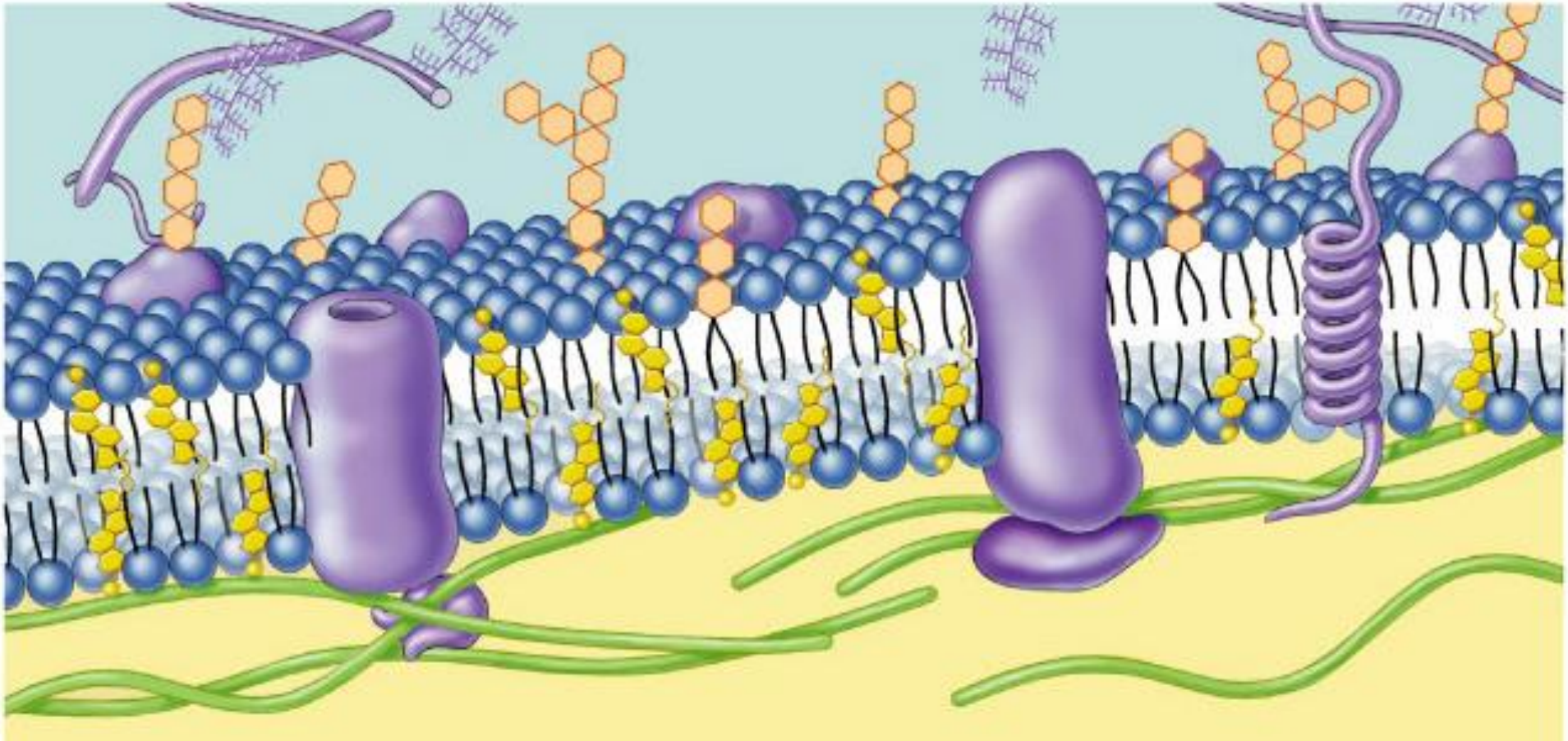
Membrane Transport



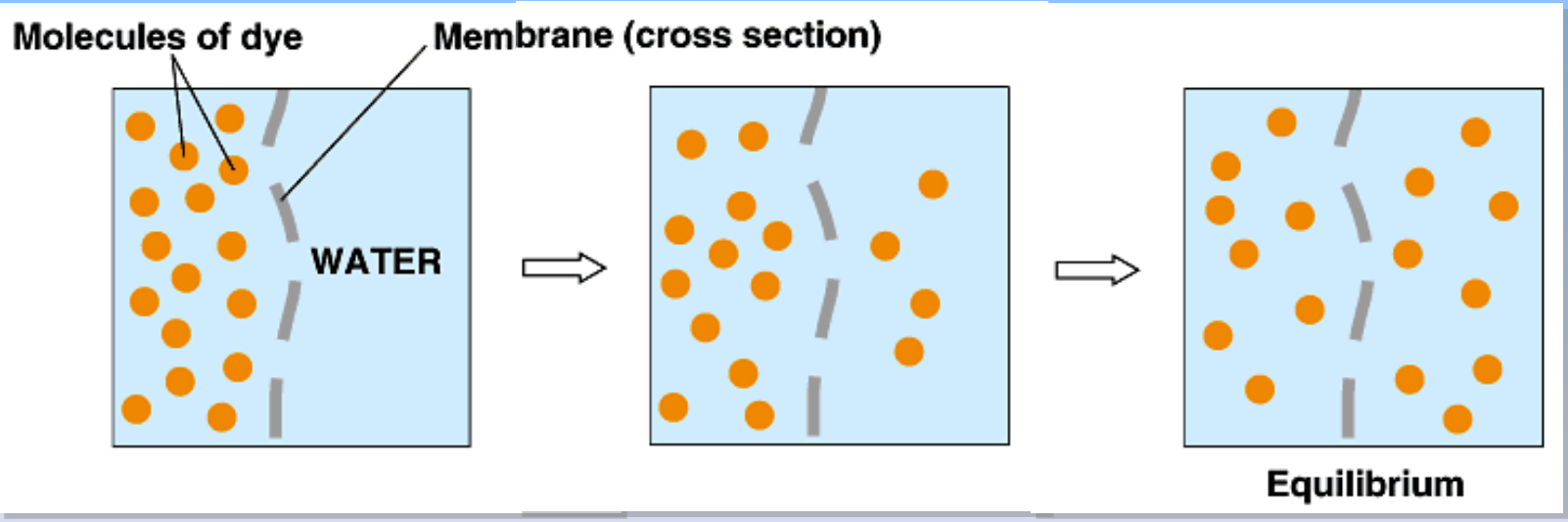
Passive Transport

- The movement of materials across a cell membrane without the use of energy (ATP)

- Movement of particles along a concentration gradient → from an area of higher concentration to an area of lower concentration (WITH a concentration gradient)

Diffusion

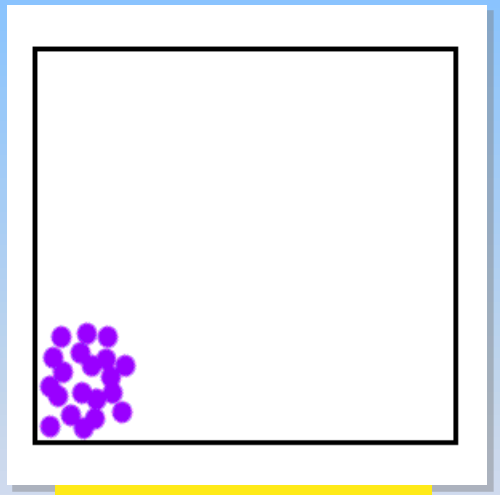
- 2nd Law of Thermodynamics governs biological systems
  - universe tends towards disorder (entropy)



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

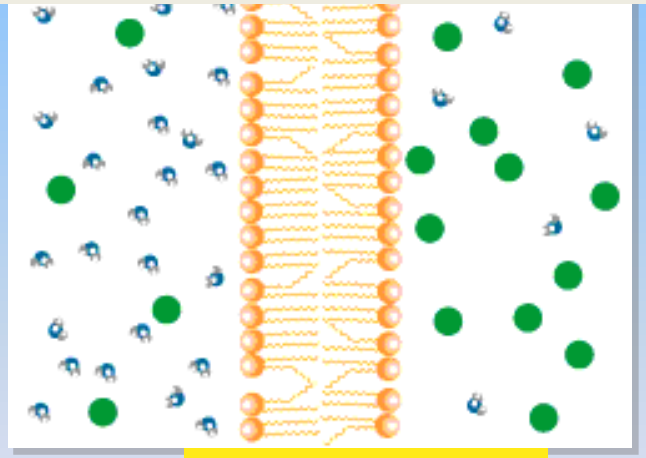
Simple Diffusion

- Movement of particles from HIGH to LOW concentration areas
  - "passive transport"
  - no energy needed
  - Will continue until equilibrium is achieved



diffusion

movement of water



osmosis

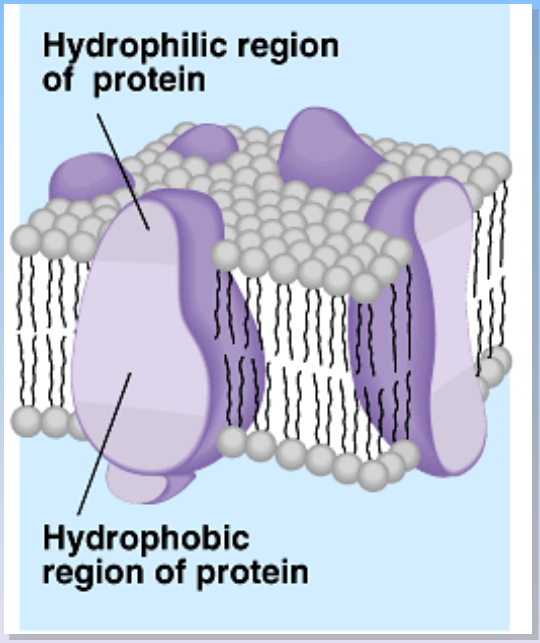
Example: Movement of O_2 into cells and CO_2 out of cells

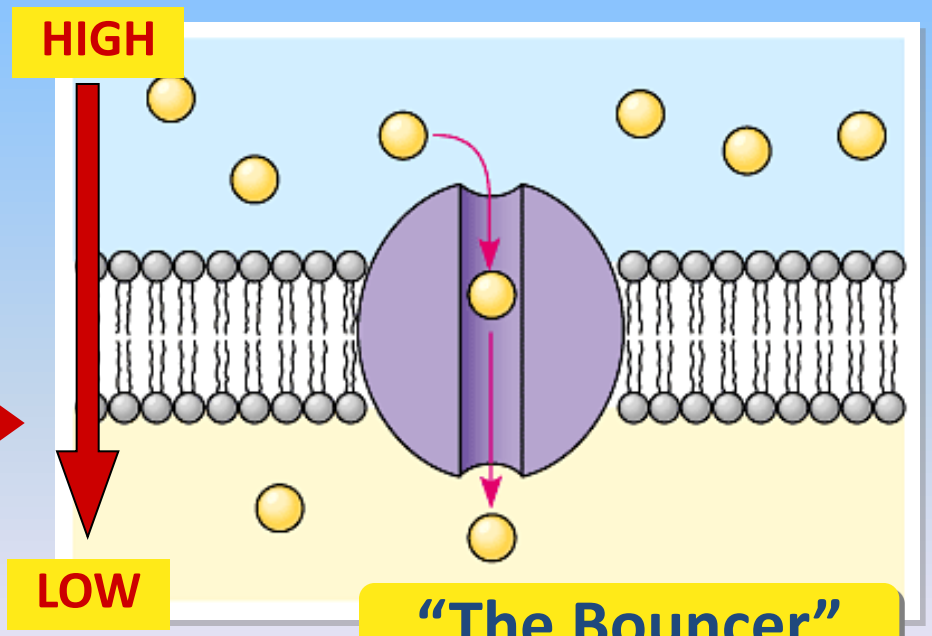
Facilitated Diffusion

- Molecules too large for simple diffusion or are hydrophilic
- Diffusion through protein channels
  - channels move specific molecules across cell membrane
  - no energy needed

facilitated = with help

open channel = fast transport

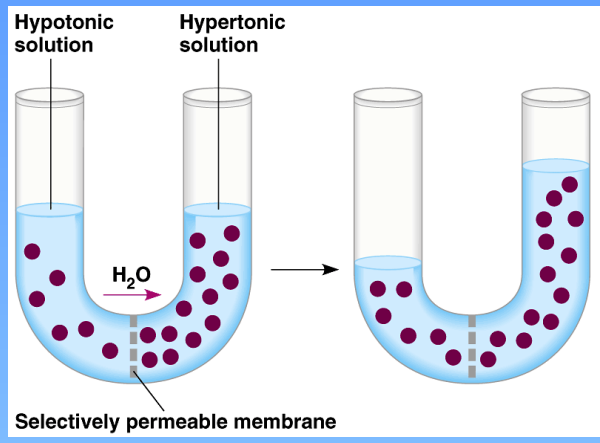




"The Bouncer"

Example: Glucose is constantly being used up inside the cell so the concentration gradient is maintained; Small ions

Osmosis

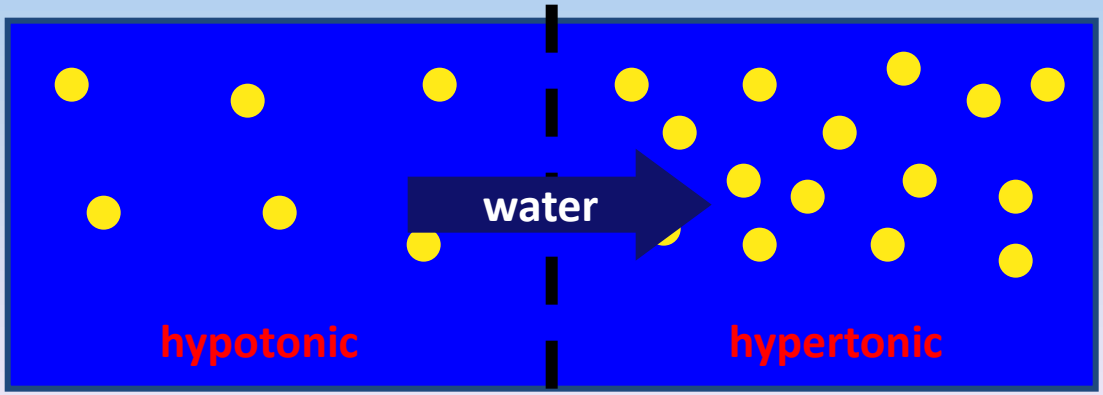


- Water is very important to life, so we talk about water separately
- Diffusion of **WATER** through a selectively permeable membrane from an area of *HIGH concentration* of water to an area of *LOW concentration* of water
  - Water moves from an area of lower solute concentration to an area of higher solute concentration

Osmosis is important to aquatic organisms.
Kidney's use osmosis to regulate water balance in the blood.

Concentration of water

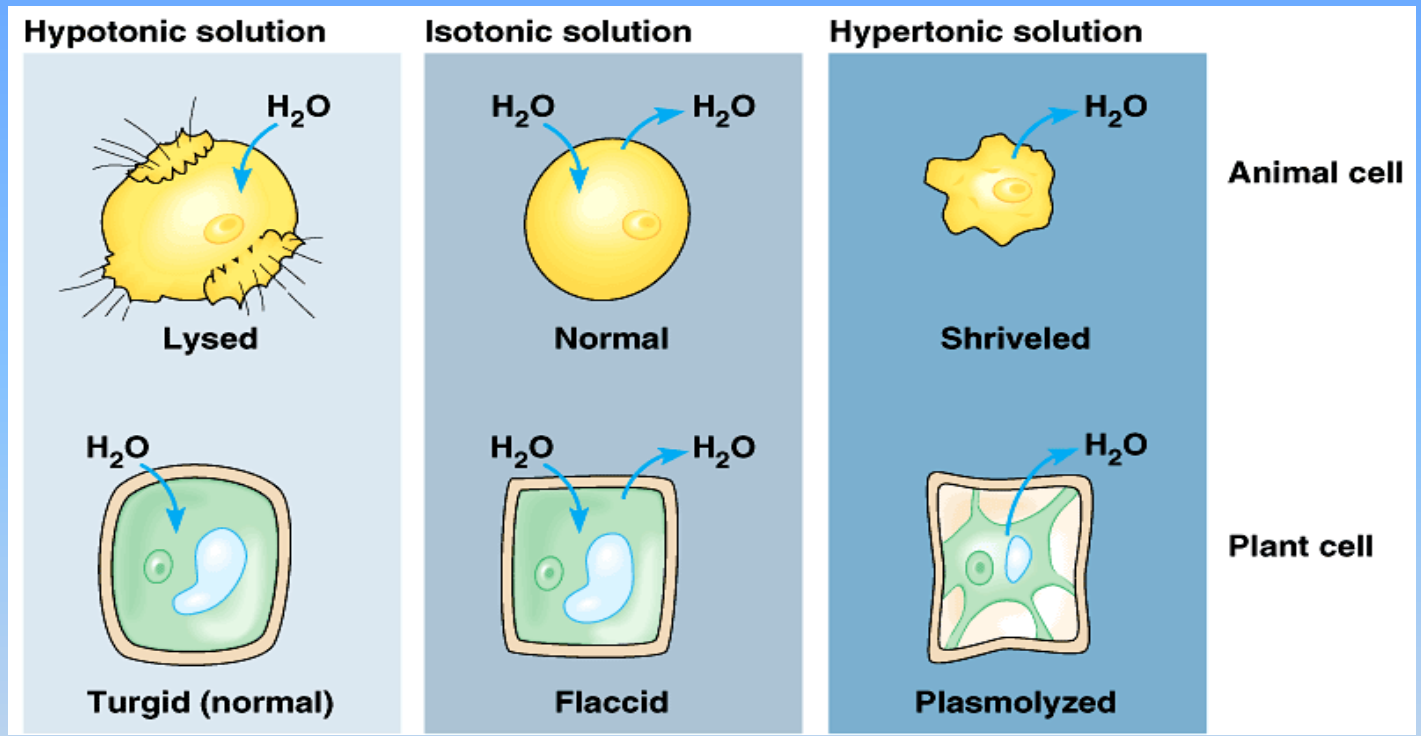
- Direction of osmosis is determined by comparing total solute concentrations
  - Hypertonic - more solute, less water
  - Hypotonic - less solute, more water
  - Isotonic - equal solute, equal water



net movement of water

Managing water balance

- Cell survival depends on balancing water uptake & loss



freshwater

In a <u>hypotonic</u> solution the concentration of solutes is <u>higher inside</u> the cell. Water moves <u>into</u> the cell

balanced

In a <u>isotonic</u> solution the concentration of solutes is <u>equal</u> inside the cell and out.

saltwater

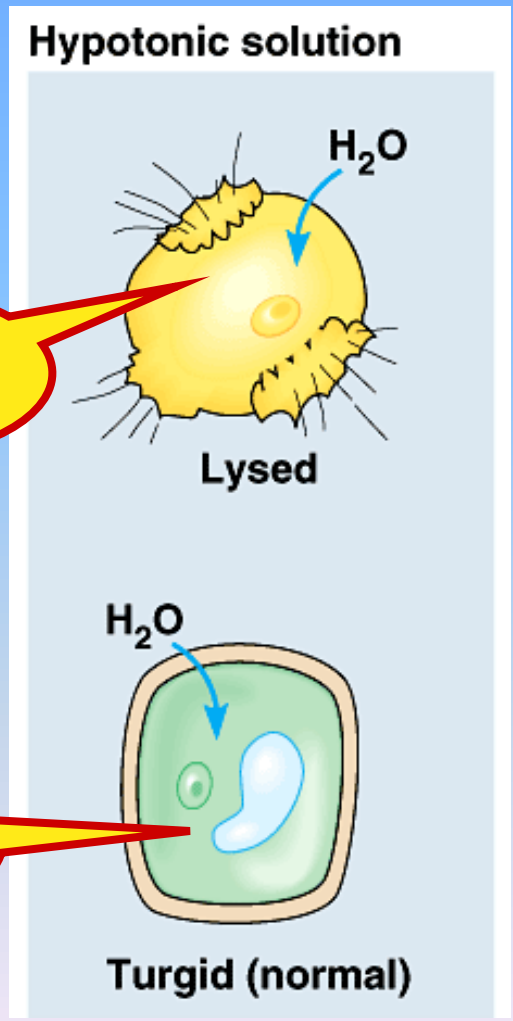
In a <u>hypertonic</u> solution the concentration of solutes is <u>higher outside</u> the cell. Water moves <u>out of</u> the cell

1

Managing water balance

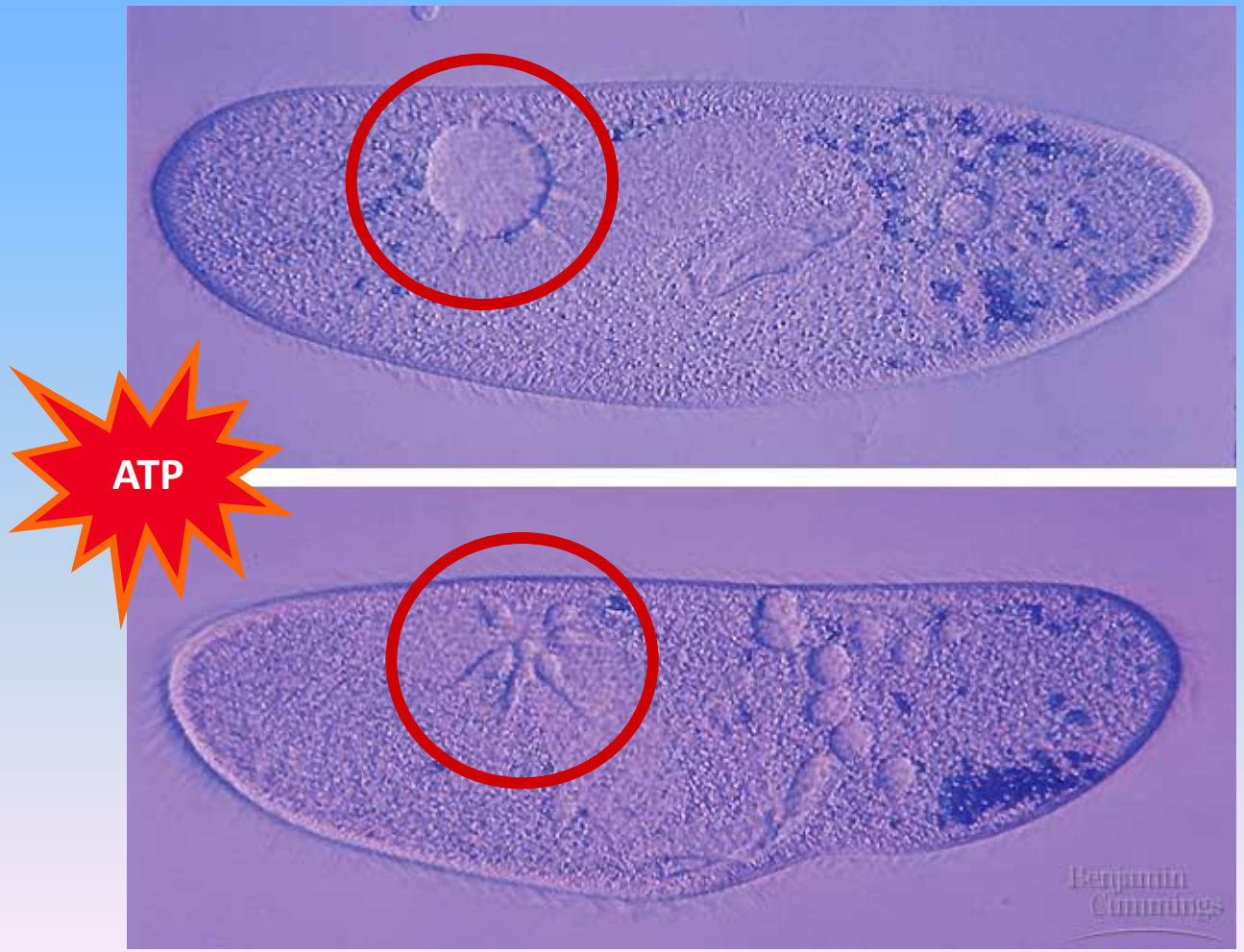
- Hypotonic
  - a cell in fresh water
  - high concentration of water around cell
    - problem: cell gains water, swells & can burst
    - example: *Paramecium*
    - solution: contractile vacuole
      - pumps water out of cell
      - Uses ATP
  - plant cells
    - turgid = full
    - cell wall protects from bu

ATP



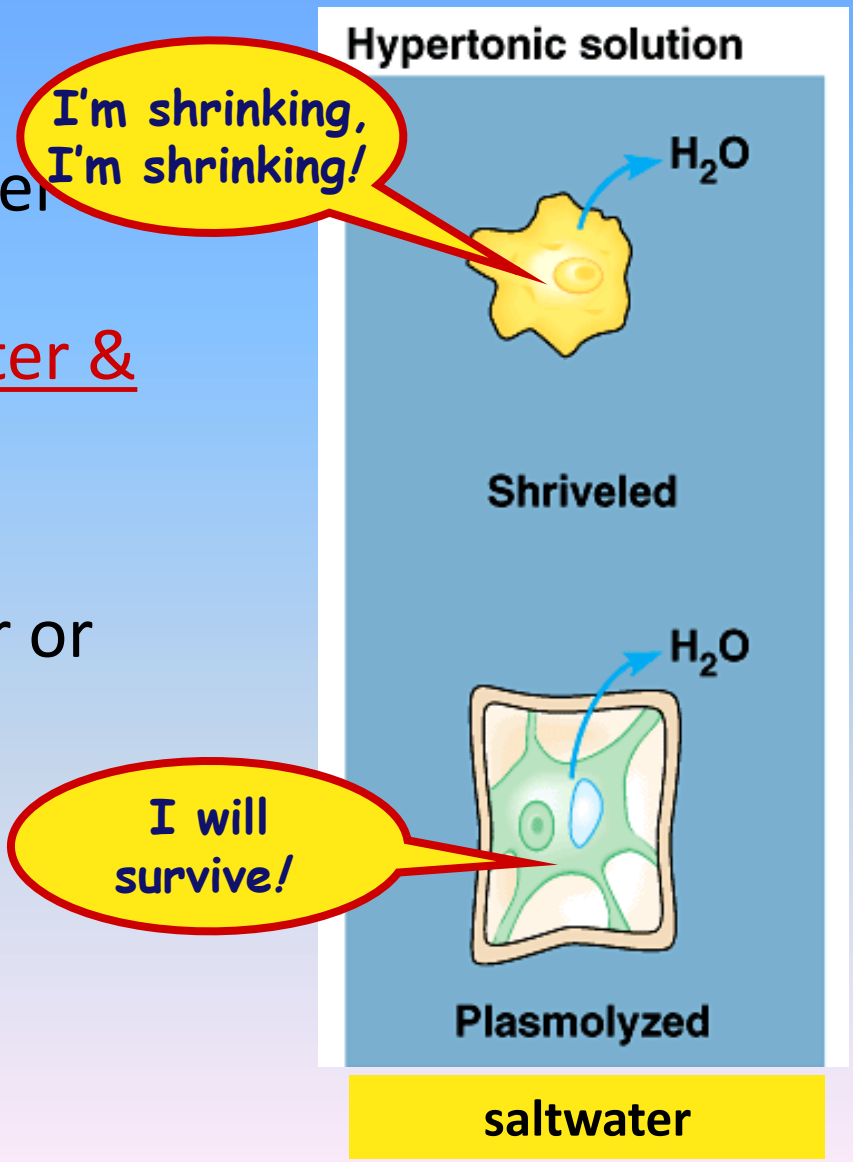
Pumping water out

- Contractile vacuole in *Paramecium*



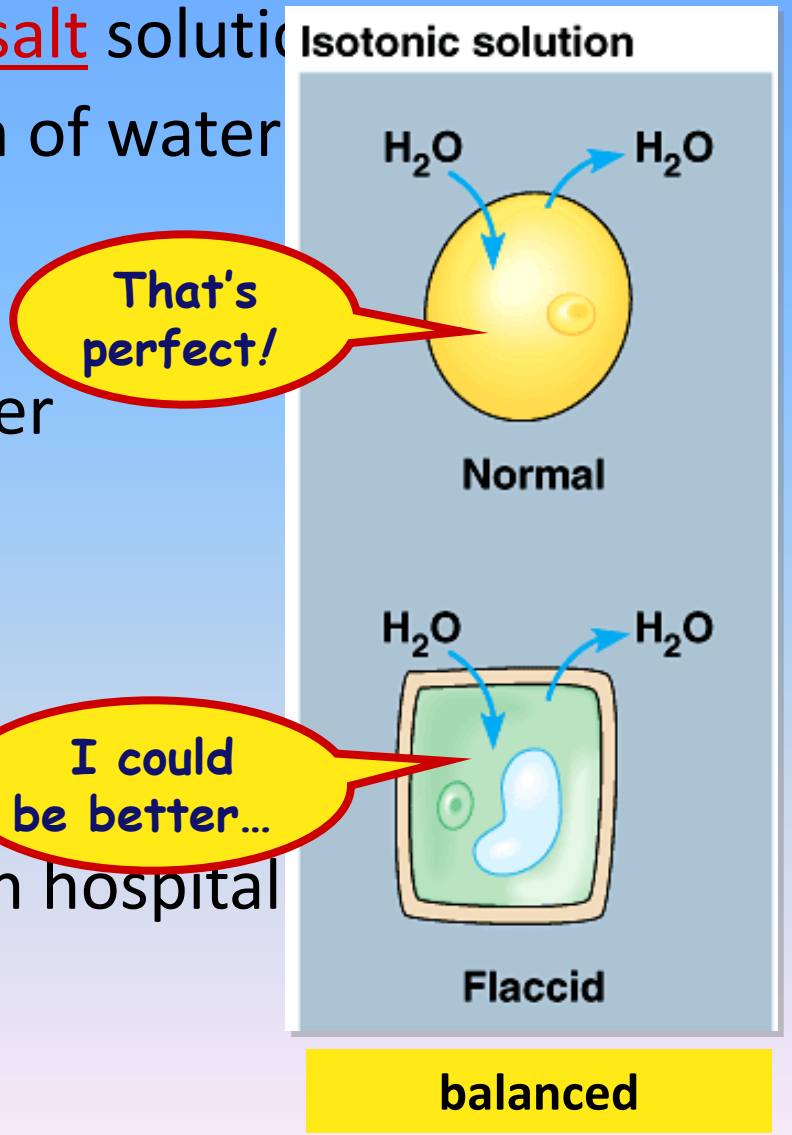
2 Managing water balance

- 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



3 Managing water balance

- Isotonic
  - animal cell immersed in mild salt soluti
  - no difference in concentration of water between cell & environment
    - problem: none
      - no net movement of water
      - cell in equilibrium
      - volume of cell is stable
    - example: blood cells in blood plasm
      - slightly salty IV solution in hospital

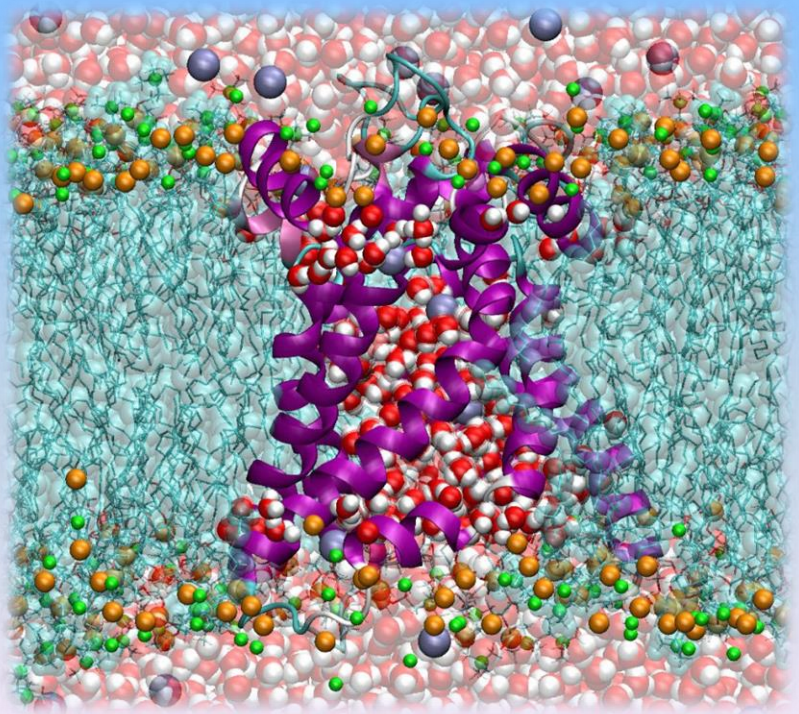


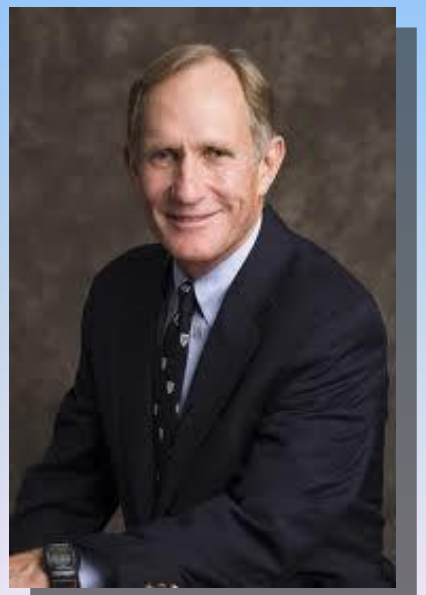
balanced

Aquaporins

1991 | 2003

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

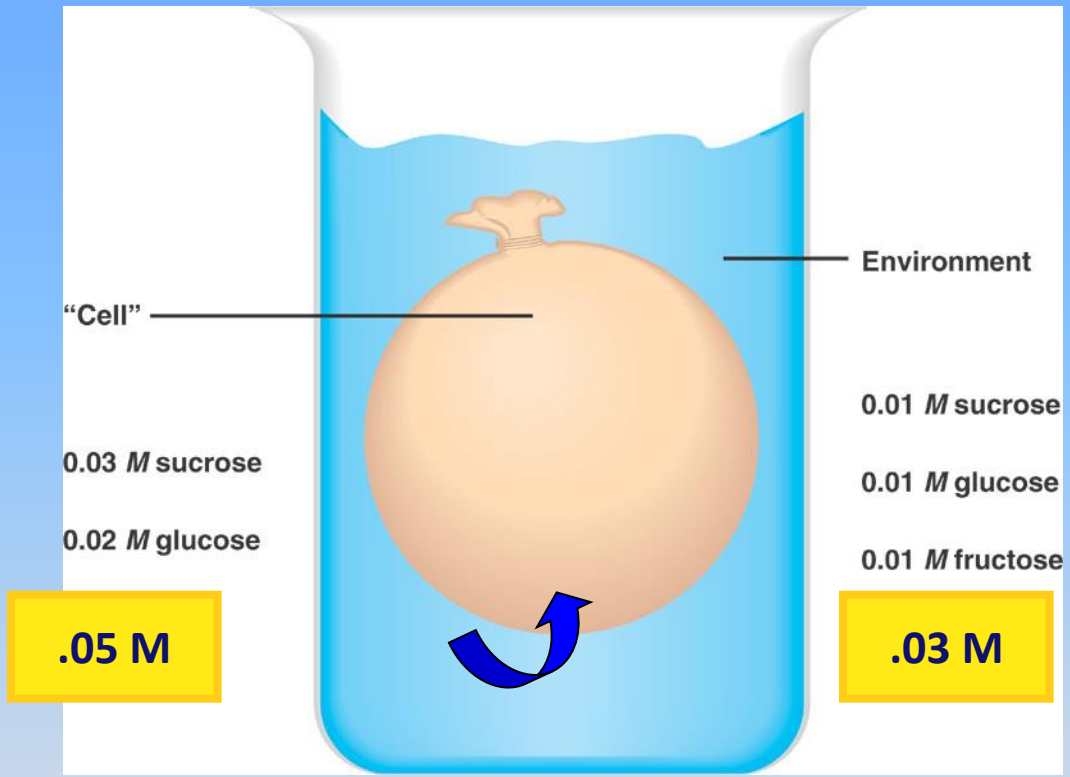




Peter Agre
John Hopkins

Roderick MacKinnon
Rockefeller

Do you understand Osmosis…



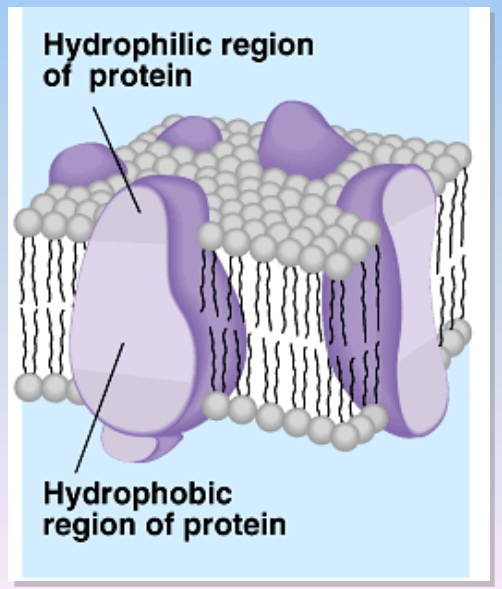
Cell (compared to beaker) → hypertonic or hypotonic

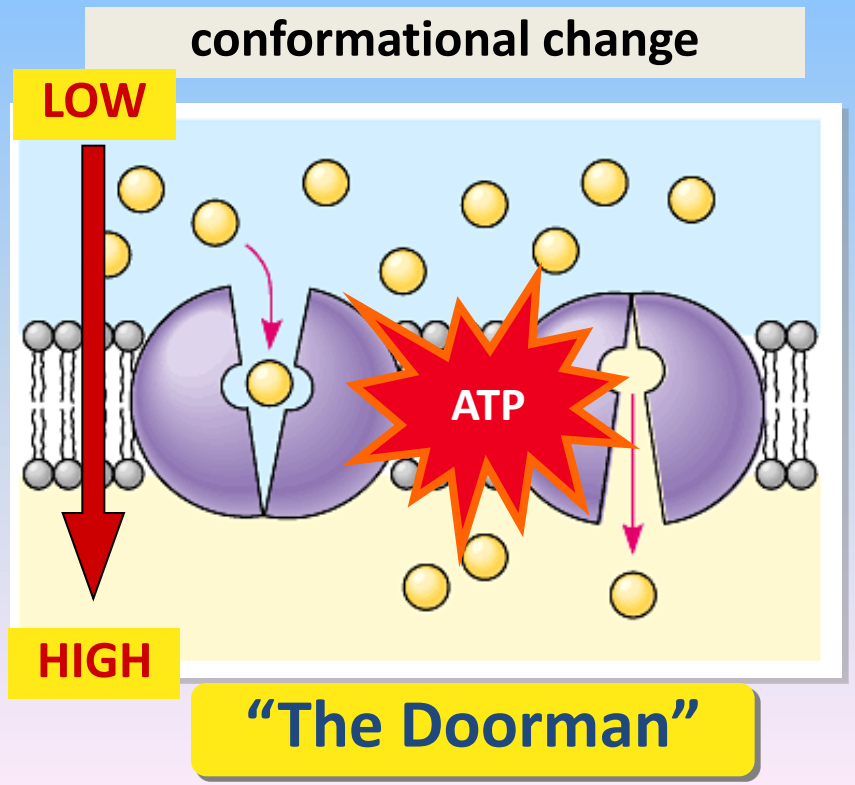
Beaker (compared to cell) → hypertonic or hypotonic

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

Active Transport

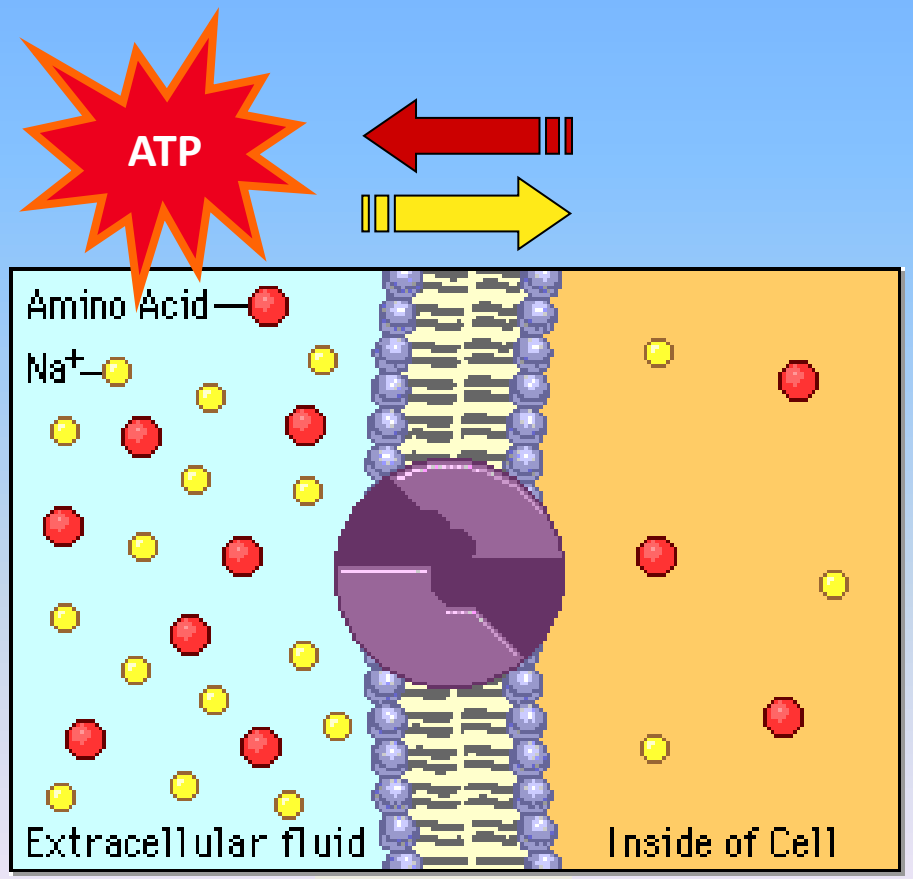
- Uses ATP (energy) to move materials across a cell membrane *against* a concentration gradient.
  - conformational shape change transports solute from one side of membrane to other
  - protein "pump"
  - "costs" energy = ATP



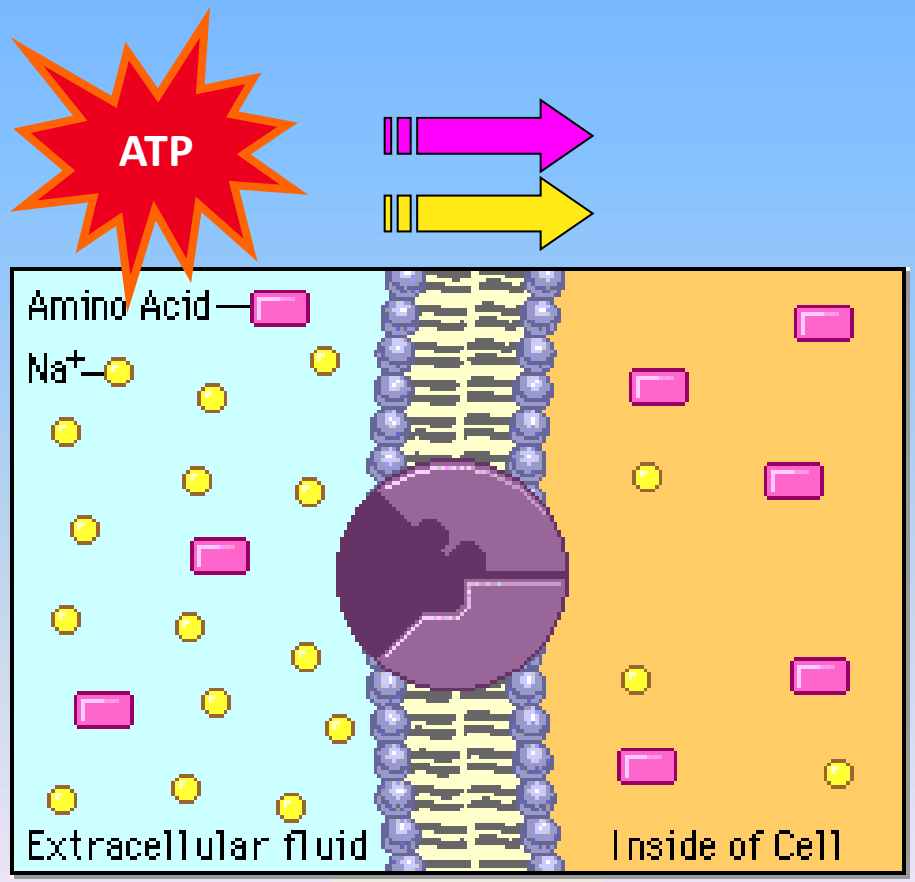


Active transport

- Many models & mechanisms



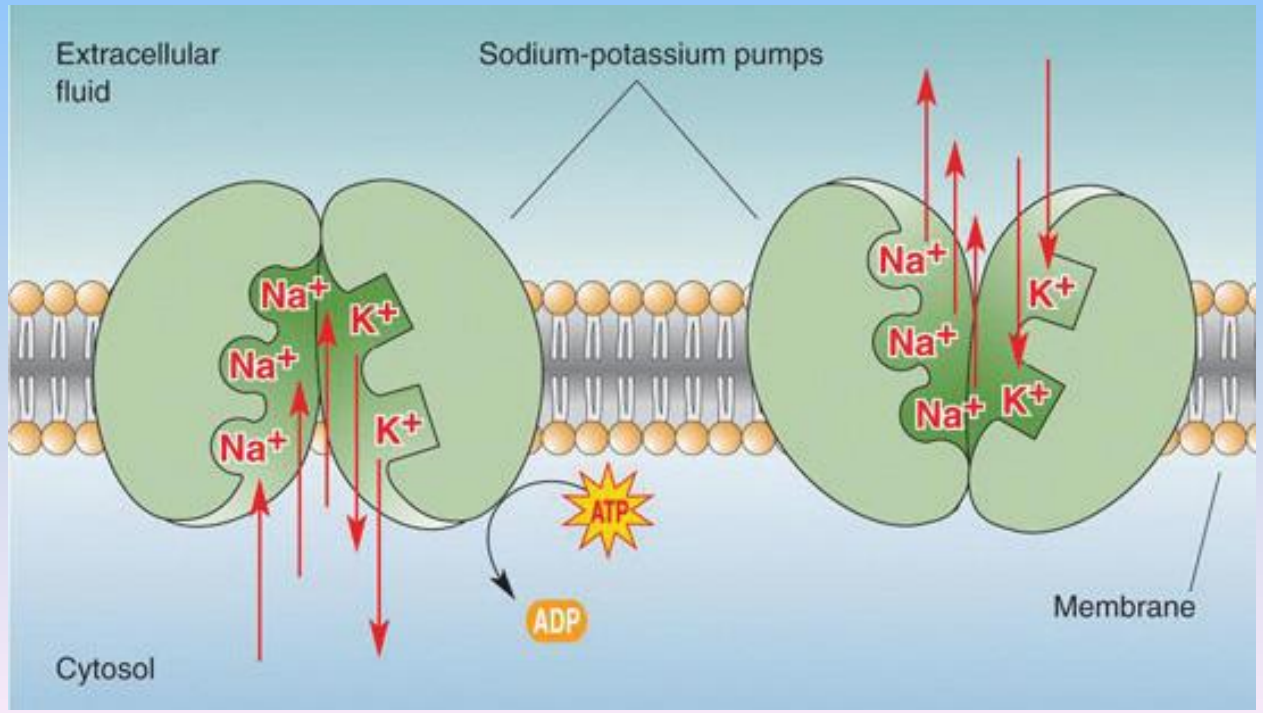
antiport



symport

Na^+/K^+ pump

- Membrane transport proteins pump Na^+ out of the cell and K^+ into the cell against the concentration gradient. Uses ATP!
- Nerve cells must maintain a higher concentration of Na^+ outside the cell and K^+ inside the cell to function.



Getting through cell membrane

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

What about large molecules?

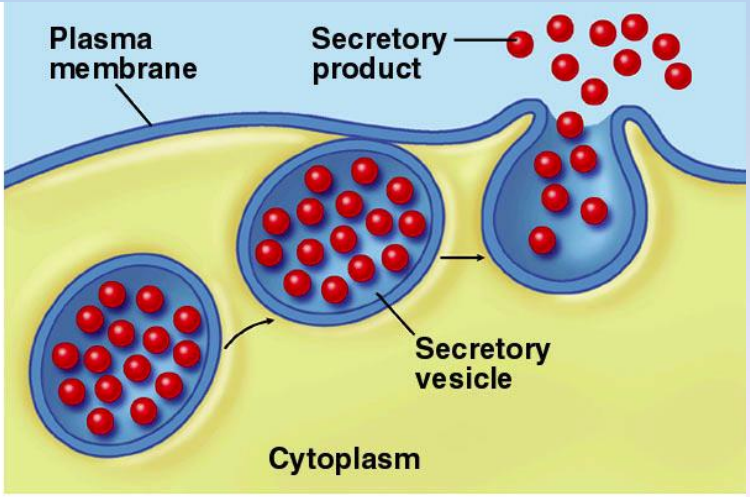
- Moving large molecules into & out of cell
  - through vesicles & vacuoles

Endocytosis – moving materials INTO the cell

- phagocytosis = "cellular eating"
- pinocytosis = "cellular drinking"
- receptor-mediated endocytosis – Molecules bind to receptors on the outside of the cell membrane.

Exocytosis – moving materials OUT of the cell

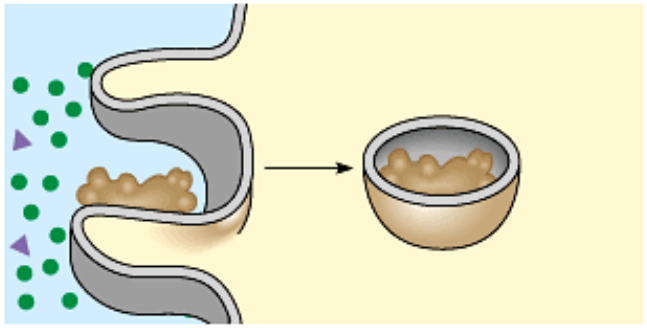
Insulin released from the pancreas into the bloodstream



exocytosis

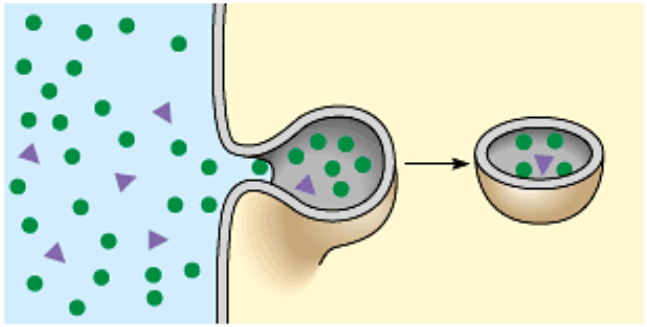
Endocytosis

phagocytosis



White blood cells (macrophages) take in bacteria. fuse with lysosome for digestion.

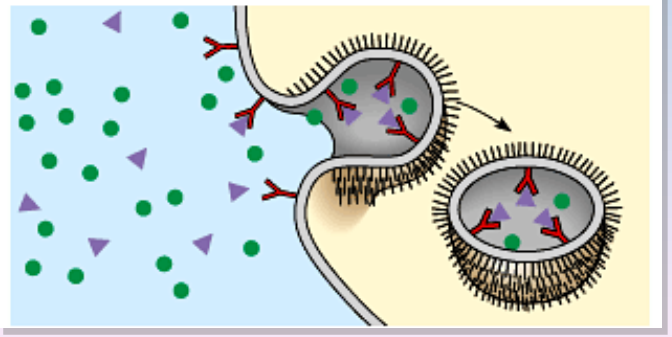
pinocytosis



End products of digestion. non-specific process

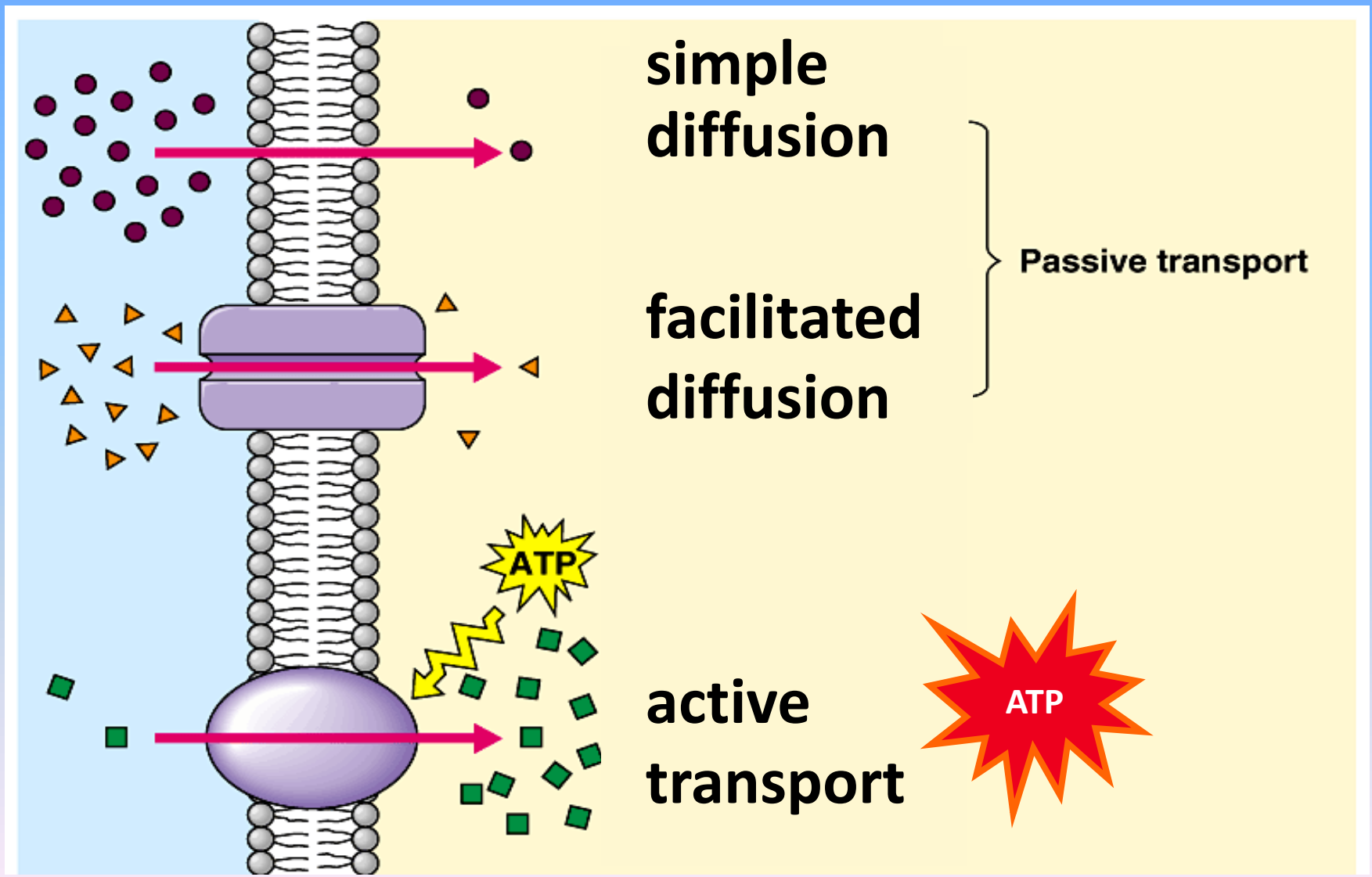
Invagination (pinching) of cell membrane forms a vesicle inside the cell.

receptor-mediated endocytosis

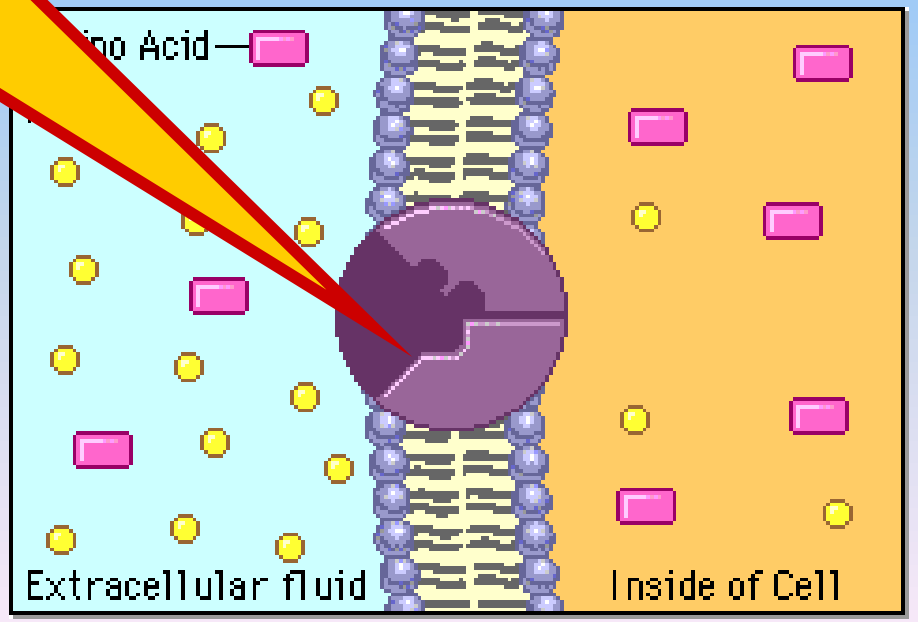


LDL's taken into cell. triggered by molecular signal

Transport summary

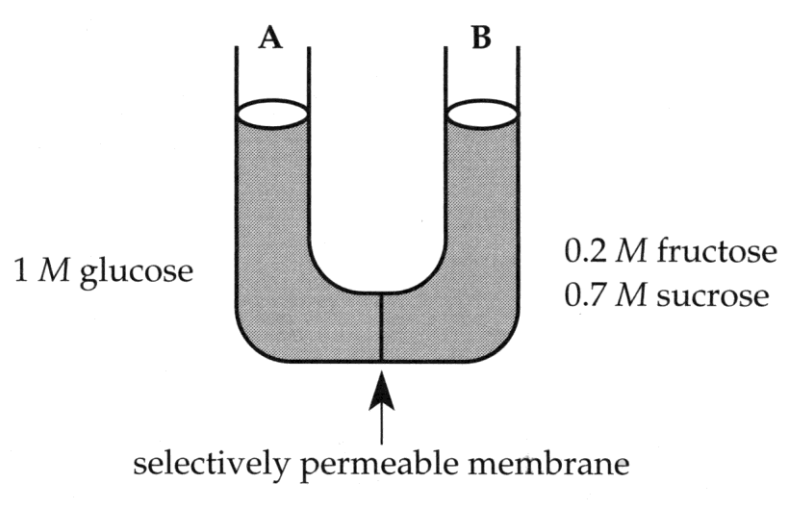


Any Questions??



Review Questions

1. A solution of 1 *M* glucose is separated by a selectively permeable membrane from a solution of 0.2 *M* fructose and 0.7 *M* sucrose. The membrane is not permeable to the sugar molecules. Which of the following statements is correct?



A. Side A is hypotonic relative to side B.

B. The net movement of water will be from side B to side A.

C. The net movement of water will be from side A to side B.

D. Side B is hypertonic relative to side A.

E. There will be no net movement of water.

2. You observe plant cells under a microscope that have just been placed in an unknown solution. First the cells plasmolyze; after a few minutes, the plasmolysis reverses and the cells appear normal. What would you conclude about the unknown solute?

   A. It is hypertonic to the plant cells, and its solute can not cross the pant cell membranes.
   B. It is hypotonic to the plant cells, and its solute can not cross the pant cell membranes.
   C. It is isotonic to the plant cells, but its solute can cross the plant cell membranes.
   D. It is hypertonic to the plant cells, but its solute can cross the plant cell membranes.
   E. It is hypotonic to the plant cells, but its solute can cross the plant cell membranes.