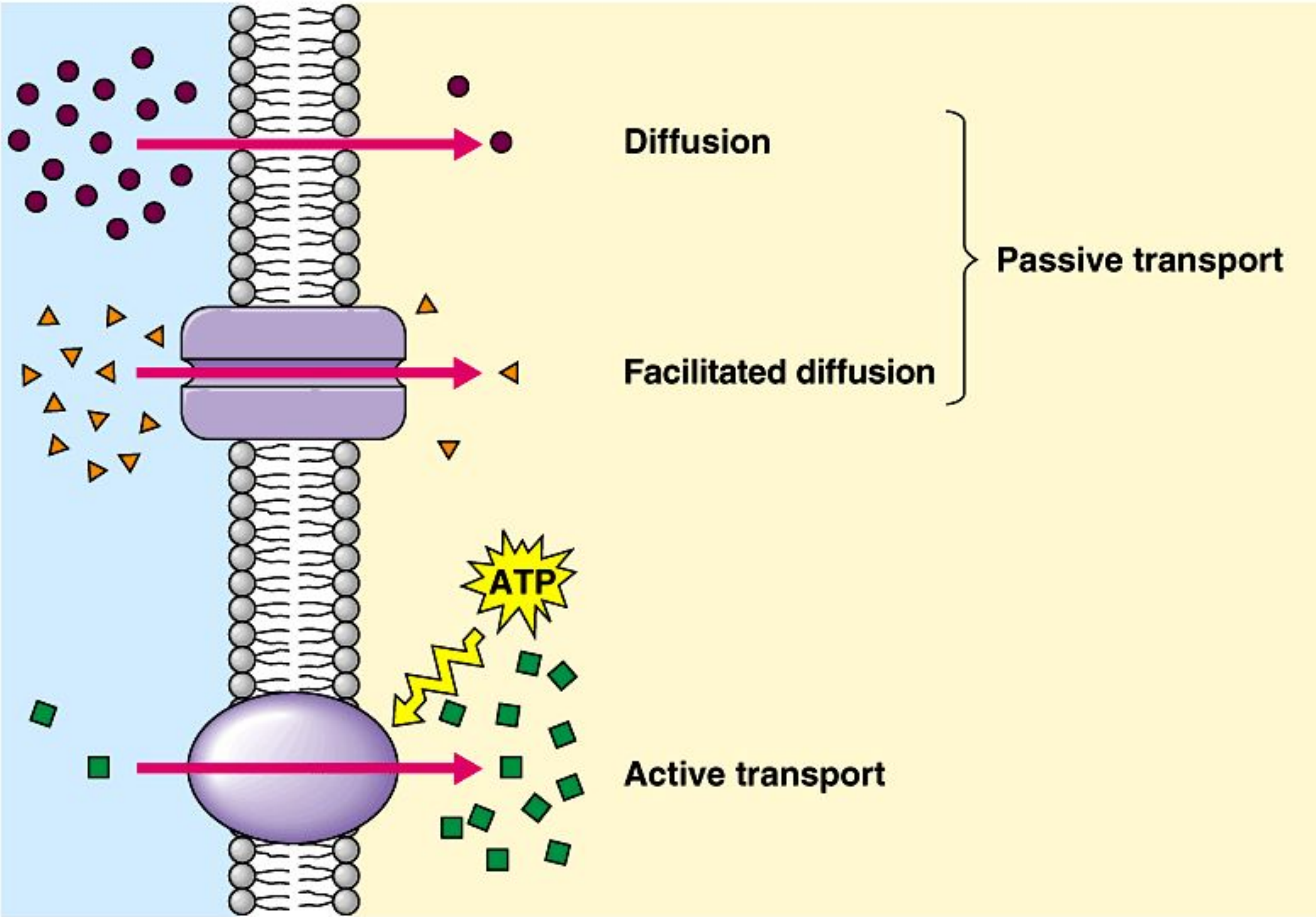
Membrane Transport

EQ 2.3: What are the mechanisms that organisms use to move ions and other molecules across membranes?

Types of Transport



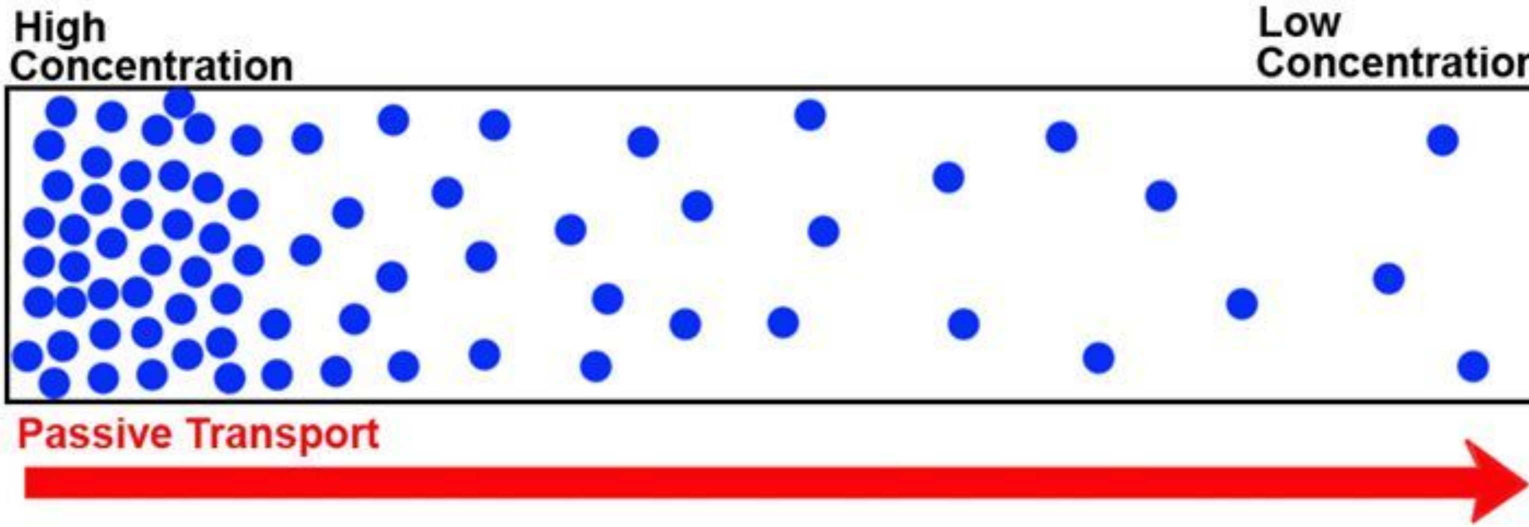
Passive Transport

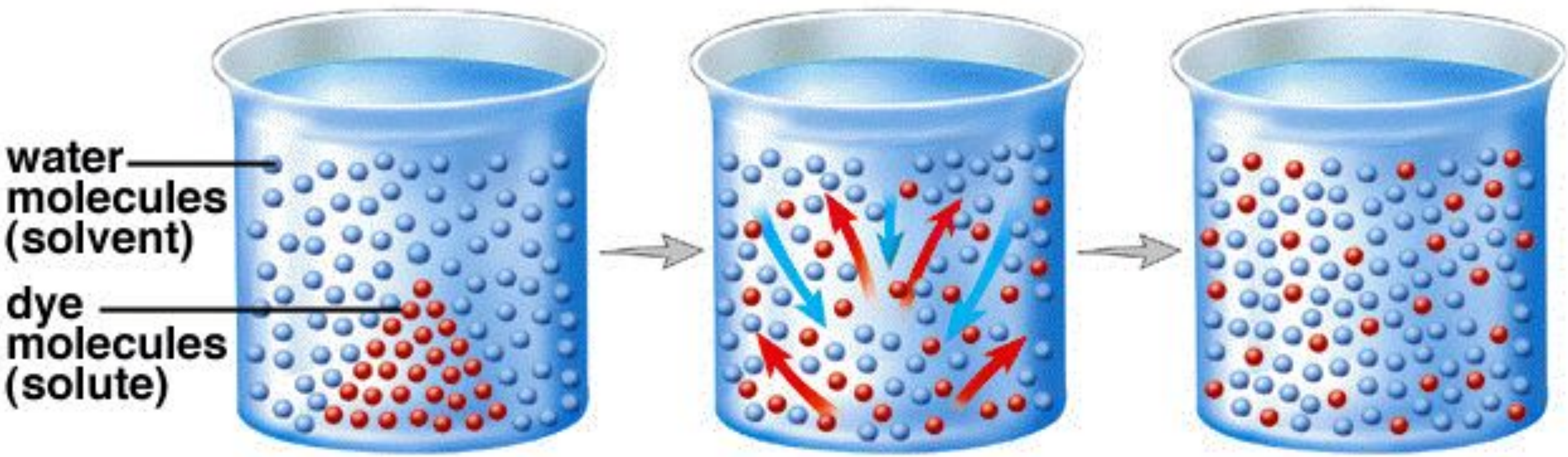
Passive Transport

- Requires NO energy - spontaneous
- Molecules move down a concentration gradient – from high to low concentration
- decreases free energy (entropy increases)
- Diffusion and osmosis

Diffusion

- The tendency for molecules to spread out into available space due to their thermal energy
- Molecules move down their concentration gradient until they are as evenly distributed as possible
- Each substance diffuses down its <u>own</u> concentration gradient, unaffected by the concentrations of other molecules in the system





a. Crystal of dye is placed in water

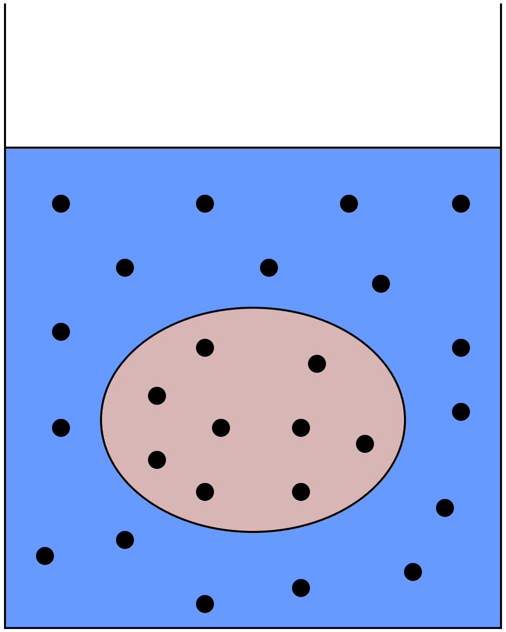
b. Diffusion of water and dye molecules

c. Equal distribution of molecules results

Osmosis

- The diffusion of water down its concentration gradient across a semipermeable membrane.
  - Moves from high water to low water concentration (low solute to high solute concentration).

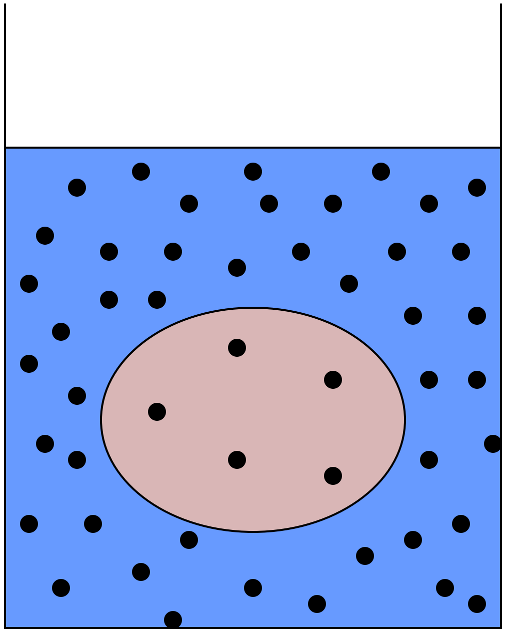
Types of Solutions:
(relative to the cell)



Isotonic solution

- Equal concentration of solute particles inside and out
- <u>Net</u> movement of water is zero
- Cell stays the same size

Types of Solutions:
(relative to the cell)

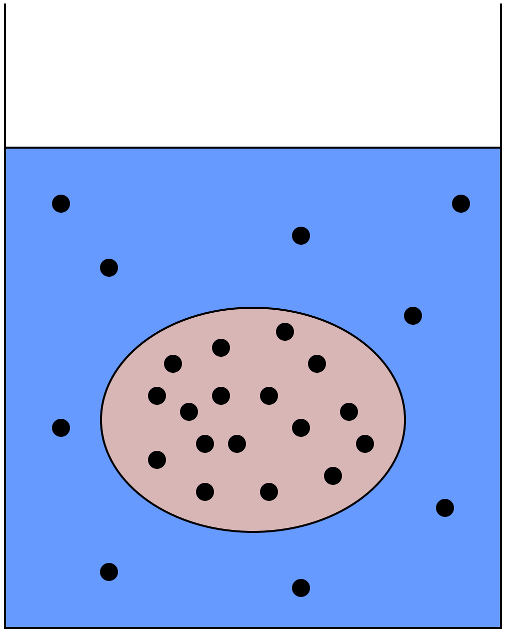


Hypertonic solution

- More solute particles in the solution than in the cell
- Water moves from the hypotonic cell into this solution
- Cell shrivels

Types of Solutions:

(relative to the cell)

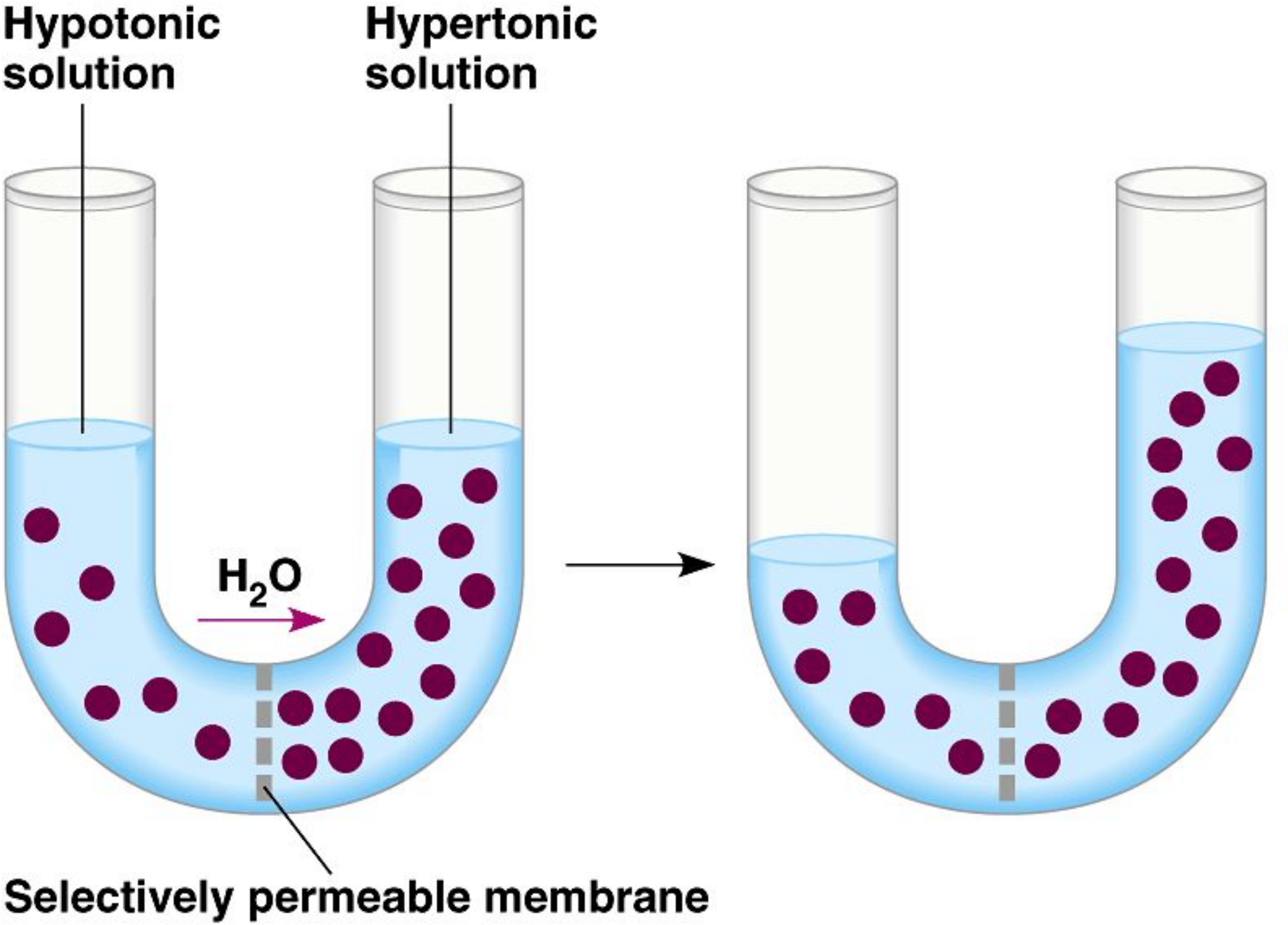


Hypotonic solution

- Fewer solute particles in the solution than in the cell

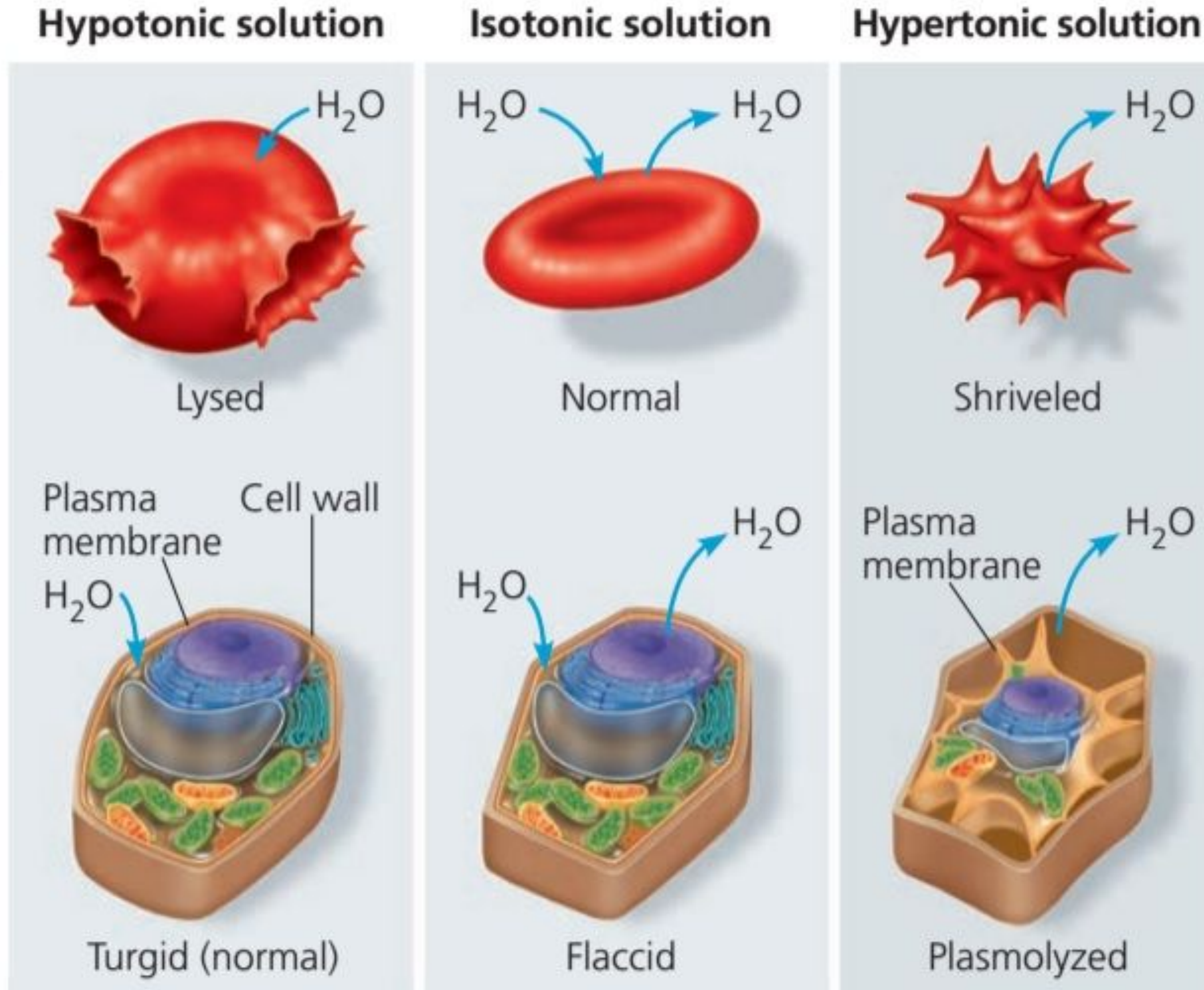
- Water moves from the solution into the hypertonic cell

- Cell expands


Hypotonic solution
Hypertonic solution
H_2O
Selectively permeable membrane

(a) Animal cell. An animal cell fares best in an isotonic environment unless it has special adaptations that offset the osmotic uptake or loss of water.

(b) Plant cell. Plant cells are turgid (firm) and generally healthiest in a hypotonic environment, where the uptake of water is eventually balanced by the wall pushing back on the cell.



Hypertonic and Hypotonic are relative terms

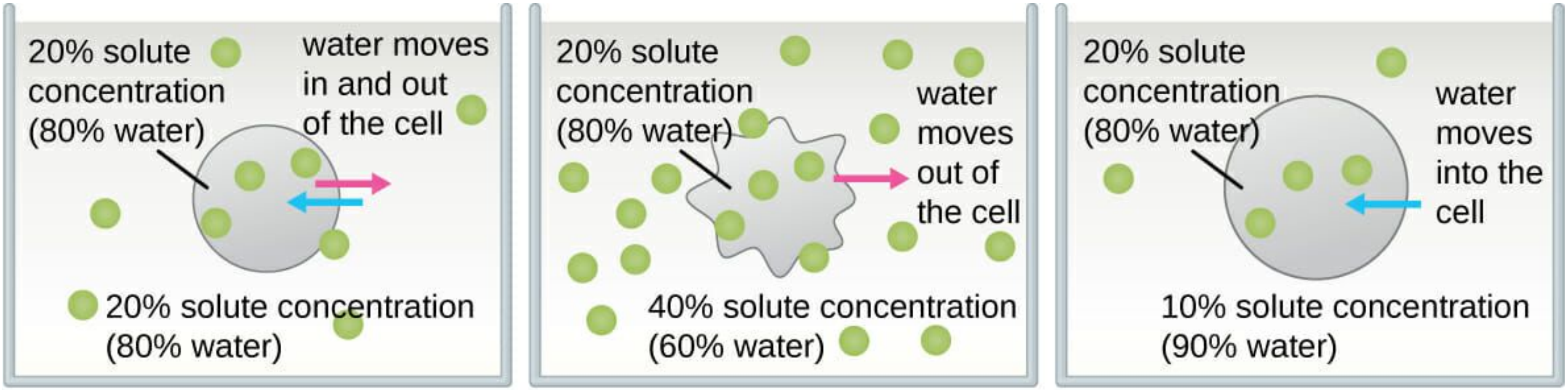
- You can't have one without the other.
  - ex. a glass of concentrated salt water sitting on your counter is not hypertonic by itself.
- Get into the habit of being **very specific** when using them:
  - *A hypertonic cell in a hypotonic solution.*
  - *The solution is hypertonic to the hypotonic solution inside the cell.*

How can you describe the cell and external solution in each of these scenarios?

This cell and its solution are isotonic to one another

This is a hypotonic cell in a hypertonic solution.

This is a hypertonic cell in a hypotonic solution.



Osmoregulation

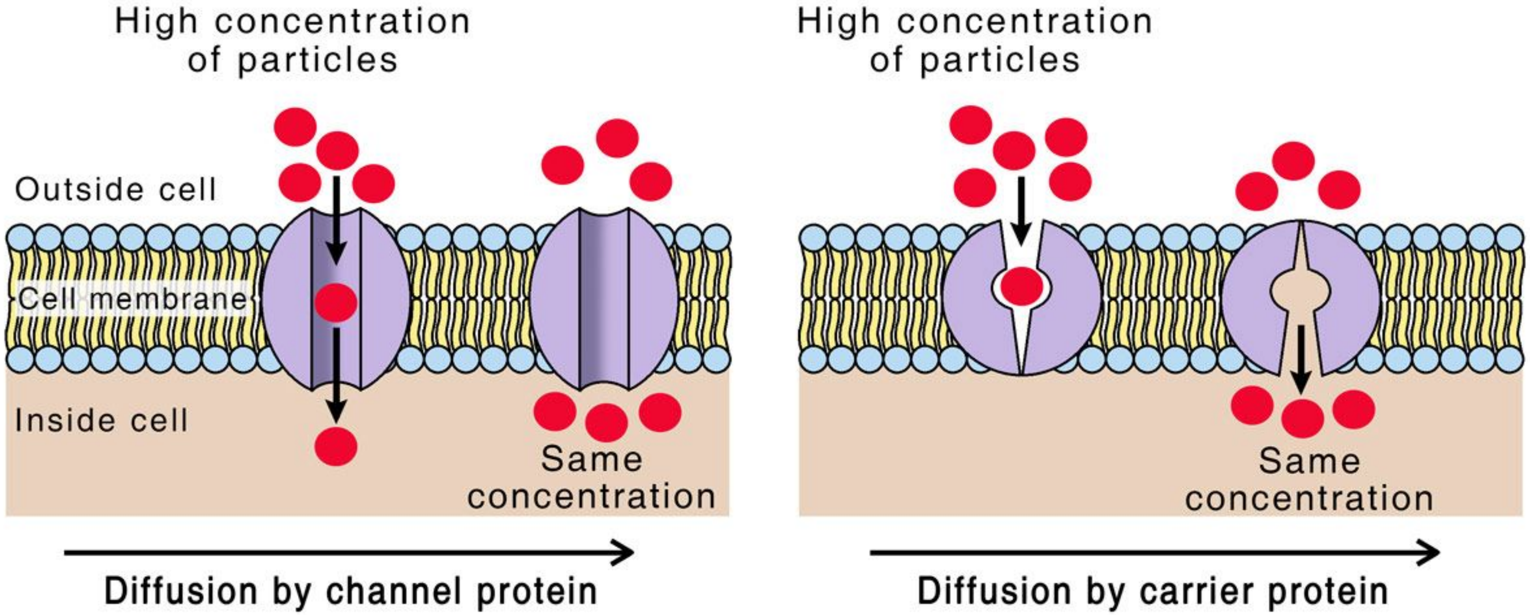
- Cells must be able to maintain balance in different types of aquatic environments

Especially important for animal cells (no cell wall)

ex. Cells pump water out as it comes in
(paramecium1)
(paramecium popping)

Facilitated Diffusion

- Still passive (high to low), but requires the presence of a specific channel
- Often used for polar molecules and ions
- Channels may be gated



ATP! ATP! ATP!

Active Transport

ATP! ATP!

ATP! ATP! ATP!

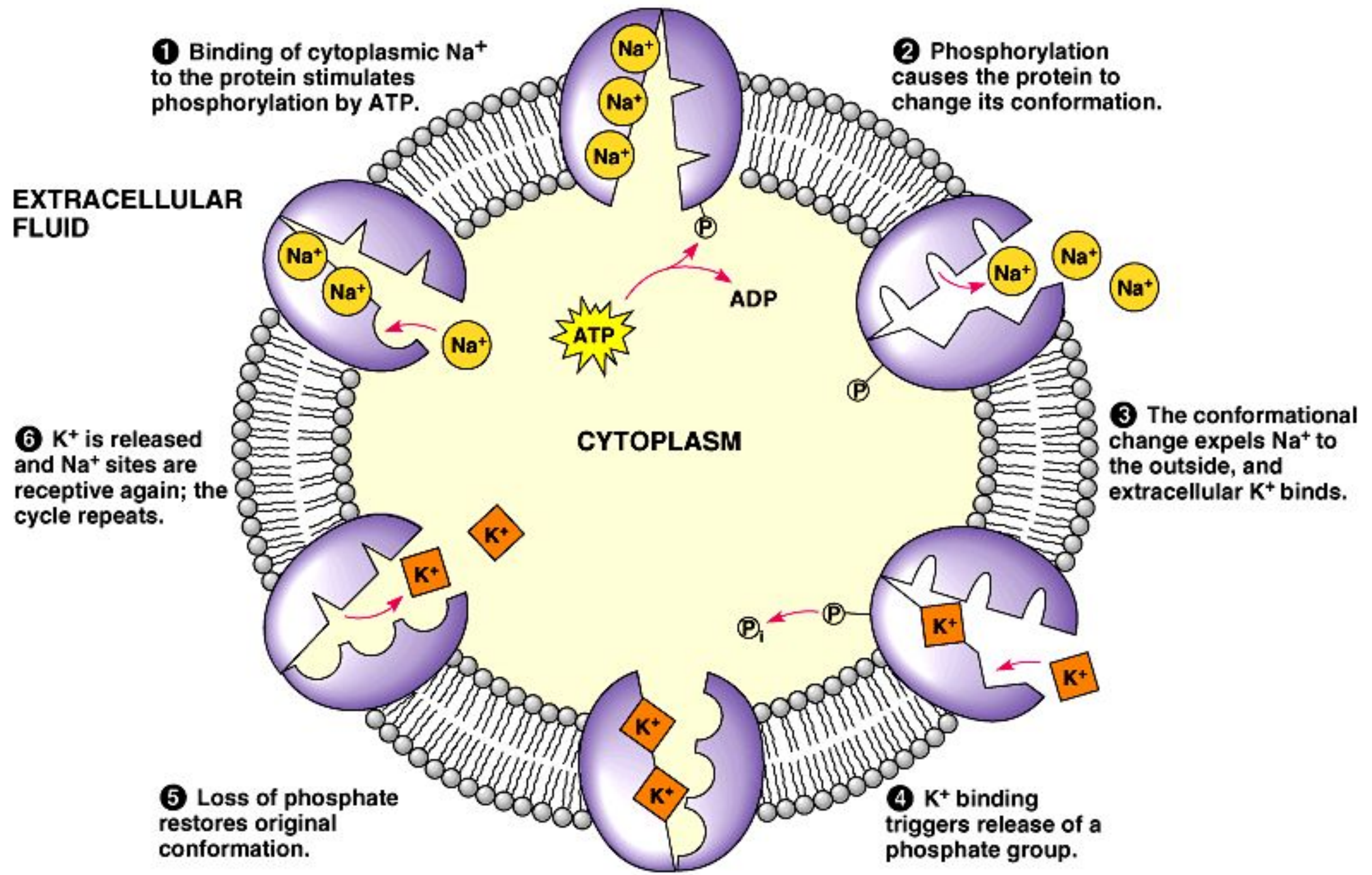
Active Transport

- Requires ATP to pump molecules AGAINST their concentration gradients (low to high)
- Proteins and channels are involved
- Often used to maintain homeostasis

It takes energy to push molecules against their gradient, to an area where they are already highly concentrated!!

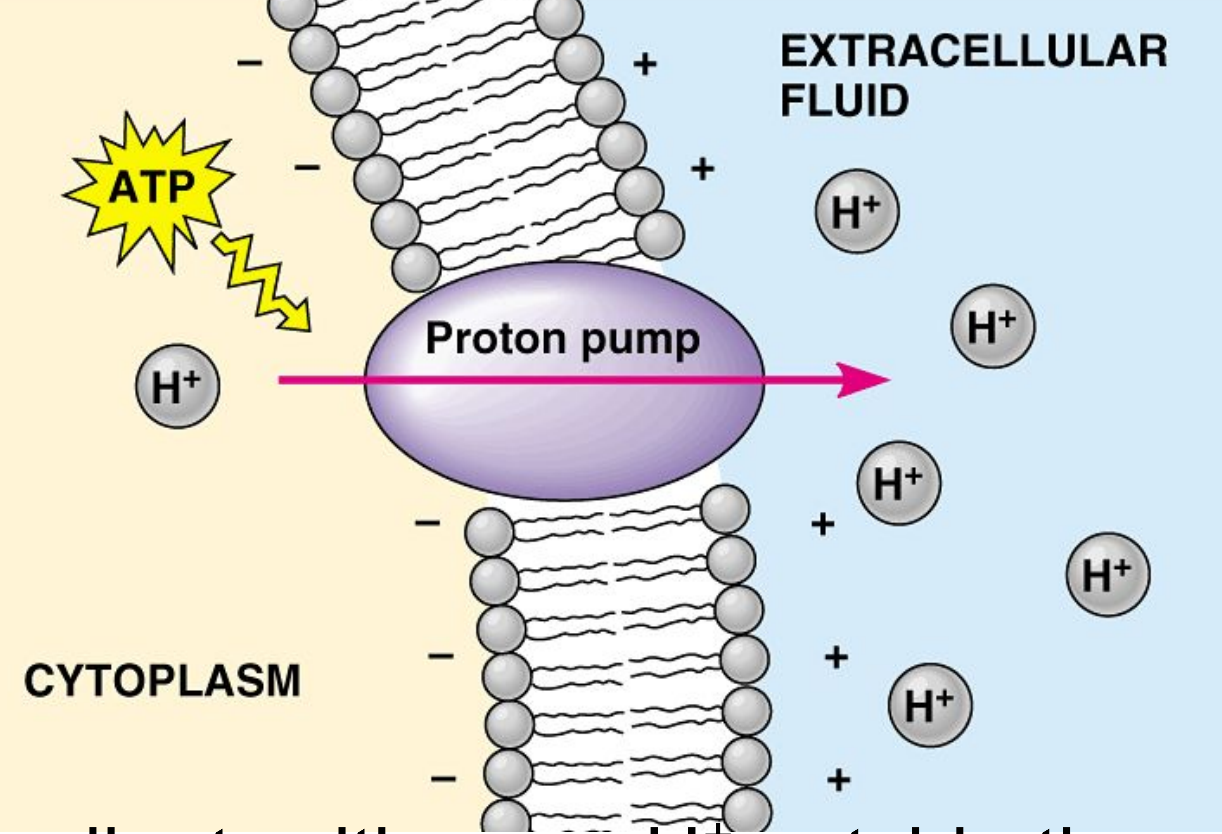
Sodium-Potassium Pump

- Uses 1 ATP to pump out 3 Na^+ and pump in 2 K^+
- The pump establishes & maintains a gradient with more Na^+ outside the cell and more K^+ inside.
- Sets up an electrochemical gradient
  - cell's inside is negatively charged compared to the outside (membrane potential)



❶ Binding of cytoplasmic Na^+ to the protein stimulates phosphorylation by ATP.
❷ Phosphorylation causes the protein to change its conformation.
EXTRACELLULAR FLUID
Na^+
ATP
ADP
P
CYTOPLASM
❸ The conformational change expels Na^+ to the outside, and extracellular K^+ binds.
❻ K^+ is released and Na^+ sites are receptive again; the cycle repeats.
K^+
P_i
❺ Loss of phosphate restores original conformation.
❹ K^+ binding triggers release of a phosphate group.

Proton pumps



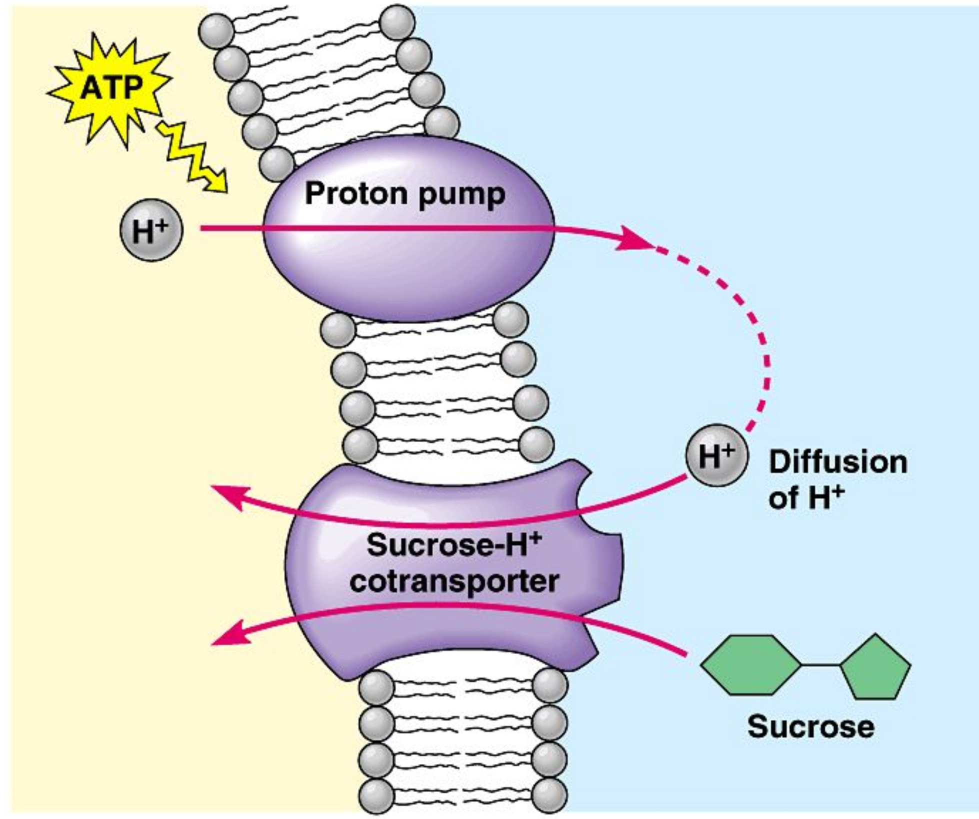
- Maintain a H^+ gradient, with more H^+ outside the cell
- Use ATP to pump H^+ outside the cell, against its gradient
- Concentration of protons can be used for cellular work.

Na^+/K^+ and H^+ pump summary:

- These two pumps maintain an electrochemical gradient. Cell interior is negative. Membrane potential.
  - Membrane potential of most cells is -20 to -50mV. Neurons are about -70mV.
- They maintain ion gradients that can be used to perform work for the cell

Cotransport

Use ATP to pump a molecule to one side of a membrane, and then have it do work as it passively diffuses back in!



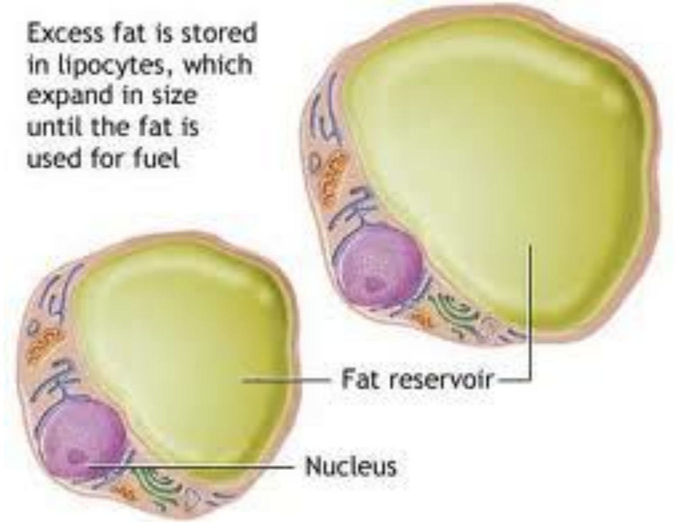
Ex: sucrose cotransporter. Plant cells pump out H^+ ions with a proton pump. They diffuse back in and bring a sucrose along with them! Plants use this mechanism to load sucrose into specialized storage cells.

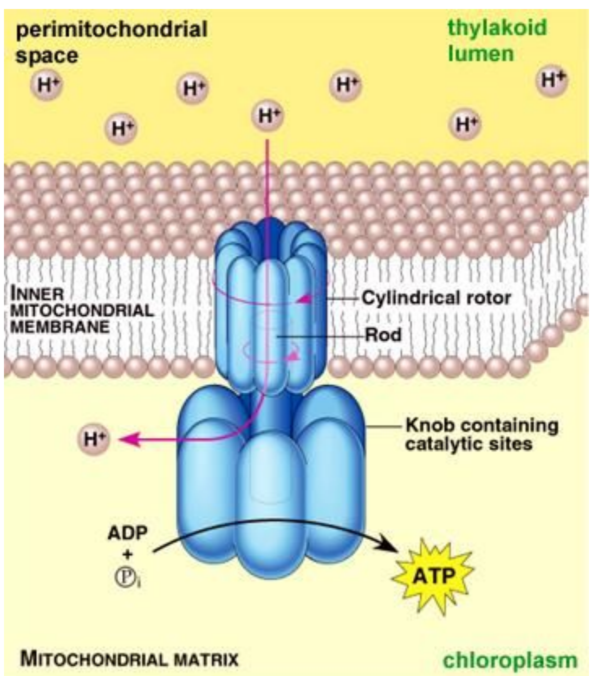
General cotransport ideas…

- Proton (or other) pumps establish a gradient.
- Ions diffuse back in through the cotransporter, which is easier than going through the membrane. Another molecule can tag along!
- The only energy used is spent on pumping out the ion, which the cell was going to do anyway.

Other examples of cotransport:

Animals store fat in fat cells using ion gradients and lipid co-transport proteins. The [lipid] is higher inside the cell and increases over time.





Chloroplasts and mitochondria create an H^+ gradient used to make ATP through an ATP synthase.