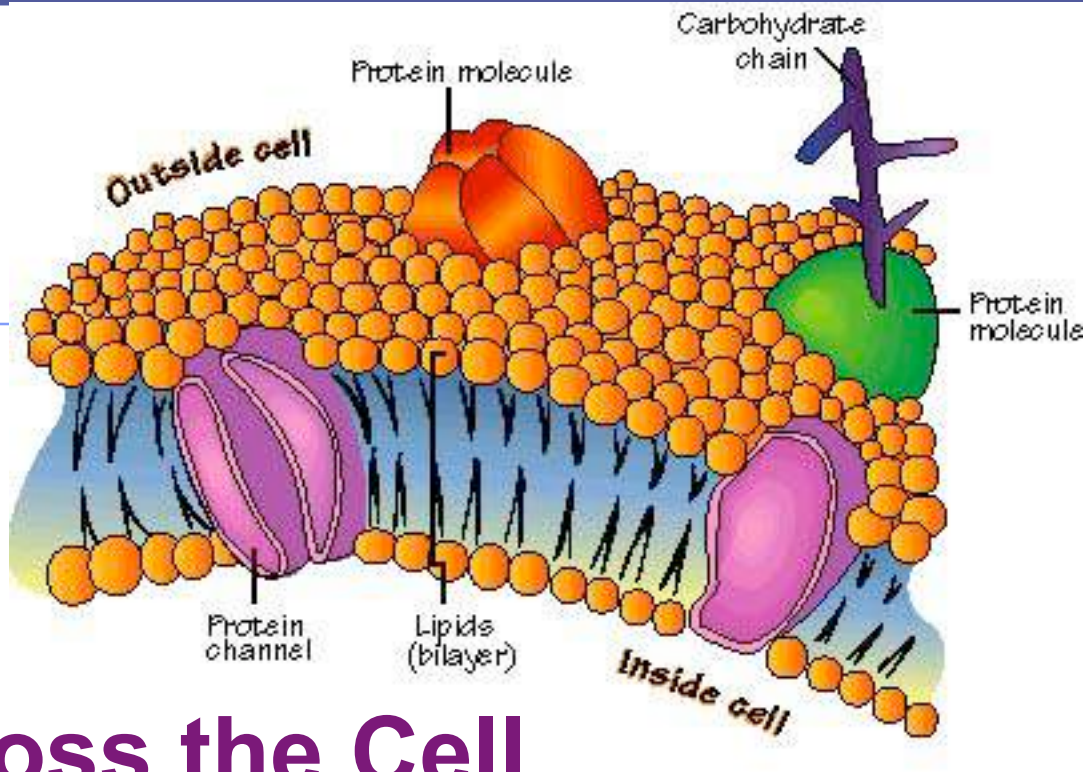
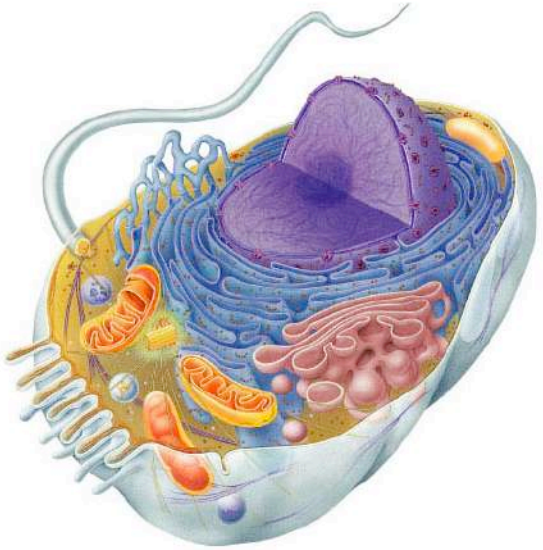


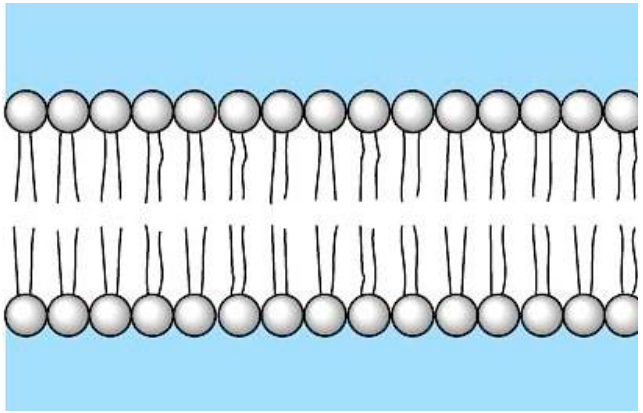
Chapter 8.

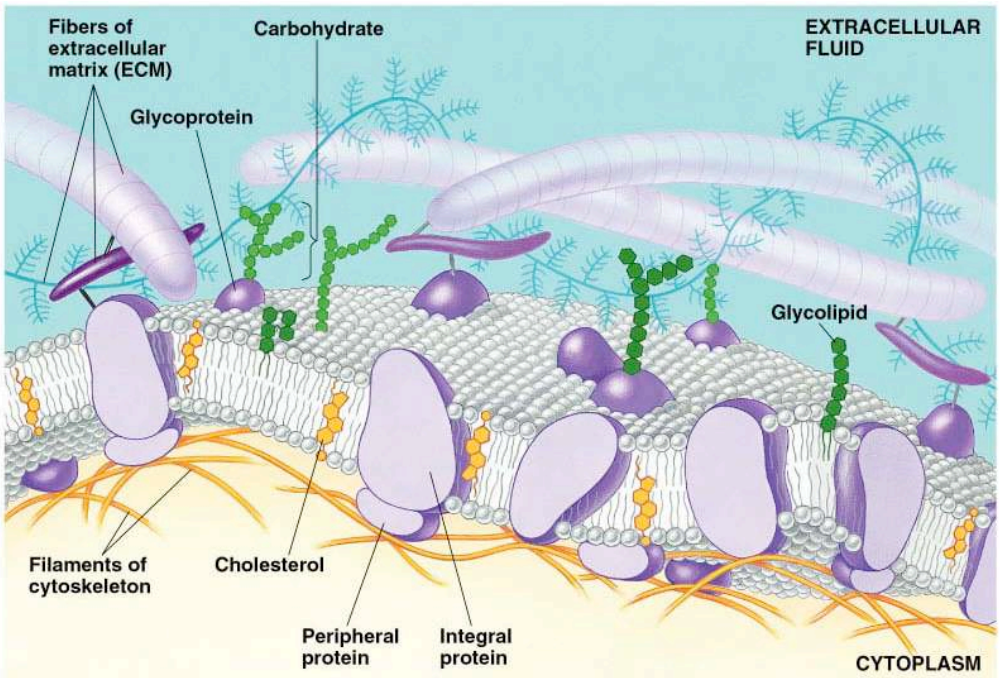
Movement across the Cell Membrane



More than just a barrier…

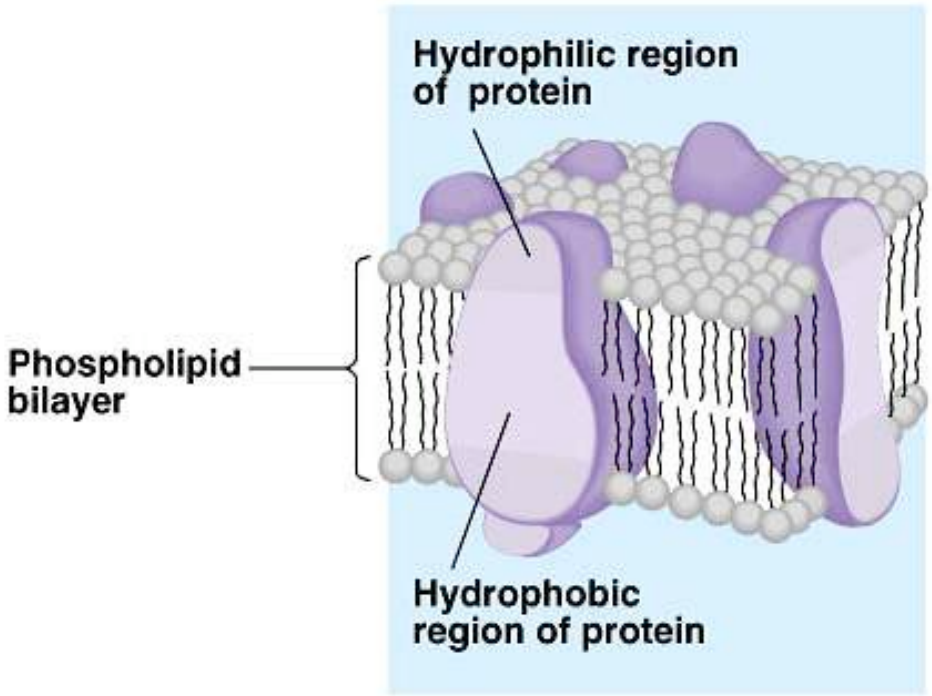
- Expanding our view of cell membrane beyond just a phospholipid bilayer barrier
  - phospholipids plus…



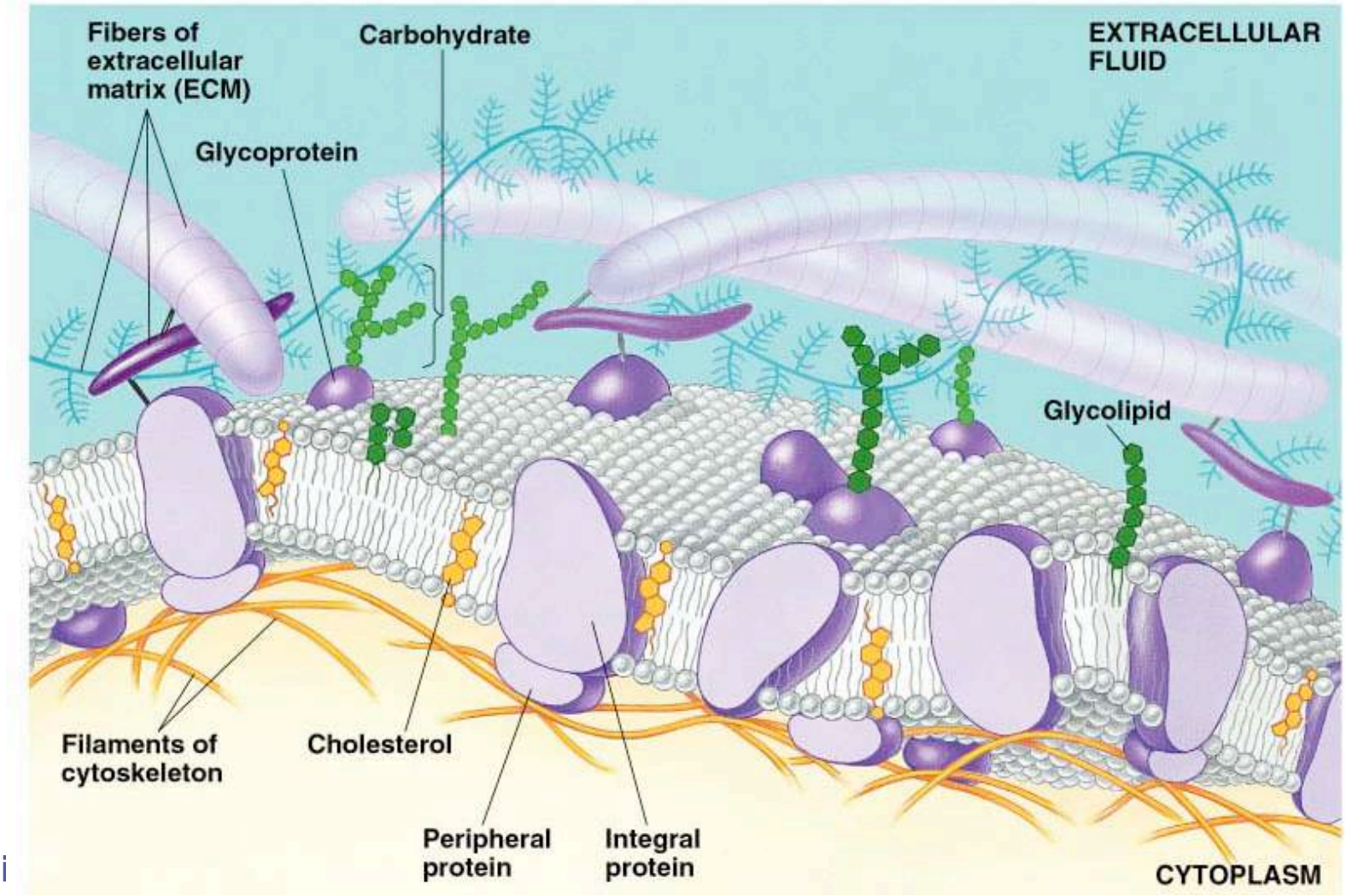


Fluid Mosaic Model

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

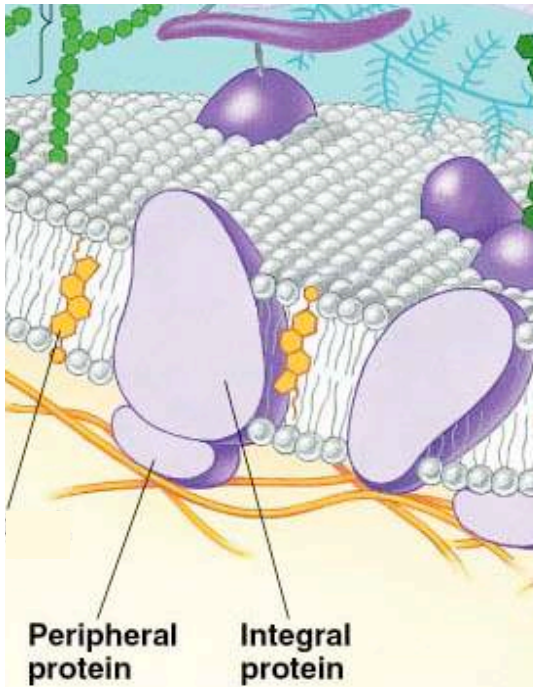


A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer



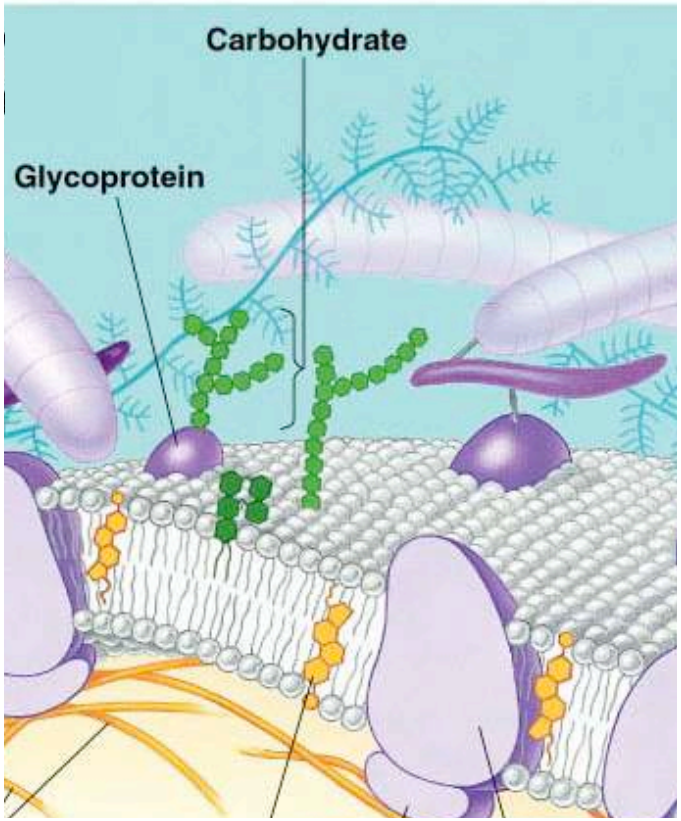
Membrane Proteins

- **Proteins determine most of membrane's specific functions**
  - cell membrane & organelle membranes each have unique collections of proteins
- **Membrane proteins:**
  - peripheral proteins = loosely bound to surface of membrane
  - integral proteins = penetrate into lipid bilayer, often completely spanning the membrane = *transmembrane* protein

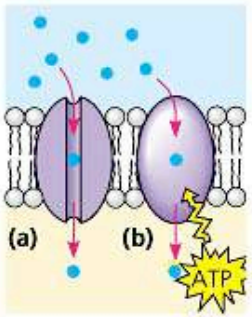


Membrane Carbohydrates

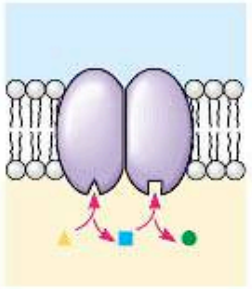
- Play a key role in cell-cell recognition
  - ability of a cell to distinguish neighboring cells from another
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system



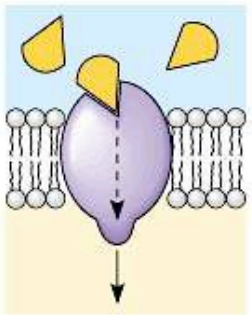
Membranes provide a variety of cell functions



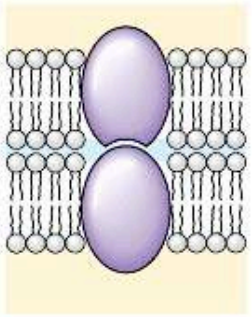
Transport



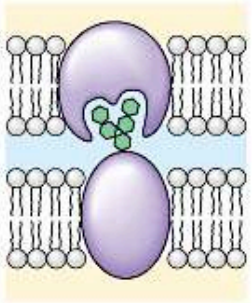
Enzymatic activity



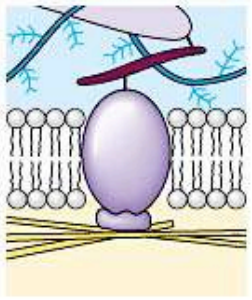
Signal transduction



Intercellular joining



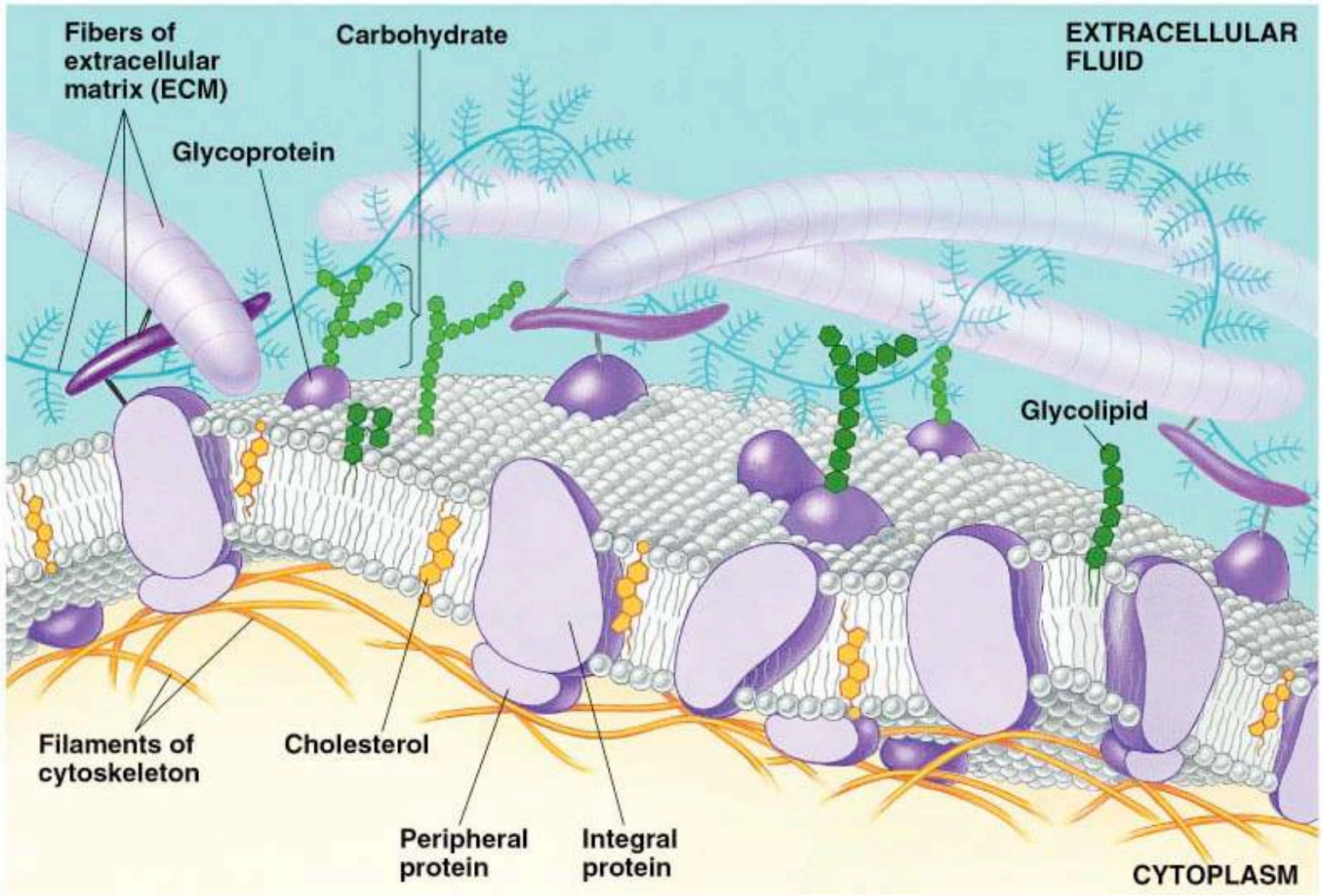
Cell-cell recognition



Attachment to the cytoskeleton and extracellular matrix (ECM)

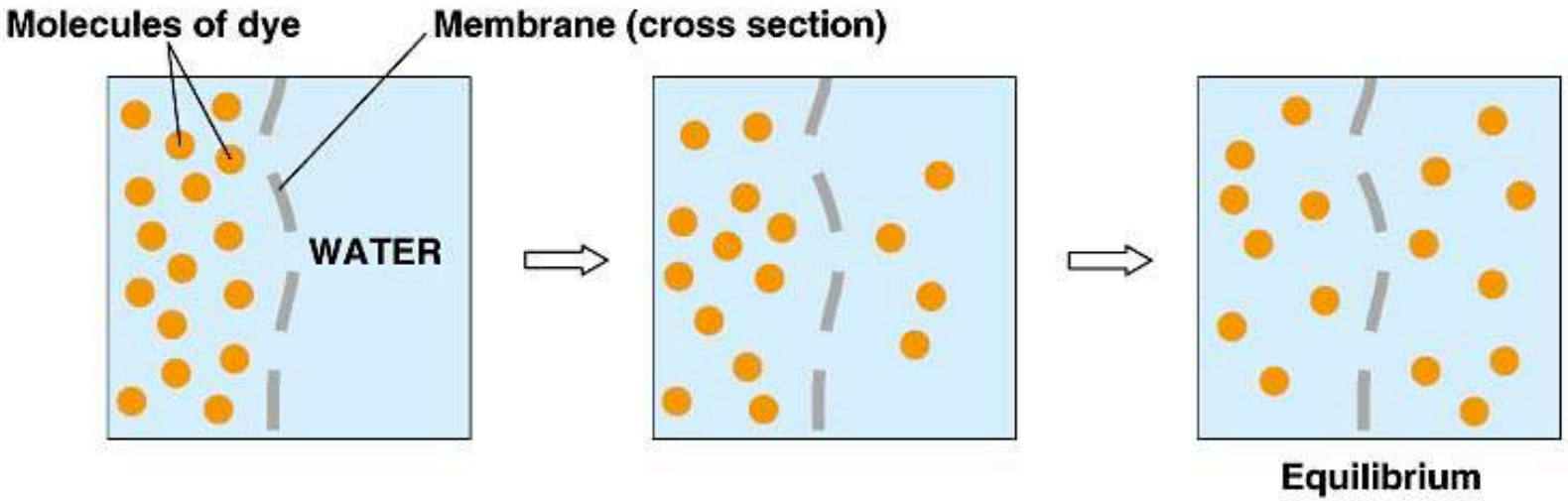
Any Questions??

Fluid Mosaic Model



Diffusion

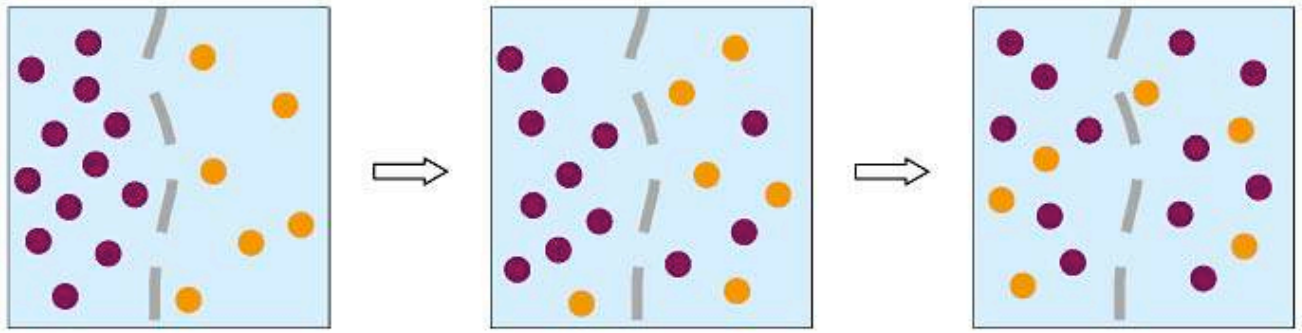
- **2nd Law of Thermodynamics governs biological systems**
  - Universe tends towards disorder



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

Diffusion of 2 solutes

- Each substance diffuses down its ***own*** concentration gradient, independent of concentration gradients of other substances



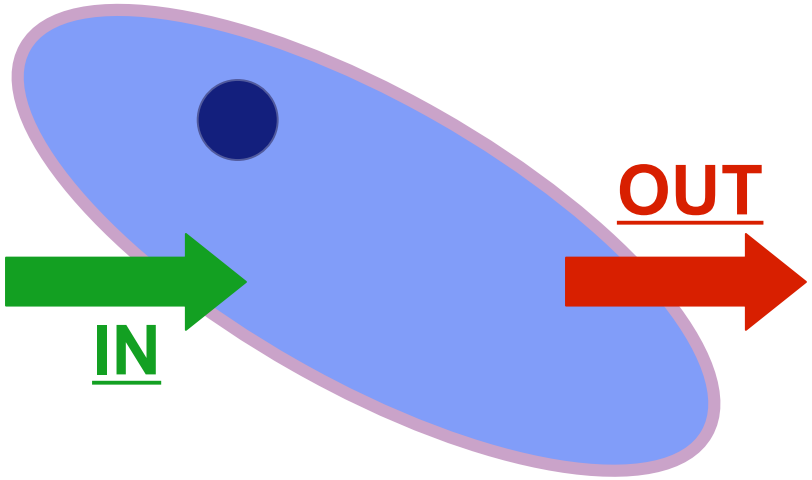
(b) Diffusion of two solutes

Cell (plasma) membrane

- Cells need an inside & an outside…
  - separate cell from its environment
  - cell membrane is the boundary

Can it be an impenetrable boundary? **NO!**

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

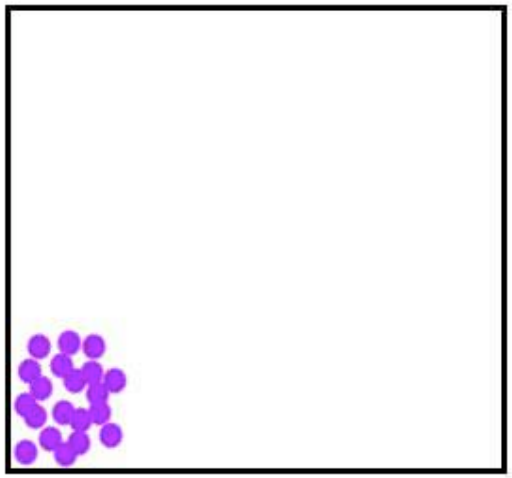


OUT
waste
ammonia
salts
CO_2
H_2O
products

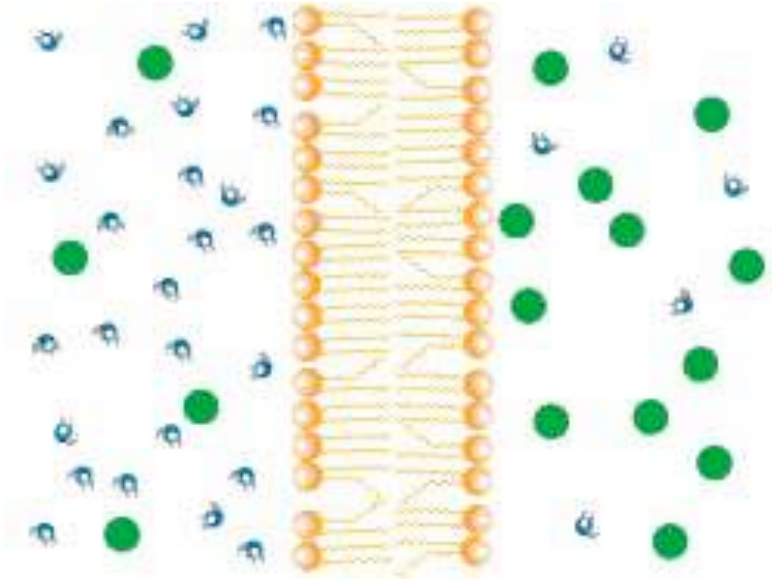
cell needs materials in & products or waste out

Diffusion

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



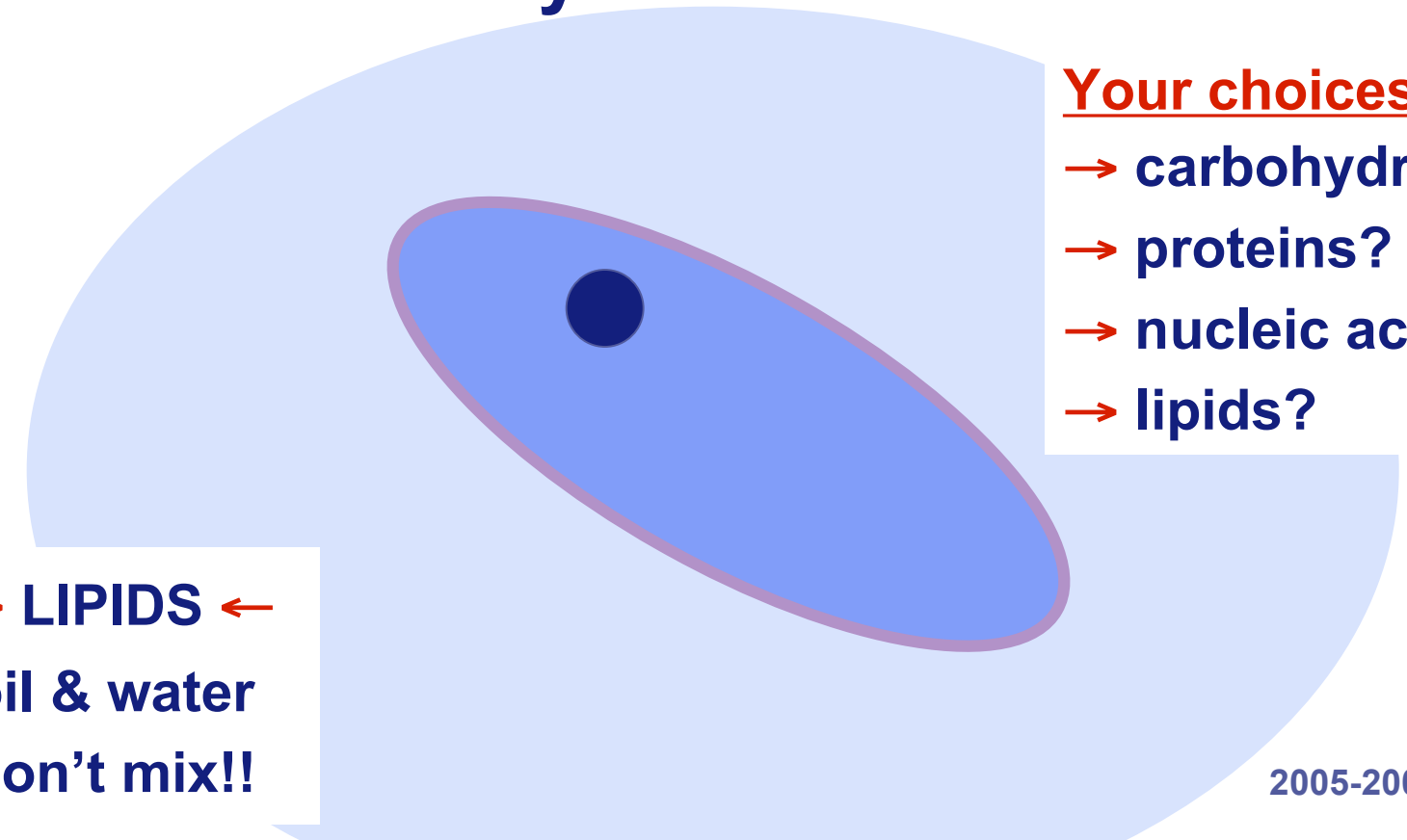
diffusion



osmosis

Building a membrane

- How do you build a barrier that keeps the watery contents of the cell separate from the watery environment?



Your choices

→ carbohydrates?

→ proteins?

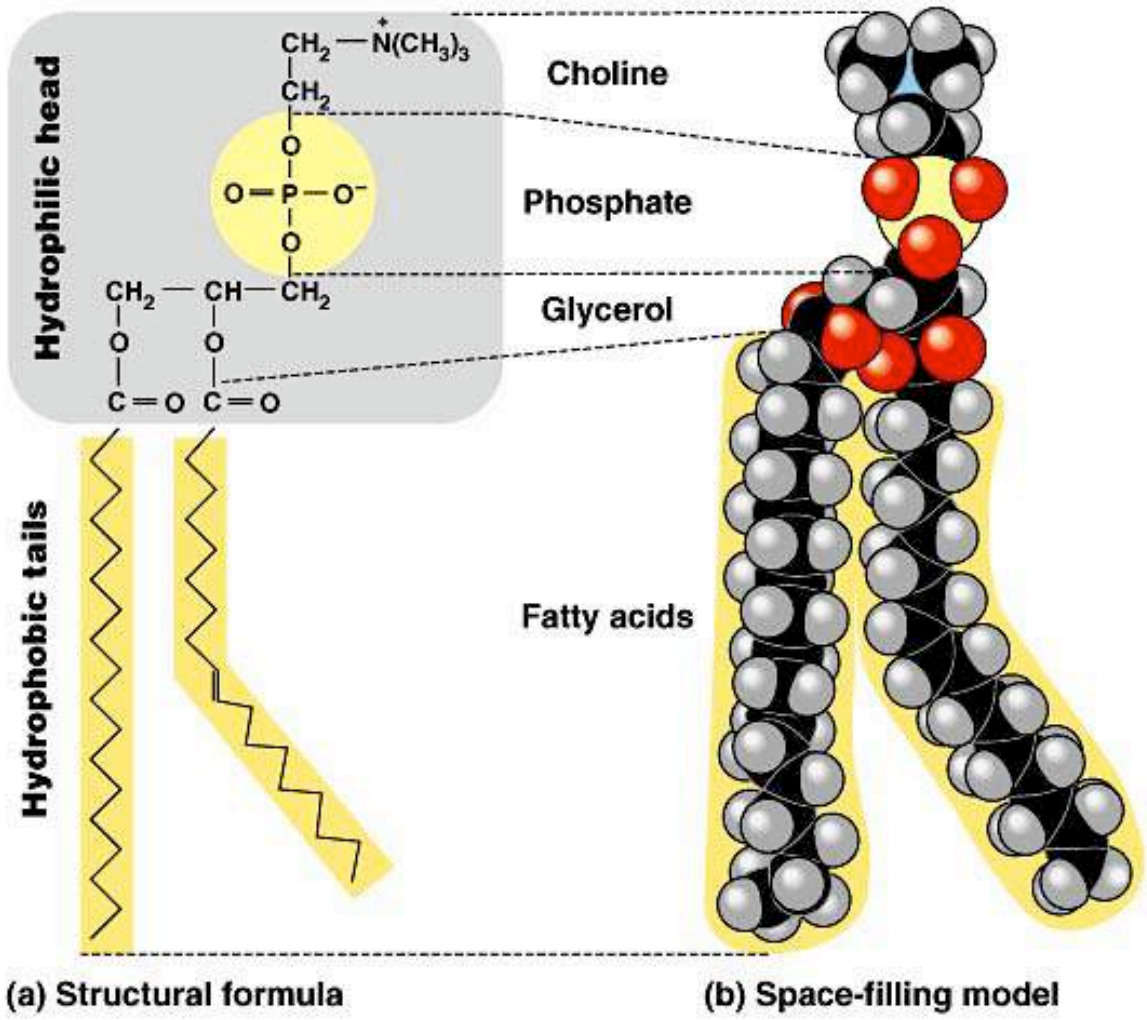
→ nucleic acids?

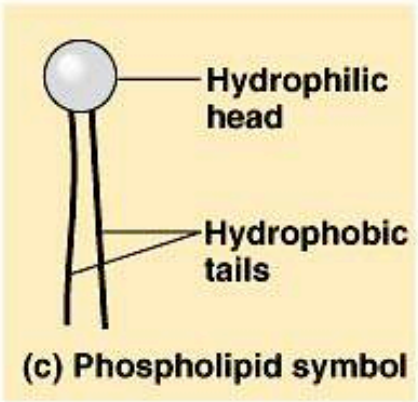
→ lipids?

→ LIPIDS ←

oil & water don't mix!!

Phospholipids





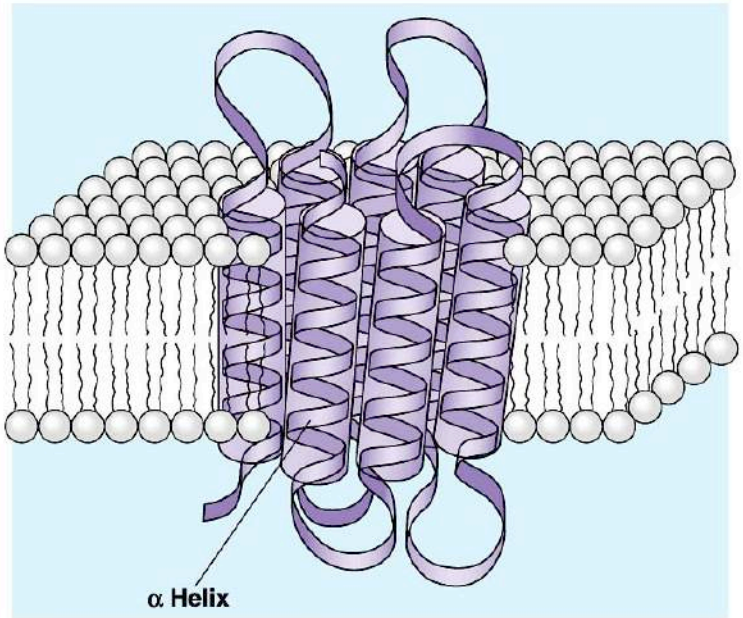
Semi-permeable membrane

- Need to allow passage through the membrane
- But need to control what gets in or out
  - membrane needs to be semi-permeable

So how do you build a semi-permeable membrane?

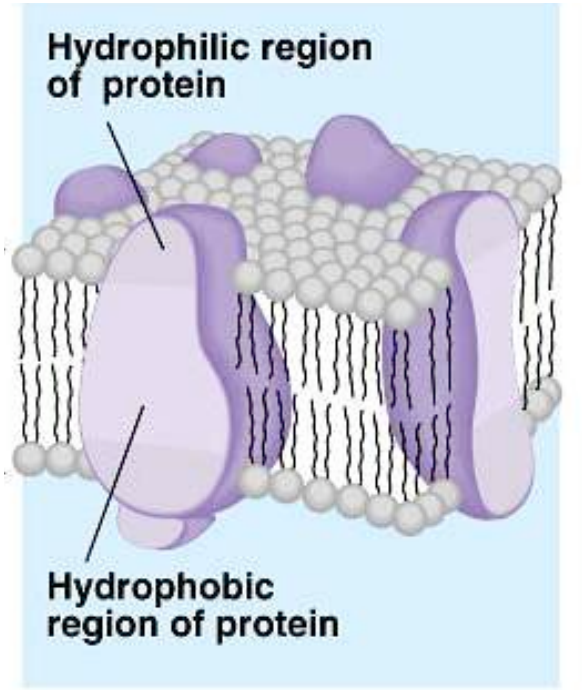
Why proteins?

- Proteins are mixed molecules
  - hydrophobic amino acids
    - stick in the lipid membrane
    - anchors the protein in membrane
  - hydrophilic amino acids
    - stick out in the watery fluid in & around cell
    - specialized “receptor” for specific molecules

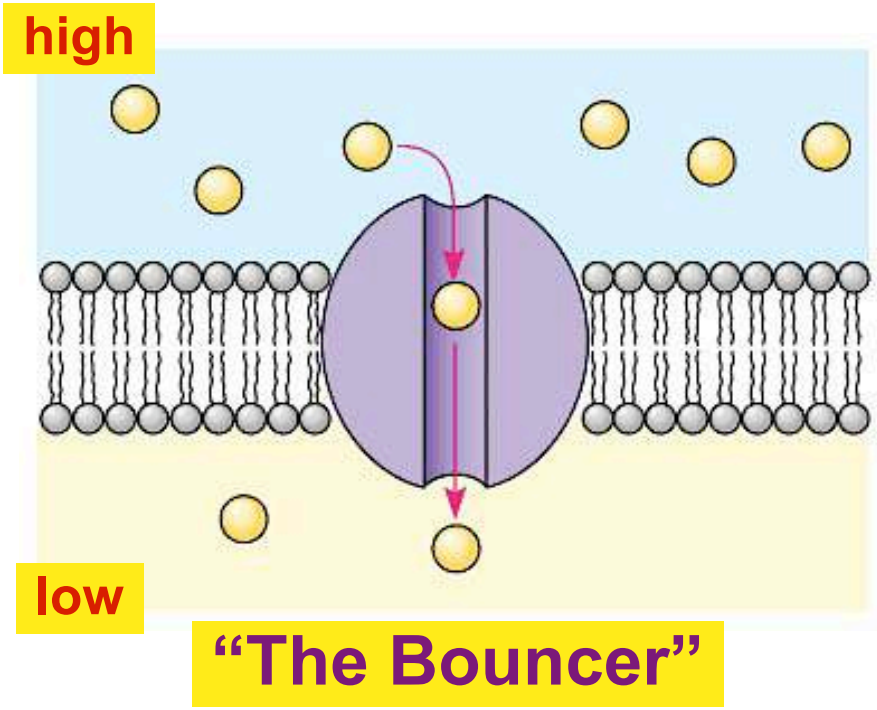


Facilitated Diffusion

- Globular proteins act as doors in membrane
  - channels to move specific molecules through cell membrane



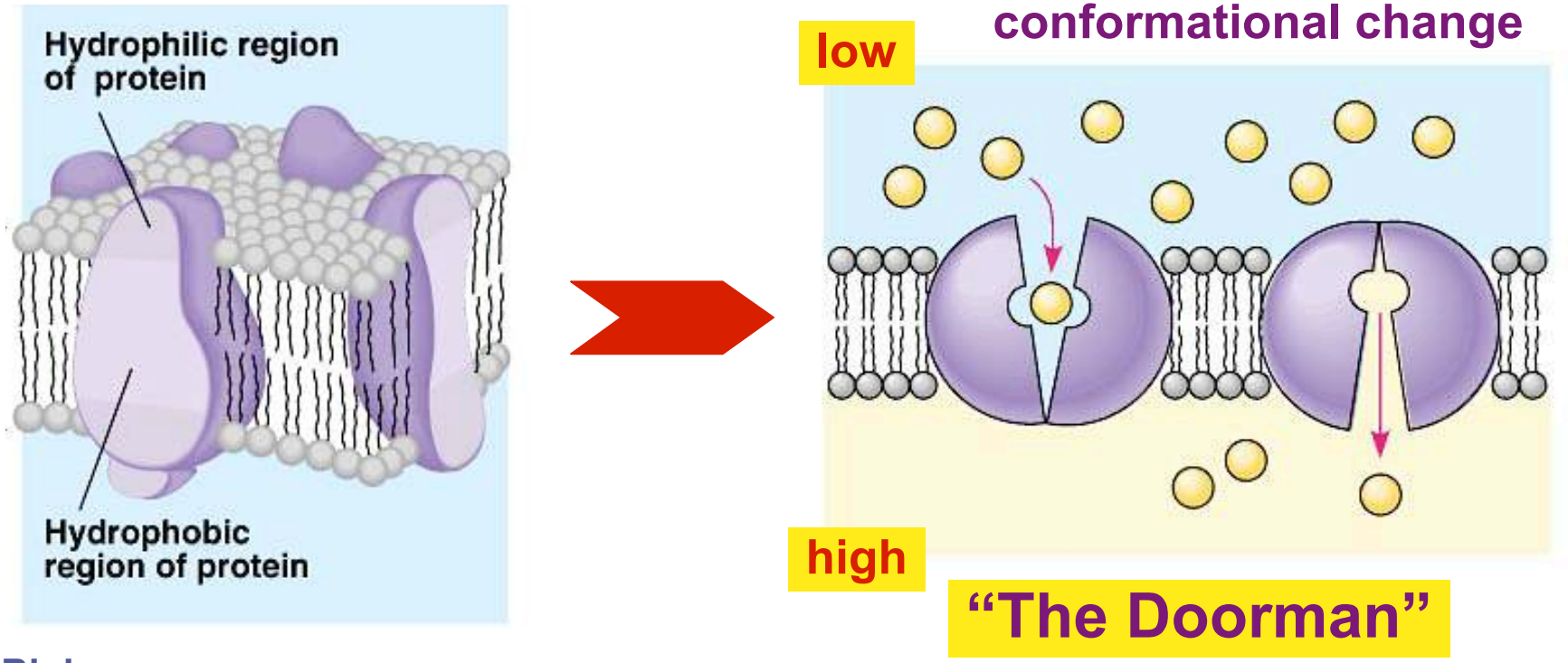
open channel = fast transport



"The Bouncer"

Active Transport

- **Globular proteins act as ferry for specific molecules**
  - shape change transports solute from one side of membrane to other → protein "pump"
  - "costs" energy

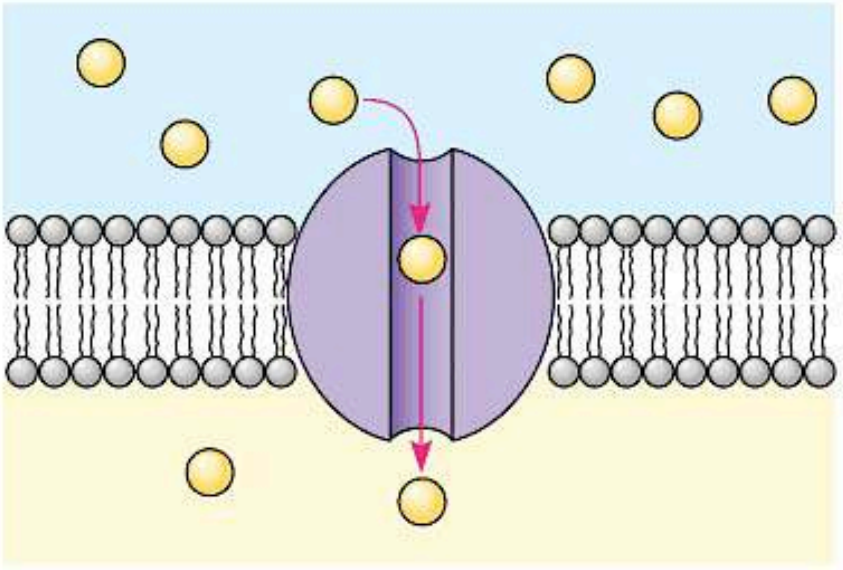


Getting through cell membrane

- **Passive transport**
  - diffusion of hydrophobic (lipids) molecules
    - high → low concentration gradient
- **Facilitated transport**
  - diffusion of hydrophilic molecules
  - through a protein channel
    - high → low concentration gradient
- **Active transport**
  - diffusion against concentration gradient
    - low → high
  - uses a protein pump
  - requires ATP

Facilitated diffusion

- Move from HIGH to LOW concentration through a protein channel
  - passive transport
  - no energy needed
  - facilitated = with help

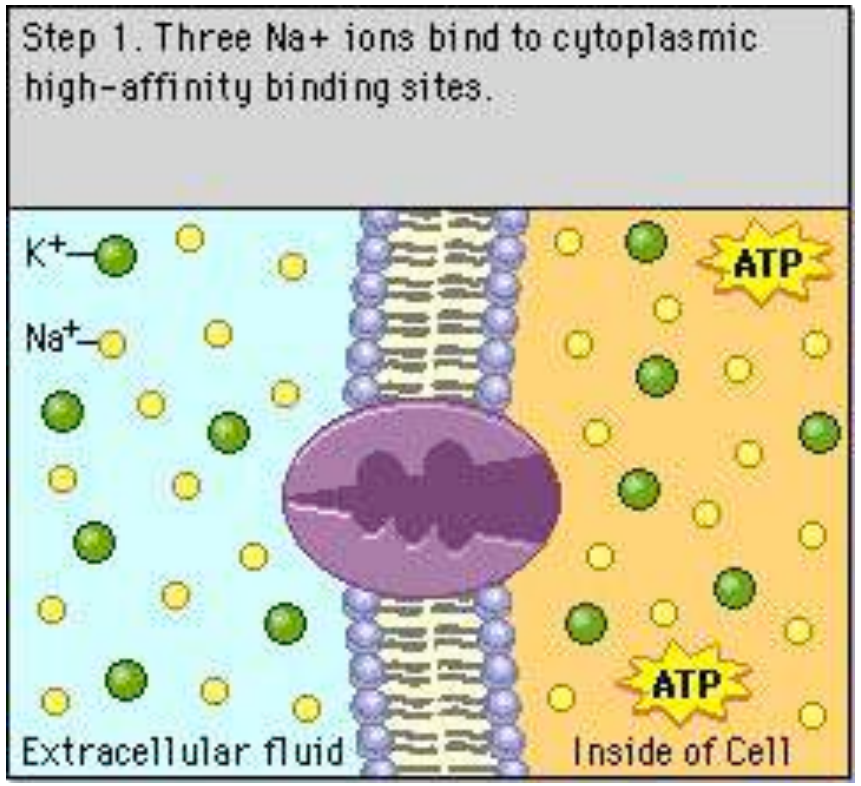


Gated channels

- **Some channel proteins open only in presence of stimulus (signal)**
  - **stimulus usually different from transported molecule**
    - **ex: ion-gated channels**
      when neurotransmitters bind to a specific gated channels on a neuron, these channels open = allows Na^+ ions to enter nerve cell
    - **ex: voltage-gated channels**
      change in electrical charge across nerve cell membrane opens Na^+ & K^+ channels

Active transport

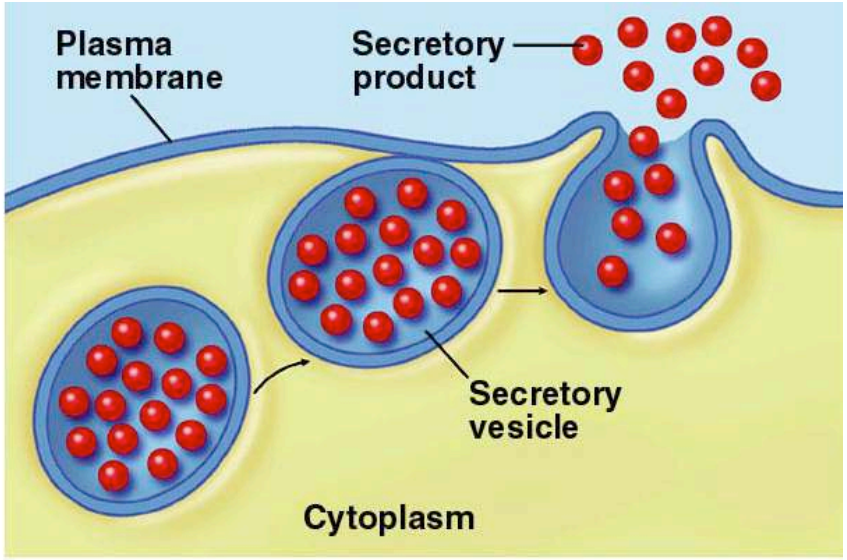
- Cells may need molecules to move ***against*** concentration situation
  - need to pump against concentration
  - protein pump
  - requires energy
    - ATP



Na+/K+ pump in nerve cell membranes

How about large molecules?

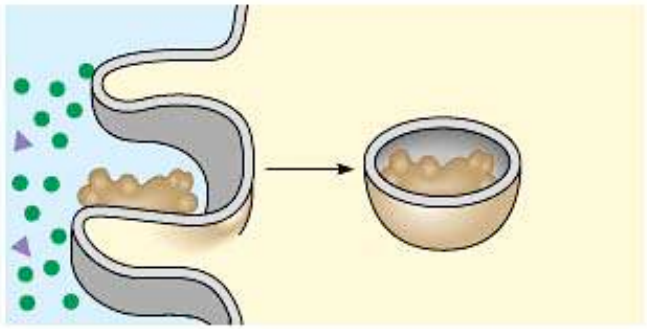
- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - endocytosis
    - phagocytosis = “cellular eating”
    - pinocytosis = “cellular drinking”
    - receptor-mediated endocytosis
  - exocytosis



exocytosis

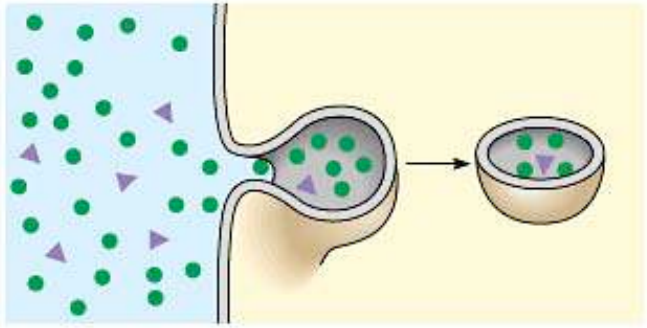
Endocytosis

phagocytosis



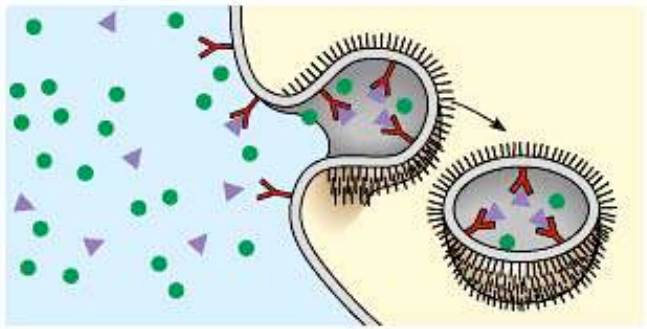
fuse with lysosome for digestion

pinocytosis



non-specific process

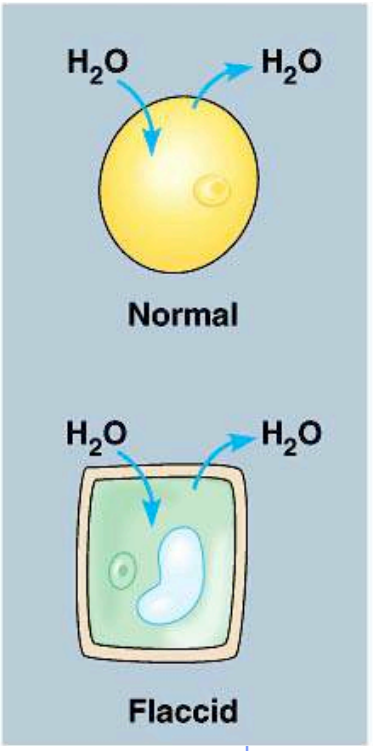
receptor-mediated endocytosis

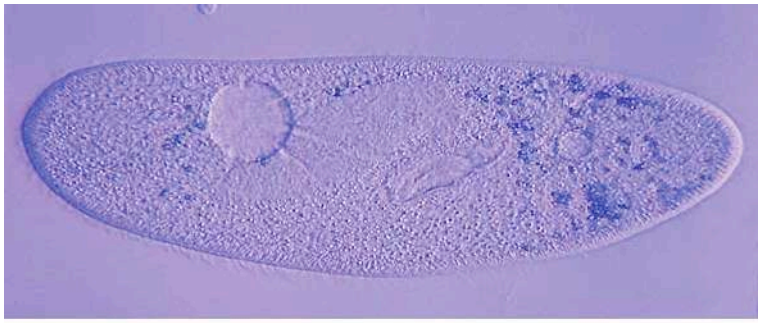


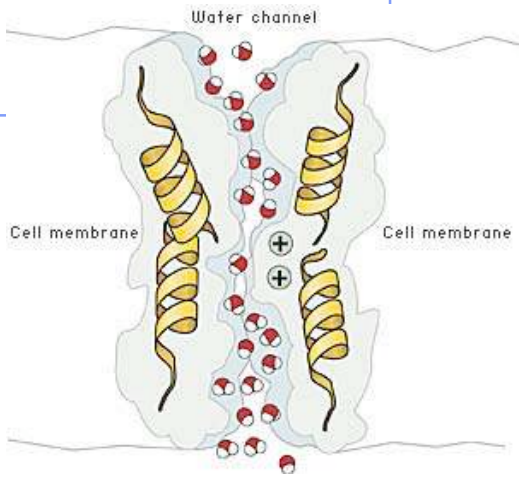
triggered by ligand signal

The Special Case of Water

Movement of water across the cell membrane

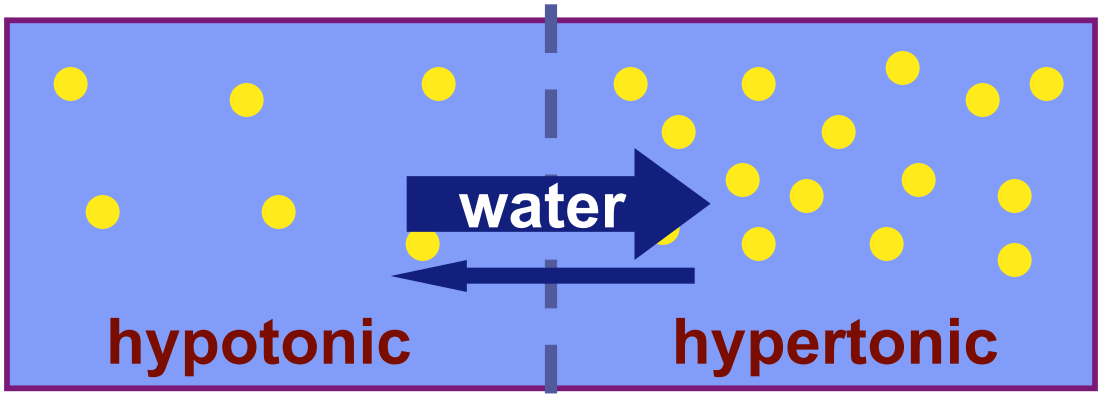






Concentration of water

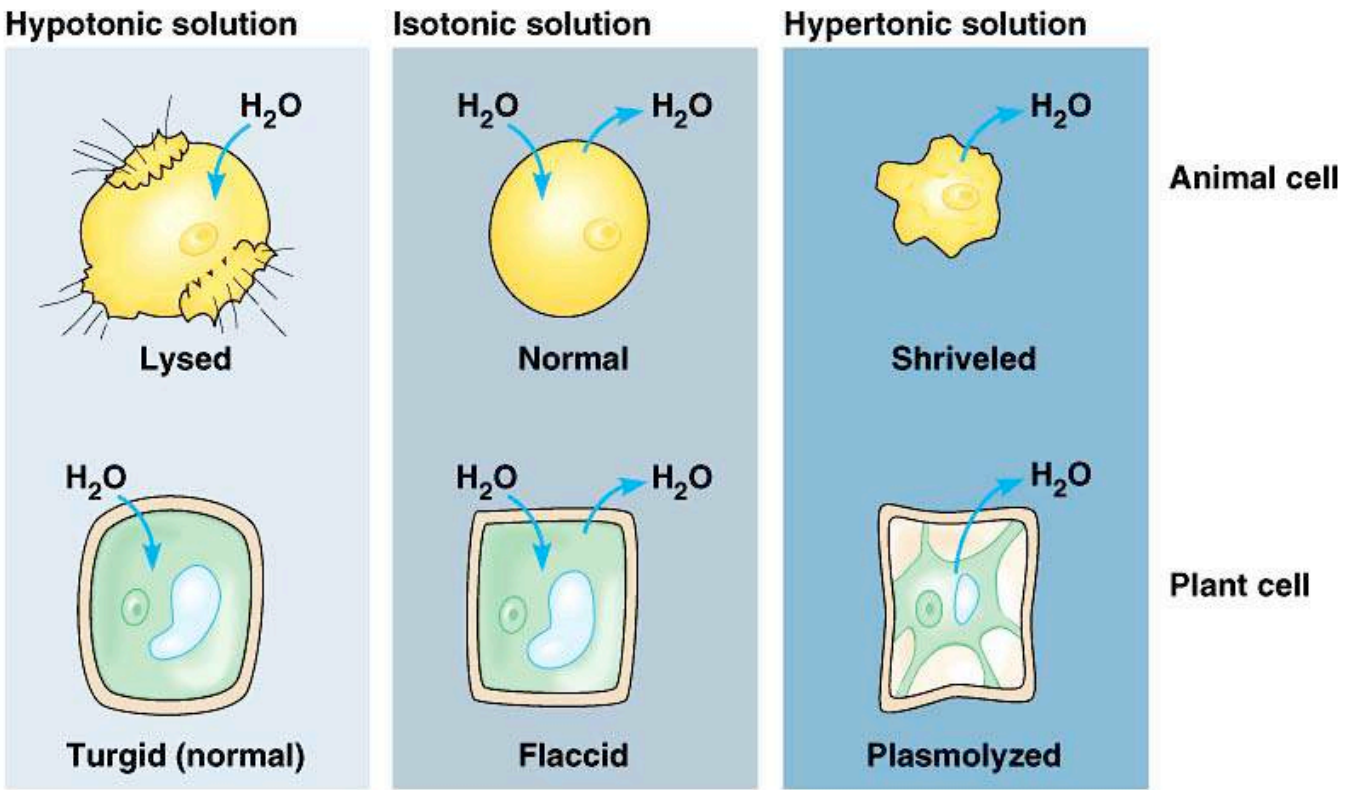
- **Direction of osmosis is determined by comparing total solute concentrations**
  - **Hypertonic - more solute, less water**
  - **Hypotonic - less solute, more water**
  - **Isotonic - equal solute, equal water**



net movement of water

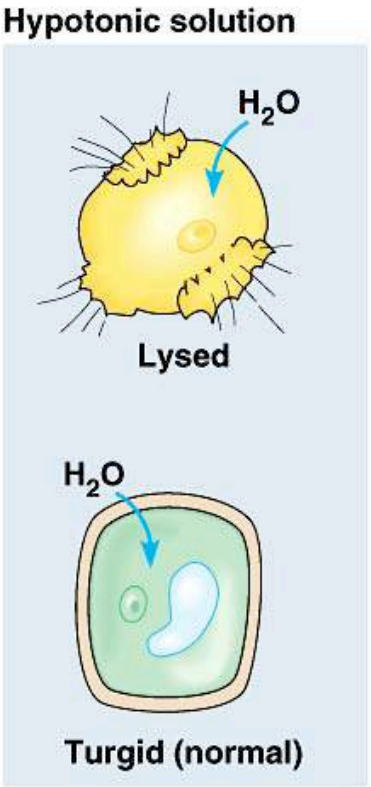
Managing water balance

- Cell survival depends on balancing water uptake & loss



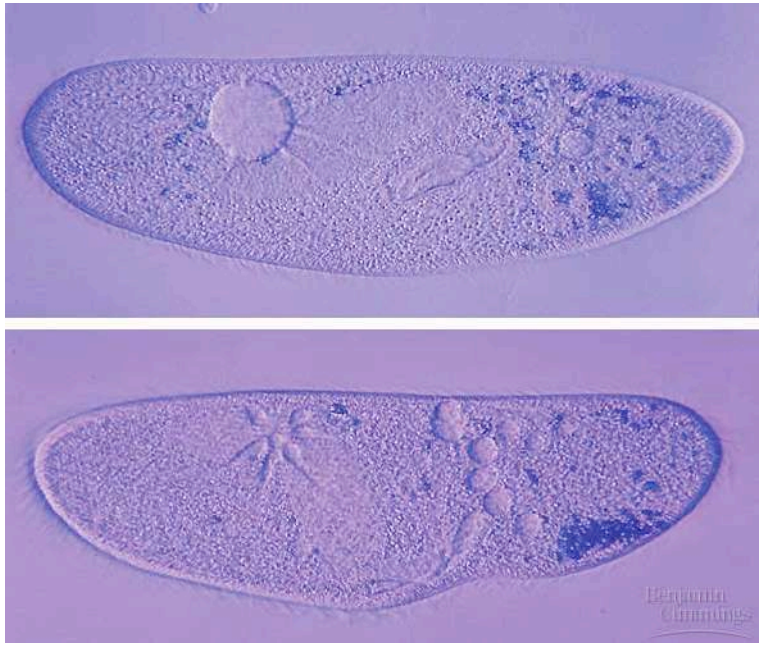
Managing water balance

- **Hypotonic**
  - animal cell in hypotonic solution will gain water, swell & burst
    - *Paramecium* vs. pond water
    - *Paramecium* is hypertonic
    - H_2O continually enters cell
    - to solve problem, specialized organelle, contractile vacuole
    - pumps H_2O out of cell = ATP
  - plant cell
    - turgid



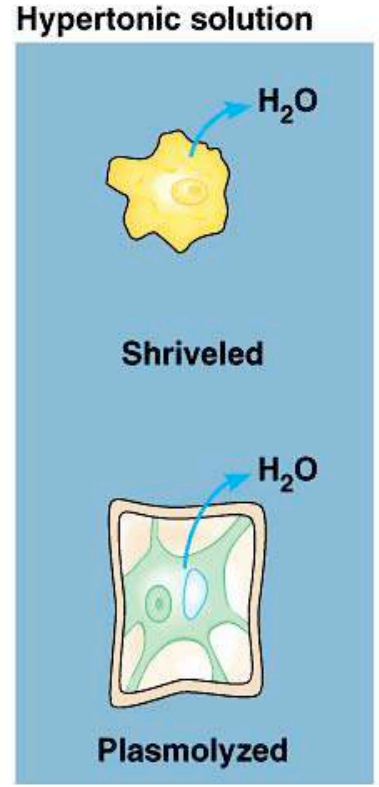
Water regulation

- Contractile vacuole in *Paramecium*



Managing water balance

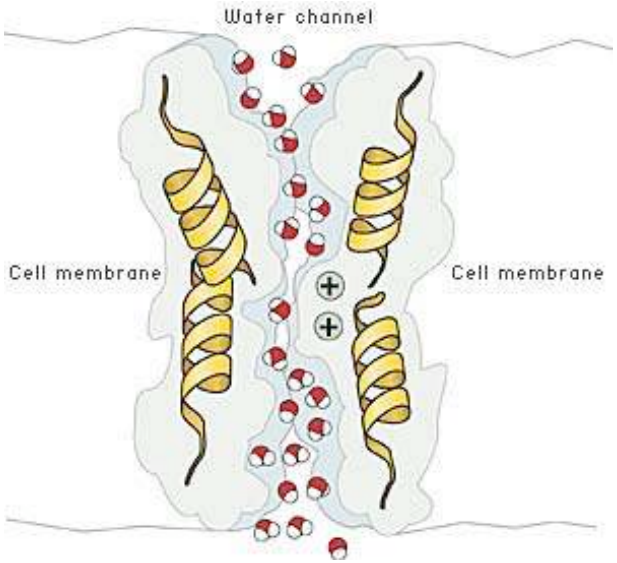
- **Hypertonic**
  - animal cell in hypertonic solution will loose water, shrivel & probably die
    - salt water organisms are hypotonic compared to their environment
    - they have to take up water & pump out salt
  - plant cells
    - plasmolysis = wilt



1991 | 2003

Aquaporins

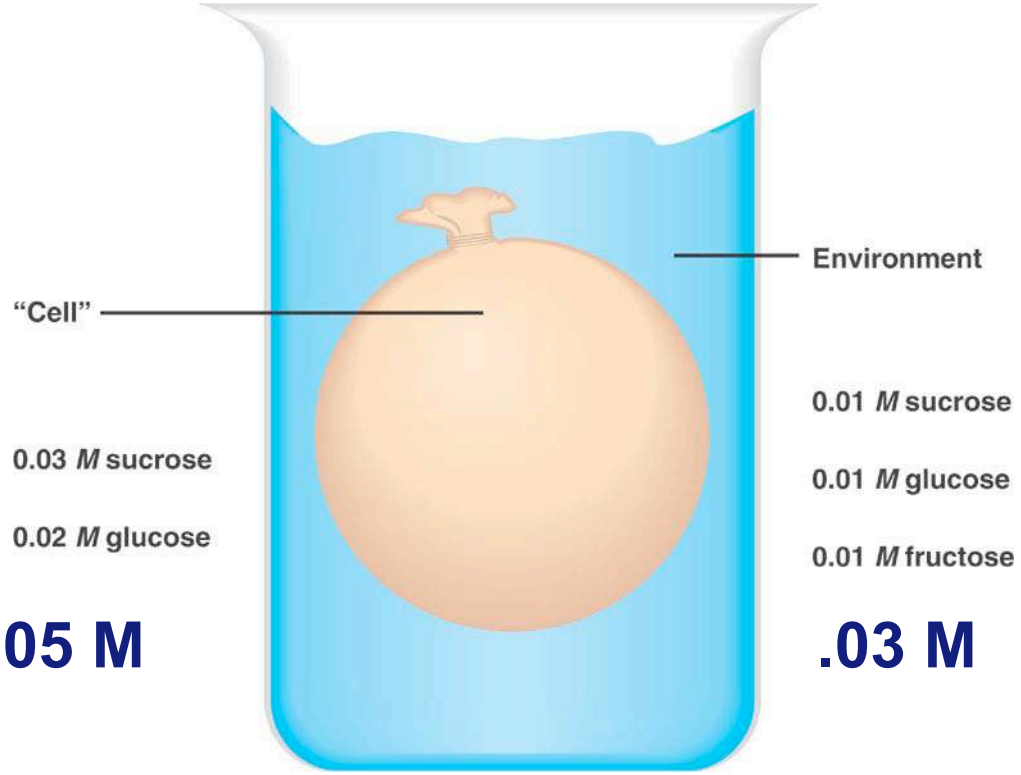
- Water moves rapidly into & out of cells
  - evidence that there were water channels



Peter Agre
John Hopkins

Roderick MacKinnon
Rockefeller

Osmosis…



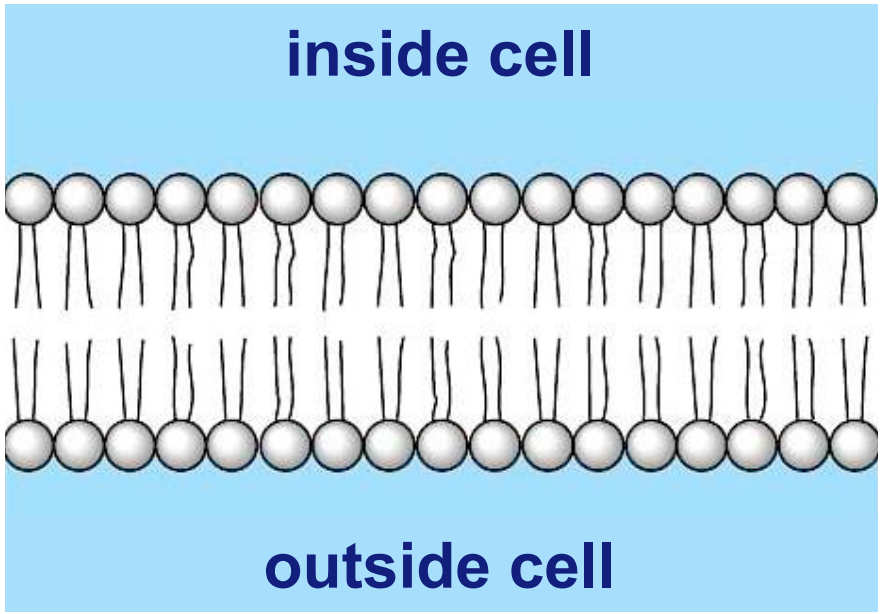
Cell (compared to beaker) → hypertonic or hypotonic

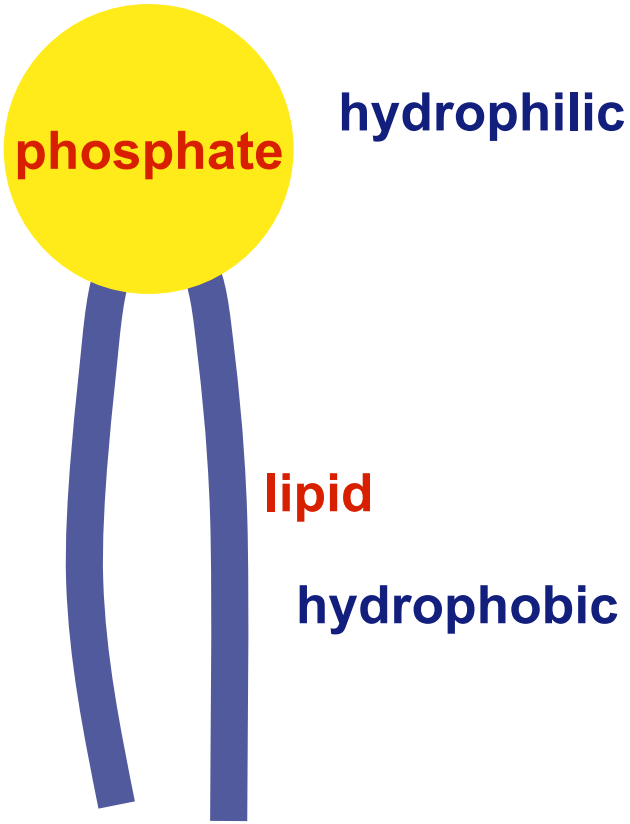
Beaker (compared to cell) → hypertonic or hypotonic

Which way does the water flow? → in or out of cell

Lipids of cell membrane

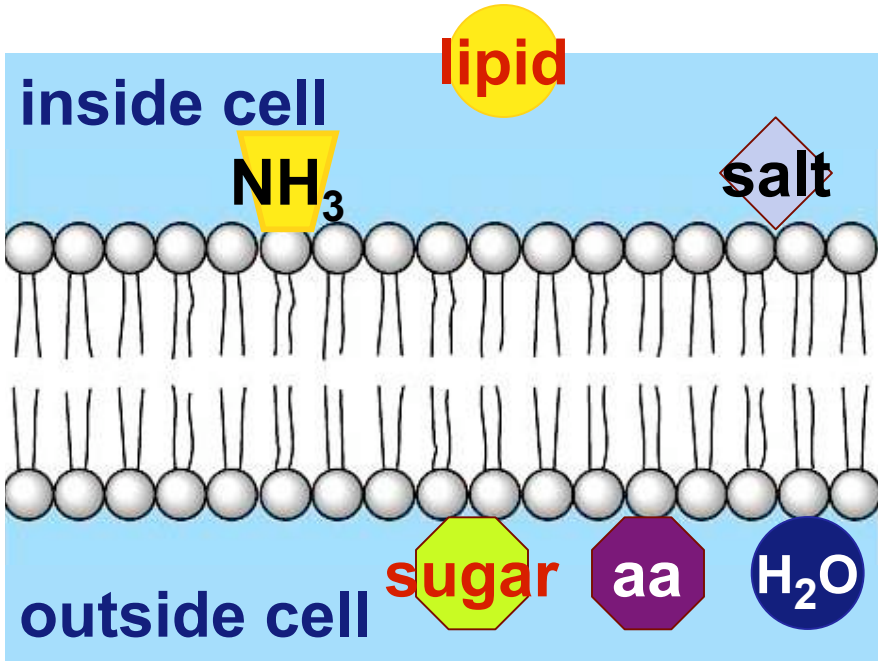
- Membrane is made of phospholipids
  - phospholipid bilayer





Phospholipid bilayer

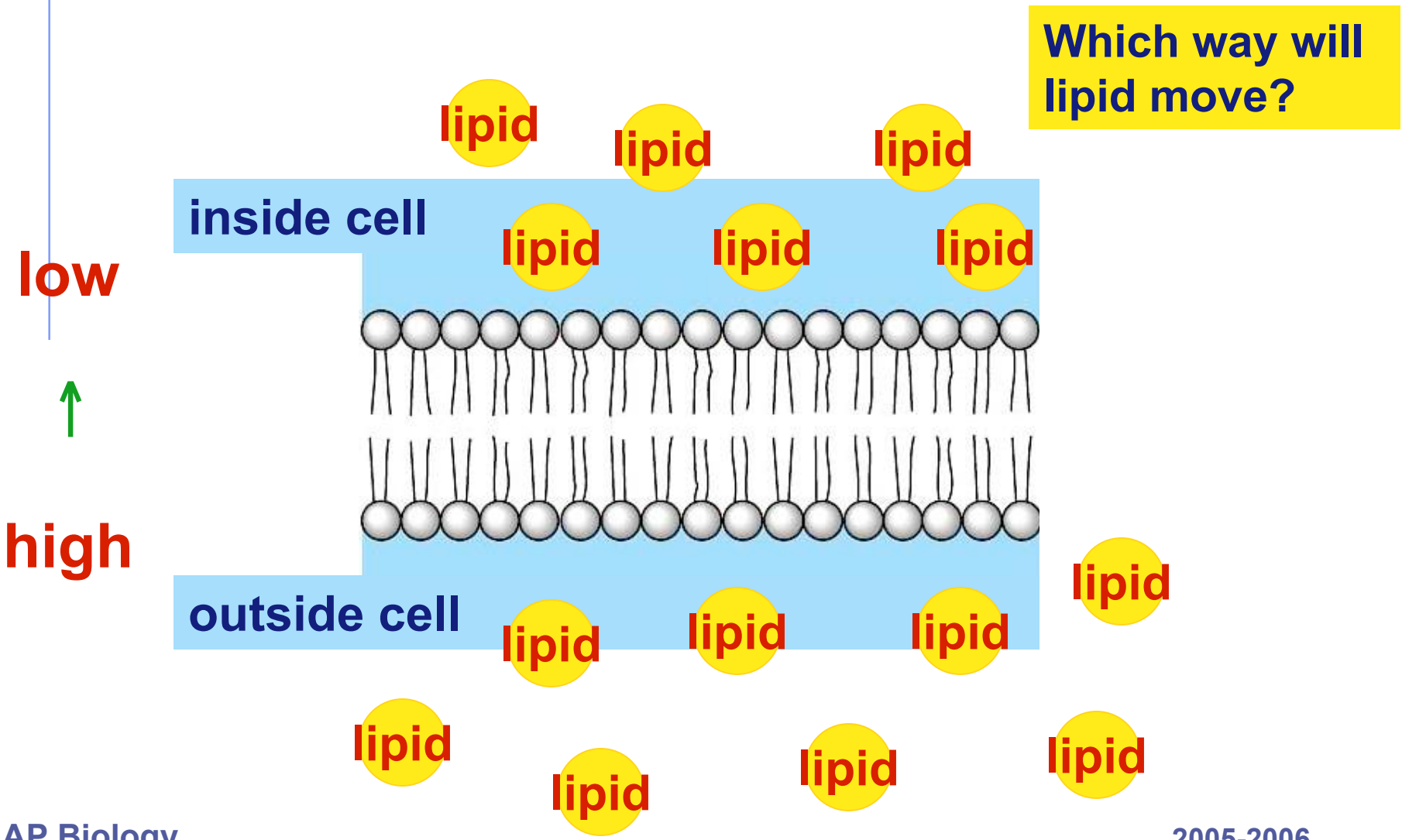
- What molecules can get through directly?



fats & other lipids can slip directly through the phospholipid cell membrane, but…

what about other stuff?

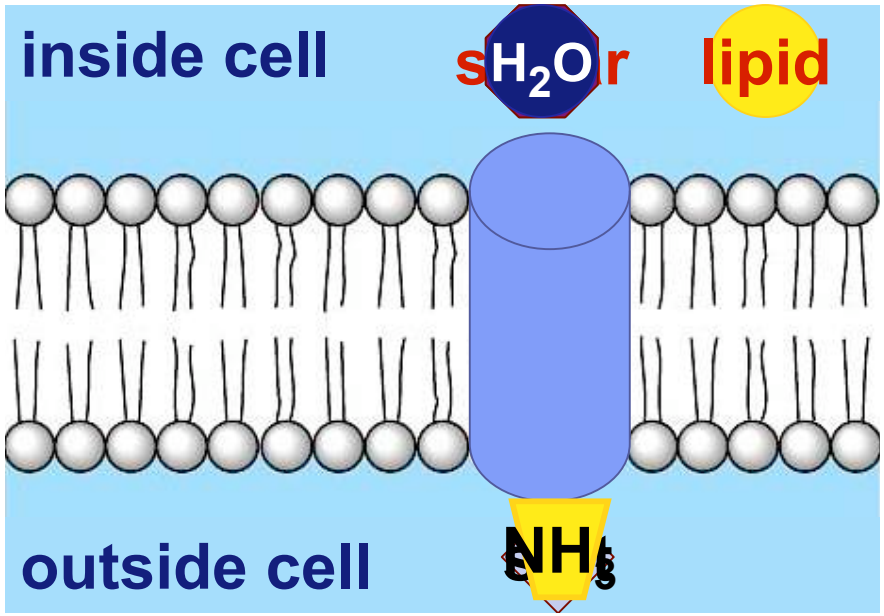
Simple diffusion across membrane



Permeable cell membrane

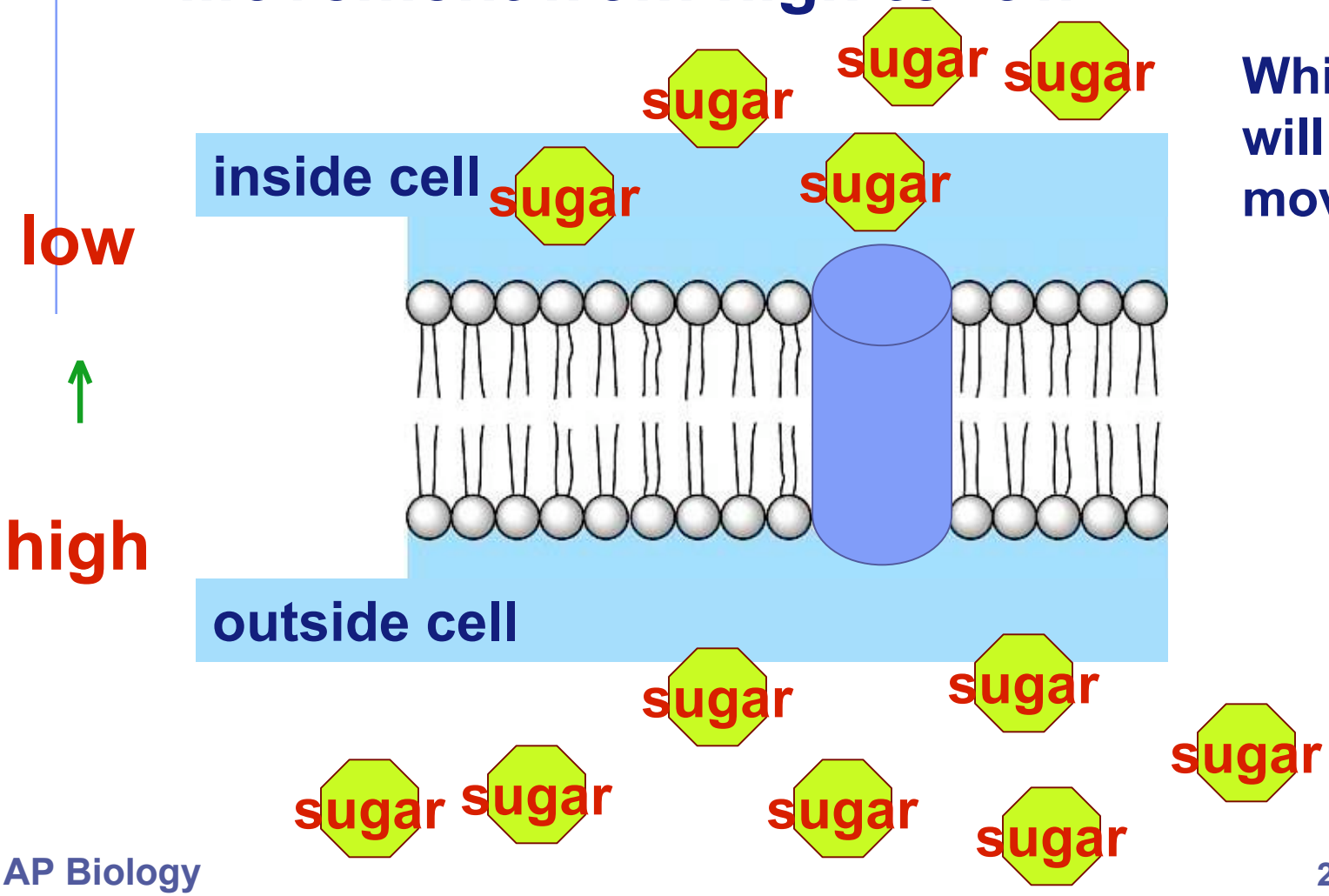
- Need to allow more material through
  - membrane needs to be permeable to…
    - all materials a cell needs to bring in
    - all waste a cell needs excrete out
    - all products a cell needs to export out

"holes", or channels, in cell membrane allow material in & out



Diffusion through a channel

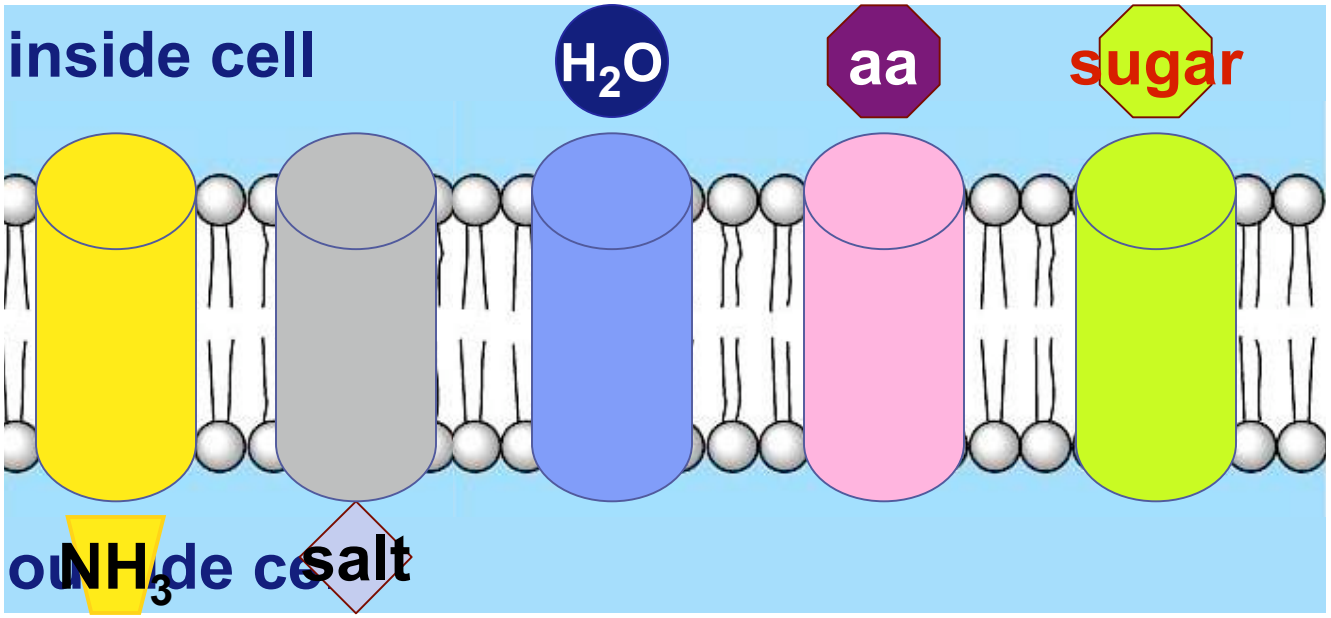
- Movement from high to low



Which way will sugar move?

Semi-permeable cell membrane

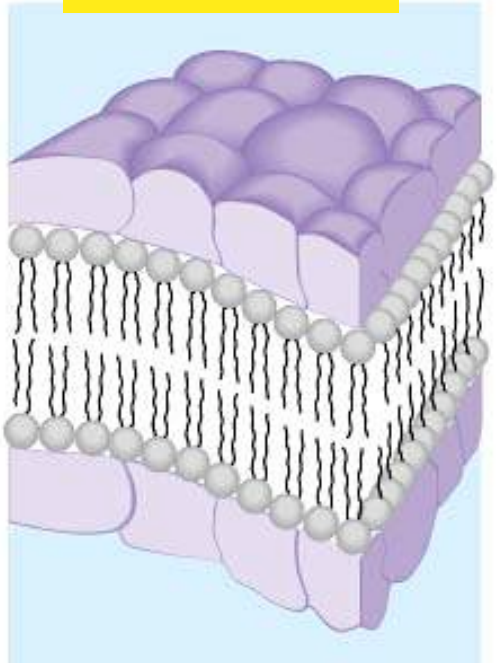
- But the cell still needs control
  - membrane needs to be semi-permeable
    - specific channels allow specific material in & out



How do you build a semi-permeable cell membrane?

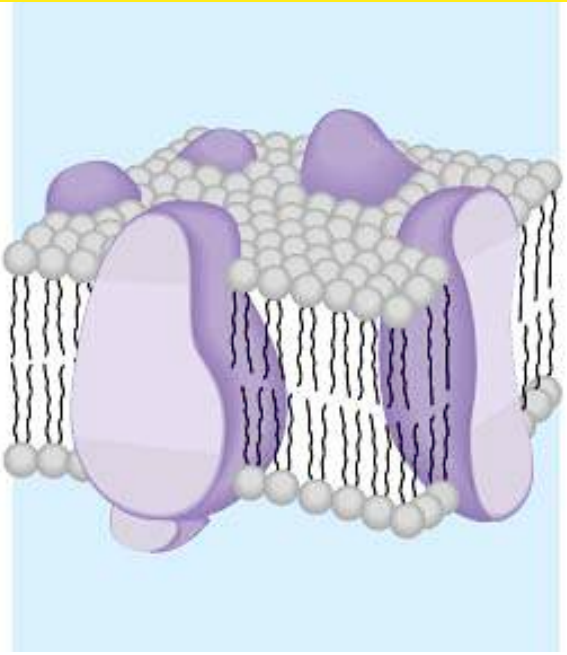
- What molecule will sit "comfortably" in a phospholipid bilayer forming channels

bi-lipid membrane



what properties does it need?

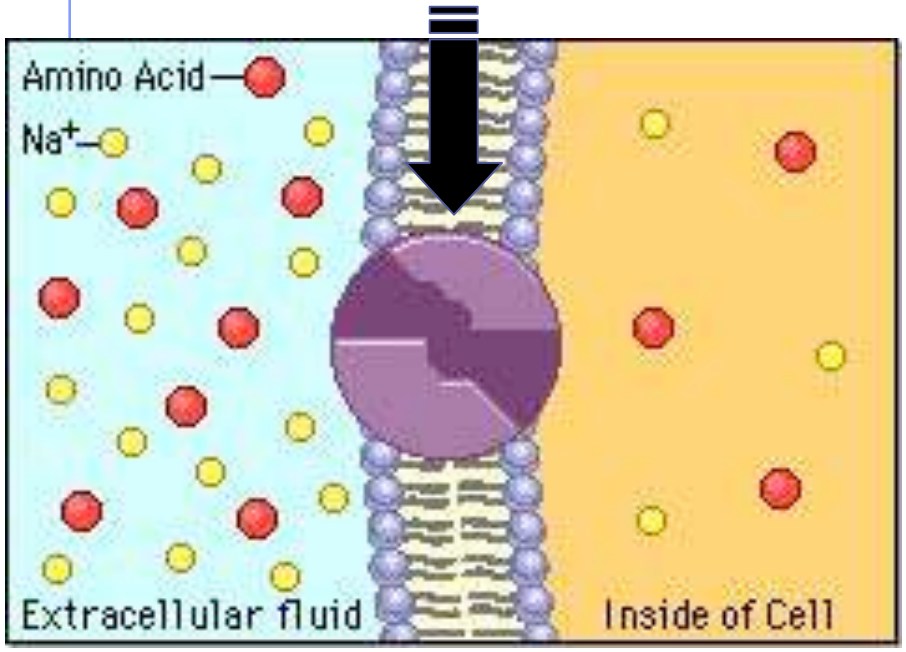
protein channels in bi-lipid membrane



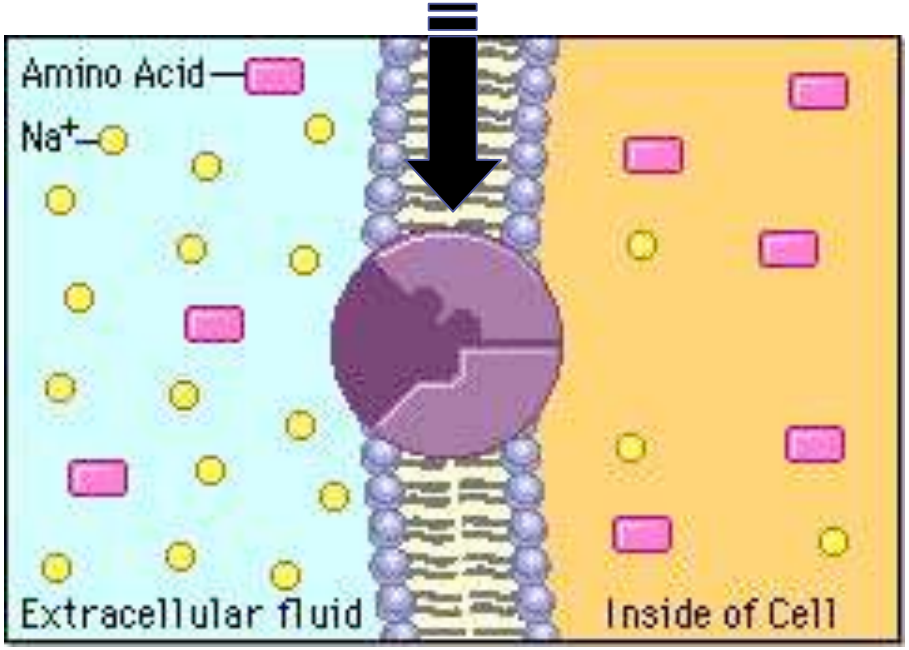
Active transport

- Many models & mechanisms

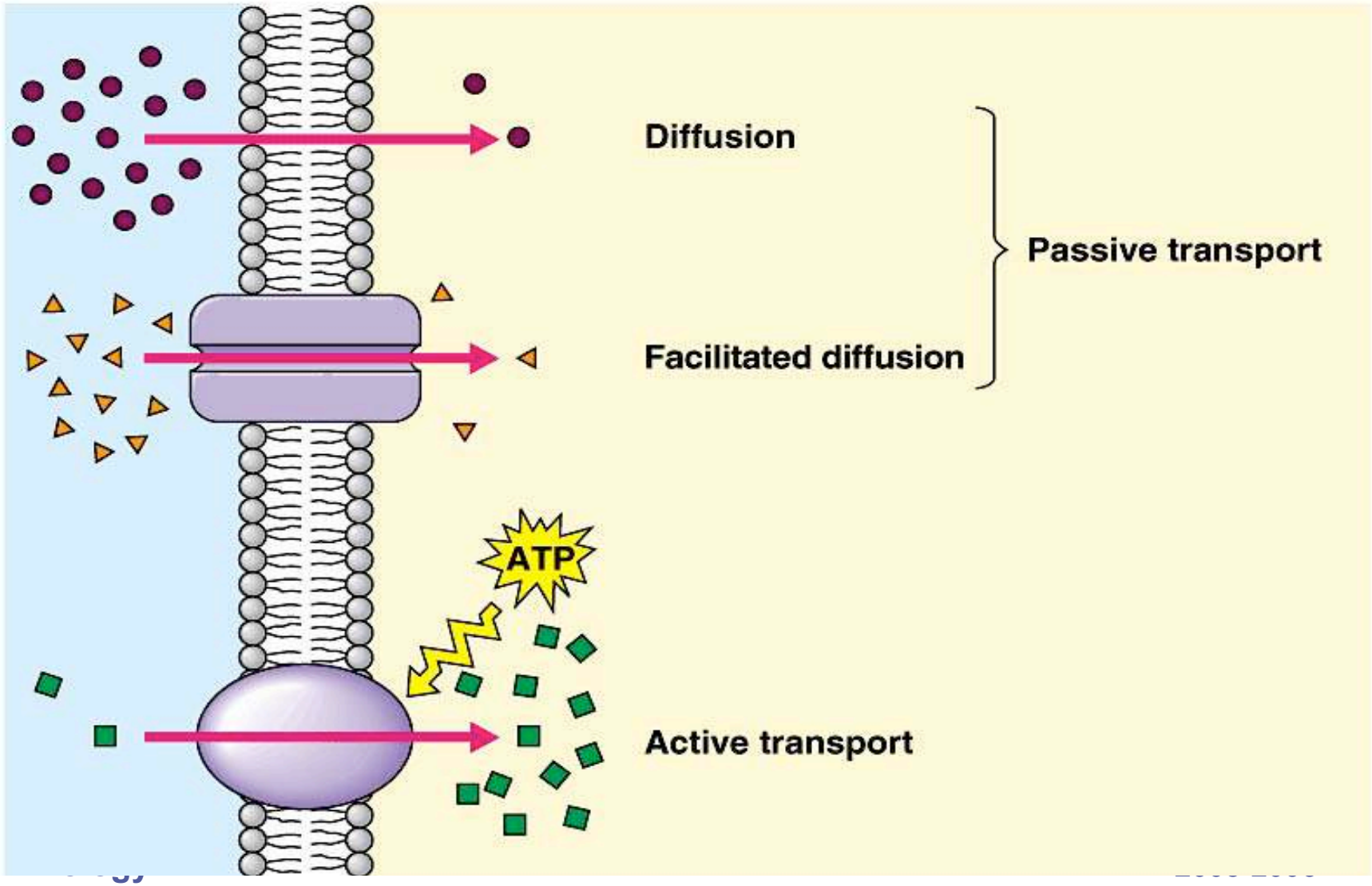
using ATP



using ATP

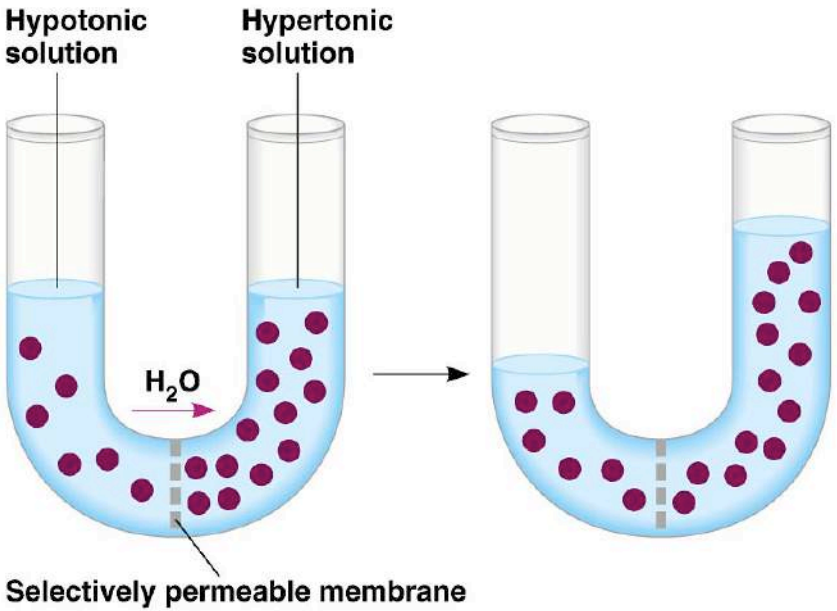


Transport summary



Osmosis is diffusion of water

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



Managing water balance

- **Isotonic**
  - animal cell immersed in isotonic solution
    - **blood cells in blood**
    - **no net movement of water across plasma membrane**
    - **water flows across membrane, at same rate in both directions**
    - **volume of cell is stable**