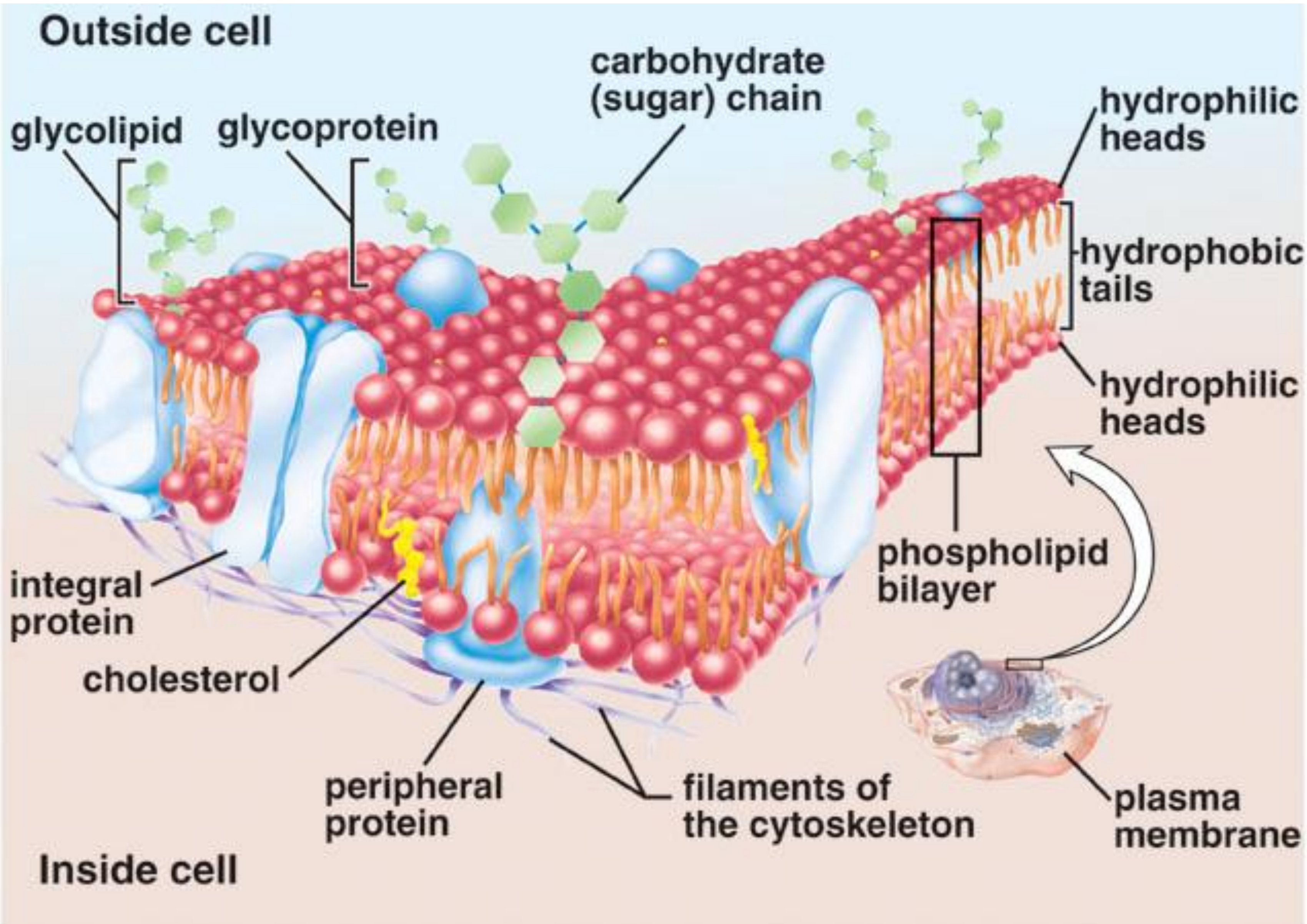
Plasma Membrane Structure and Function

The *plasma membrane* separates the internal environment of the cell from its surroundings.

The plasma membrane is a *phospholipid bilayer* with *embedded proteins*.

The plasma membrane has a *fluid* consistency and a *mosaic* pattern of embedded proteins.

Fluid-mosaic model of membrane structure



Cells live in fluid environments, with water inside and outside the cell.

Hydrophilic (water-loving) *polar* heads of the phospholipid molecules lie on the outward-facing surfaces of the plasma membrane.

Hydrophobic (water-fearing) *nonpolar* tails extend to the interior of the plasma membrane.

Plasma membrane proteins may be *peripheral proteins* or *integral proteins*.

Aside from phospholipid, *cholesterol* is another lipid in animal plasma membranes; related steroids are found in plants.

Cholesterol strengthens the plasma membrane.

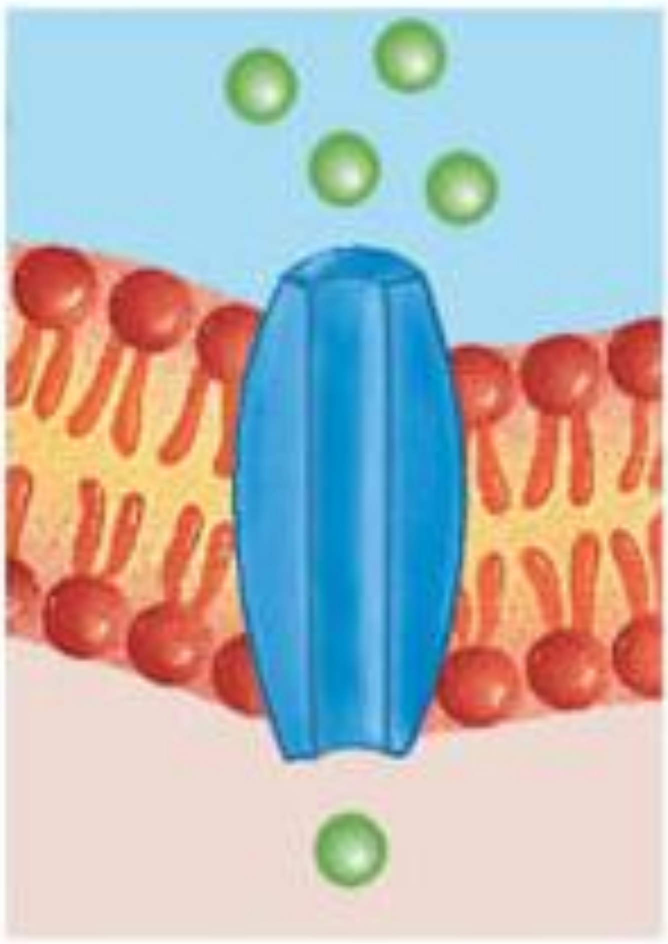
When phospholipids have carbohydrate chains attached, they are called *glycolipids*.

When proteins have carbohydrate chains attached, they are called glycoproteins.

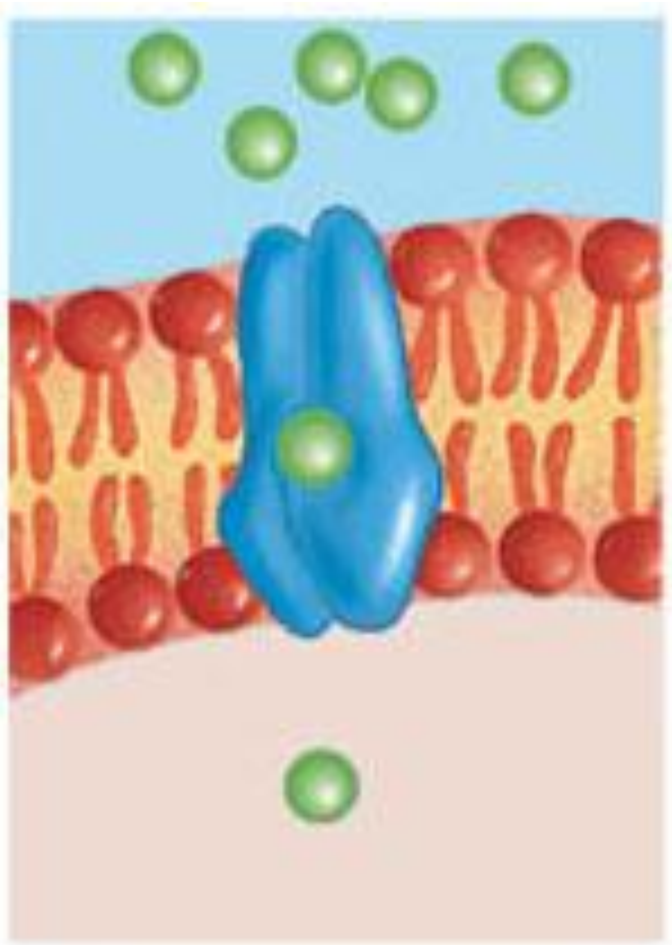
Carbohydrate chains occur only on the *exterior* surface of the plasma membrane.

The outside and inside surfaces of the plasma membrane are not identical.

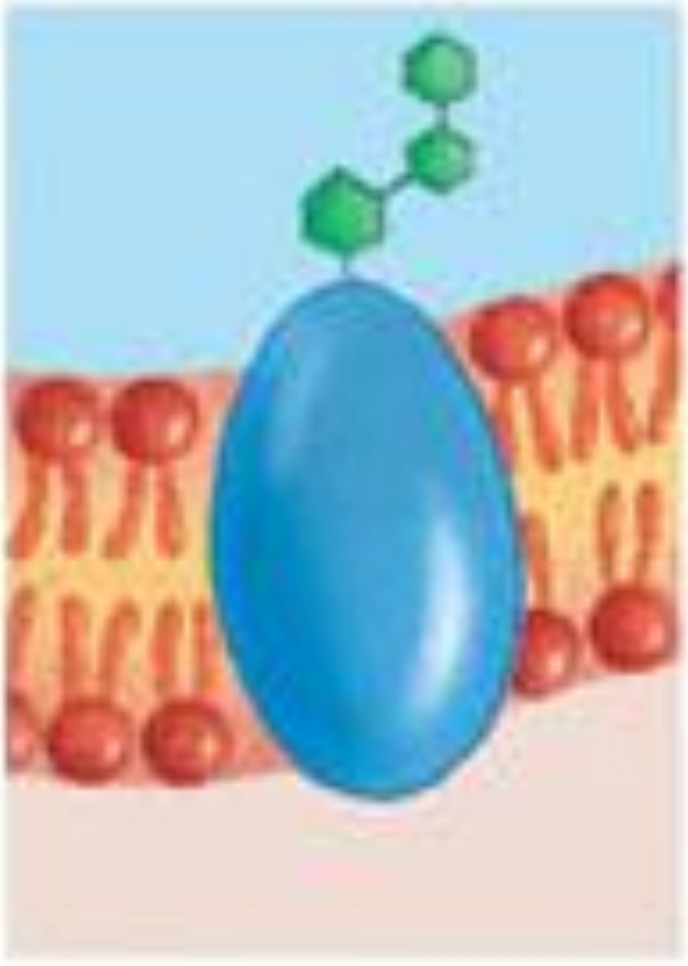
Channel protein



Carrier protein



Cell recognition protein

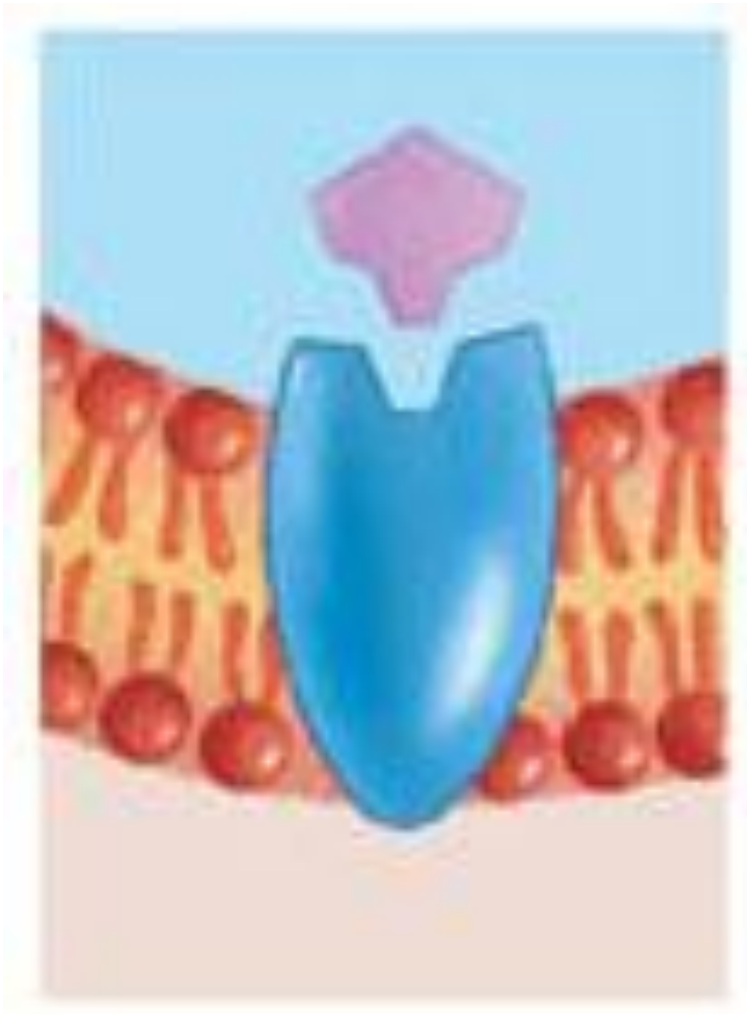


In animal cells, the carbohydrate chains of cell recognition proteins are collectively called the *glycocalyx*.

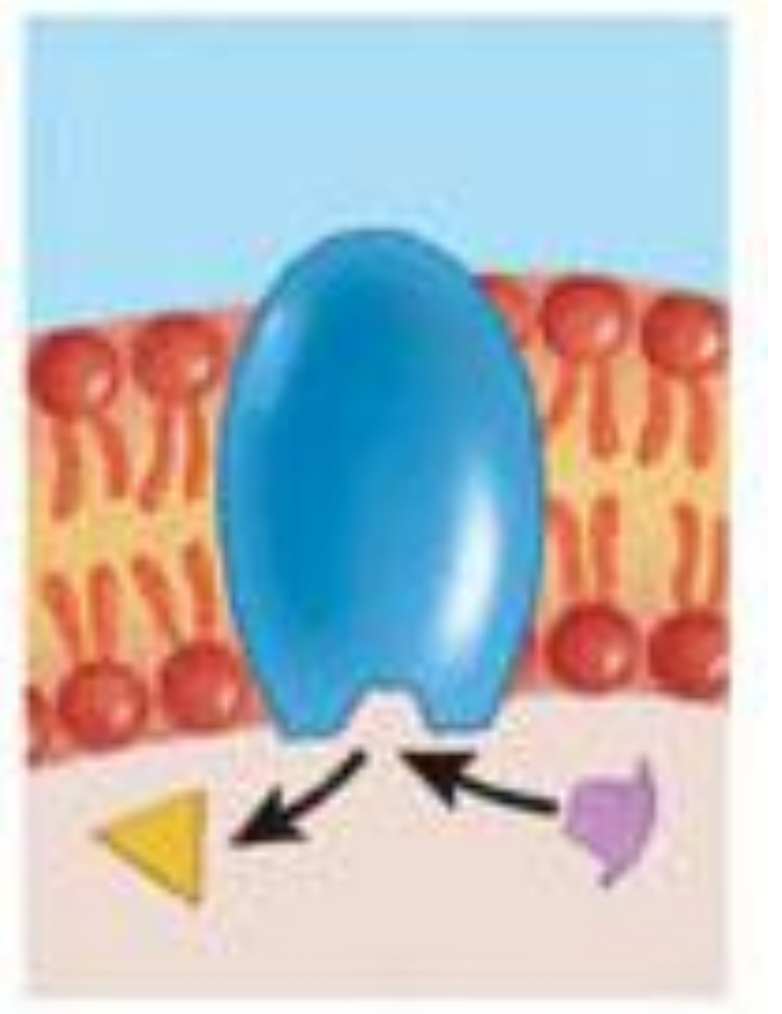
The glycocalyx can function in cell-to-cell recognition, adhesion between cells, and reception of signal molecules.

The diversity of carbohydrate chains is enormous, providing each individual with a unique cellular “fingerprint”.

Receptor protein



Enzymatic protein



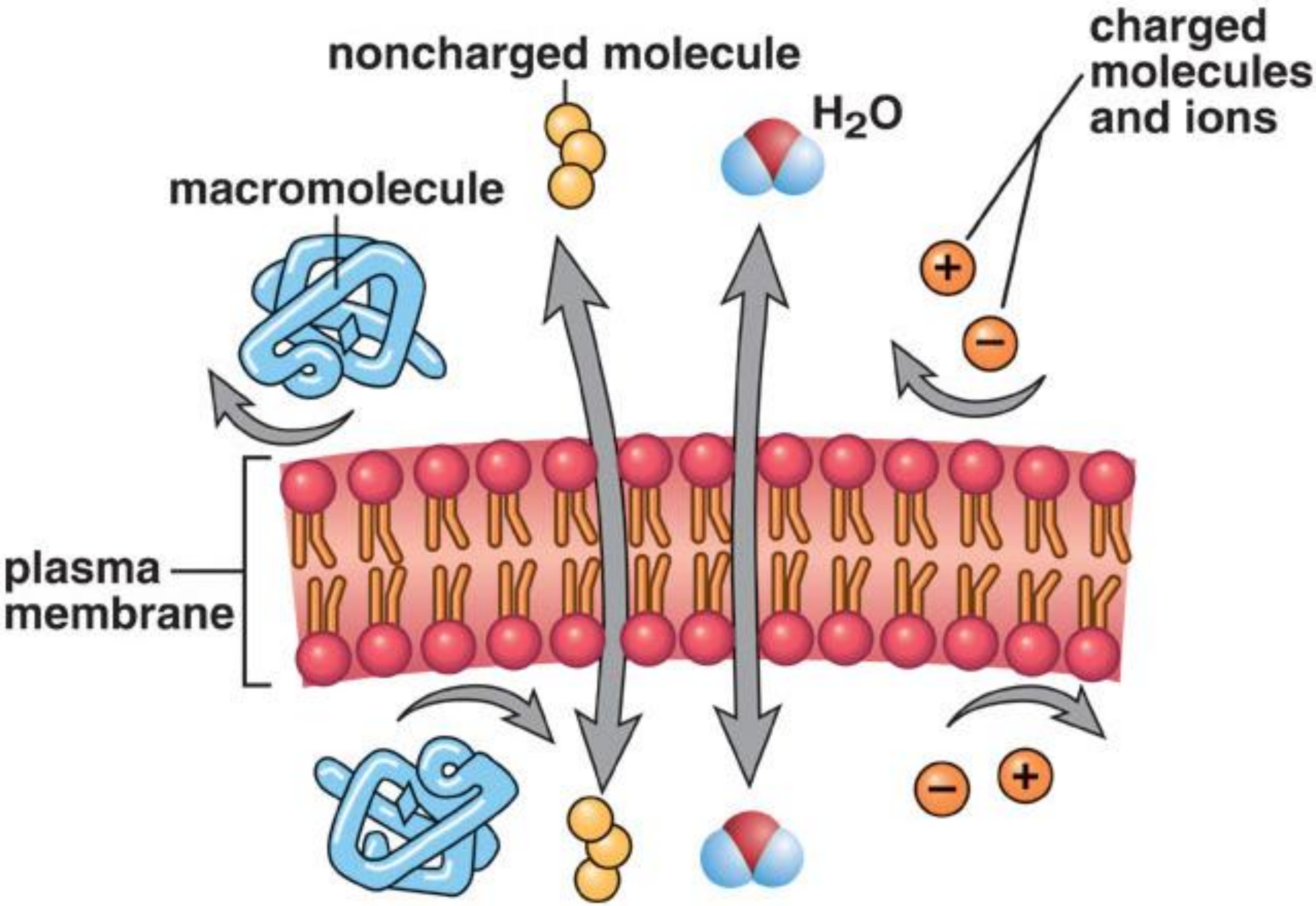
The Permeability of the Plasma Membrane

The plasma membrane is *differentially permeable*.

Macromolecules cannot pass through because of *size*, and tiny *charged* molecules do not pass through the nonpolar interior of the membrane.

Small, uncharged molecules pass through the membrane, following their *concentration gradient*.

How molecules cross the plasma membrane



Movement of materials across a membrane may be passive or active.

Passive transport does not use chemical energy; *diffusion* and *facilitated transport* are both passive.

Active transport requires chemical energy and usually a carrier protein.

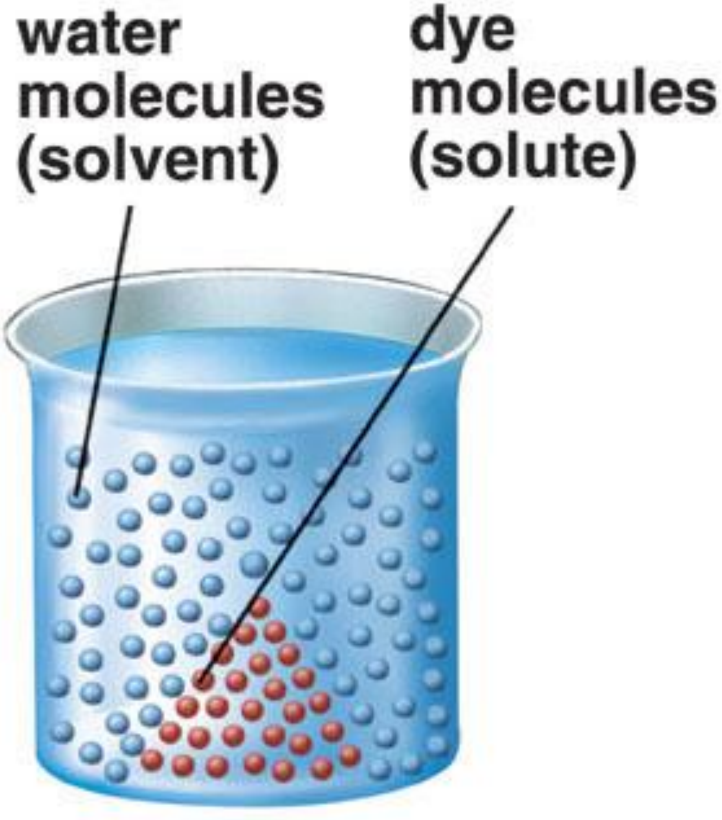
Exocytosis and *endocytosis* transport macromolecules across plasma membranes using vesicle formation, which requires energy.

Diffusion

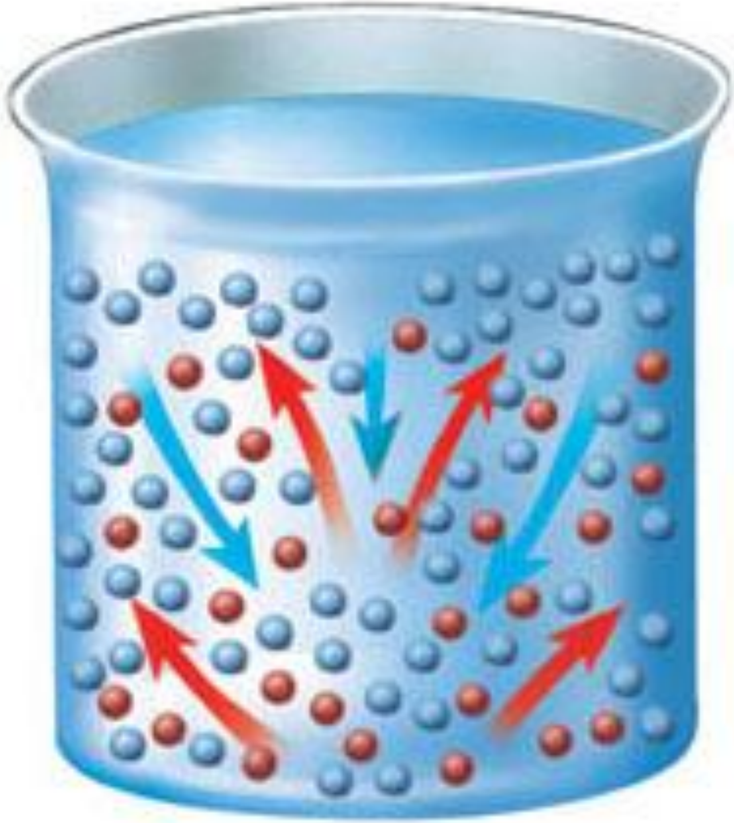
Diffusion is the passive movement of molecules from a higher to a lower concentration until *equilibrium* is reached.

Gases move through plasma membranes by diffusion.

Process of diffusion



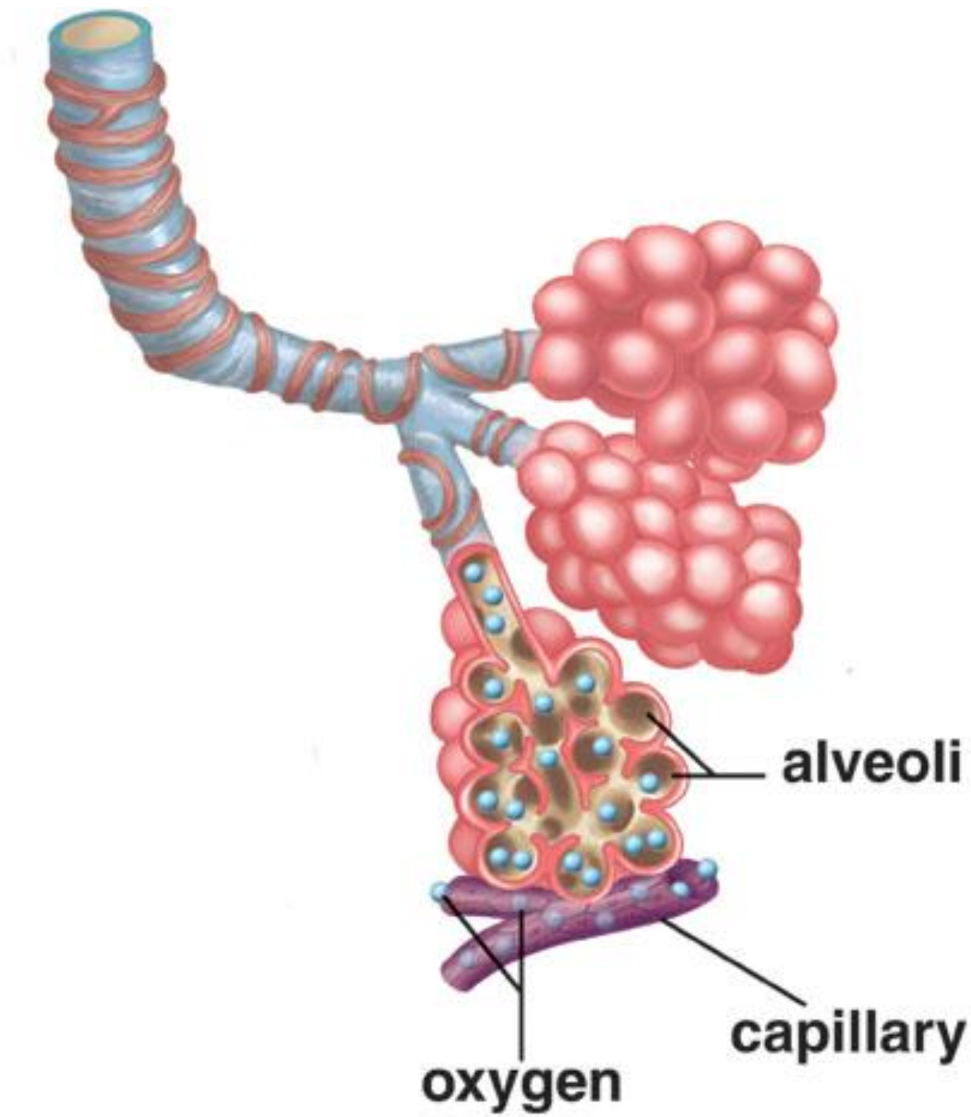
a. Crystal of dye placed in water



b. Diffusion of water and dye molecules

c. Equal distribution of molecules results

Gas exchange in lungs occurs by diffusion



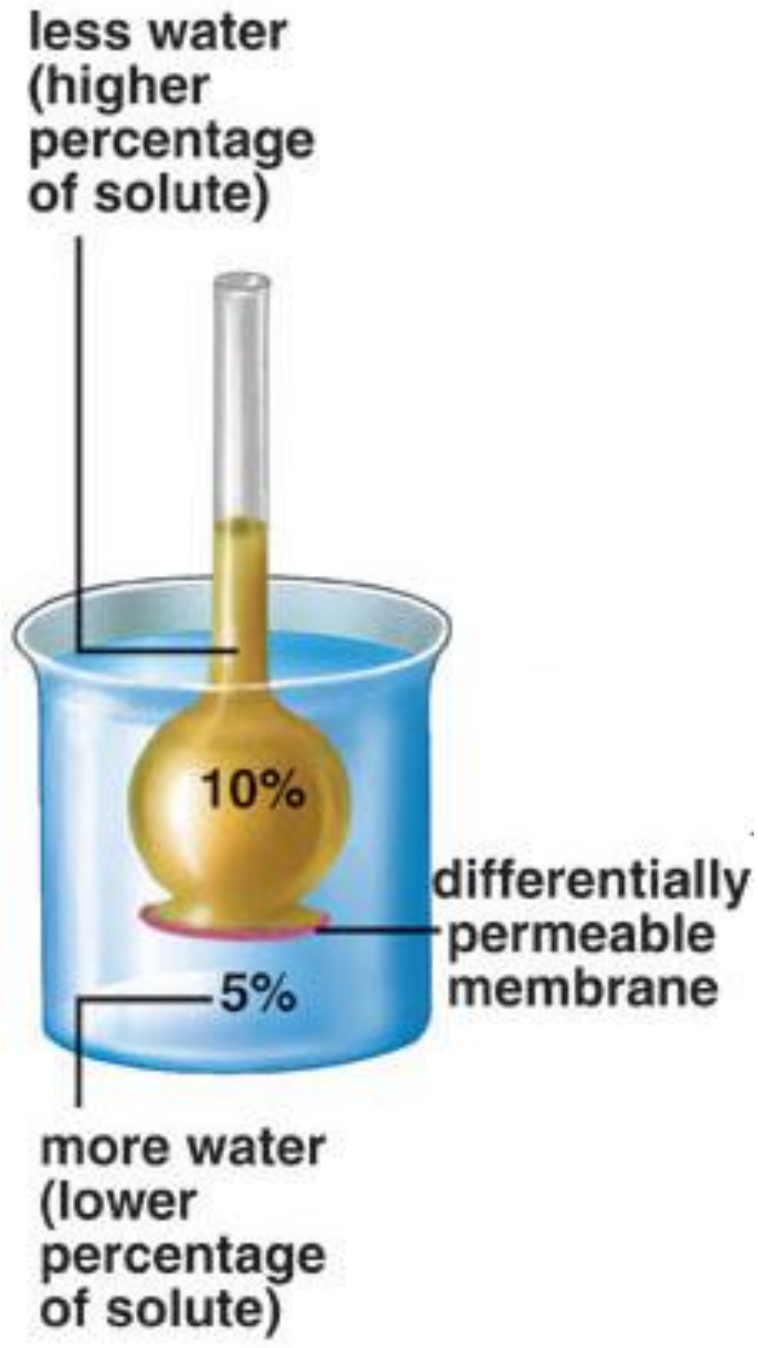
Osmosis

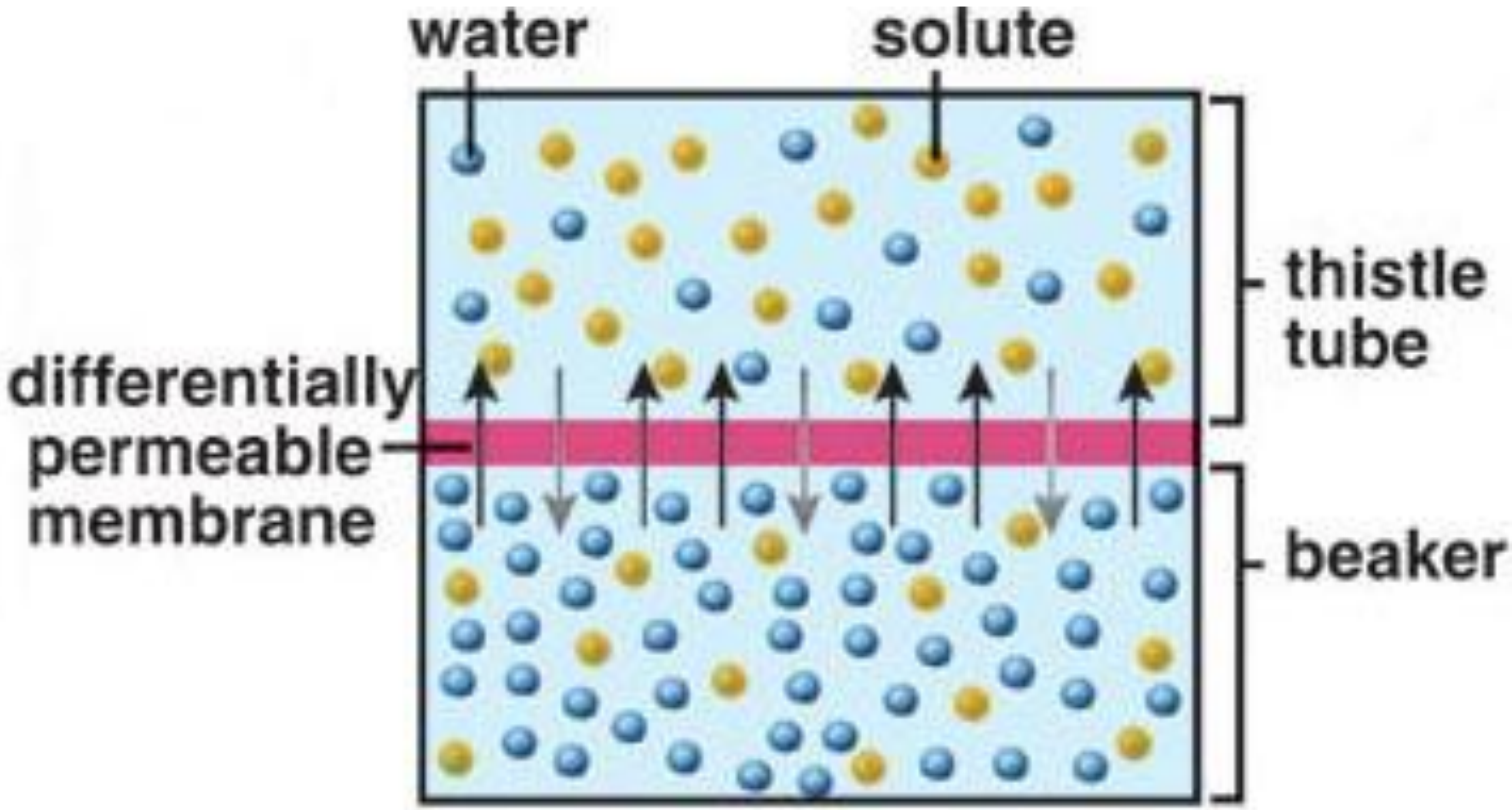
The diffusion of water across a differentially permeable membrane due to concentration differences is called *osmosis*.

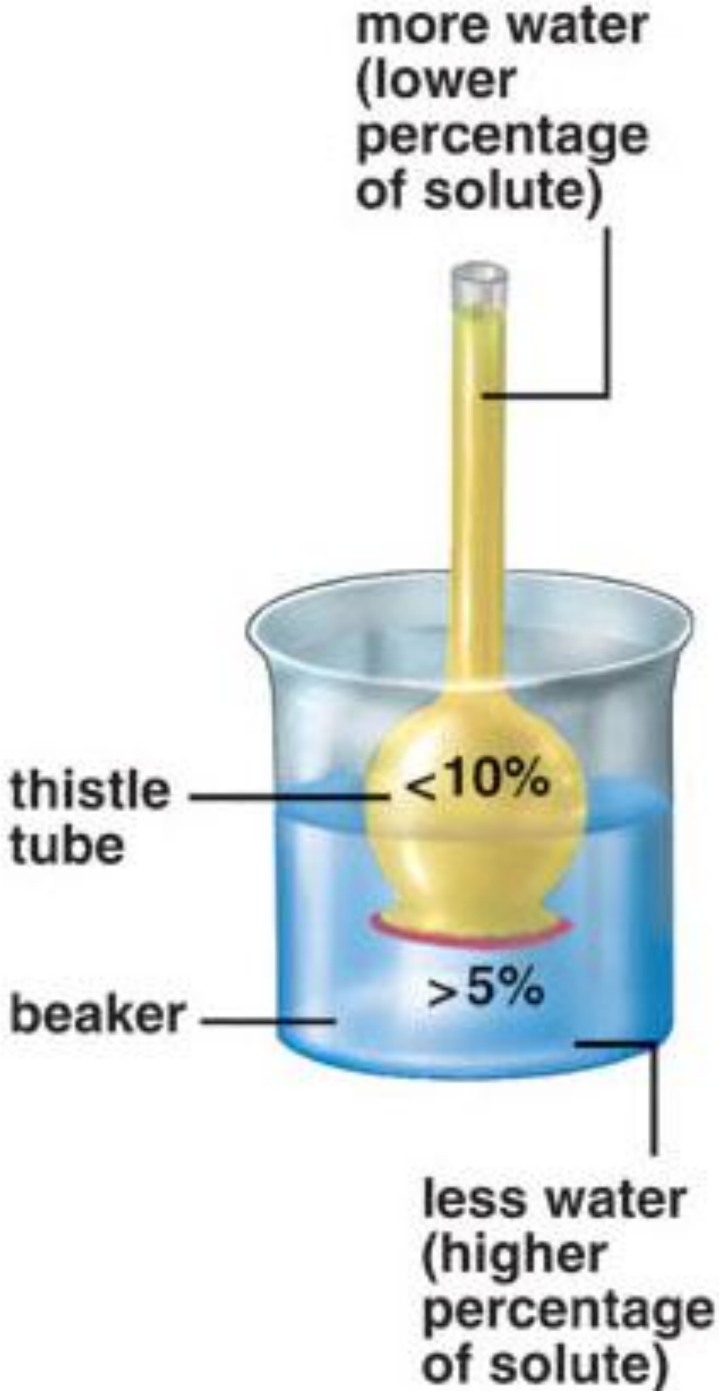
Diffusion always occurs from higher to lower concentration.

Water enters cells due to *osmotic pressure* within cells.

Osmosis demonstration




water
solute
thistle tube
differentially permeable membrane
beaker


more water
(lower
percentage
of solute)
thistle
tube
<10%
>5%
beaker
less water
(higher
percentage
of solute)

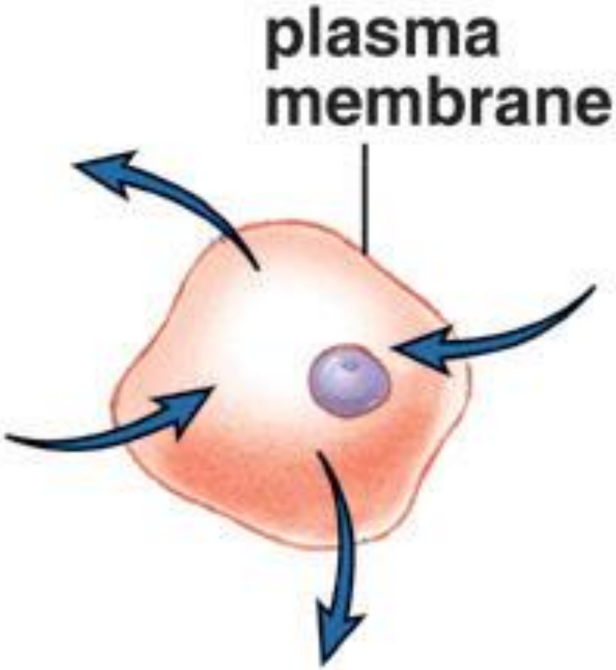
Osmosis in cells

A *solution* contains a *solute* (solid) and a *solvent* (liquid).

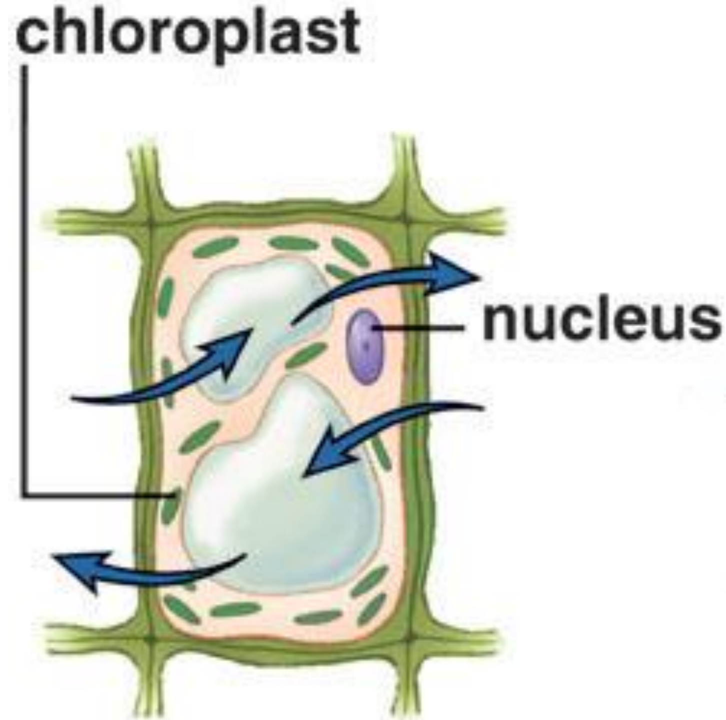
Cells are normally *isotonic* to their surroundings, and the solute concentration is the same inside and out of the cell.

"*Iso*" means the same as, and "*tonocity*" refers to the strength of the solution.

Osmosis in plant and animal cells



In an isotonic solution, there is no net movement of water.



In an isotonic solution, there is no net movement of water.

Hypotonic solutions cause cells to swell and possibly burst.

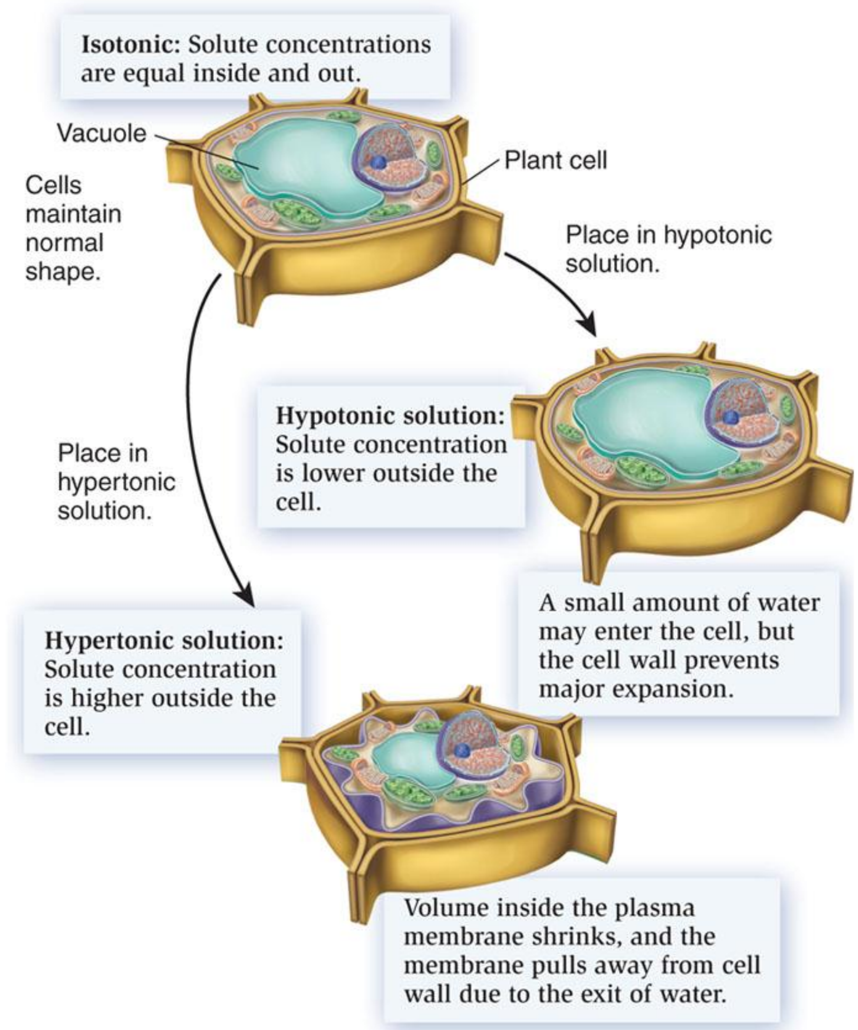
"*Hypo*" means less than.

Animal cells undergo *lysis* in hypotonic solution.

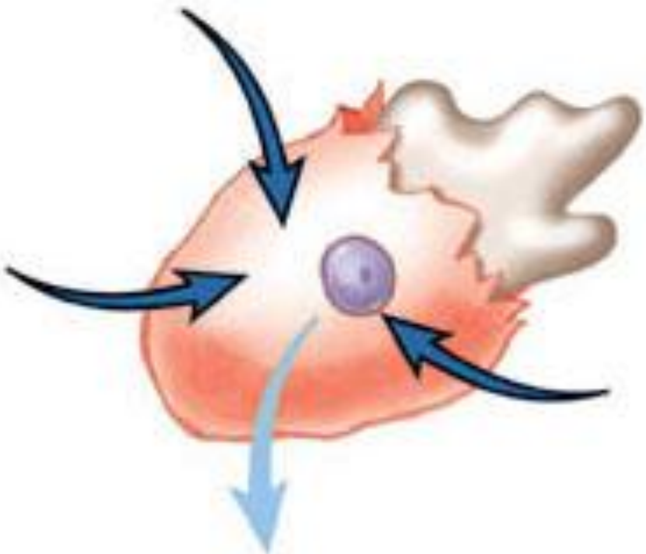
Increased *turgor pressure* occurs in plant cells in hypotonic solutions.

Plant cells do not burst because they have a *cell wall*.

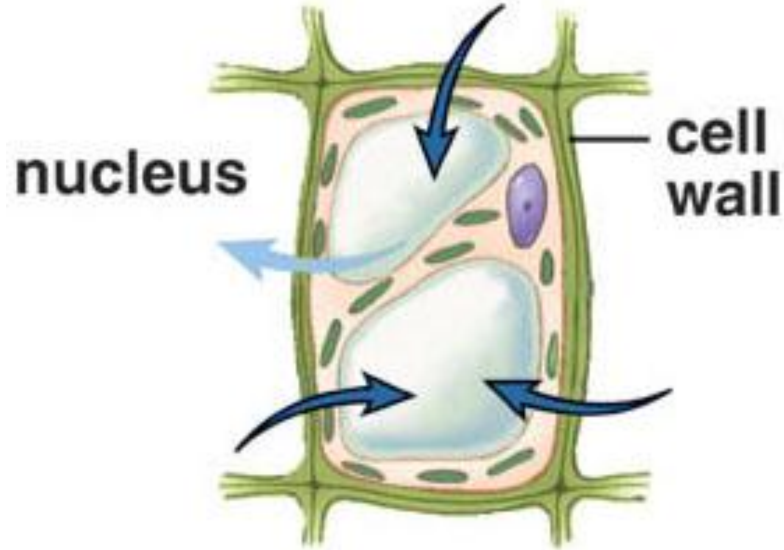
- A cell wall prevents major changes in cell size
- Turgor pressure- pushes plasma membrane against cell wall
  - – Maintains shape and size
- Plasmolysis- plants wilt because water leaves plant cells



(b) Osmosis in plant cells



In a hypotonic solution, water enters the cell, which may burst (lysis).



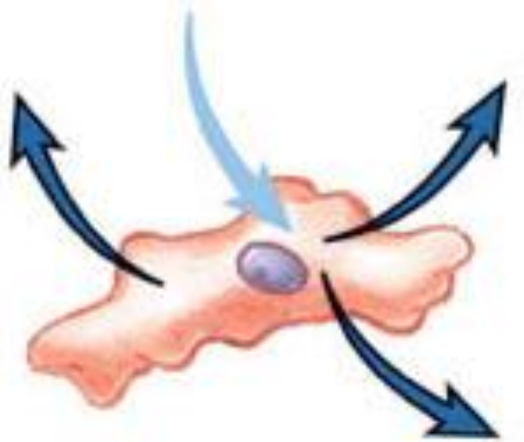
In a hypotonic solution, vacuoles fill with water, turgor pressure develops, and chloroplasts are seen next to the cell wall.

Hypertonic solutions cause cells to lose water.

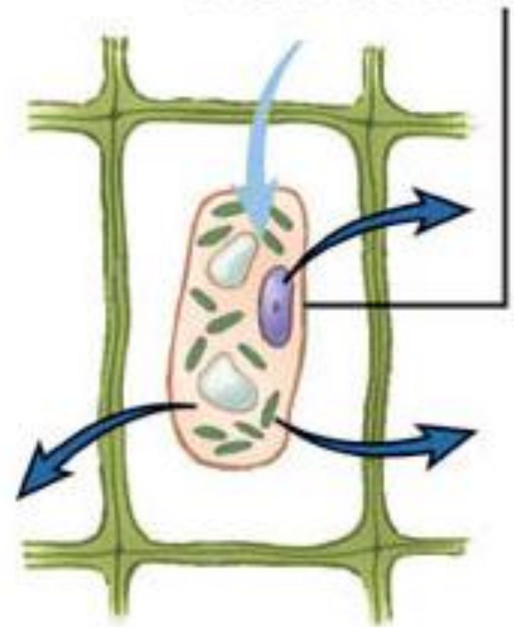
"*Hyper*" means more than; hypertonic solutions contain more solute.

Animal cells undergo *crenation* (shrivel) in hypertonic solutions.

Plant cells undergo *plasmolysis*, the shrinking of the cytoplasm.

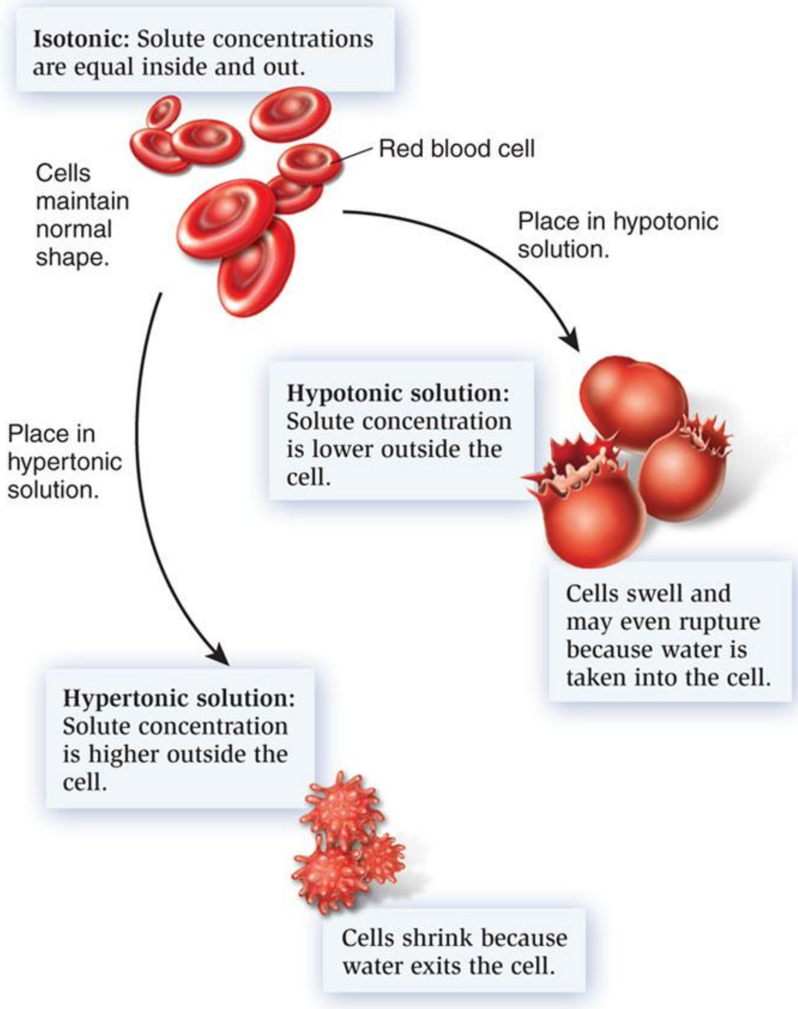


In a hypertonic solution, water leaves the cell, which shrivels (crenation).

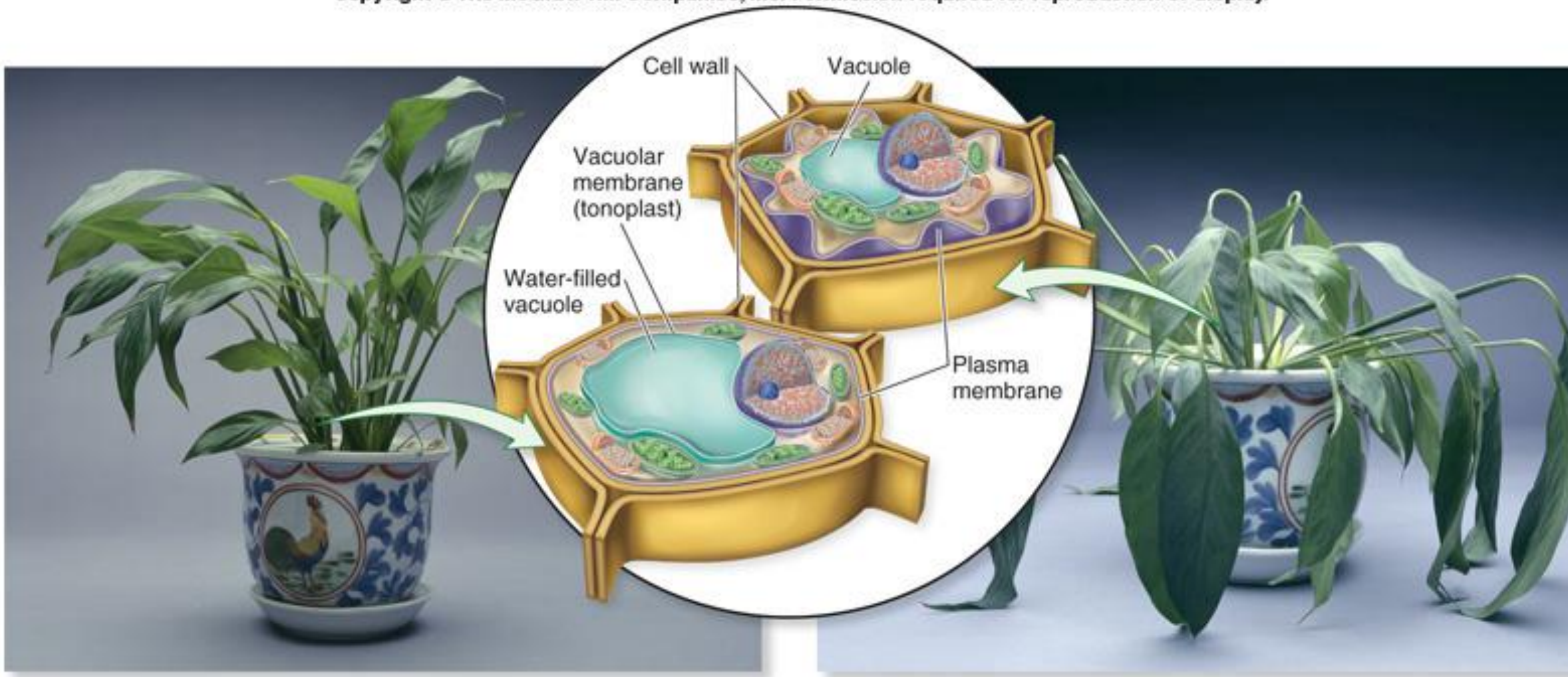


In a hypertonic solution, vacuoles lose water, the cytoplasm shrinks (plasmolysis), and chloroplasts are seen in the center of the cell.

- Animal cells must maintain a balance between extracellular and intracellular solute concentrations to maintain their size and shape
- Crenation- shrinking in a hypertonic solution



(a) Osmosis in animal cells



(a) Sufficient water

(b) Wilting

Transport by Carrier Proteins

Some biologically useful molecules pass through the plasma membrane because of channel proteins and carrier proteins that span the membrane.

Carrier proteins are specific and combine with only a certain type of molecule.

Facilitated transport and *active transport* both require carrier proteins.

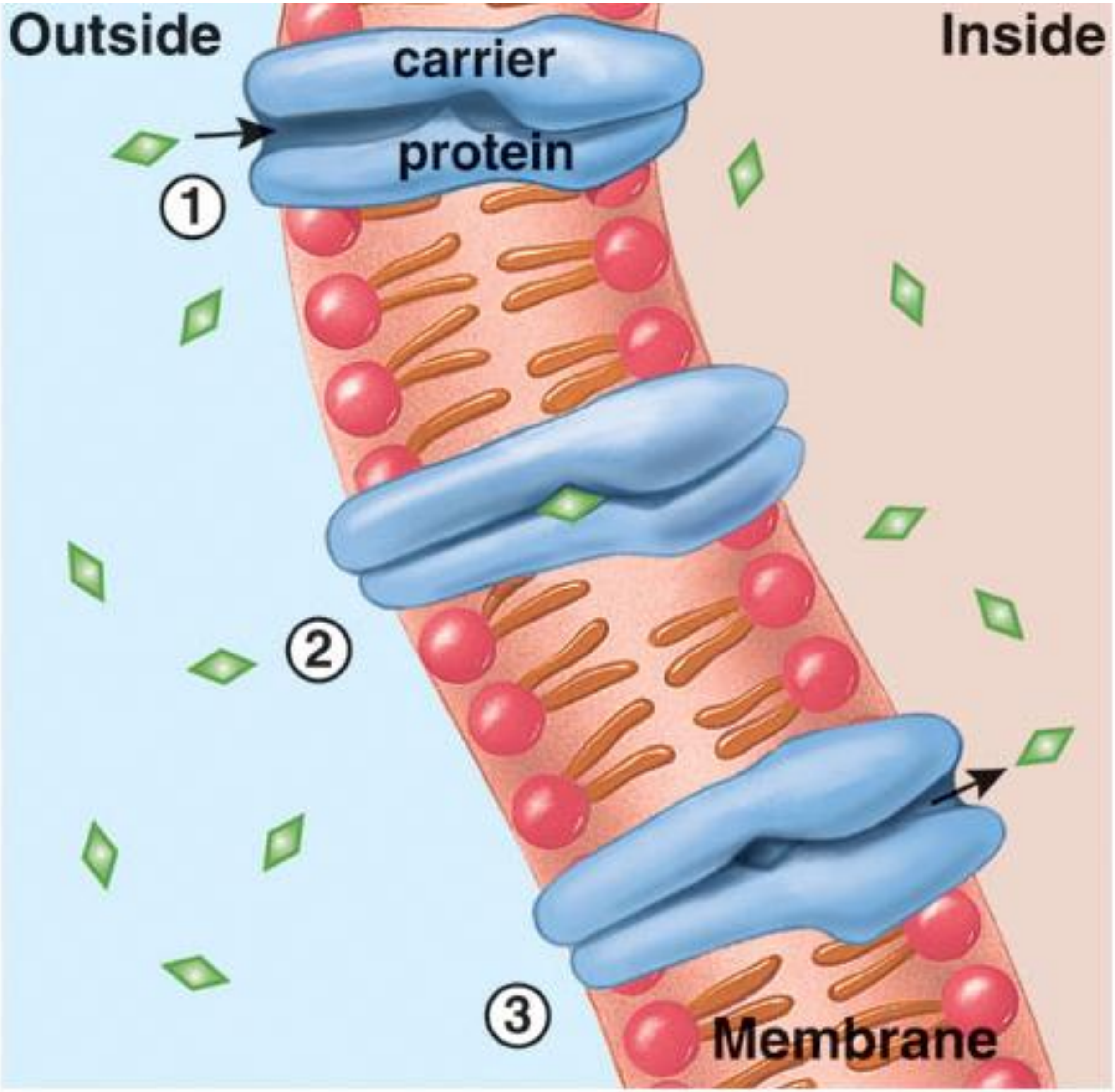
Facilitated transport

During *facilitated transport*, substances pass through a carrier protein following their concentration gradients.

Facilitated transport does not require energy.

The carrier protein for glucose has two *conformations* and switches back and forth between the two, carrying glucose across the membrane.

Facilitated diffusion of glucose

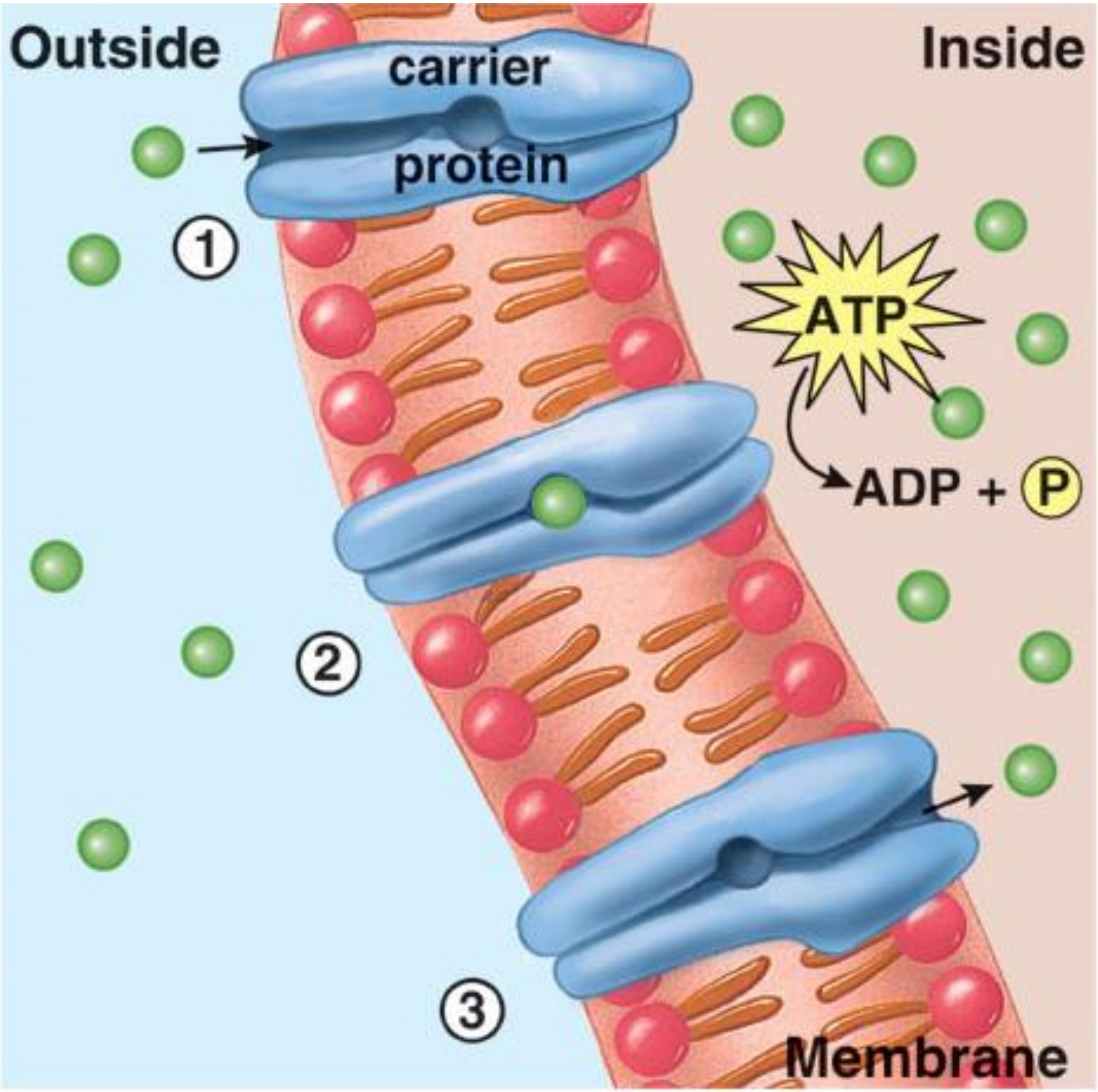


Active transport

During *active transport*, ions or molecules are moved across the membrane against the concentration gradient – from an area of lower to higher concentration.

Energy in the form of *ATP* is required for the carrier protein to combine with the transported molecule.

Active transport



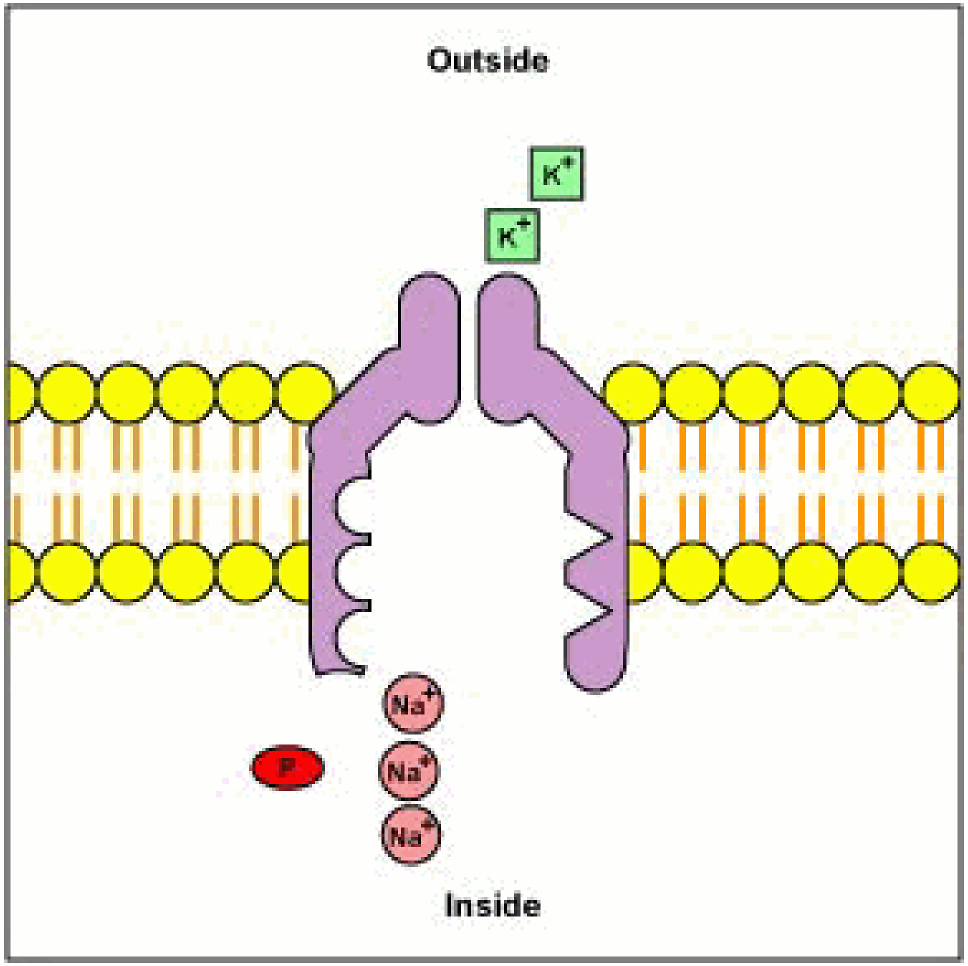
Carrier proteins involved in active transport are called *pumps*.

The *sodium-potassium pump* is active in all animal cells, and moves *sodium ions* to the outside of the cell and *potassium ions* to the inside.

The sodium-potassium pump carrier protein exists in two conformations; one that moves sodium to the inside, and the other that moves potassium out of the cell.

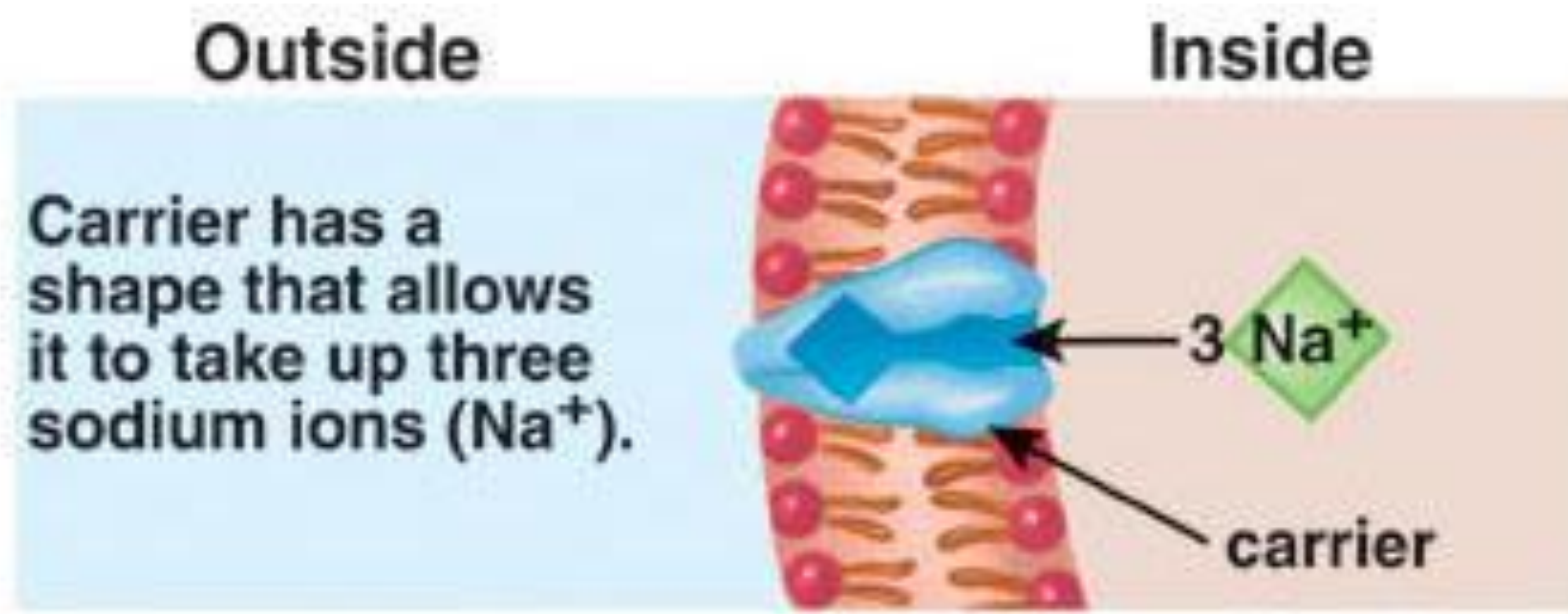
Sodium-Potassium Pump

http://www.cat.cc.md.us/courses/bio141/lecguide/unit1/eustruct/images/sppump.gif

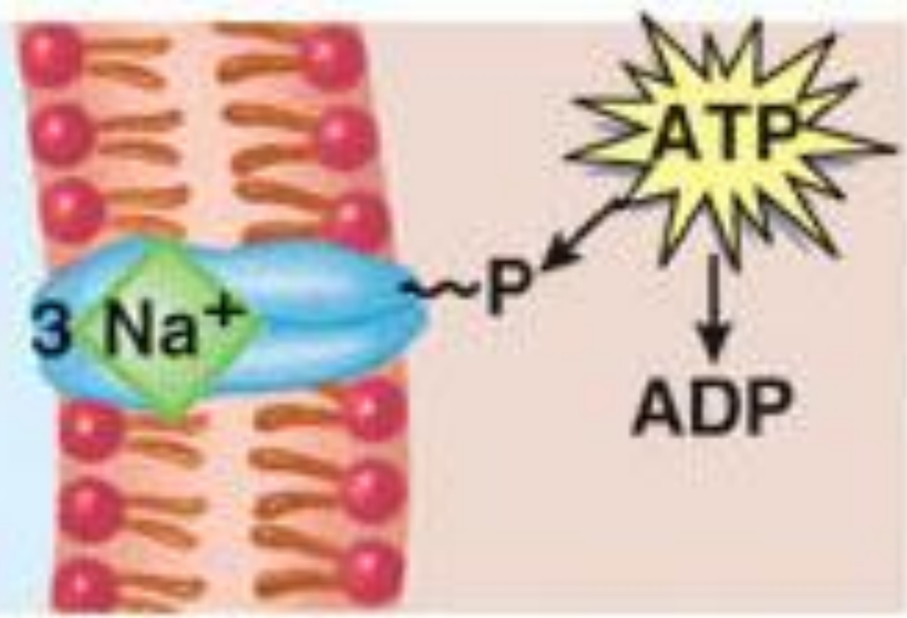


www.soulcare.org Sid Galloway

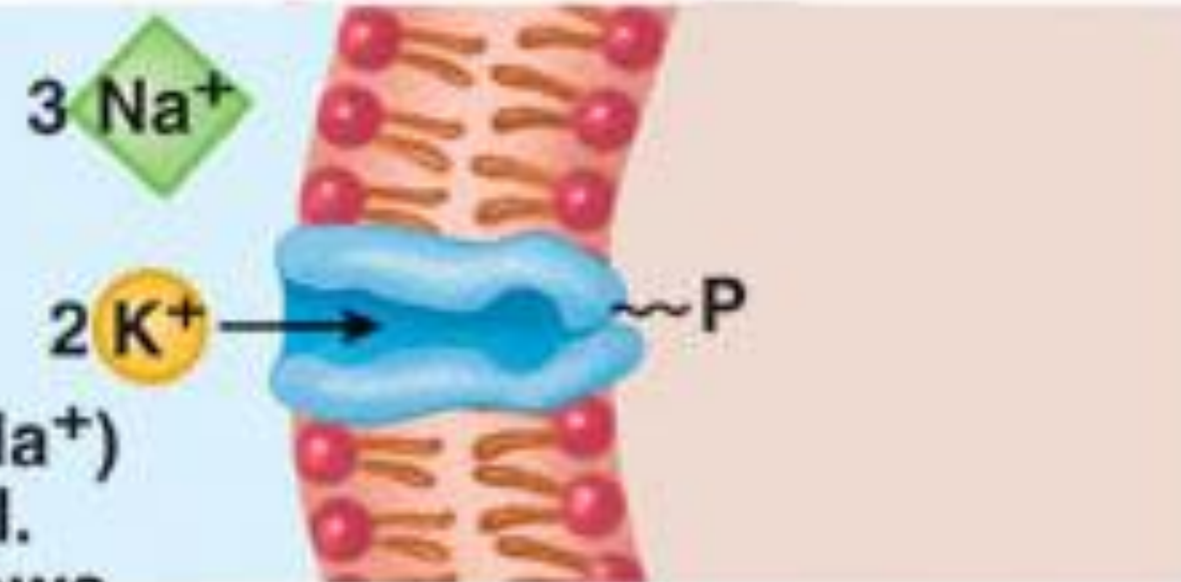
The sodium-potassium pump

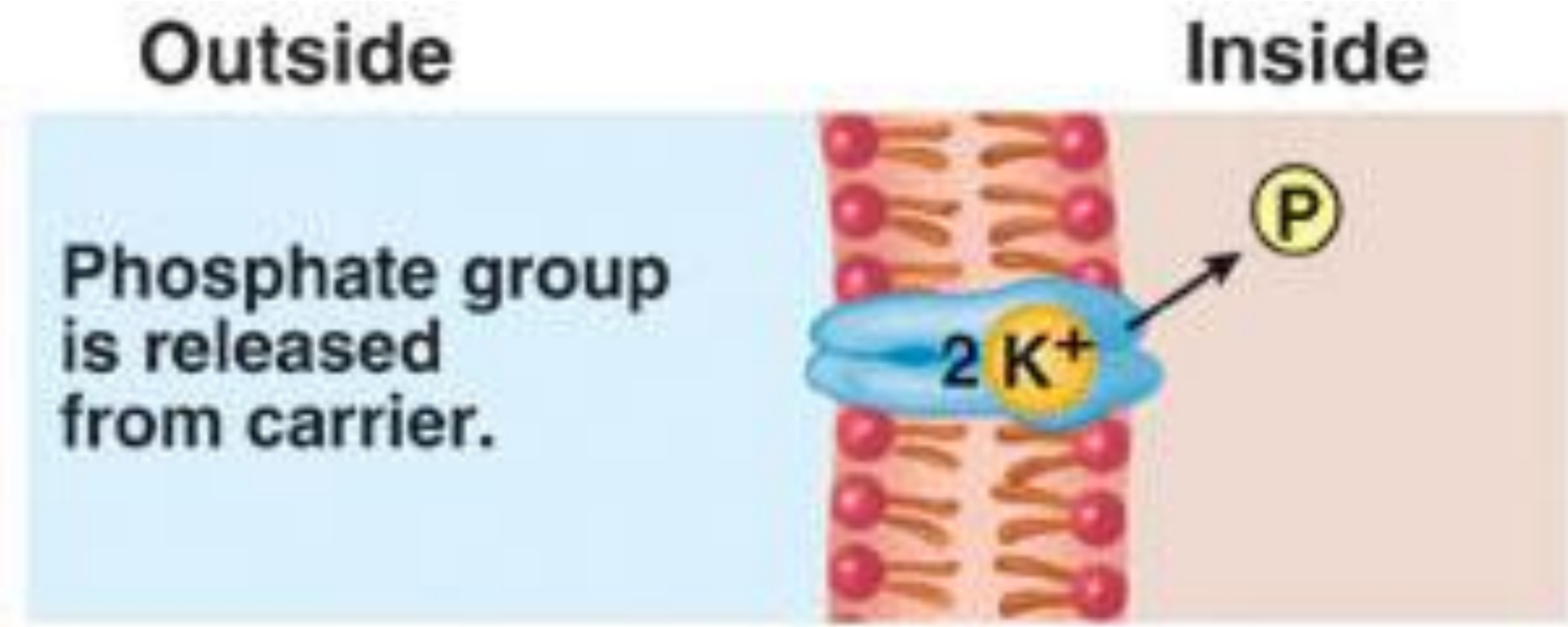


ATP is split, and phosphate group is transferred to carrier.

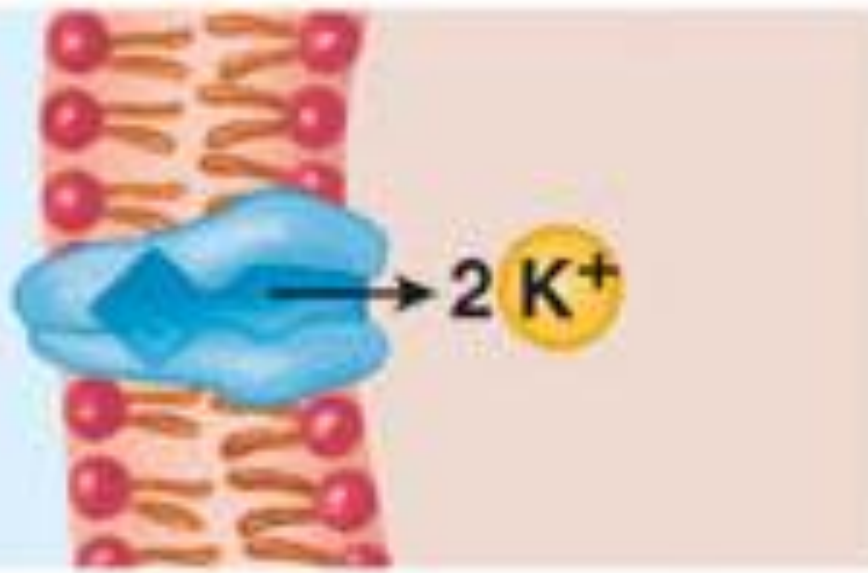


Change in shape results that causes carrier to release three sodium ions (Na^+) outside the cell. New shape allows carrier to take up two potassium ions (K^+).




Outside
Inside
Phosphate group
is released
from carrier.
2 K+
P

Change in shape results that causes carrier to release potassium ions (K^+) inside the cell. New shape is suitable to take up three sodium ions (Na^+) once again.

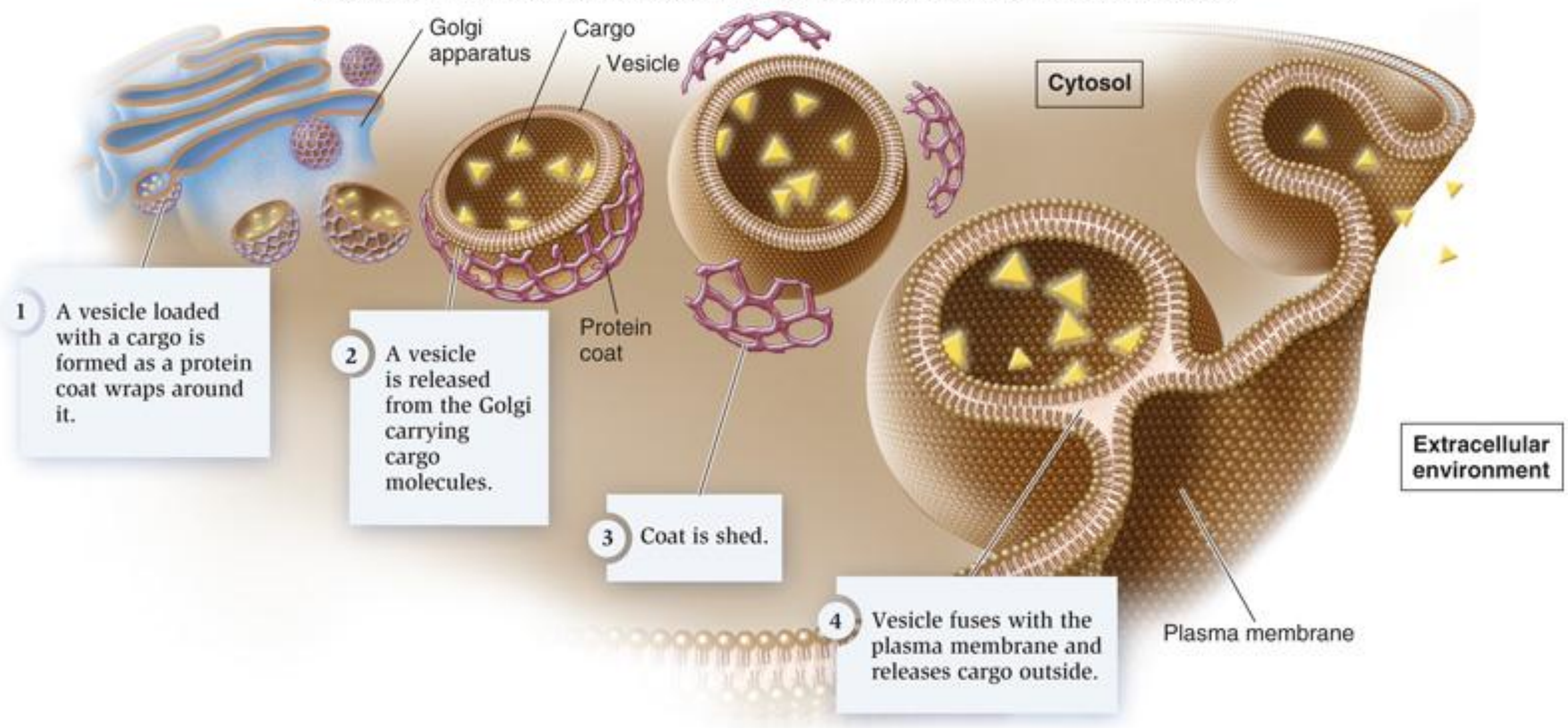


Exocytosis and Endocytosis

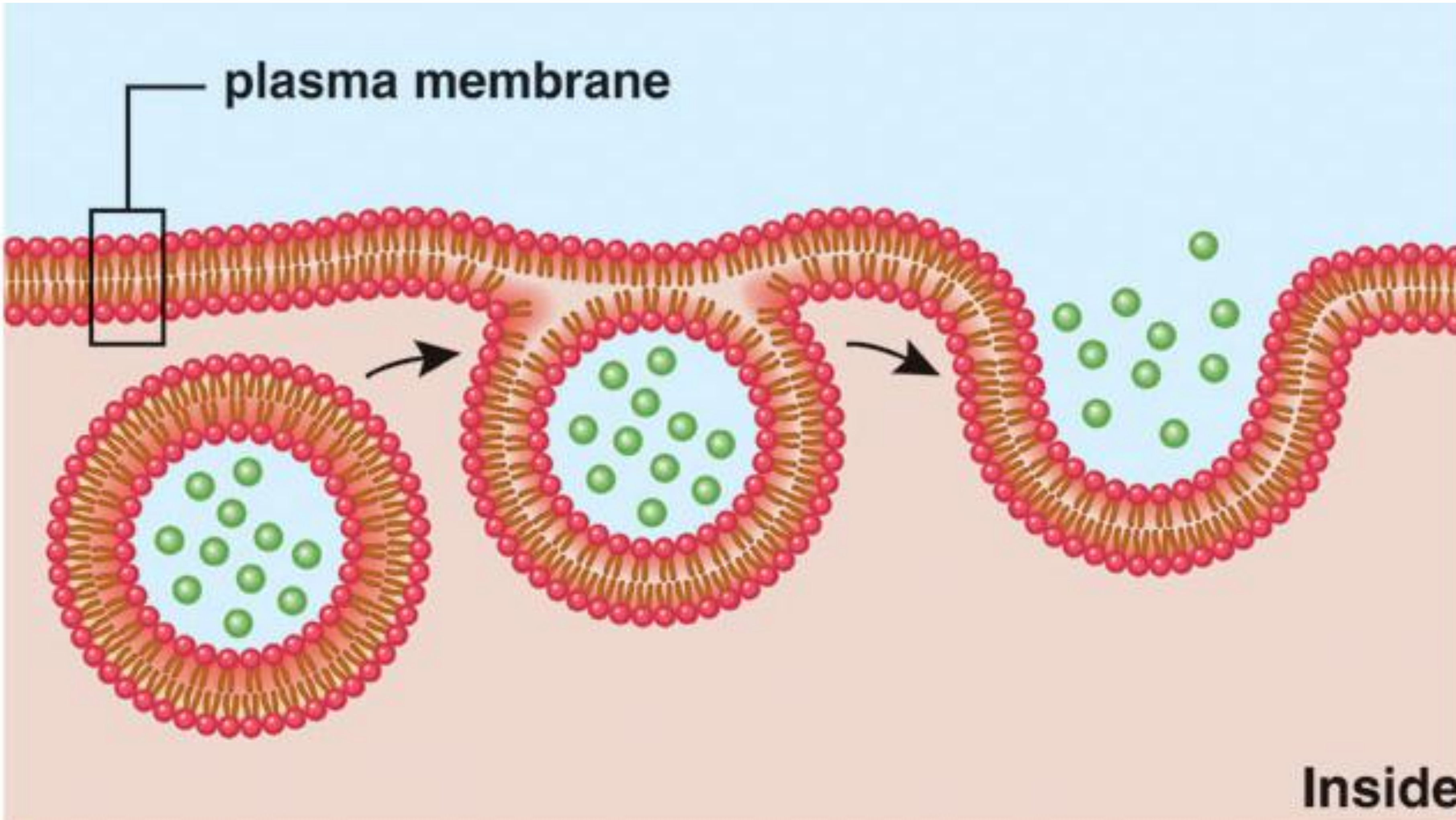
During *exocytosis*, vesicles fuse with the plasma membrane for secretion.

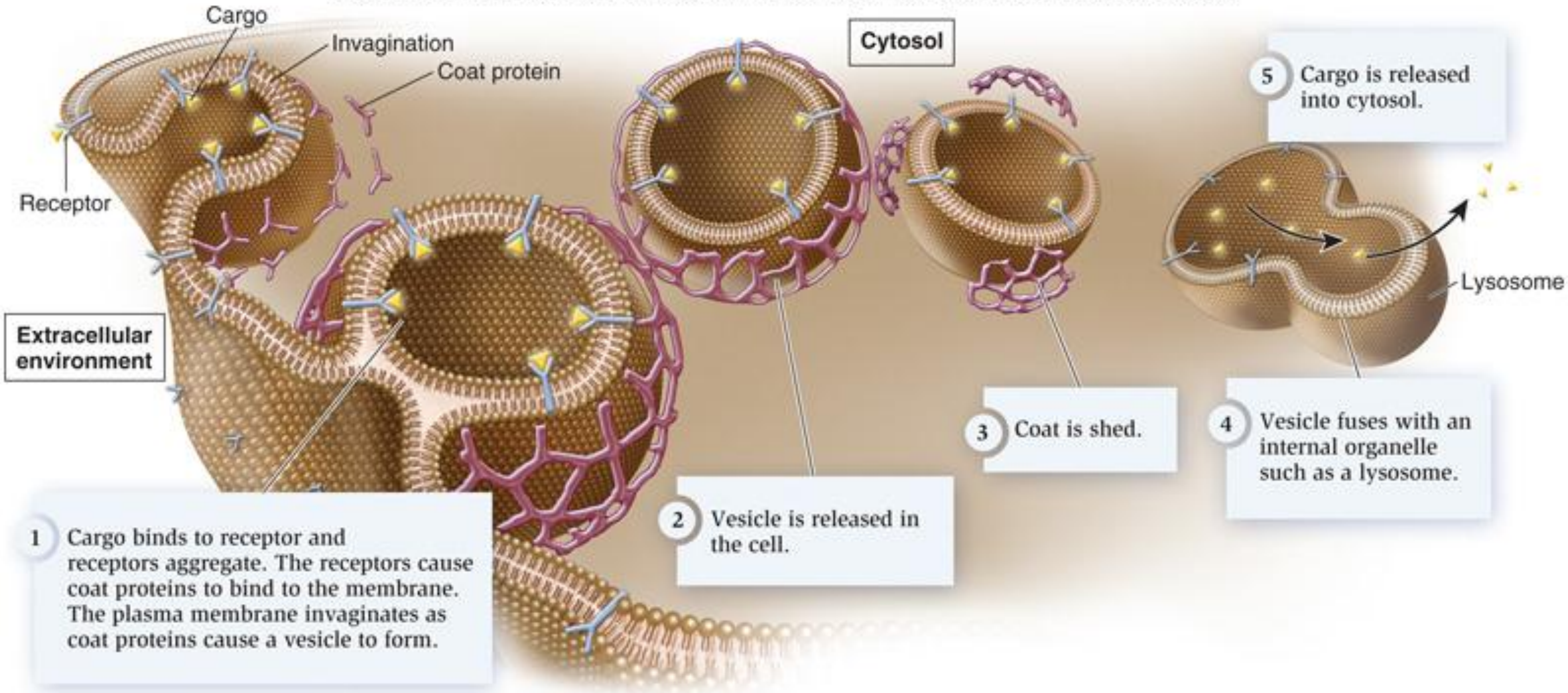
Some cells are specialized to produce and release specific molecules.

Examples include release of digestive enzymes from cells of the pancreas, or secretion of the hormone insulin in response to rising blood glucose levels.


Golgi apparatus
Cargo
Vesicle
Cytosol
Protein coat
Extracellular environment
Plasma membrane
1 A vesicle loaded with a cargo is formed as a protein coat wraps around it.
2 A vesicle is released from the Golgi carrying cargo molecules.
3 Coat is shed.
4 Vesicle fuses with the plasma membrane and releases cargo outside.

Exocytosis




Cargo
Invagination
Coat protein
Receptor
Extracellular environment
Cytosol
Lysosome
1 Cargo binds to receptor and receptors aggregate. The receptors cause coat proteins to bind to the membrane. The plasma membrane invaginates as coat proteins cause a vesicle to form.
2 Vesicle is released in the cell.
3 Coat is shed.
4 Vesicle fuses with an internal organelle such as a lysosome.
5 Cargo is released into cytosol.

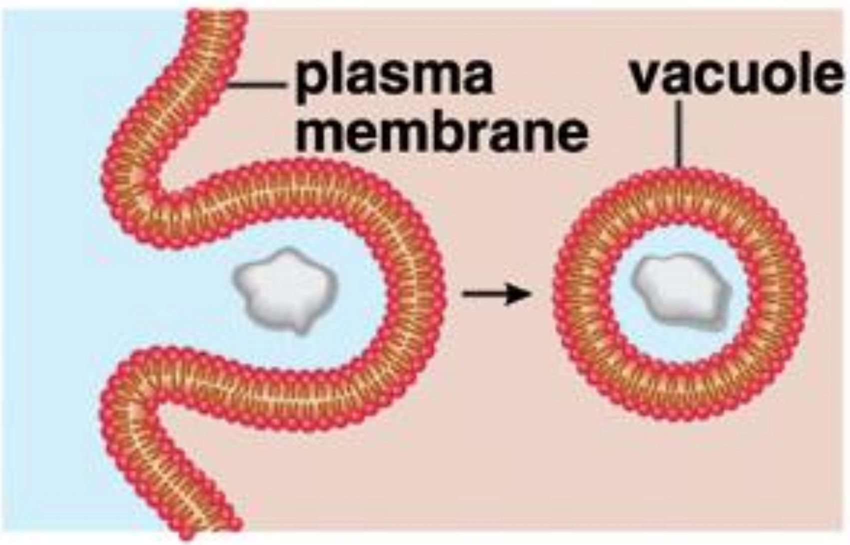
Endocytosis

During *endocytosis*, cells take in substances by invaginating a portion of the plasma membrane, and forming a *vesicle* around the substance.

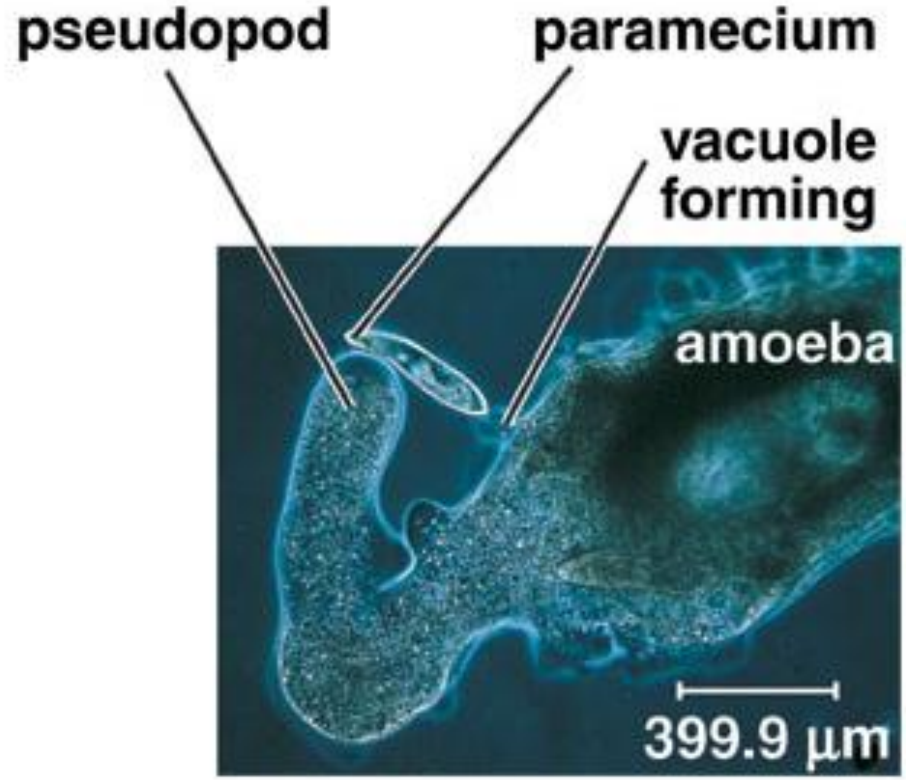
Endocytosis occurs as:

- *Phagocytosis* – large particles
- *Pinocytosis* – small particles
- *Receptor-mediated endocytosis* – specific particles

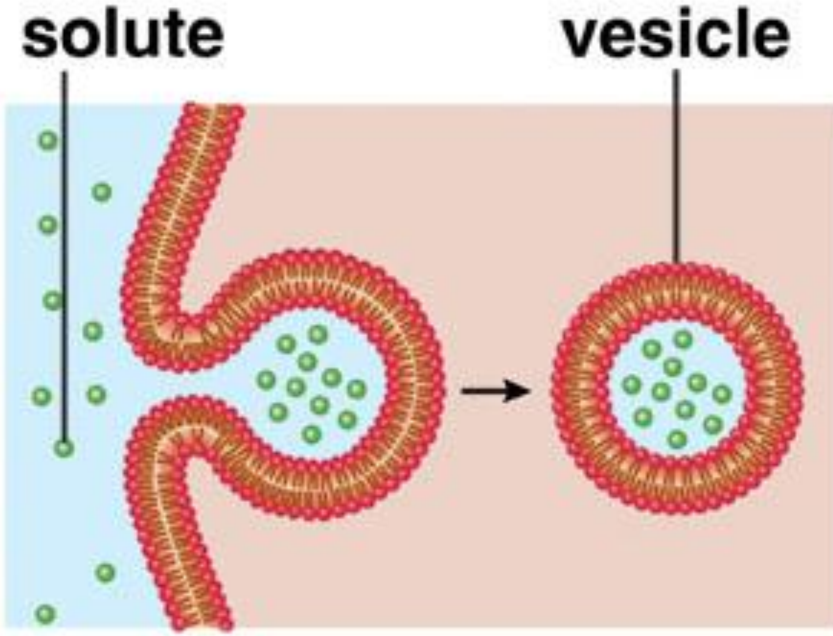
Phagocytosis



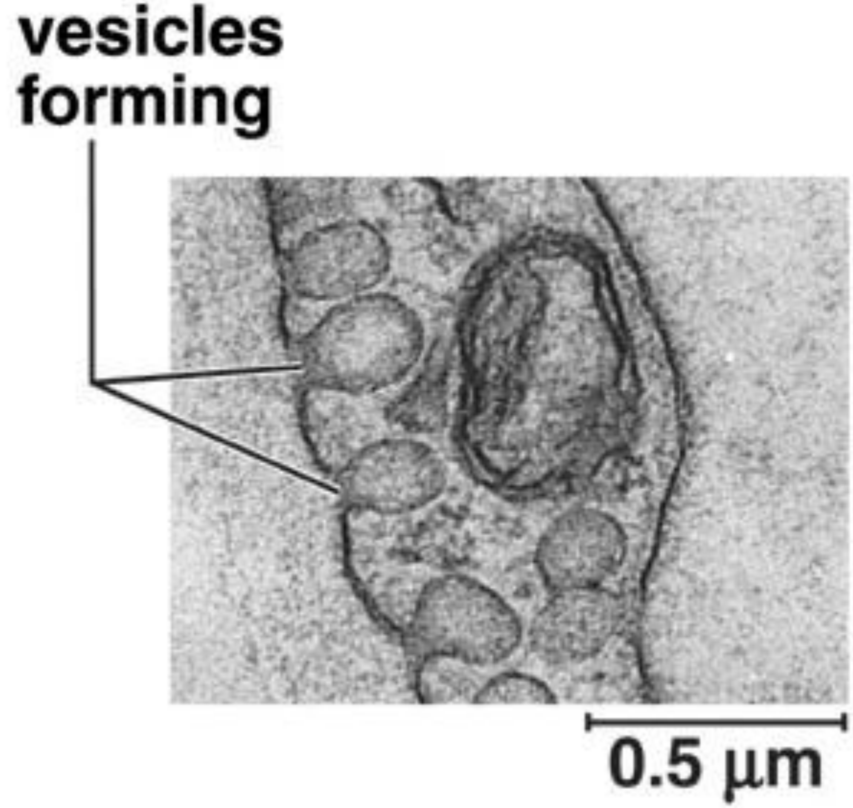
a. Phagocytosis



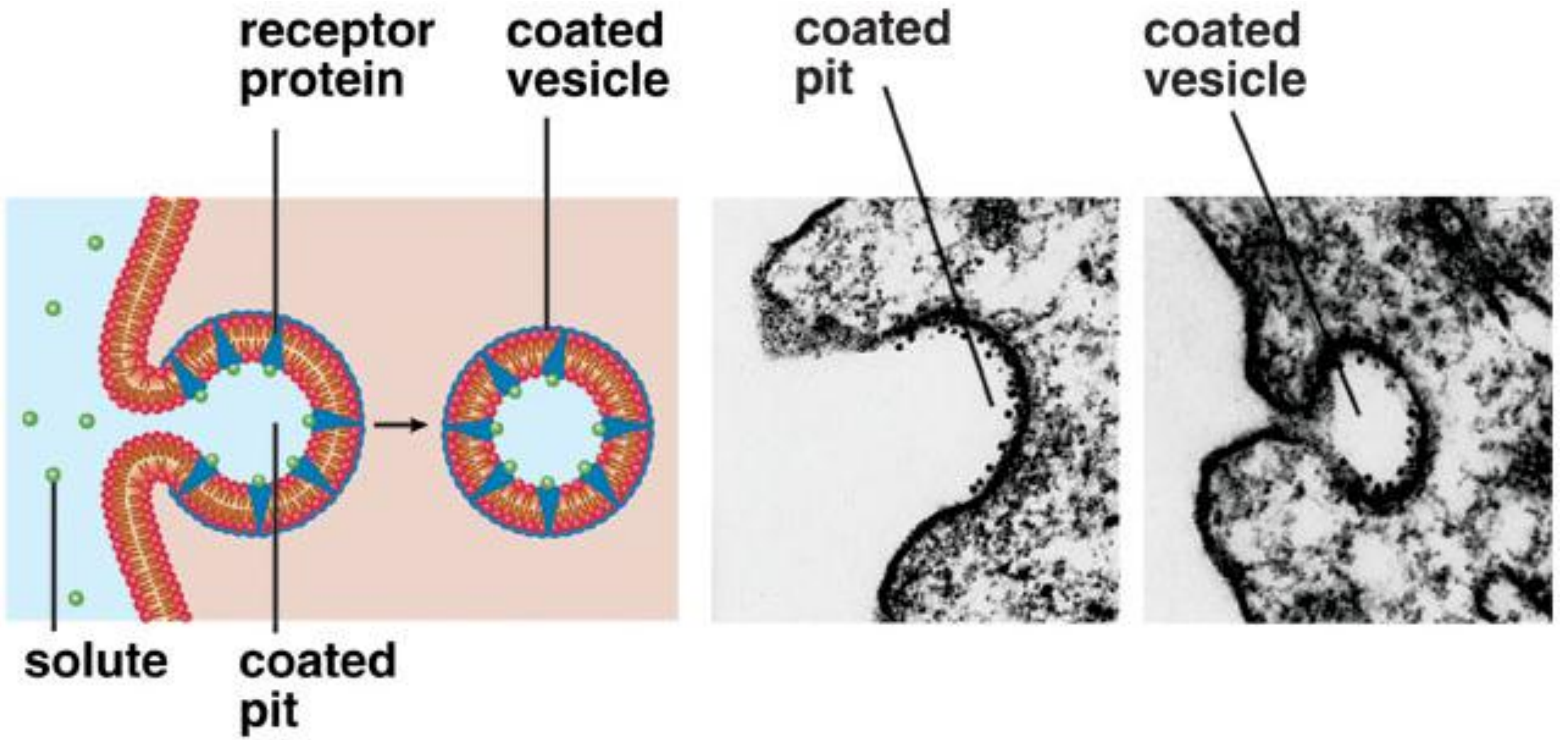
Pinocytosis



b. Pinocytosis



Receptor-mediated endocytosis



Summary

The structure of the plasma membrane allows it to be differentially permeable.

The fluid phospholipid bilayer, its mosaic of proteins, and its glycocalyx make possible many unique functions of the plasma membrane.

Passive and active methods of transport regulate materials entering and exiting cells.