Ch7: Membrane Structure & Function

History

- 1915 – RBC membranes studied – found proteins and lipids
- 1935 – membrane mostly phospholipids – 2 layers
- 1950 – electron microscopes – supported bilayer idea (Sandwich model)
- 1960's – found different membranes in different organisms and organelles – mitochondria has different # of proteins than plasma membrane
- 1970 – found that proteins are inserted into membrane and more complex imaging confirmed it

Cell Membrane

- 8nm thick – need 8,000 to equal the thickness of a sheet of paper
- Separates the internal environment of the cell from the external environment
- Selectively permeable – controls what substances are allowed into and out of the cell
  - Earliest signs of evolution included the development of a cell membrane

Fluid Mosaic Model

- Developed by Singer and Nicolson in 1972
- Proteins within a membrane are fluid and constantly move around
- Phospholipids move very quickly while proteins move slower

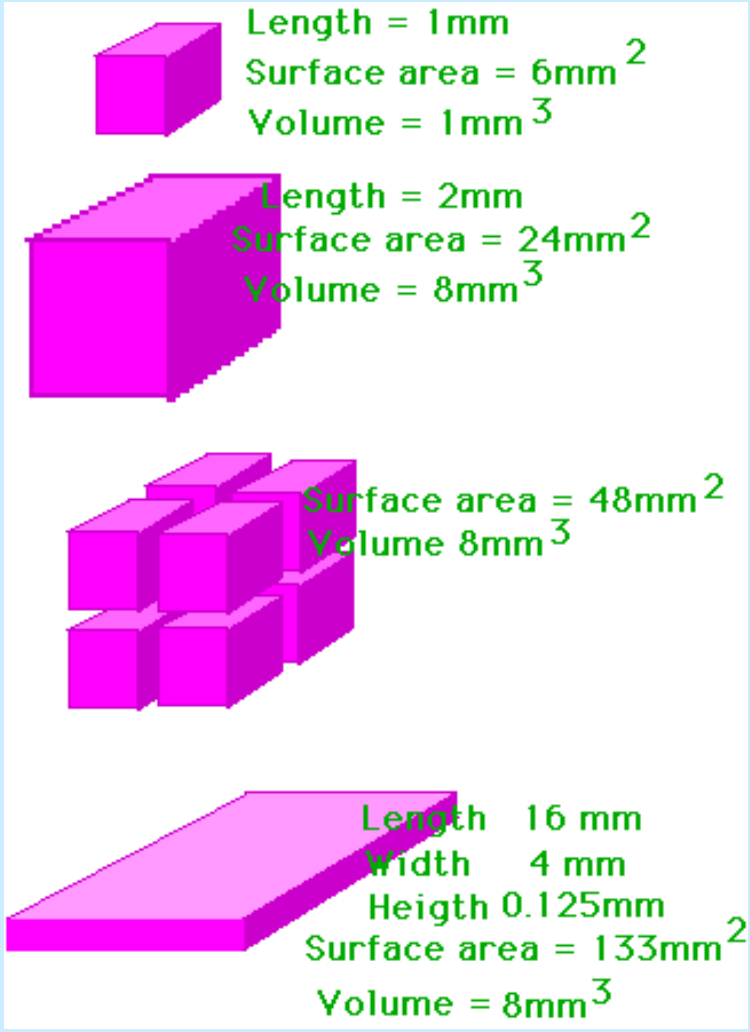
Surface Area to Volume

- The surface area of the plasma membrane must be large enough to adequately exchange materials
  - Smaller cells have a more favorable surface area-to-volume ratio for exchange of materials with the environment.

- As cells increase in volume, the relative surface area decreases and demand for material resources increases
  - More cellular structures are necessary to adequately exchange materials and energy with the environment.
  - These limitations restrict cell size.

Which cell will allow more substances through the membrane?

1



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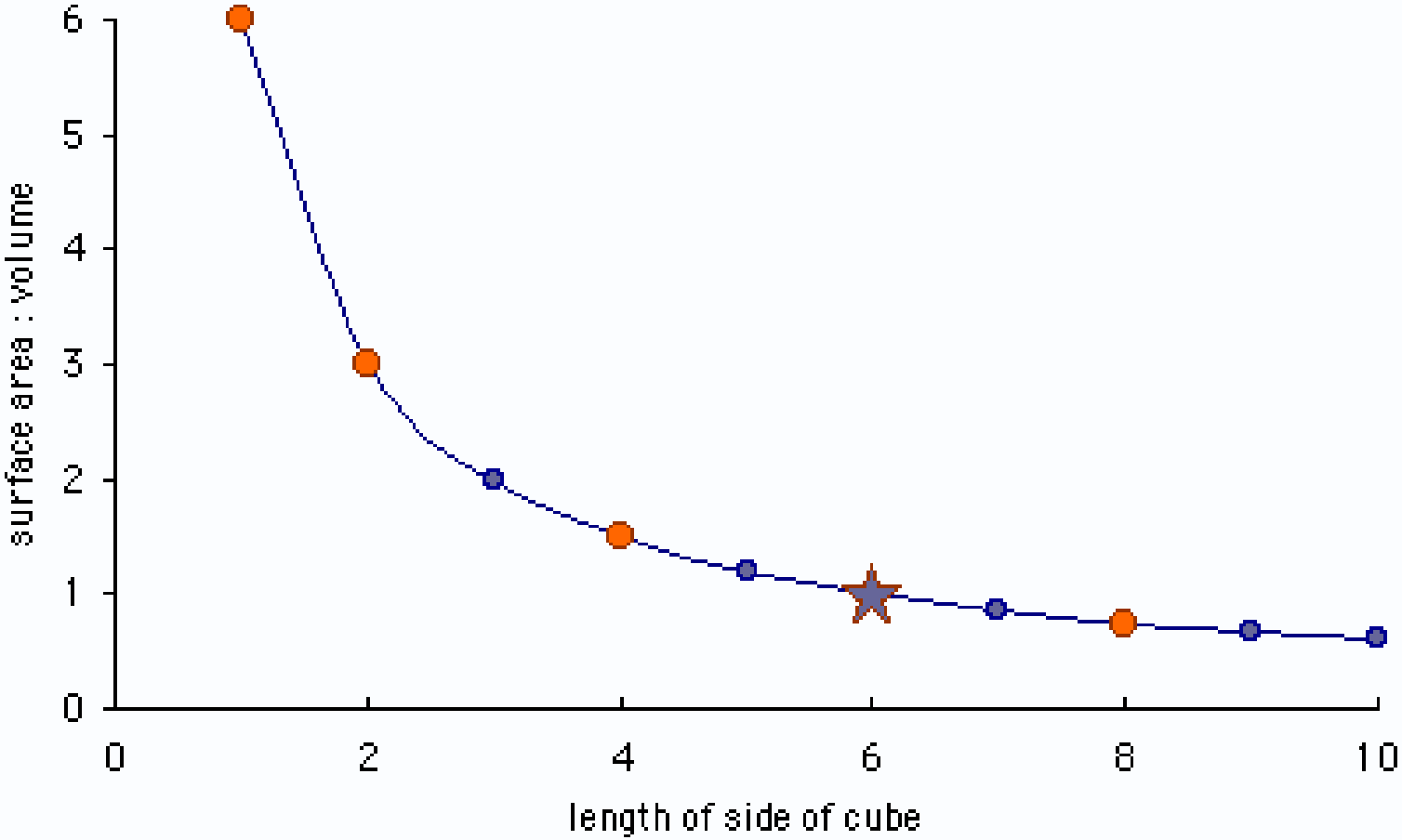
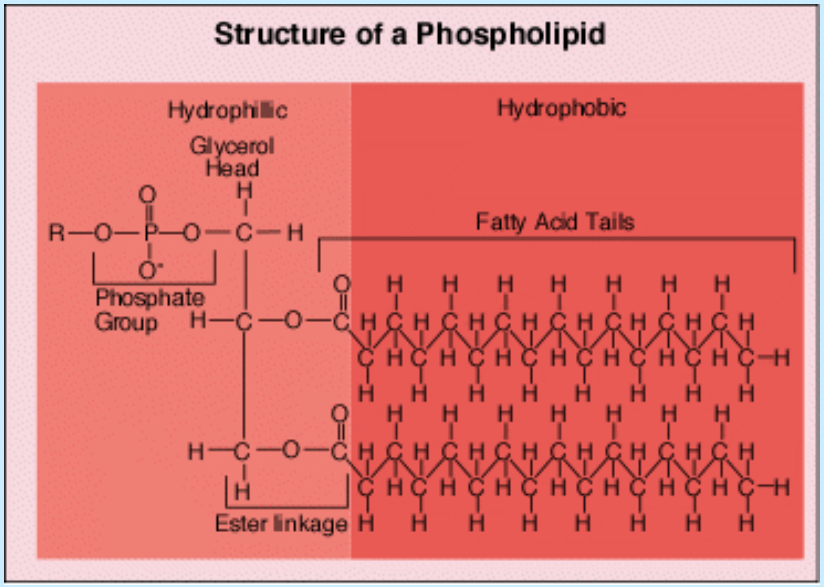

surface area : volume
0
1
2
3
4
5
6
0
2
4
6
8
10
length of side of cube

Plasma Membrane Structure

- Membranes that have more unsaturated fatty acids will remain fluid longer than saturated fatty acids
- Heat can change the fluidity of the membrane
- Cell (plasma) membranes consist of a structural framework of phospholipid molecules, embedded proteins, cholesterol, glycoproteins and glycolipids.

Plasma Membrane Structure

- Double phospholipid membrane – held together by hydrophobic interactions
- Phospholipids:
  - Hydrophilic heads with a phosphate group **(POLAR)**
  - Hydrophobic fatty acid tails **(NONPOLAR)**
  - Phospholipids are **amphiphatic** molecules – they contain both a hydrophobic and hydrophilic region



Plasma Membrane Structure

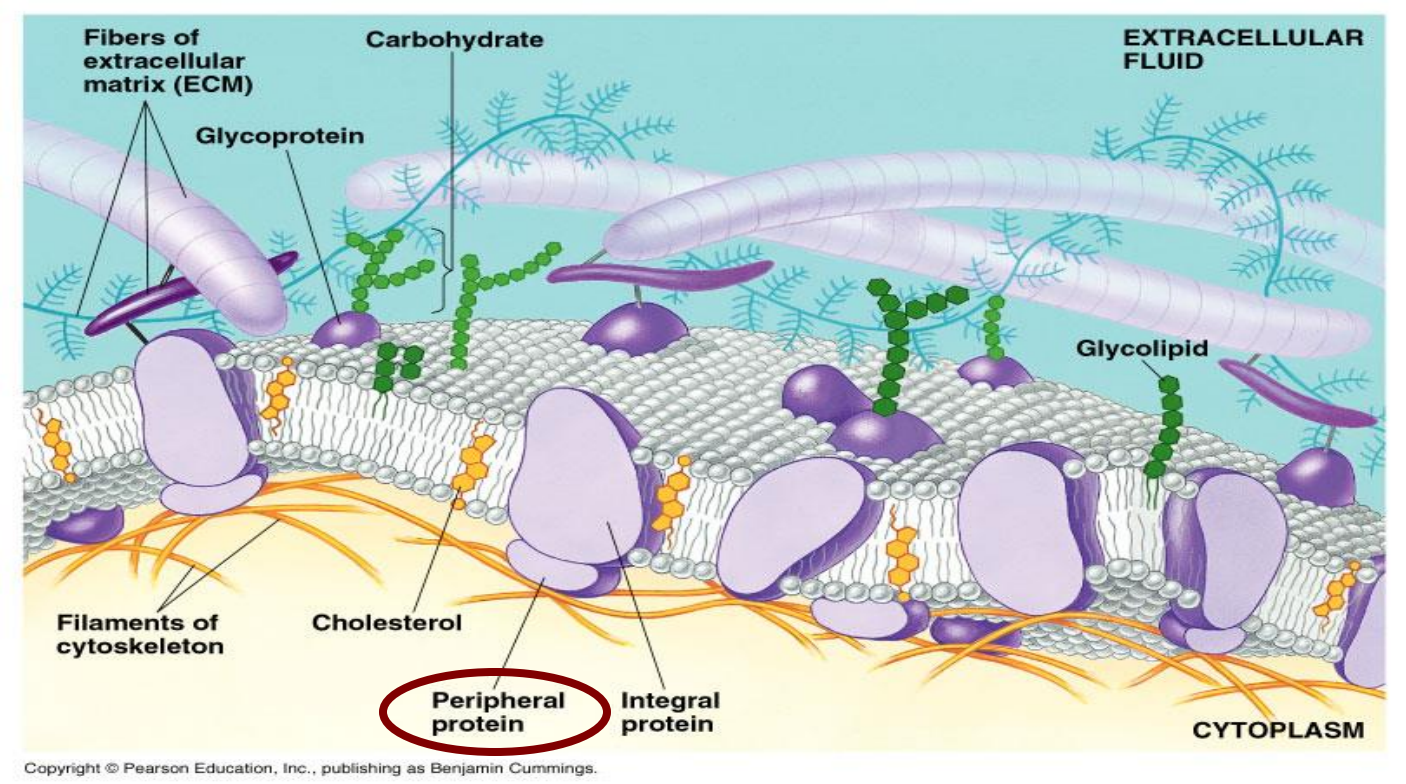
- Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.
  - Small, uncharged polar molecules and small nonpolar molecules, such as N_2, freely pass across the membrane.
  - Hydrophilic substances such as large polar molecules and ions move across the membrane through embedded channel and transport proteins.
  - Water moves across membranes and through channel proteins called aquaporins.

Review

- What does amphipathic mean?
- What is the name of the model that describes the membrane? Why is it called this?
- What are the main structural components of the plasma membrane?

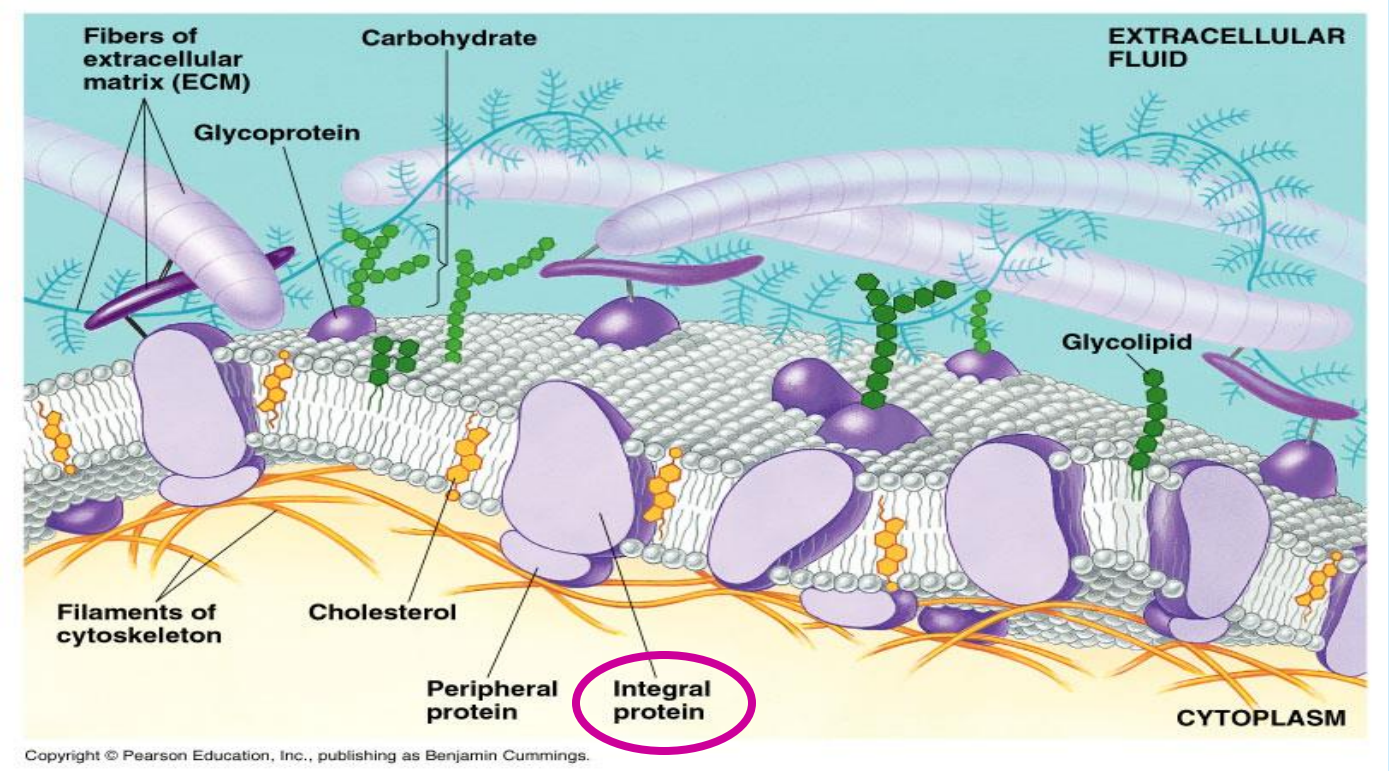
Plasma Membrane Structure - Proteins

- Proteins attached LOOSELY to the inner or outer surface of the membrane are referred to as: **PERIPHERAL PROTEINS**

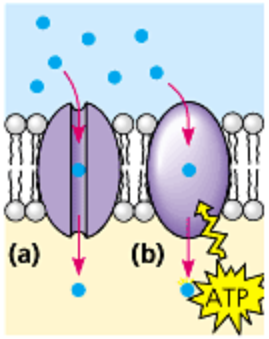


Plasma Membrane Structure - Proteins

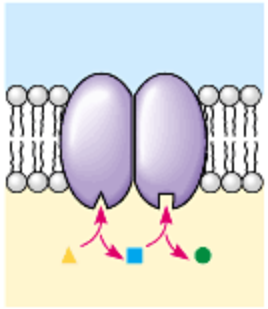
- Proteins spanning the depth of the membrane are: **INTEGRAL PROTEINS**
  - Act as **channel/transport proteins or carrier proteins**



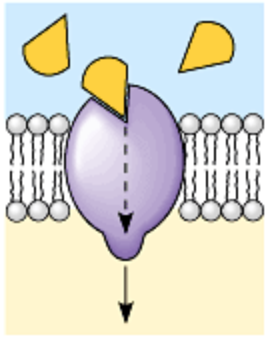
Plasma Membrane Structure – Protein Function



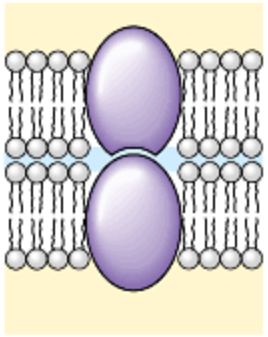
Transport



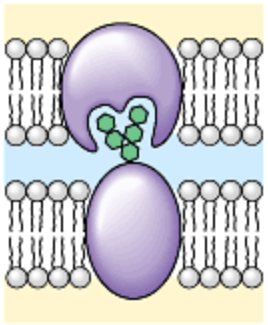
Enzymatic activity



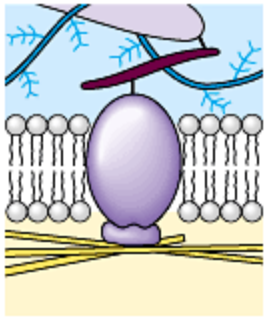
Signal transduction



Intercellular joining



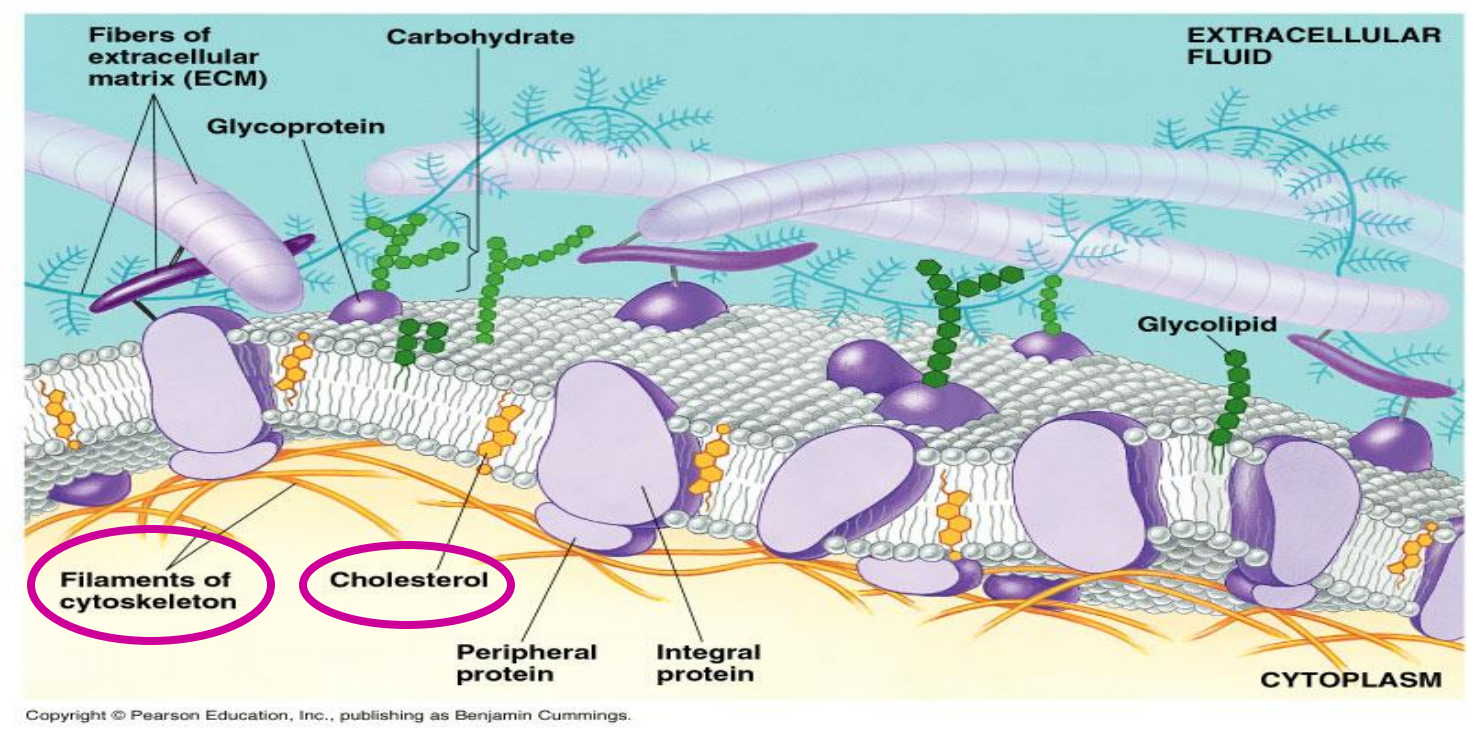
Cell-cell recognition



Attachment to the cytoskeleton and extracellular matrix (ECM)

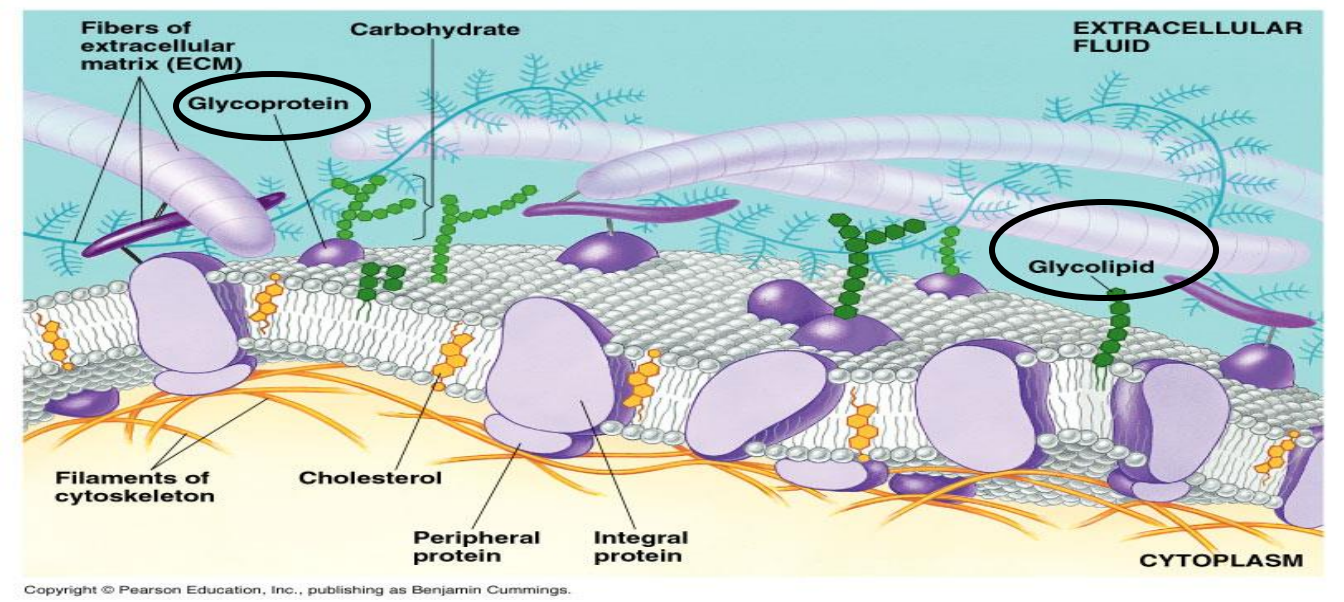
Plasma Membrane Structure

- Cytoskeleton Filaments are distributed throughout the phospholipid bilayer to provide some rigidity to the plasma membrane of cells
- Cholesterol keeps the plasma membrane flexible and fluid



Plasma Membrane Structure

- Glycolipids & Glycoproteins are carbohydrates that attach to the outside surface of the plasma membrane and are used in **<u>cell signaling and recognition.</u>**
  - **<u>Ex:</u>** human blood cells are designated A, B, AB, & O to reflect variation of carbs on the surface of the cells.



Review

- What are the 2 main types of proteins attached to the plasma membrane?
- What are the 6 functions of the proteins in the membrane?
- What is the purpose of the Glycolipids & Glycoproteins?
- What is the name of the protein channel that moves water?

CELL TRANSPORT

Passive Transport

- Passive transport plays a primary role in the import of resources and the export of wastes without the input of energy

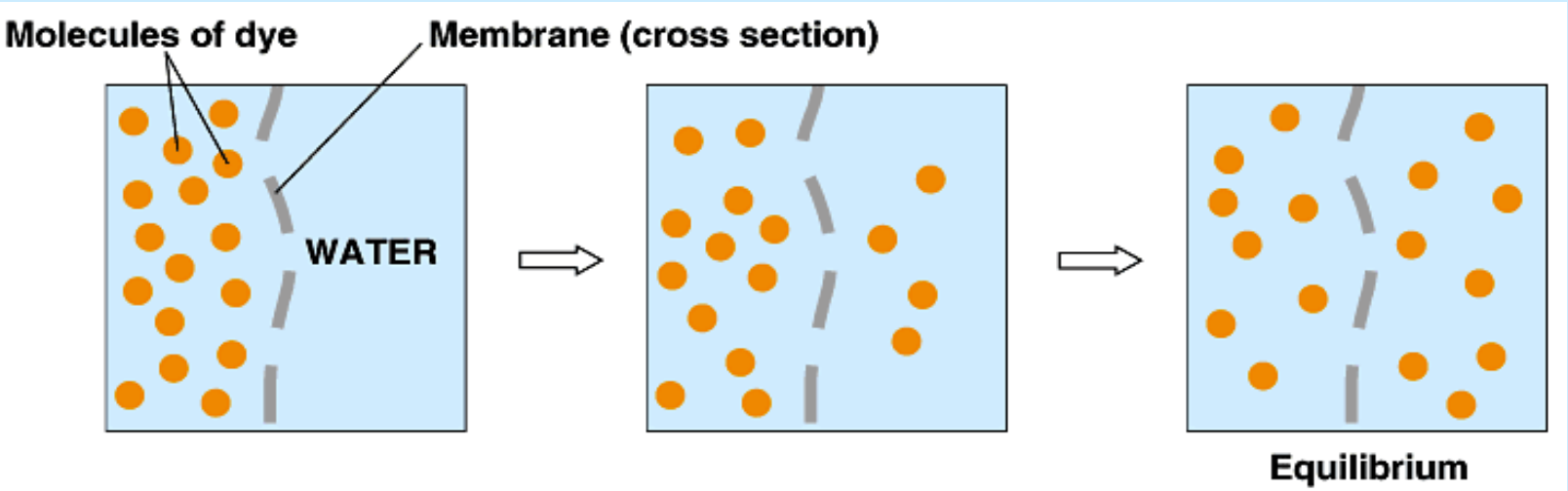
- Substances move from areas of **HIGH** concentration to areas of **LOW** concentration.
  - **Concentration Gradient** IS required.
  - Substances are moved **DOWN or WITH** their concentration gradient.

- **DOES NOT REQUIRE ATP**

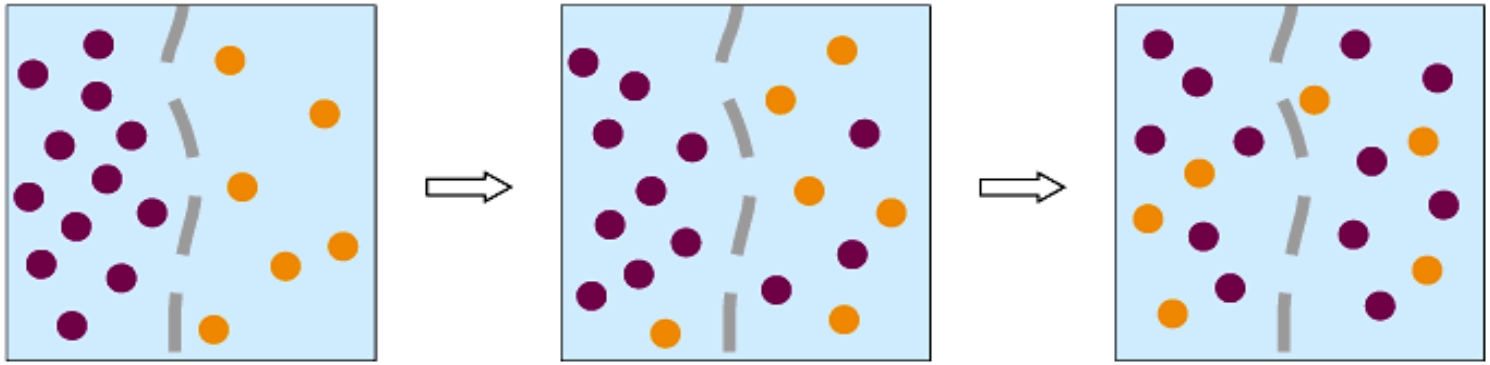
Passive Transport – Simple Diffusion

- Diffusion = the tendency of substances to spread out evenly into a space
  - moves small, nonpolar molecules (O_2, CO_2)

- **Each substance diffuses down its *own* concentration gradient, and is NOT affected by another substance**



(a) Diffusion of one solute

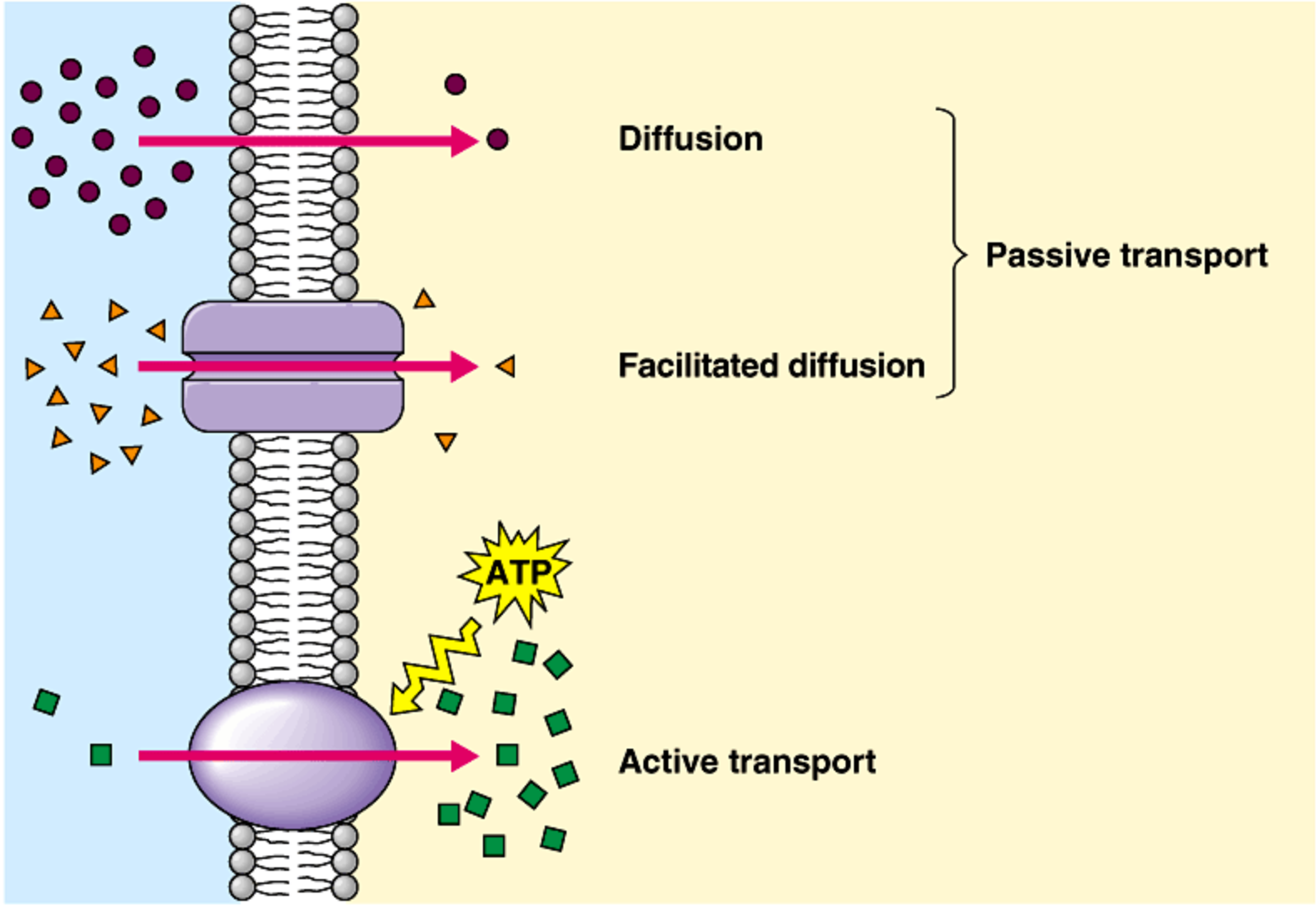


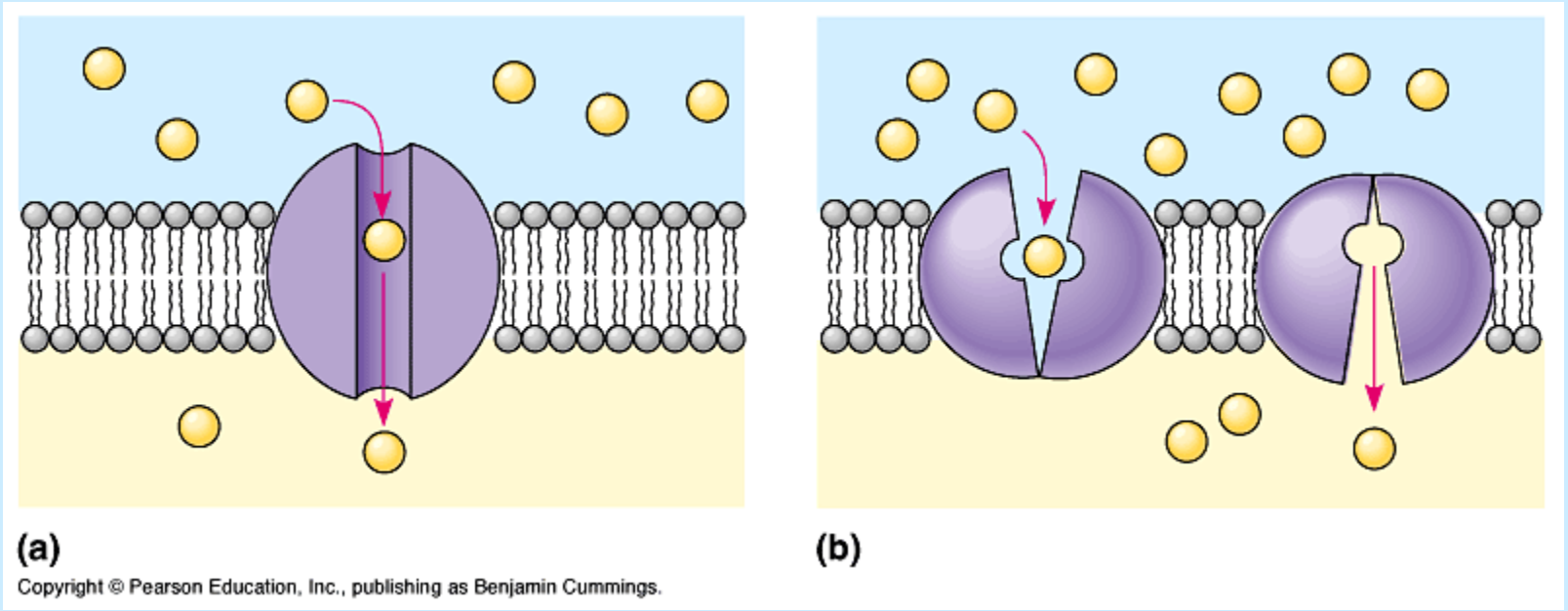
(b) Diffusion of two solutes

Passive Transport – Facilitated Diffusion

- Many **POLAR MOLECULES** and **IONS** impeded by the membrane diffuse **PASSIVELY** with the help of **TRANSPORT PROTEINS** in the plasma membrane.

- Used by solutes **UNABLE** to pass between phospholipids.
  - Water moves through **AQUAPORINS** – hydrophilic proteins that allow water and small ions to pass.
  - **ION CHANNELS** – function as gated channels, causing the protein to open or close depending on the concentration gradient.
    - Na^+ or Ca^{2+} transport
    - Change in response to a stimulus
  - **CARRIER PROTEINS** change shape to allow solutes to move across the membrane.
    - Glucose transport



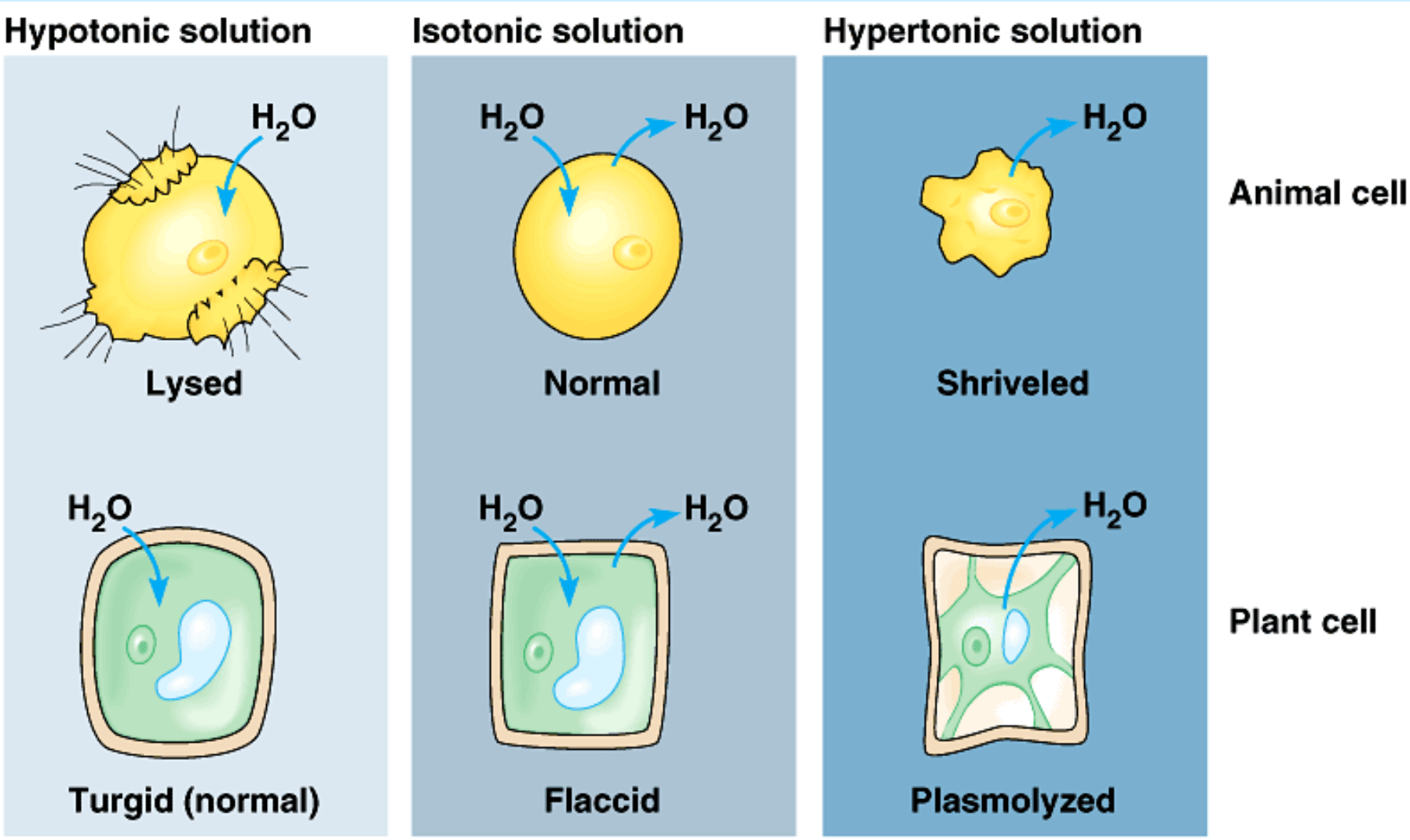


(a) Channel protein

(b) Carrier Protein

Passive Transport - Osmosis

- Movement of **WATER** from areas of high concentration to areas of low concentration without use of energy.
- Solute concentrations between two areas can be compared.
  - A solution may be **HYPERTONIC** if it has a **higher concentration** of solutes.
  - A solution may be **HYPOTONIC** if it has a **lower concentration** of solutes.
  - A solution may be **ISOTONIC** if it has an **equal concentration** of solutes relative to another region.

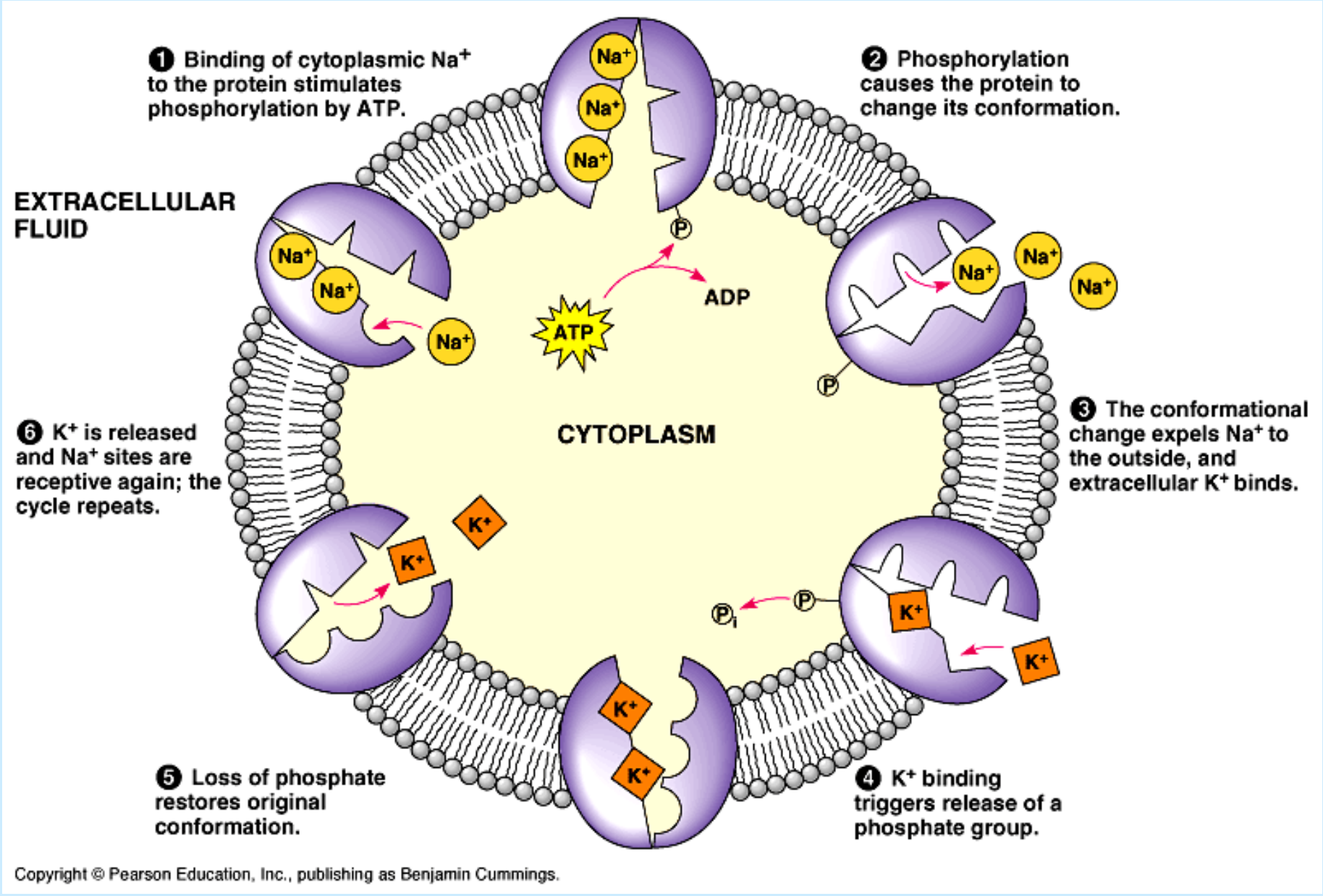


ACTIVE TRANSPORT

- Movement of solutes from areas of **LOW** concentration to areas of **HIGH** concentration, **AGAINST** their **CONCENTRATION GRADIENT**.
- ATP IS REQUIRED.
- **CARRIER PROTEINS** are used to move solutes such as small ions, amino acids and monosacharides across the membrane.

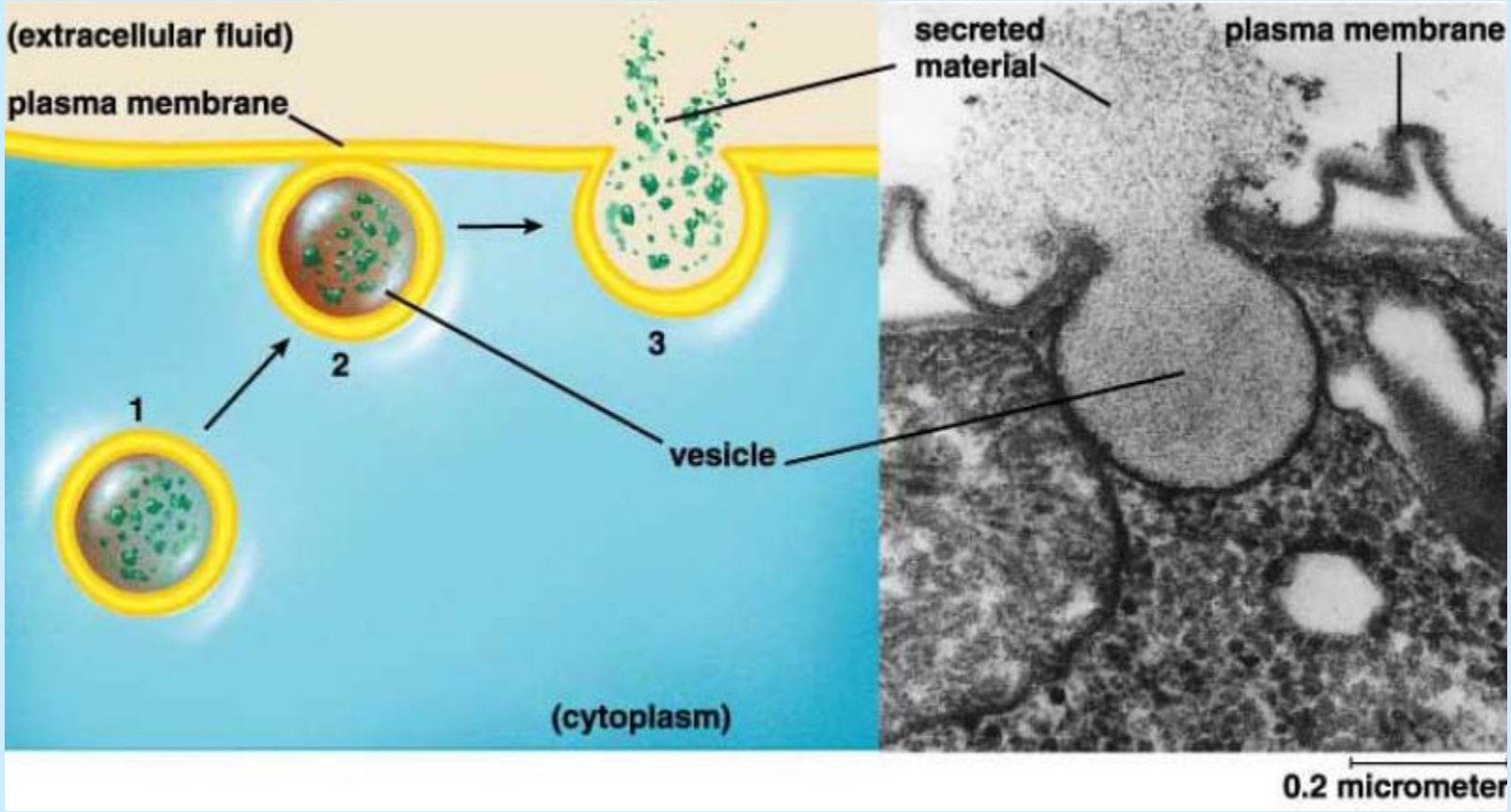
Active Transport – Na/K Pump

- Sodium-Potassium Pump uses ATP to change the shape of a protein to move a solute bound to the protein across the membrane
  - Three Na^+ are moved out and two K^+ are moved in



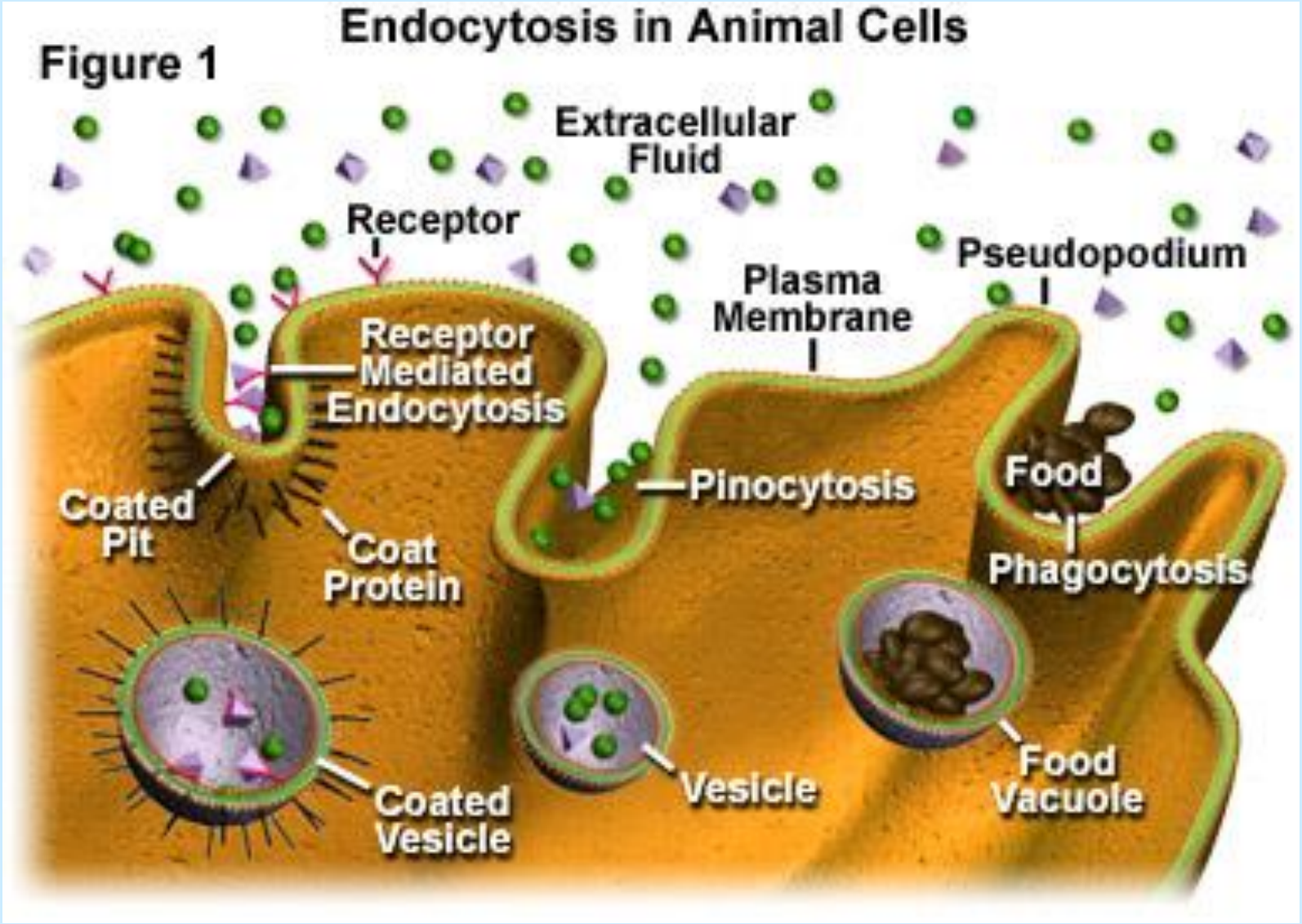
Active Transport - Exocytosis

- Secretion (release) of molecules by the fusion of vesicles to the plasma membrane.
  - Membrane of vesicle fuses to the plasma membrane.
  - Vesicle then EXPELS its contents to the outside of the cell.
    - Insulin is secreted by the pancreas in this manner, as are neurotransmitters released from nerve cells.


(extracellular fluid)
plasma membrane
1
2
3
vesicle
(cytoplasm)
secreted material
plasma membrane
0.2 micrometer

Active Transport - Endocytosis

- Taking in of macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.
- **3 types of endocytosis**:
  1. **Phagocytosis** = cellular eating; engulfing by wrapping pseudopodia around particles and packaging in a membrane bound sac.
  2. **Pinocytosis** = cellular drinking; engulfing extracellular fluid.
  3. **Receptor Mediated Endocytosis** = acquisition of bulk quantities of specific substances – specific to receptors on the membrane.


Endocytosis in Animal Cells
Figure 1
Extracellular Fluid
Receptor
Pseudopodium
Plasma Membrane
Receptor Mediated Endocytosis
Coated Pit
Coat Protein
Pinocytosis
Food
Phagocytosis
Coated Vesicle
Vesicle
Food Vacuole

- Water Potential