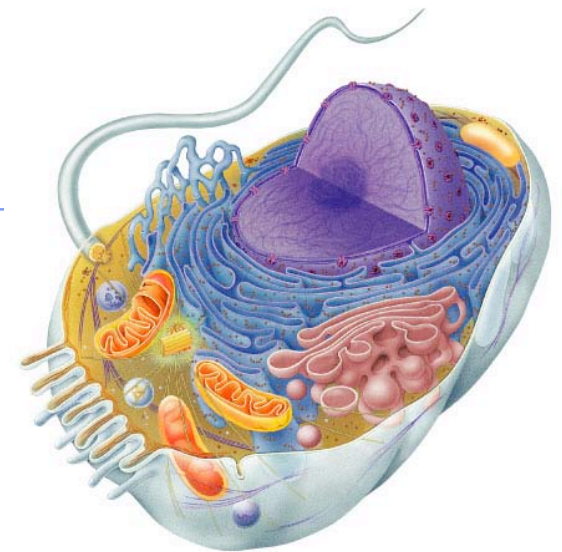
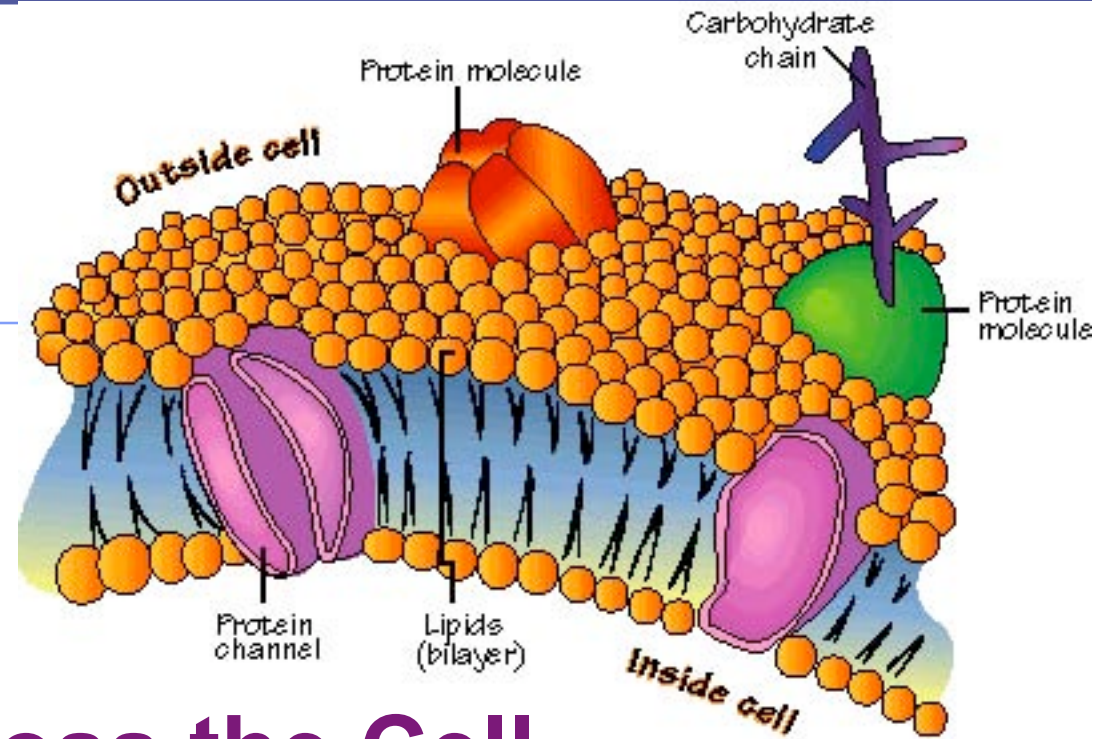


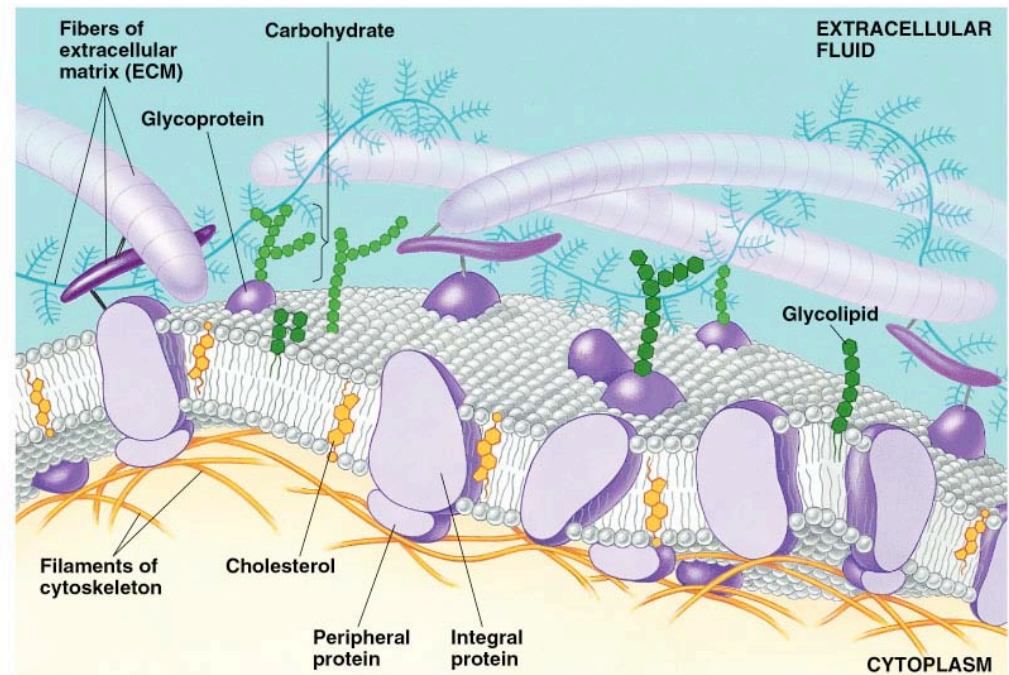
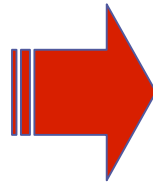
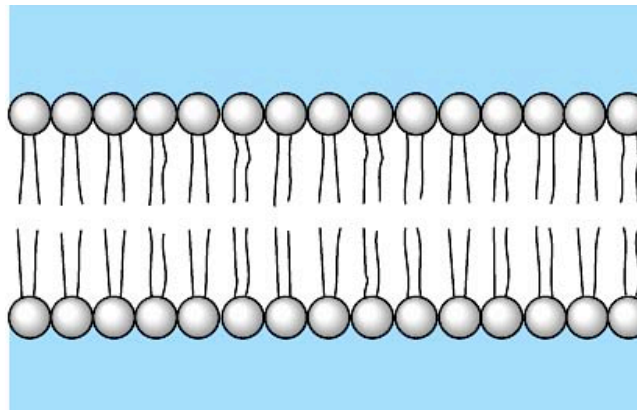
Chapter 8.

Movement across the Cell Membrane



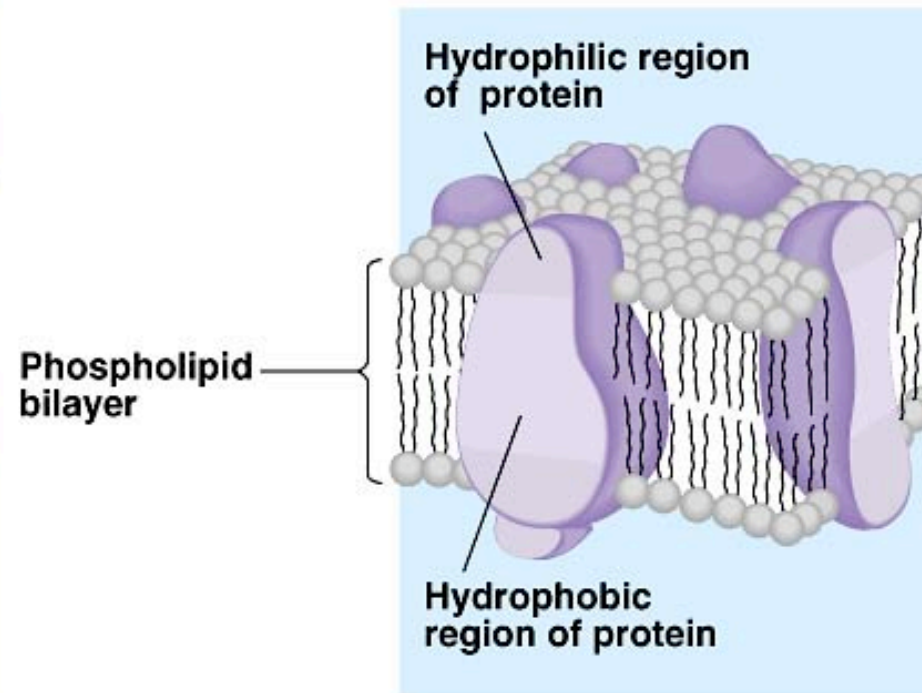
More than just a barrier...

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

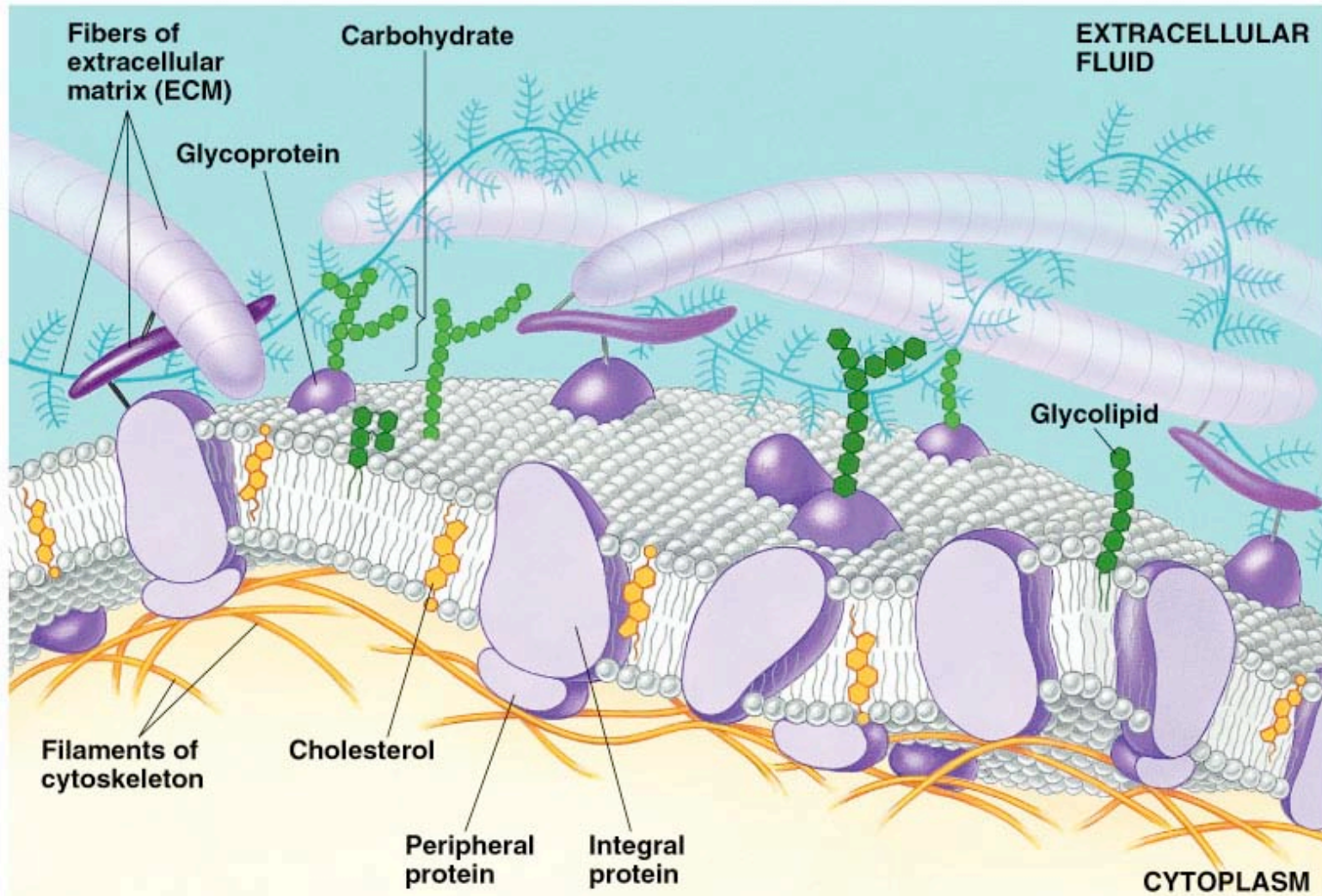


Fluid Mosaic Model

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

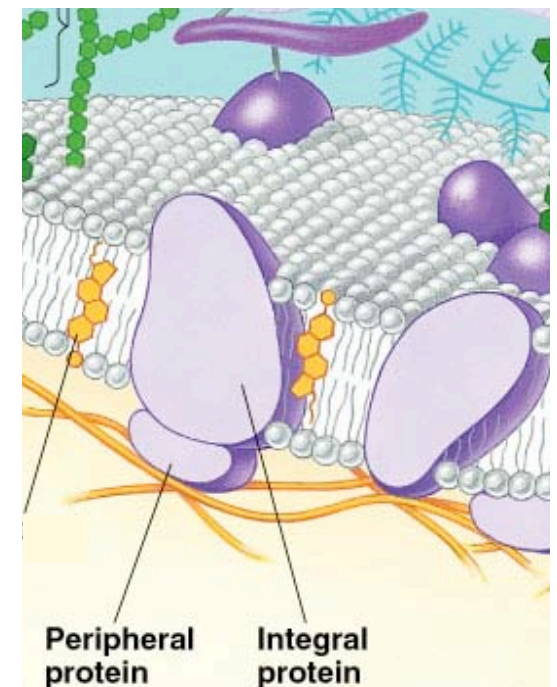


A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer



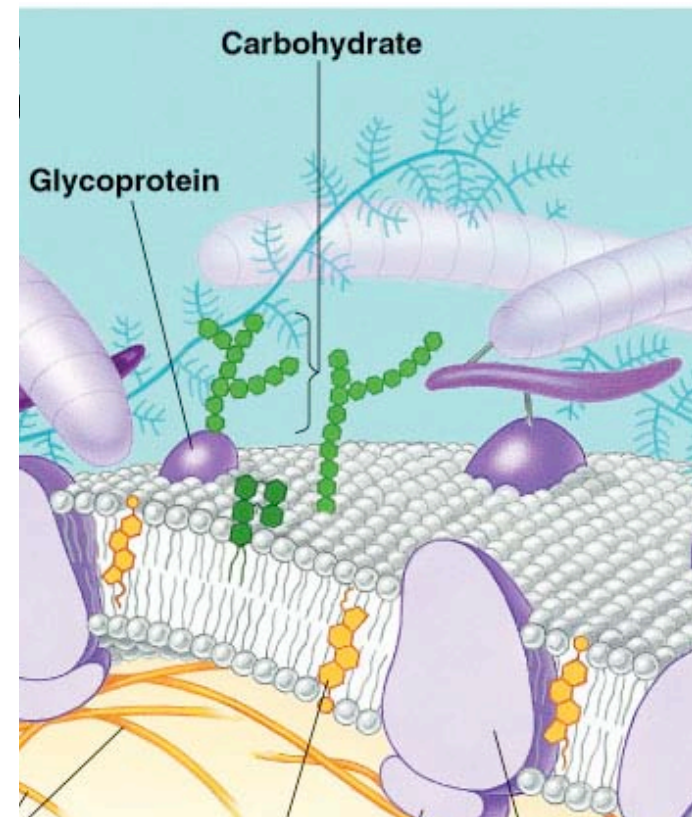
Membrane Proteins

- 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

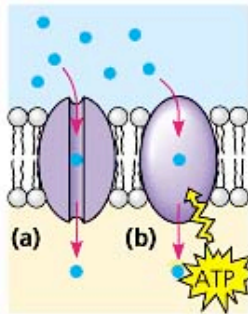


Membrane Carbohydrates

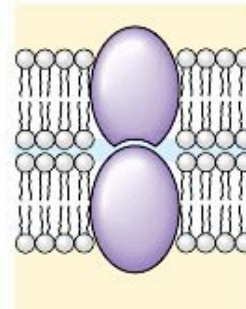
- **Play a key role in cell-cell recognition**
 - ◆ ability of a cell to distinguish neighboring cells from another
 - ◆ important in organ & tissue development
 - ◆ basis for rejection of foreign cells by immune system



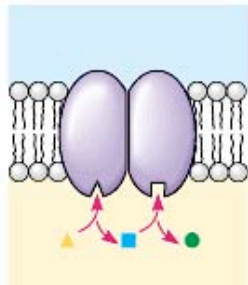
Membranes provide a variety of cell functions



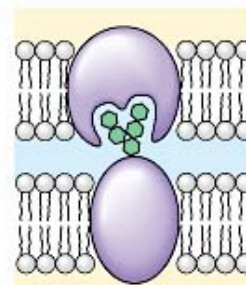
Transport



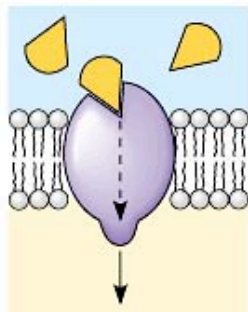
Intercellular joining



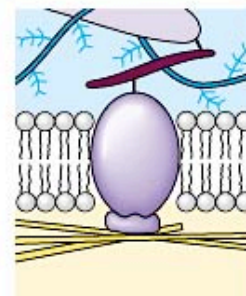
Enzymatic activity



Cell-cell recognition



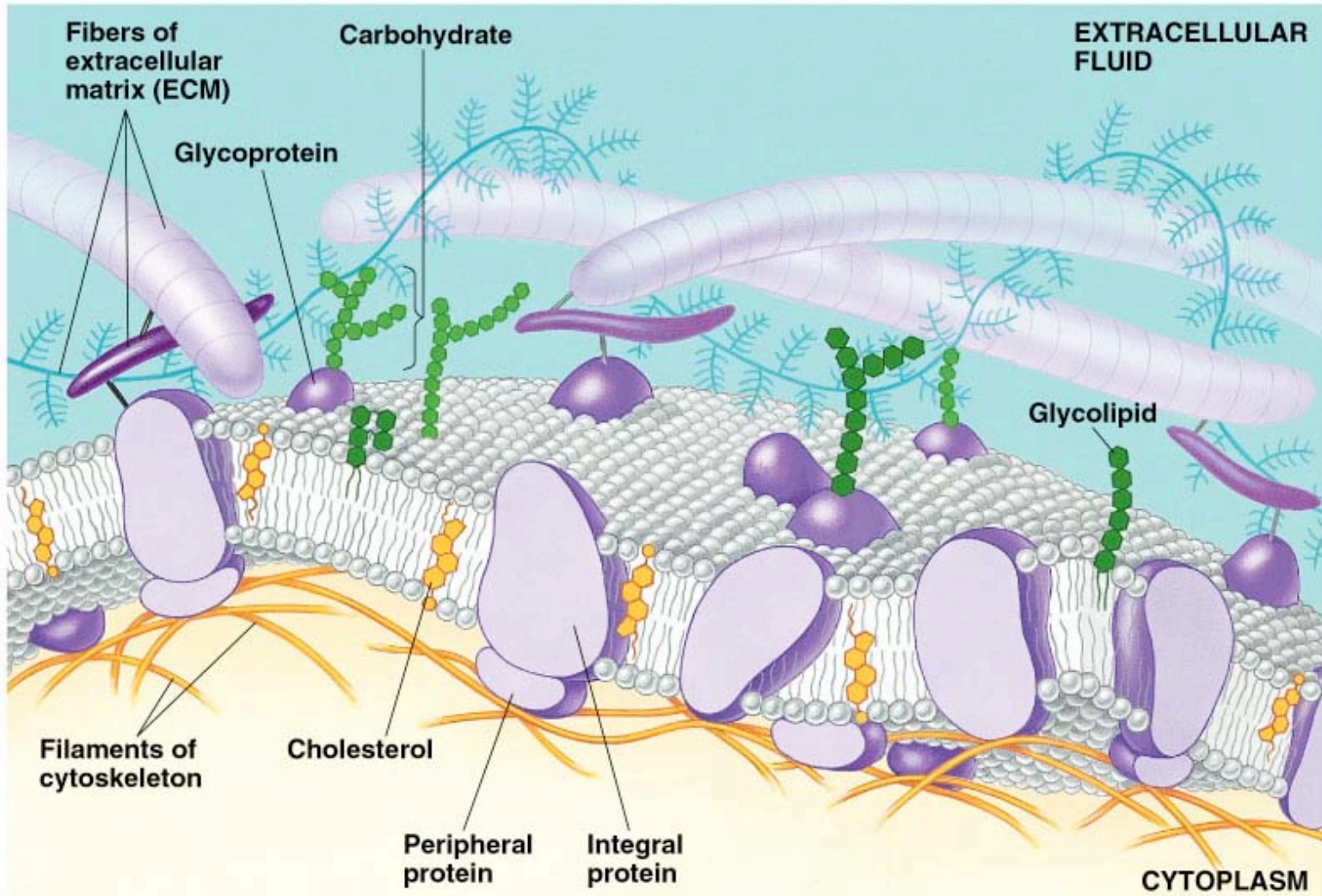
Signal transduction



Attachment to the cytoskeleton and extracellular matrix (ECM)

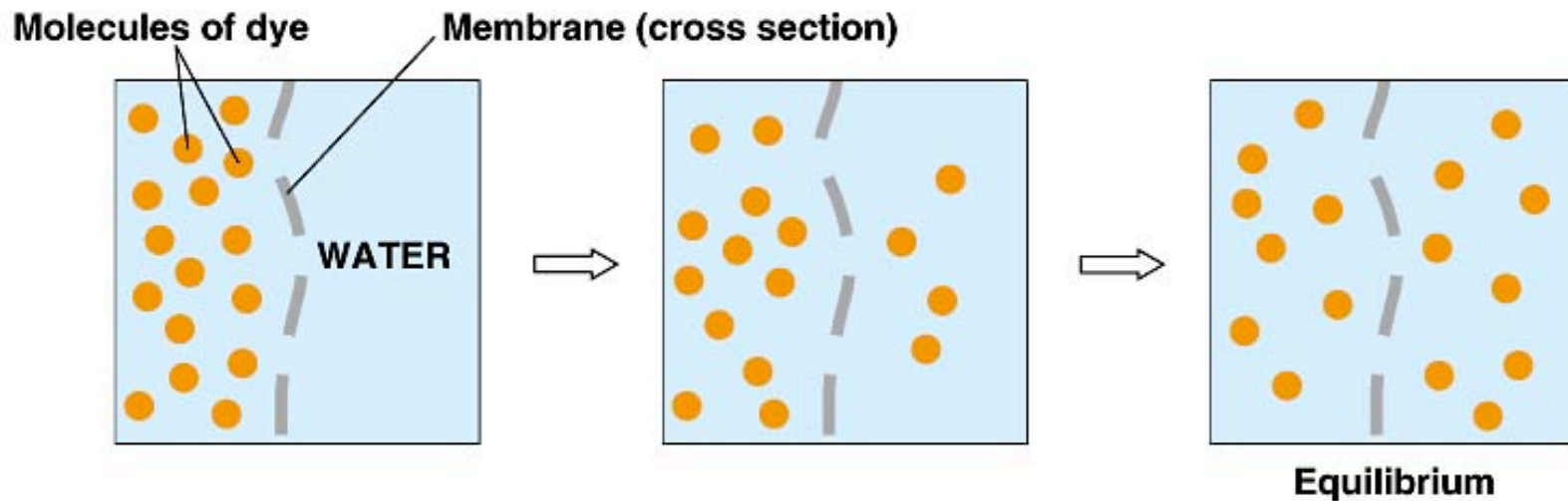
Any Questions??

Fluid Mosaic Model



Diffusion

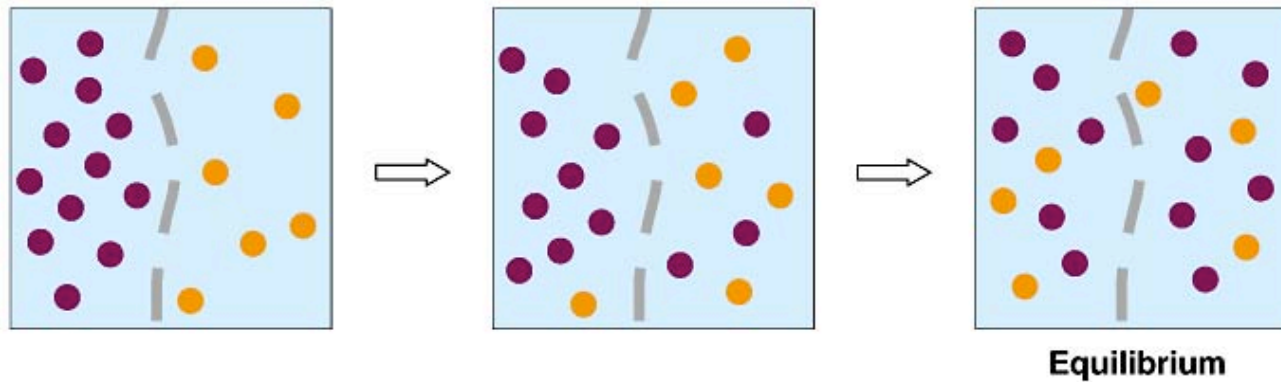
- 2nd Law of Thermodynamics governs biological systems
 - ◆ Universe tends towards disorder



- **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



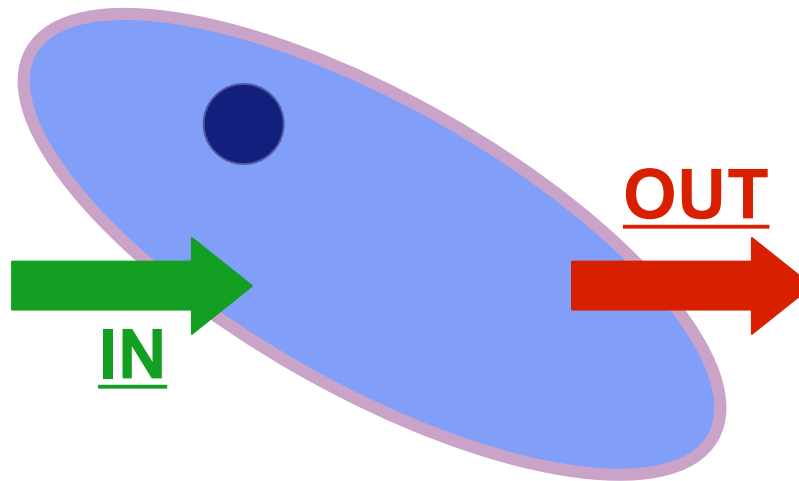
(b) Diffusion of two solutes

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, O₂, H₂O

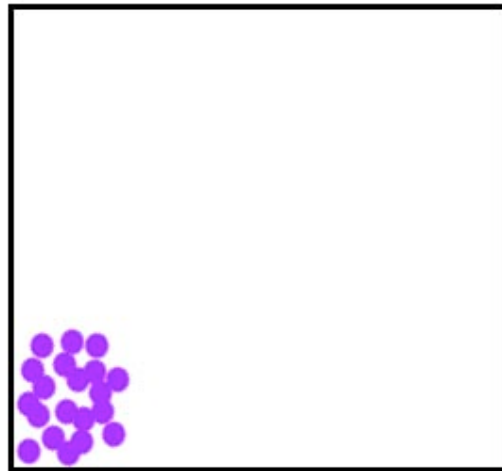


OUT
waste
ammonia
salts
CO₂
H₂O
products

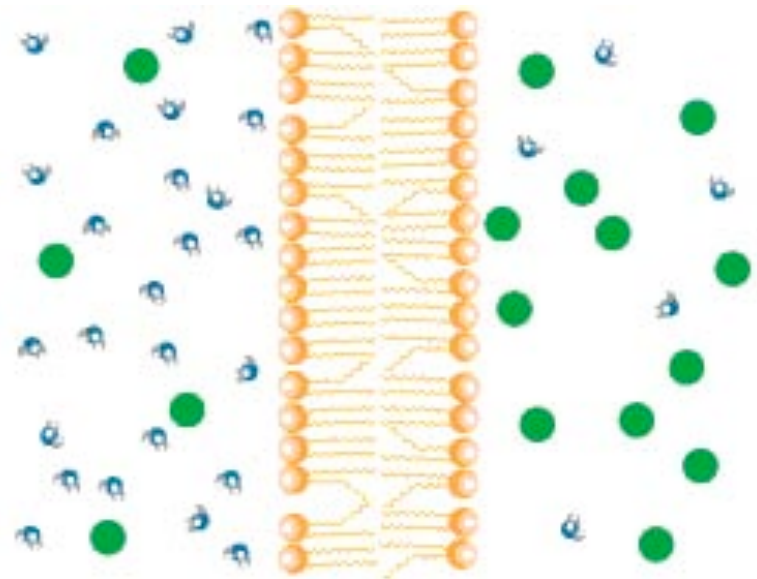
cell needs materials in & products or waste out

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?

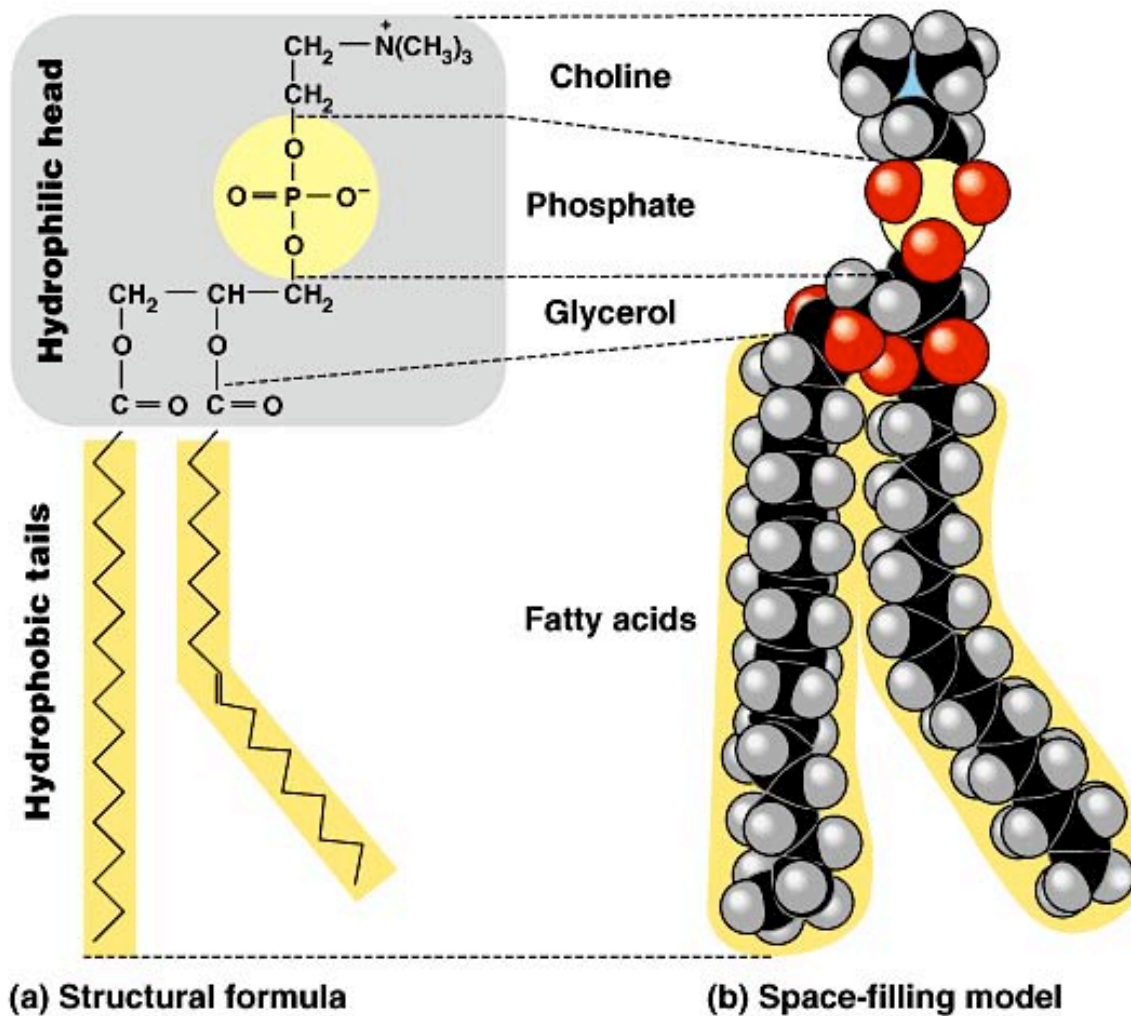
Your choices

- carbohydrates?
- proteins?
- nucleic acids?
- lipids?

→ LIPIDS ←

oil & water
don't mix!!

Phospholipids



Semi-permeable membrane

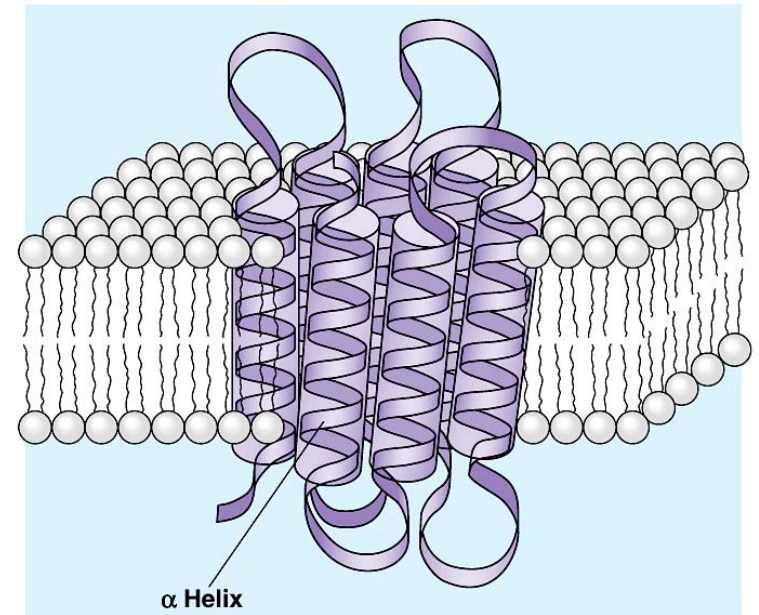
- Need to allow passage through the membrane
- But need to control what gets in or out
 - ◆ membrane needs to be semi-permeable



So how do you build a semi-permeable membrane?

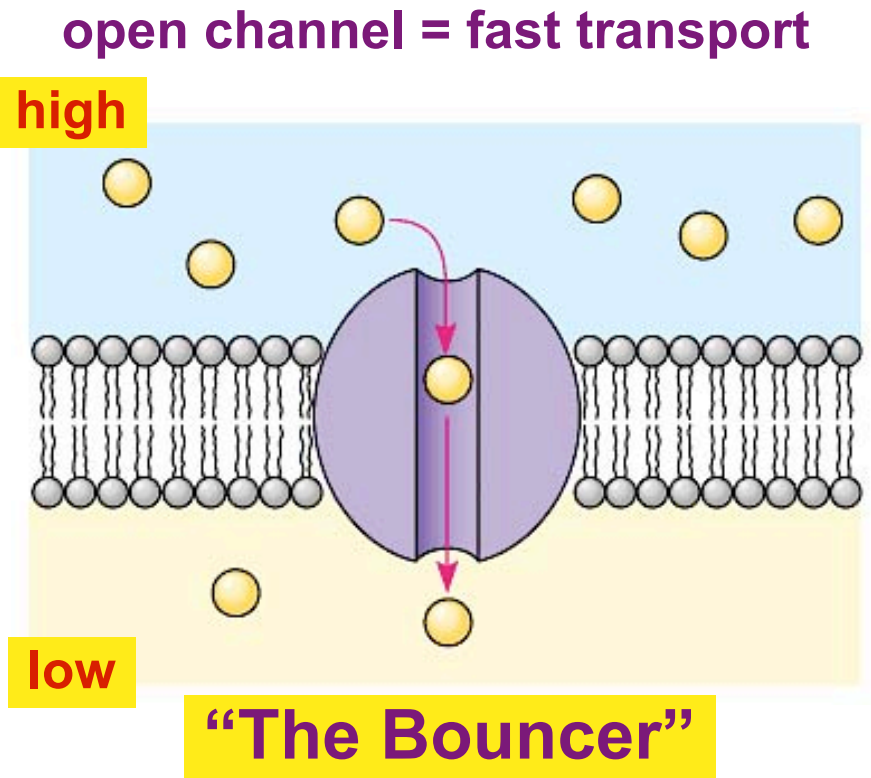
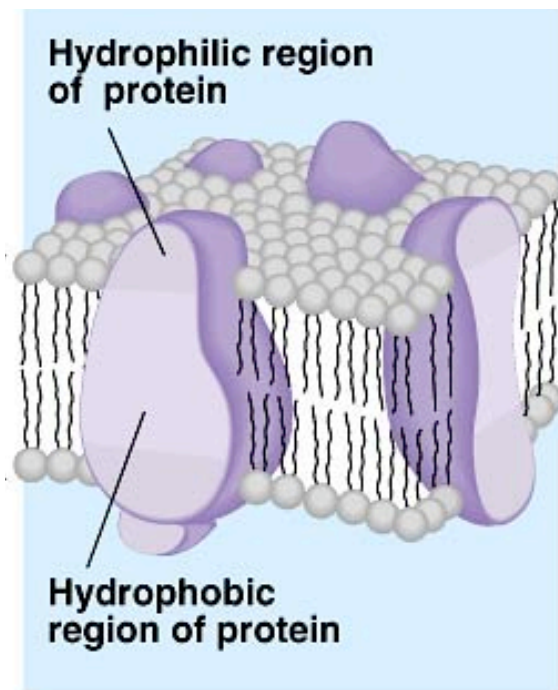
Why proteins?

- **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



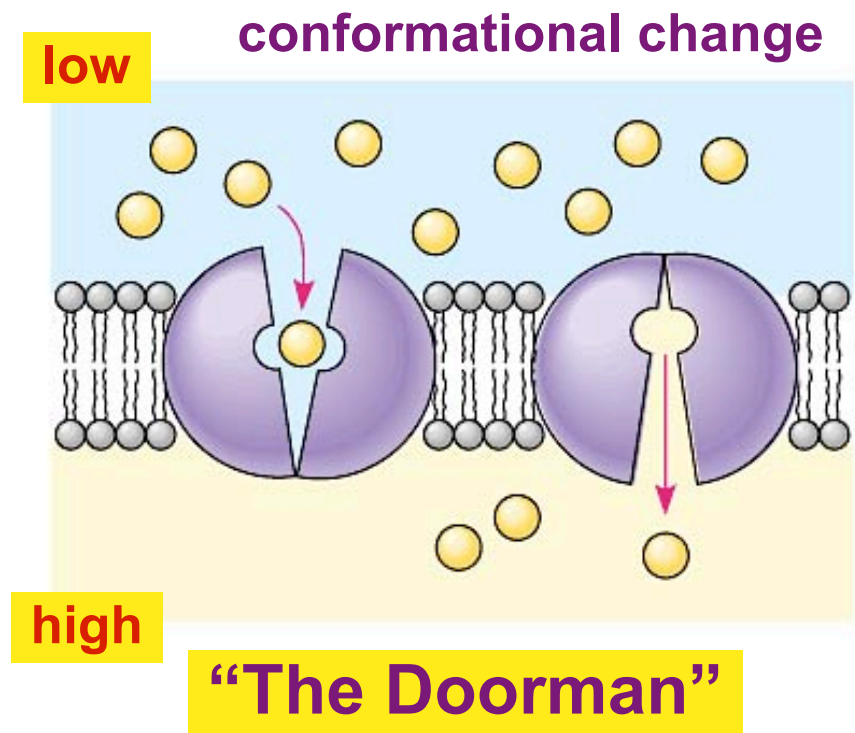
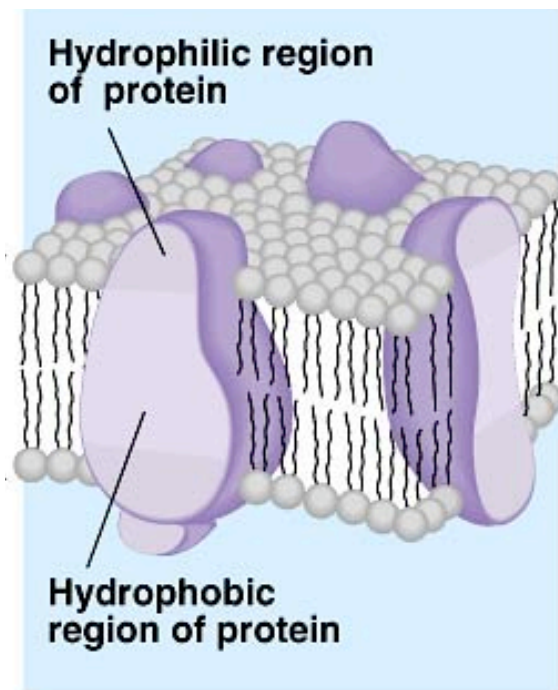
Facilitated Diffusion

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



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

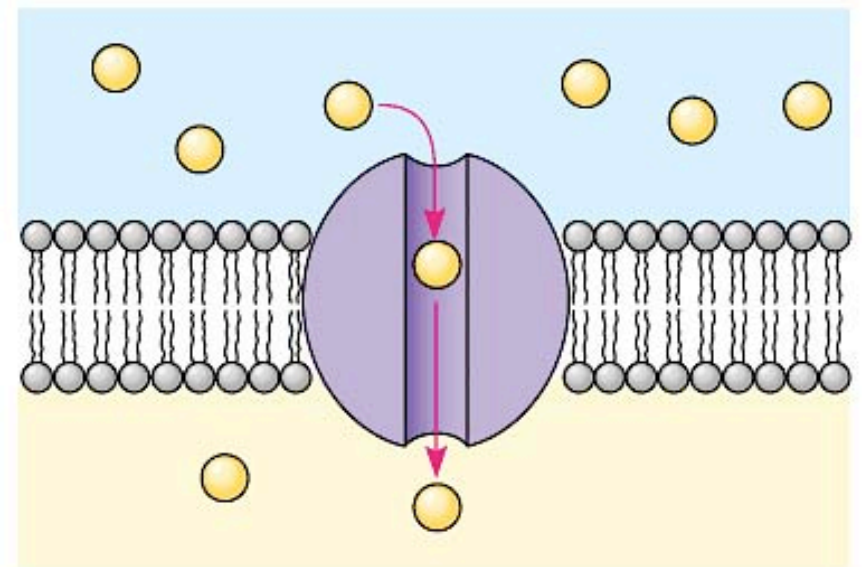


Getting through cell membrane

- **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



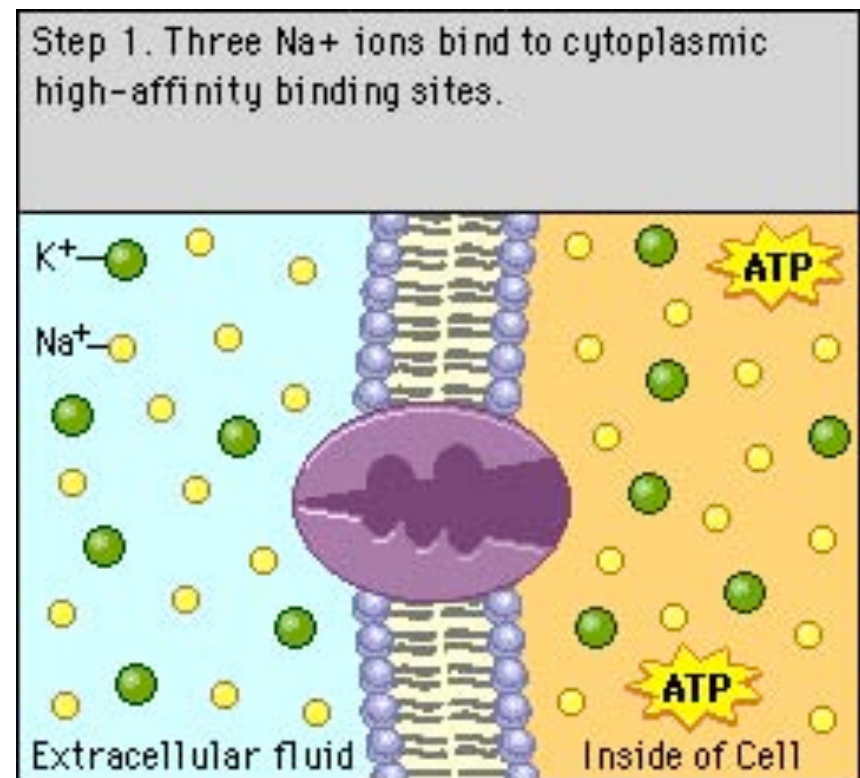
Gated channels

- **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

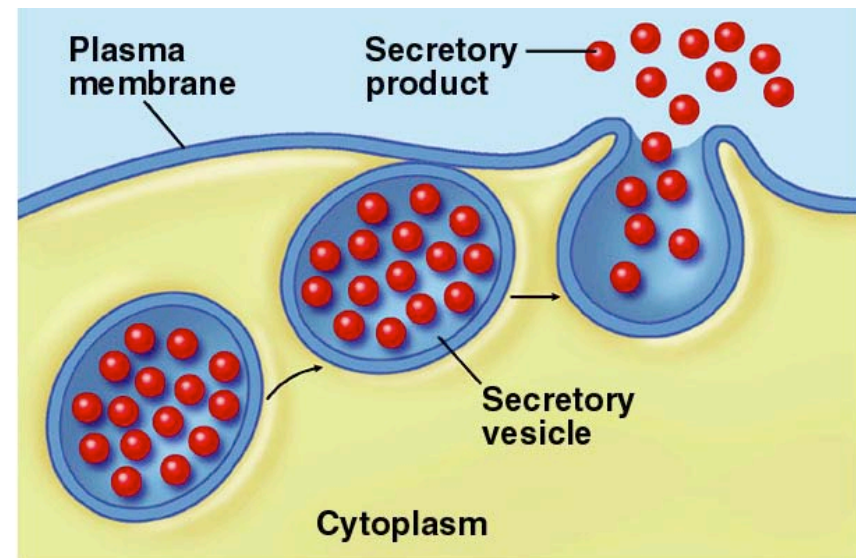
- Cells may need molecules to move ***against*** concentration situation
 - need to pump against concentration
 - protein pump
 - requires energy
 - ATP

Na⁺/K⁺ pump
in nerve cell
membranes



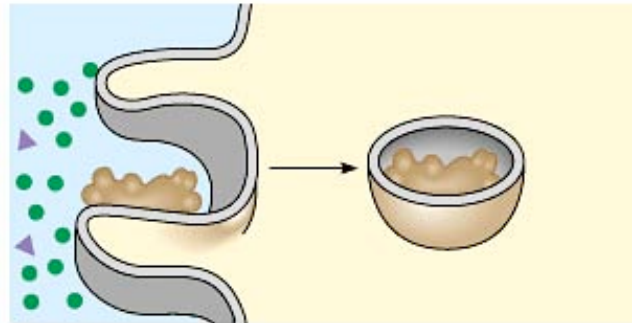
How about large molecules?

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



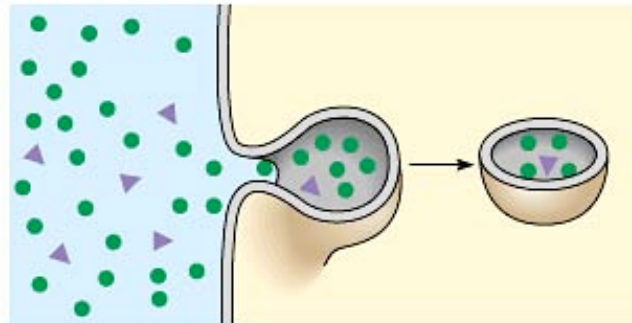
Endocytosis

phagocytosis



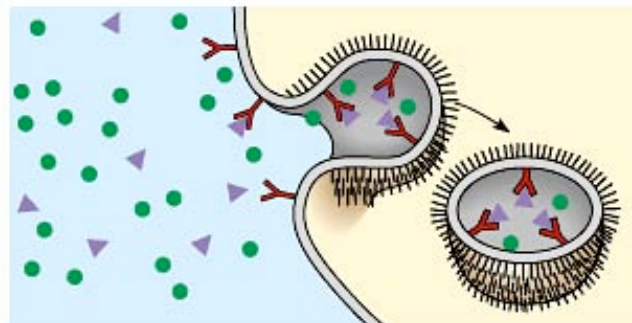
fuse with lysosome for digestion

pinocytosis



non-specific process

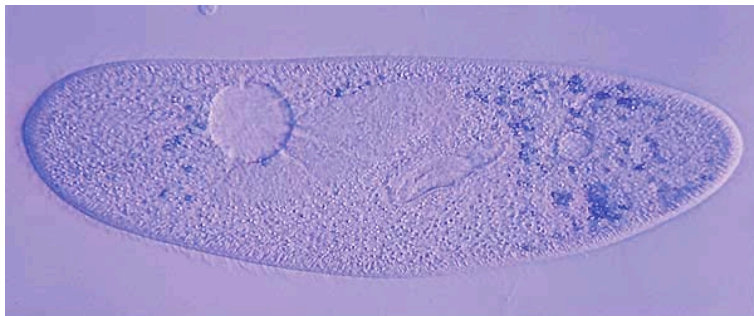
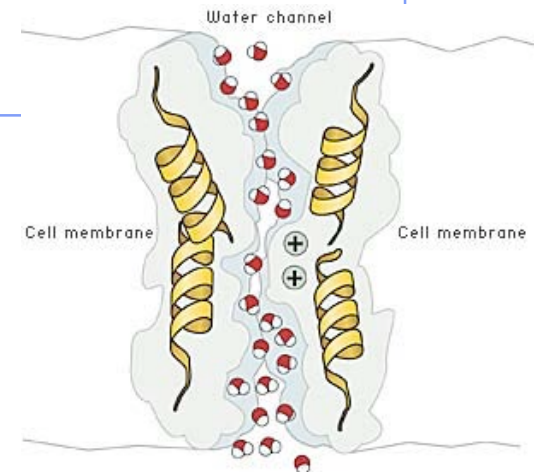
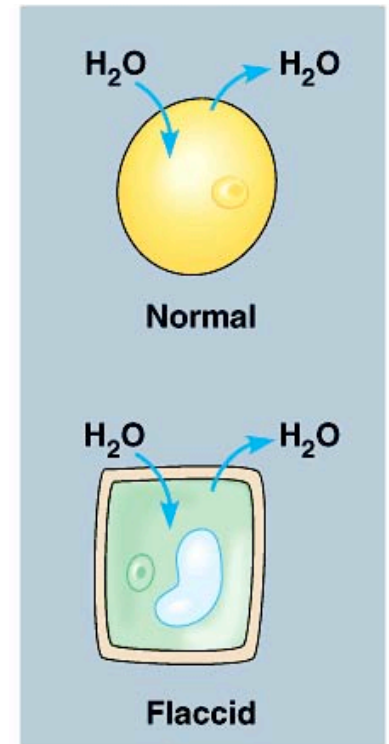
receptor-mediated endocytosis



triggered by ligand signal

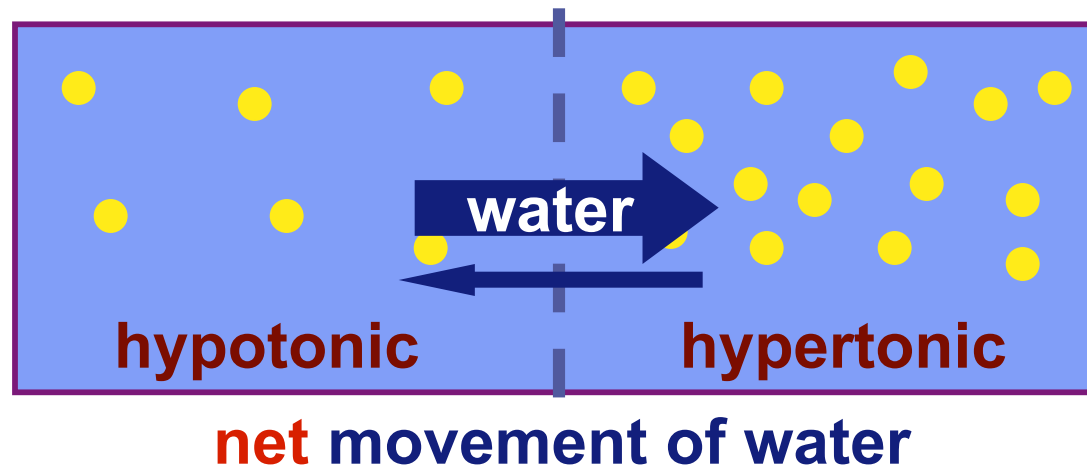
The Special Case of Water

Movement of water across the cell membrane



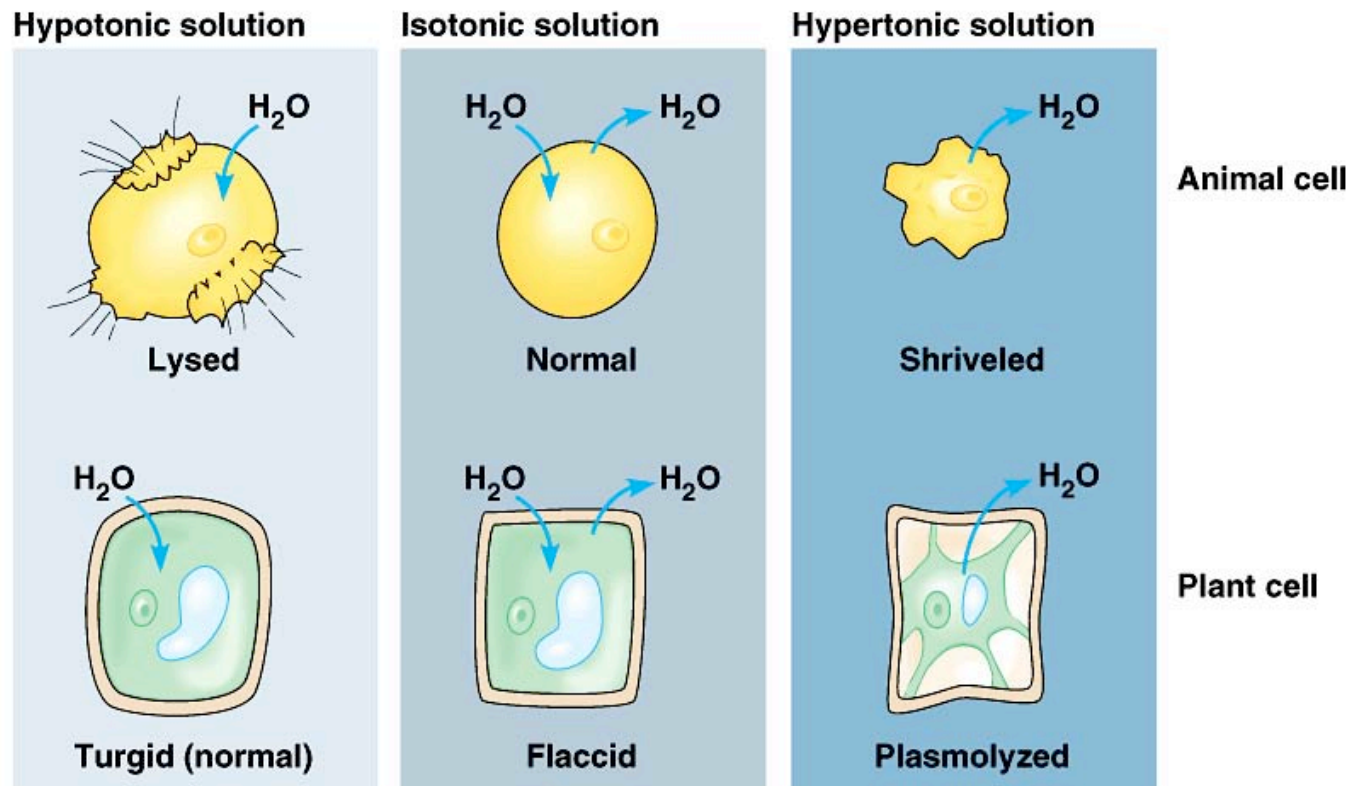
Concentration of water

- 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



Managing water balance

- Cell survival depends on balancing water uptake & loss

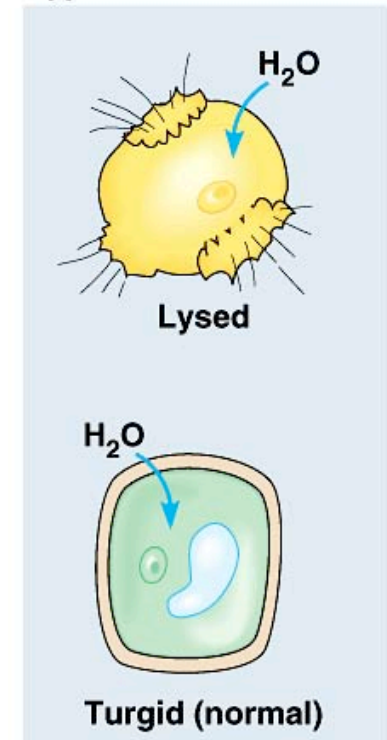


Managing water balance

■ Hypotonic

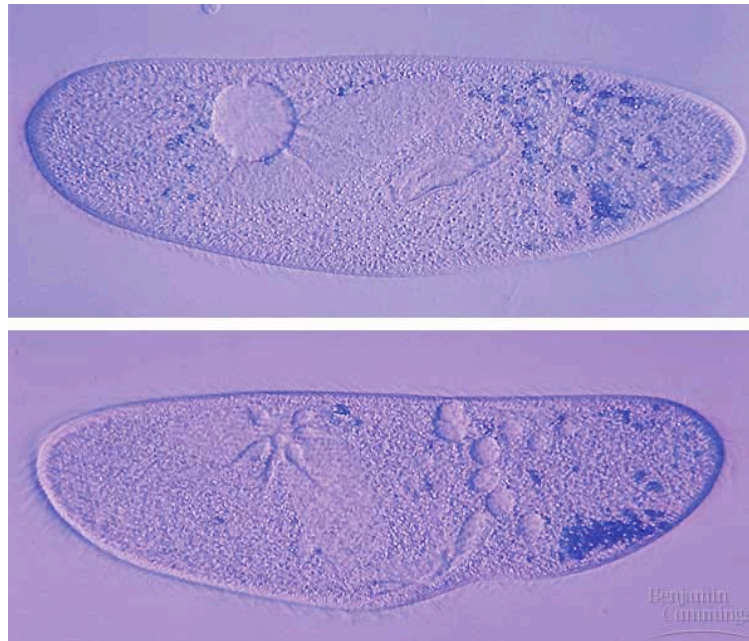
- ◆ animal cell in hypotonic solution will gain water, swell & burst
 - *Paramecium* vs. pond water
 - *Paramecium* is hypertonic
 - H₂O continually enters cell
 - to solve problem, specialized organelle, contractile vacuole
 - pumps H₂O out of cell = ATP
- ◆ plant cell
 - turgid

Hypotonic solution



Water regulation

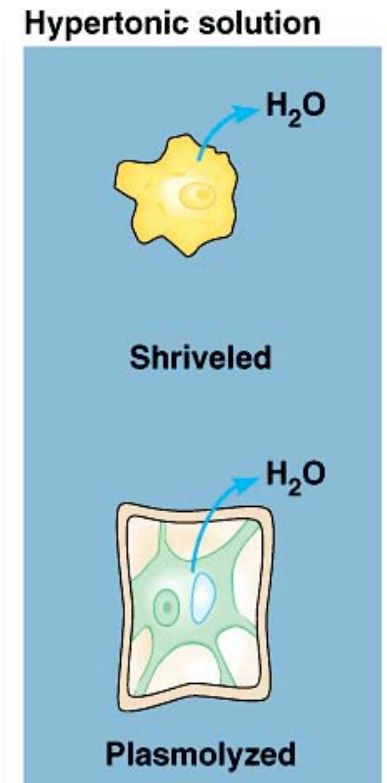
- Contractile vacuole in *Paramecium*



Managing water balance

■ Hypertonic

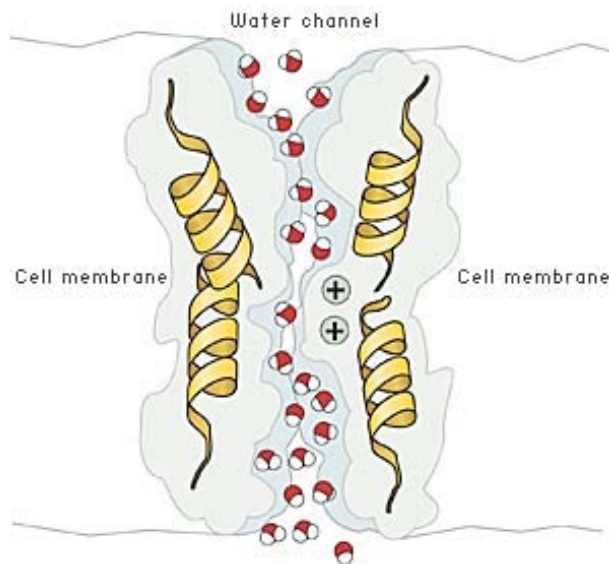
- ◆ animal cell in hypertonic solution will lose water, shrivel & probably die
 - salt water organisms are hypotonic compared to their environment
 - they have to take up water & pump out salt
- ◆ plant cells
 - plasmolysis = wilt



1991 | 2003

Aquaporins

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

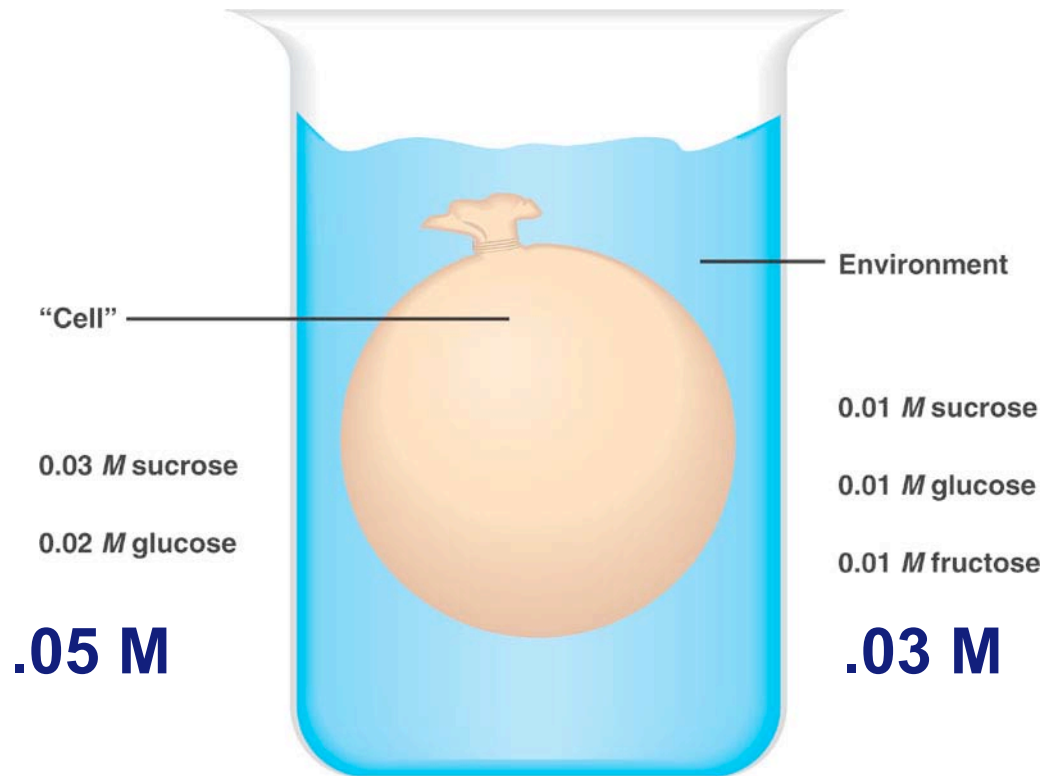


Peter Agre
John Hopkins



Roderick MacKinnon
Rockefeller
2005-2006

Osmosis...



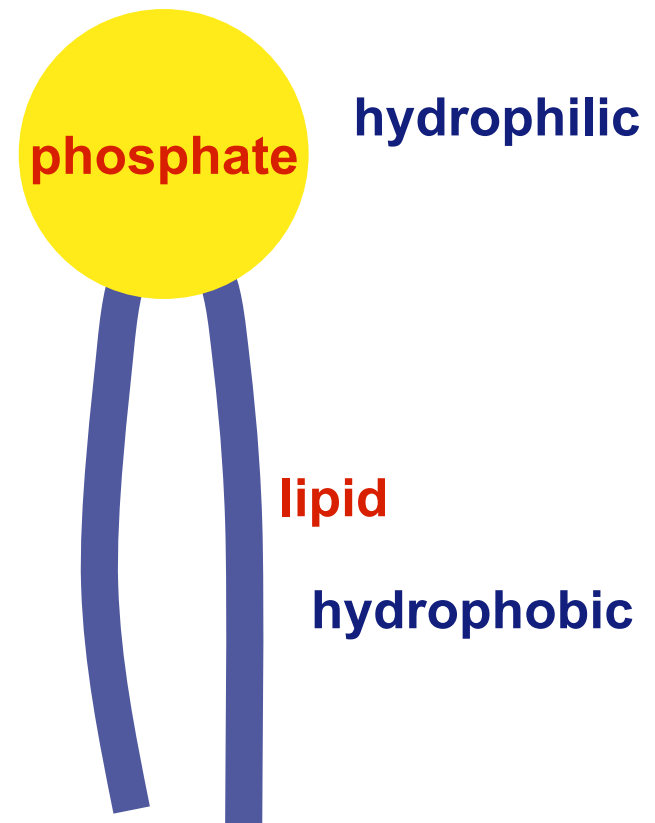
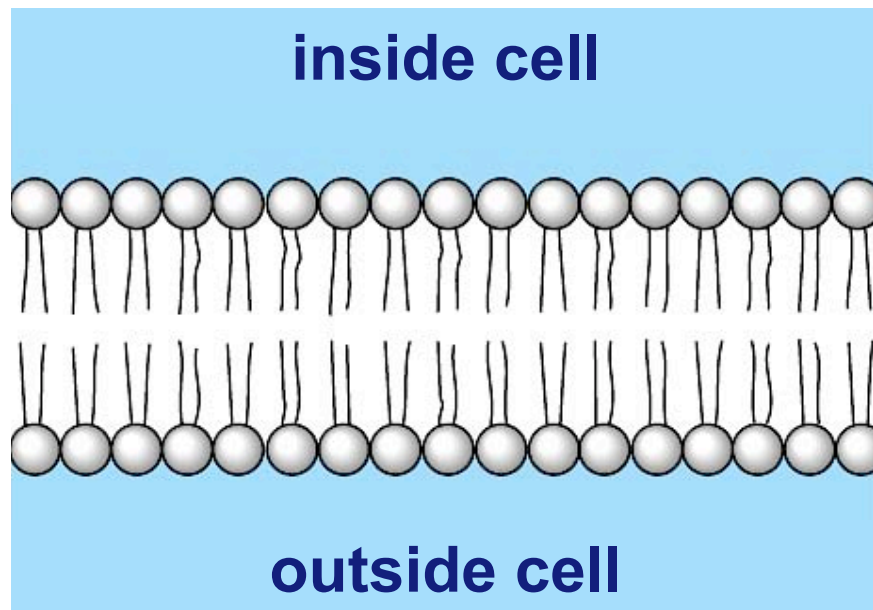
Cell (compared to beaker) → hypertonic or hypotonic

Beaker (compared to cell) → hypertonic or hypotonic

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

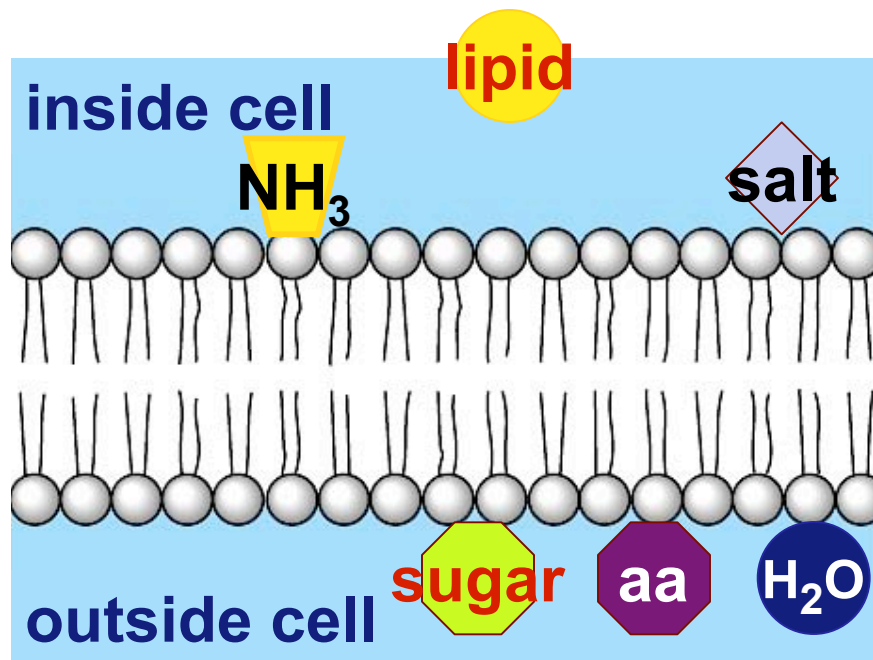
Lipids of cell membrane

- Membrane is made of phospholipids
 - ◆ phospholipid bilayer



Phospholipid bilayer

- What molecules can get through directly?

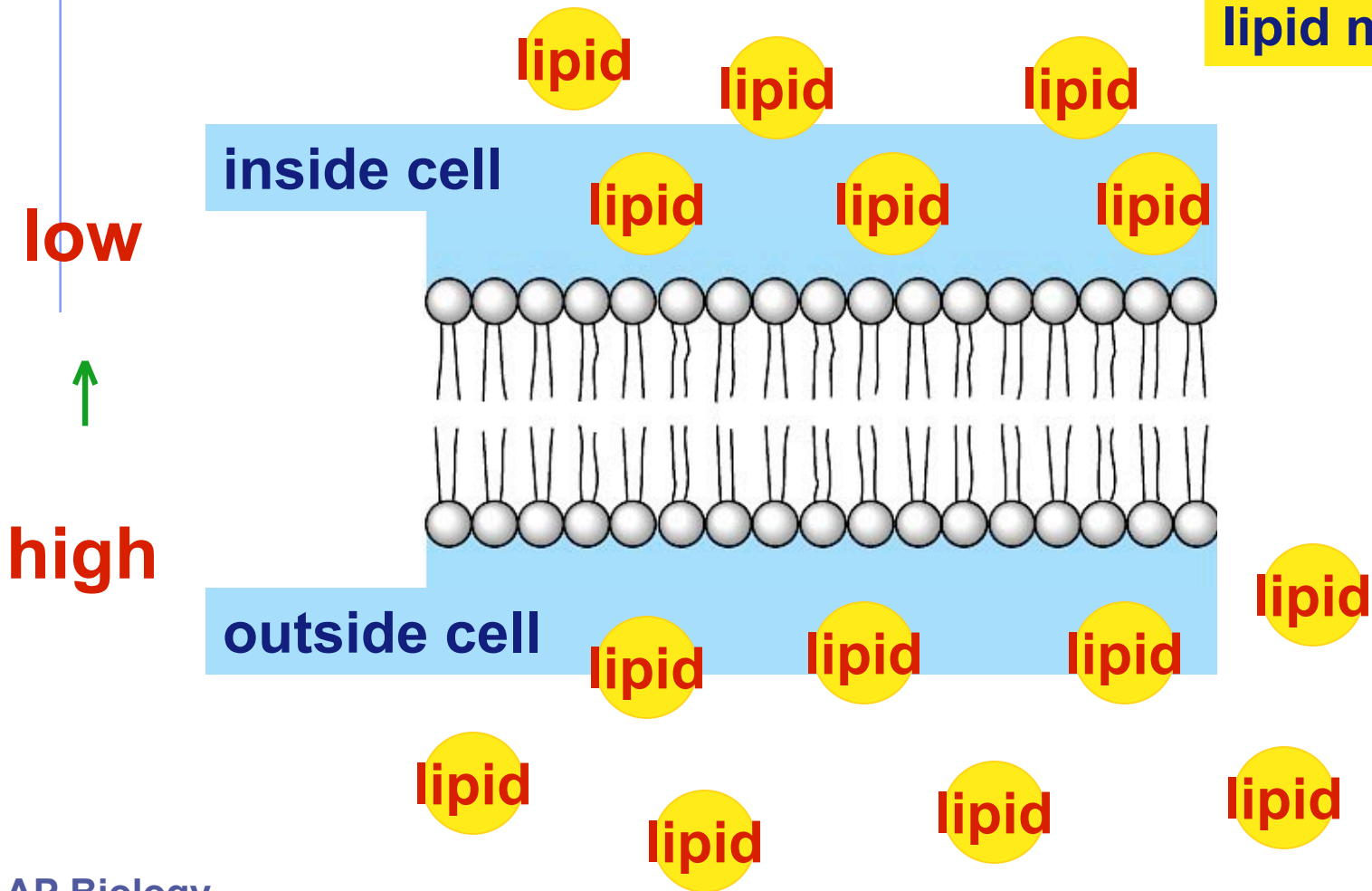


fats & other lipids
can slip directly
through the
phospholipid cell
membrane, but...

what about other
stuff?

Simple diffusion across membrane

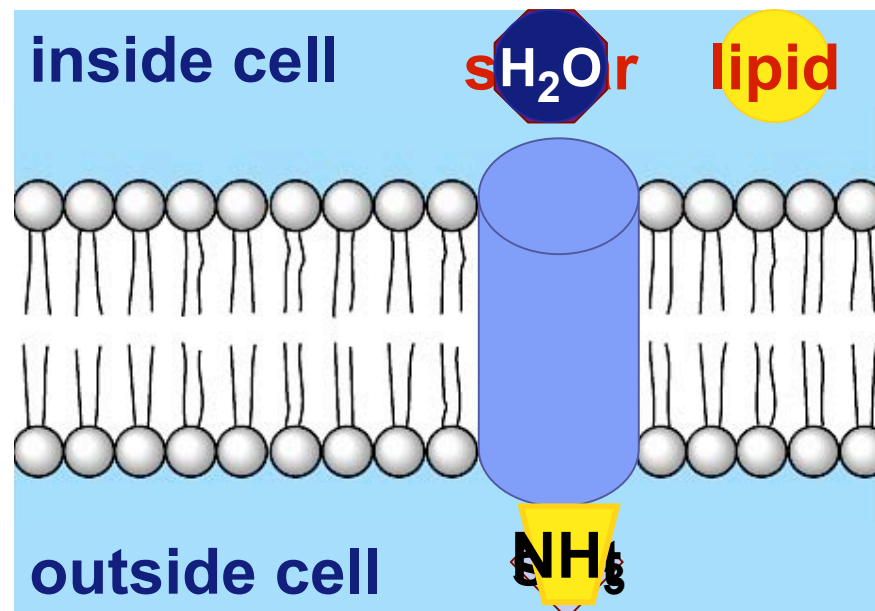
Which way will lipid move?



Permeable cell membrane

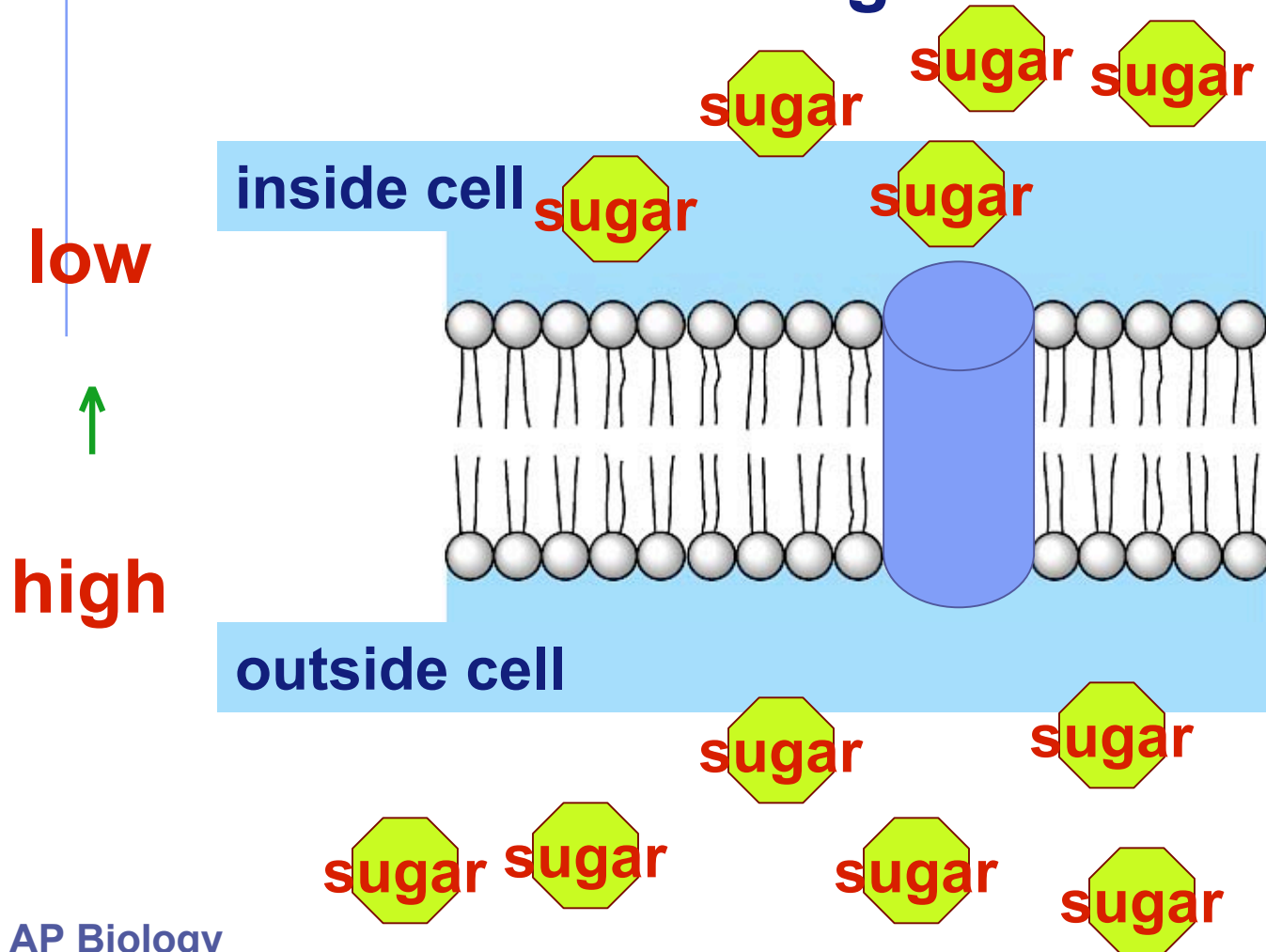
- Need to allow more material through
 - ◆ membrane needs to be permeable to...
 - all materials a cell needs to bring in
 - all waste a cell needs excrete out
 - all products a cell needs to export out

“holes”, or channels, in cell membrane allow material in & out



Diffusion through a channel

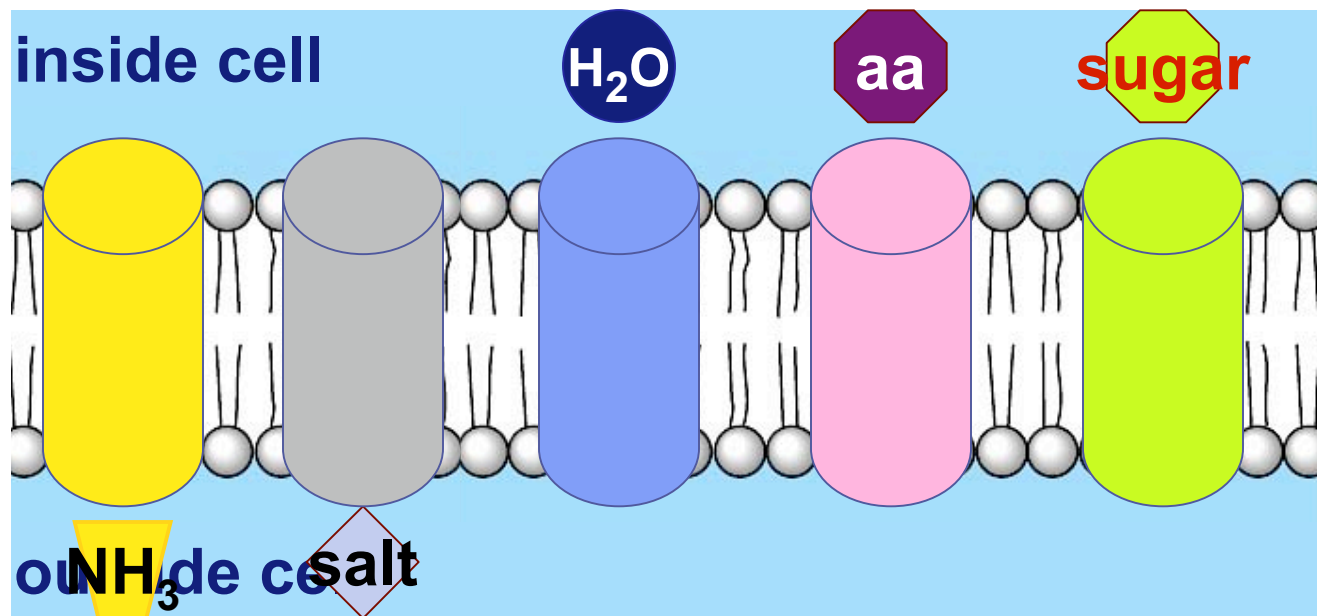
- Movement from high to low



Which way will sugar move?

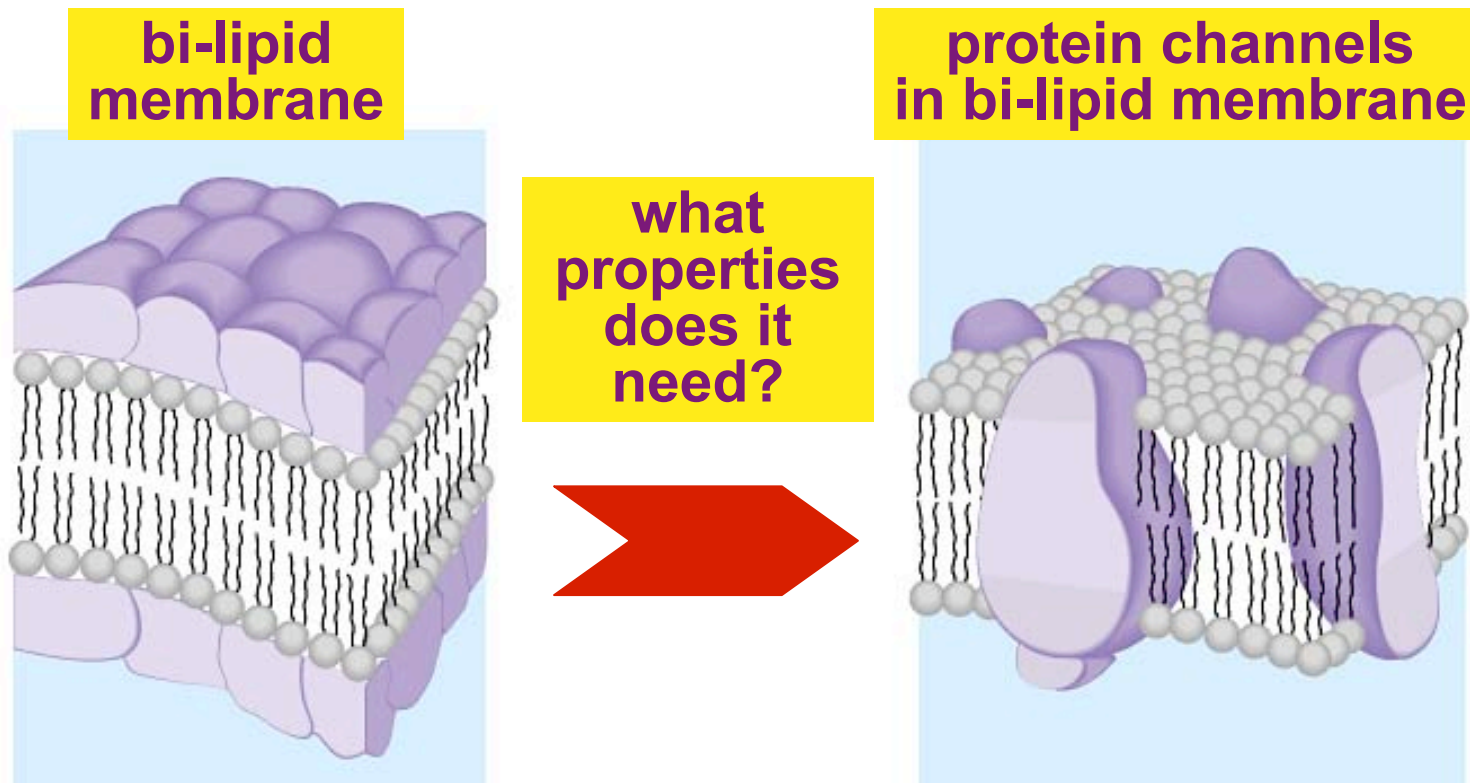
Semi-permeable cell membrane

- 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?

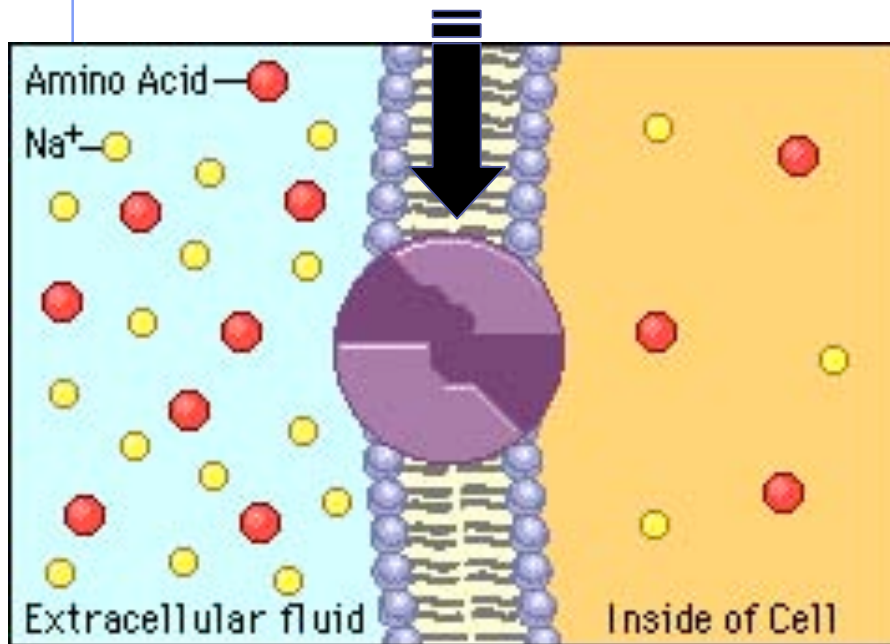
- What molecule will sit “comfortably” in a phospholipid bilayer forming channels



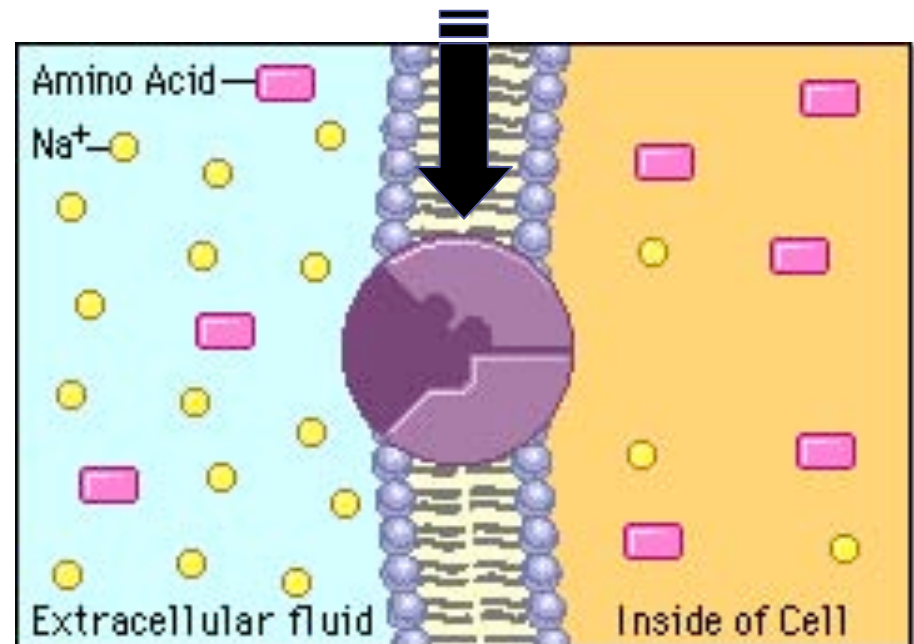
Active transport

- Many models & mechanisms

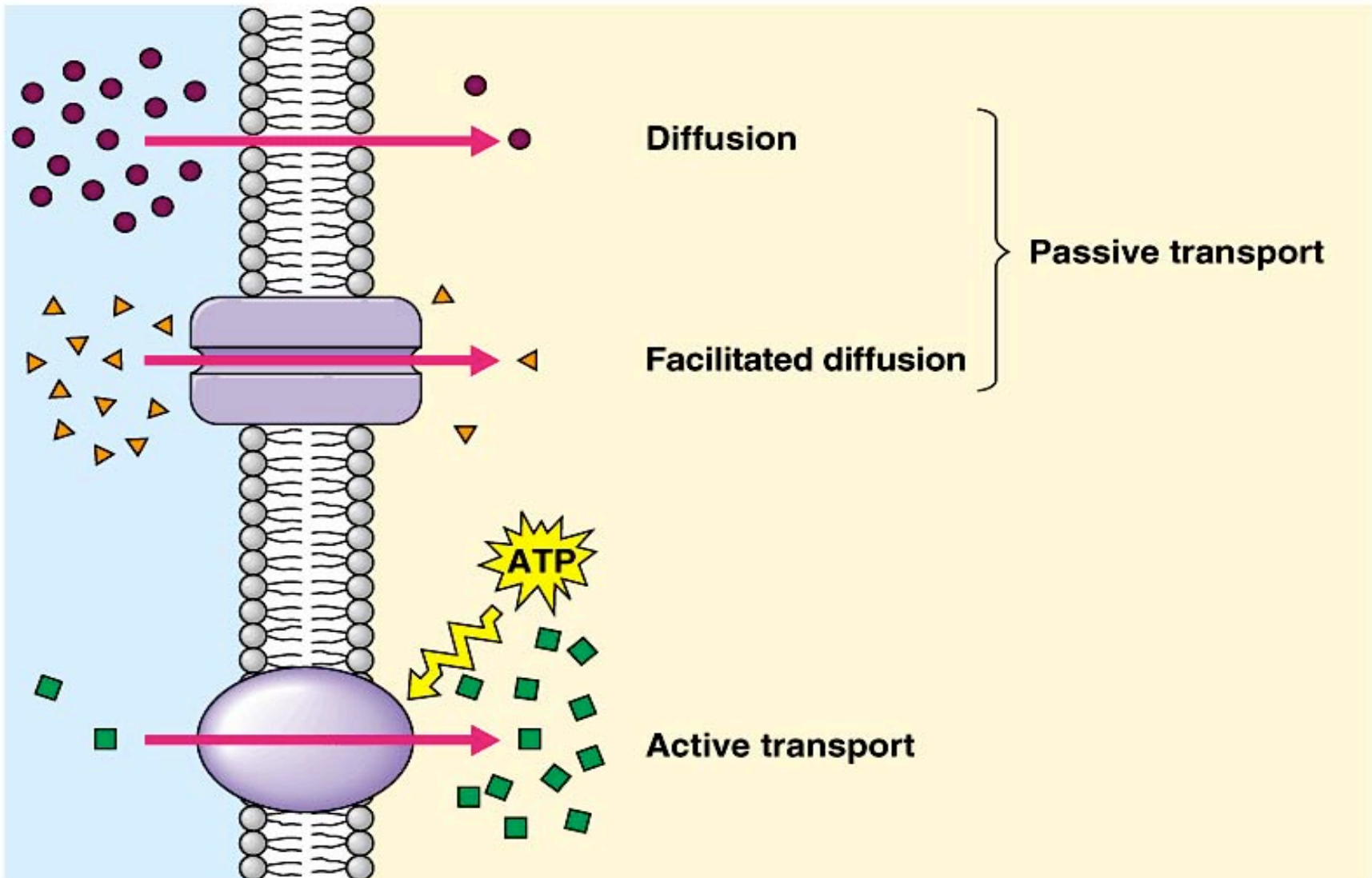
using ATP



using ATP



Transport summary

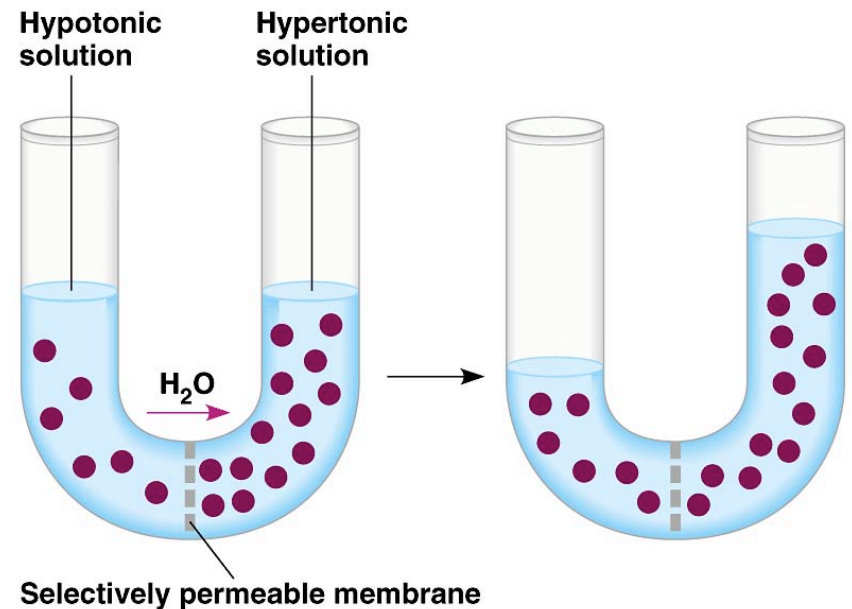


A

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

