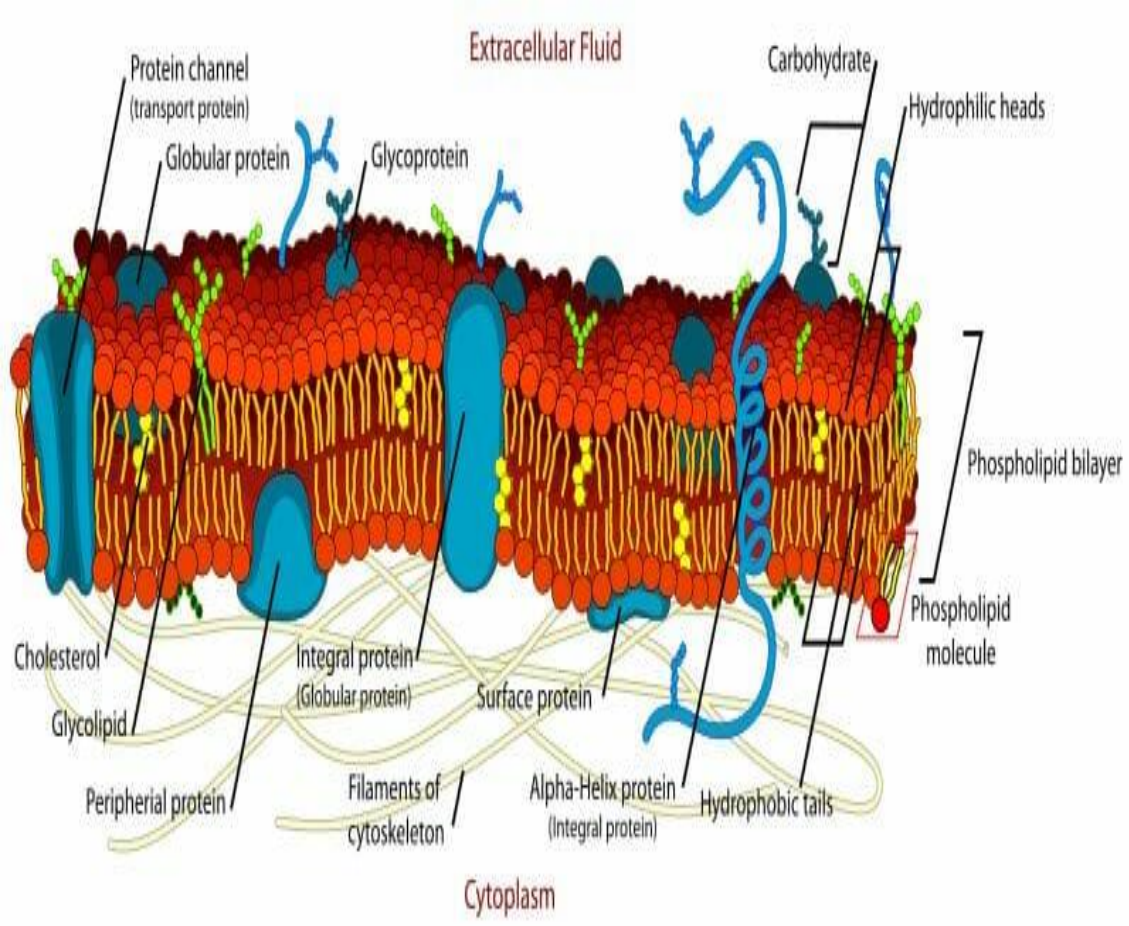
Medical Biology – Year 1



Chapter 1: The Plasma membrane

Lecture 6

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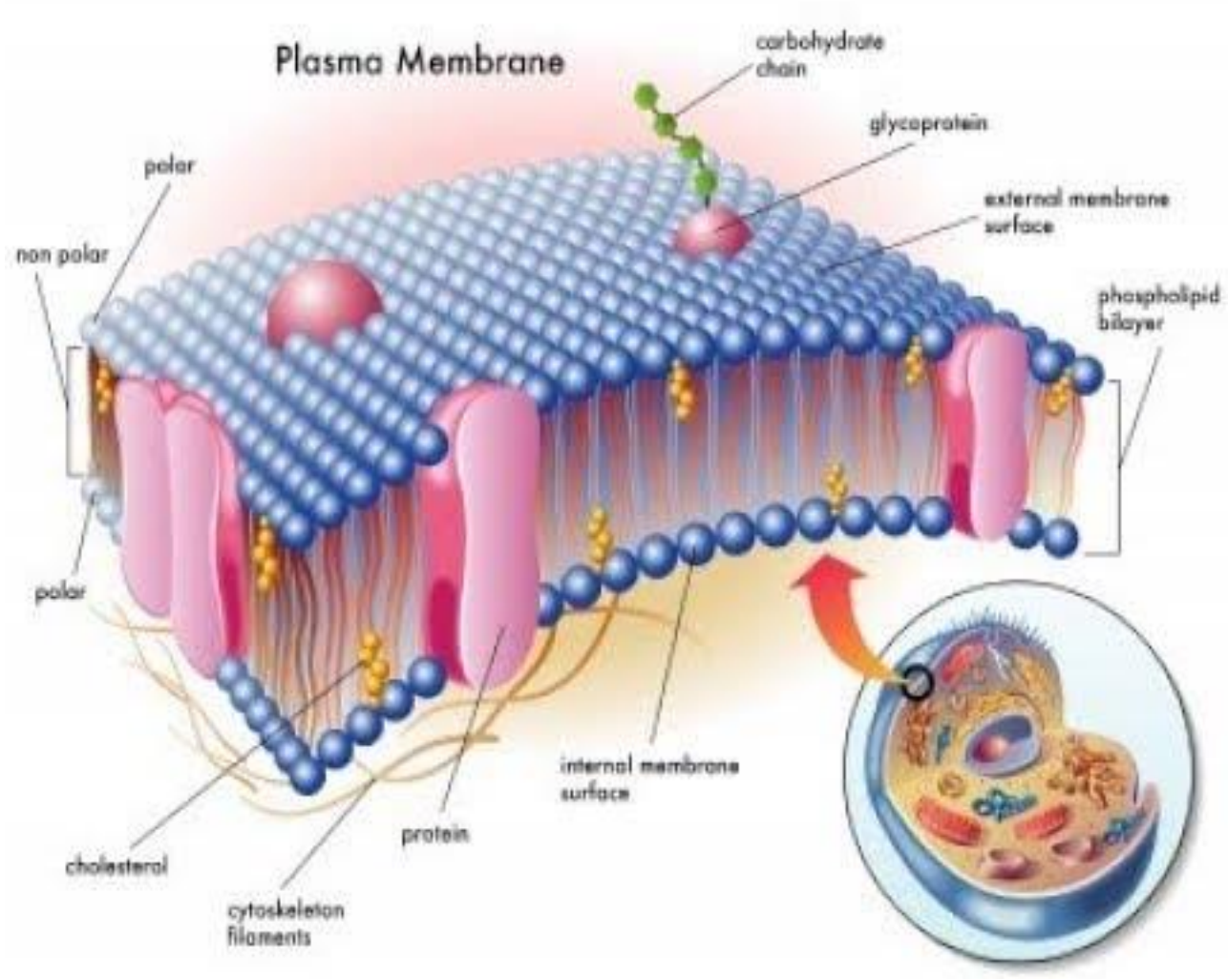
Objectives

- The term of the cell membrane and plasma membrane.
- Structure of the plasma membrane.
- Different characters of plasma membrane.
- Describe the modification of the plasma membrane.
- Understand the active and passive transport mechanisms.
- Describe the osmolality of the cell.
- Describe the tonicity of the cell.

The Plasma membrane

- The **plasma membrane** of a cell is a network of lipids and proteins that forms the boundary between a cell's contents and the outside of the cell.
- It is also simply called the cell membrane.
- The main function of the plasma membrane is to protect the cell from its surrounding environment.
- It is semi-permeable and regulates the materials that enter and exit the cell.
- The cells of all living things have plasma membranes.



Functions of the Plasma Membrane

A. **Physical Barrier:** The plasma membrane surrounds all cells and physically separates the cytoplasm, which is the material that makes up the cell, from the extracellular fluid outside the cell. This protects all the components of the cell from the outside environment and allows separate activities to occur inside and outside the cell.

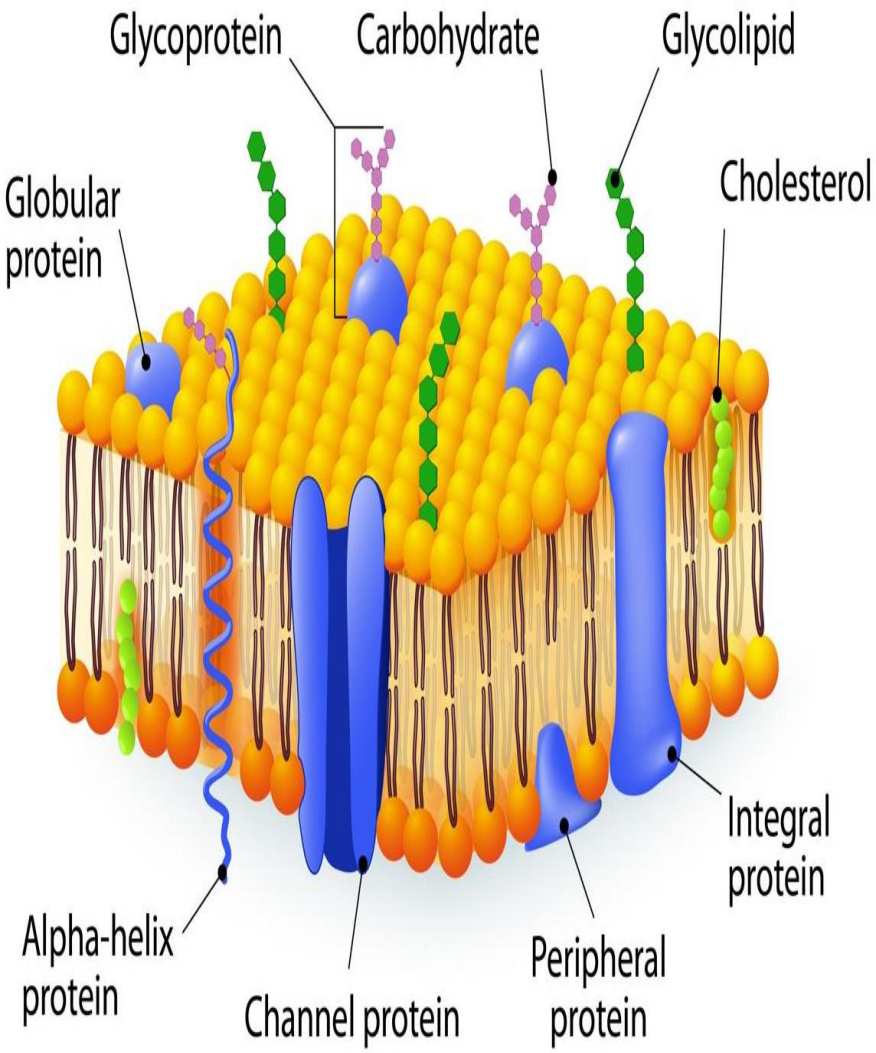
B. **Selective Permeability:** Plasma membranes are selectively permeable (or semi-permeable), meaning that only certain molecules can pass through them. Water, oxygen, and carbon dioxide can easily travel through the membrane. Generally, ions (e.g. sodium, potassium) and polar molecules cannot pass through the membrane; they must go through specific channels or pores in the membrane instead of freely diffusing through. This way, the membrane can control the rate at which certain molecules can enter and exit the cell.

C. **Endocytosis and Exocytosis**

D. **Cell Signaling:** Another important function of the membrane is to facilitate communication and signaling between cells. It does so through the use of various proteins and carbohydrates in the membrane. Proteins on the cell "mark" that cell so that other cells can identify it. The membrane also has receptors that allow it to carry out certain tasks when molecules such as hormones bind to those receptors.

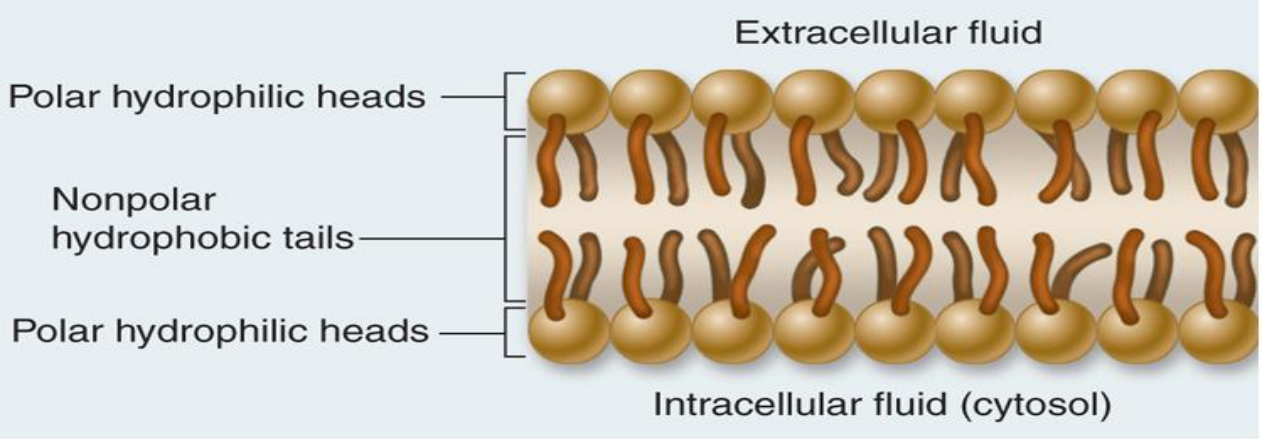
The Plasma membrane

- The **plasma membrane** is thin (7-10 nm) bilayer membrane made up of **lipid molecules** and a dispersed **protein molecules** embedded in between.
- **Glycogen** molecules are also found attached to both lipids and protein molecules.
- **Carbohydrates** are also found in the plasma membrane; specifically, most carbohydrates in the membrane are part of glycoproteins, which are formed when a carbohydrate attaches to a protein.
- **Glycoproteins** play a role in the interactions between cells, including cell adhesion, the process by which cells attach to each other.
- The structure of plasma membrane well described by a model known as the **fluid mosaic model**.
- The lipid bilayer is made up of phospholipids molecules, with small amounts of **cholesterol and glycolipids**.
- The protein molecules are found imbedded or floated between the fluid bilayer giving the mosaic pattern, hence the name of the model (**fluid mosaic model**).



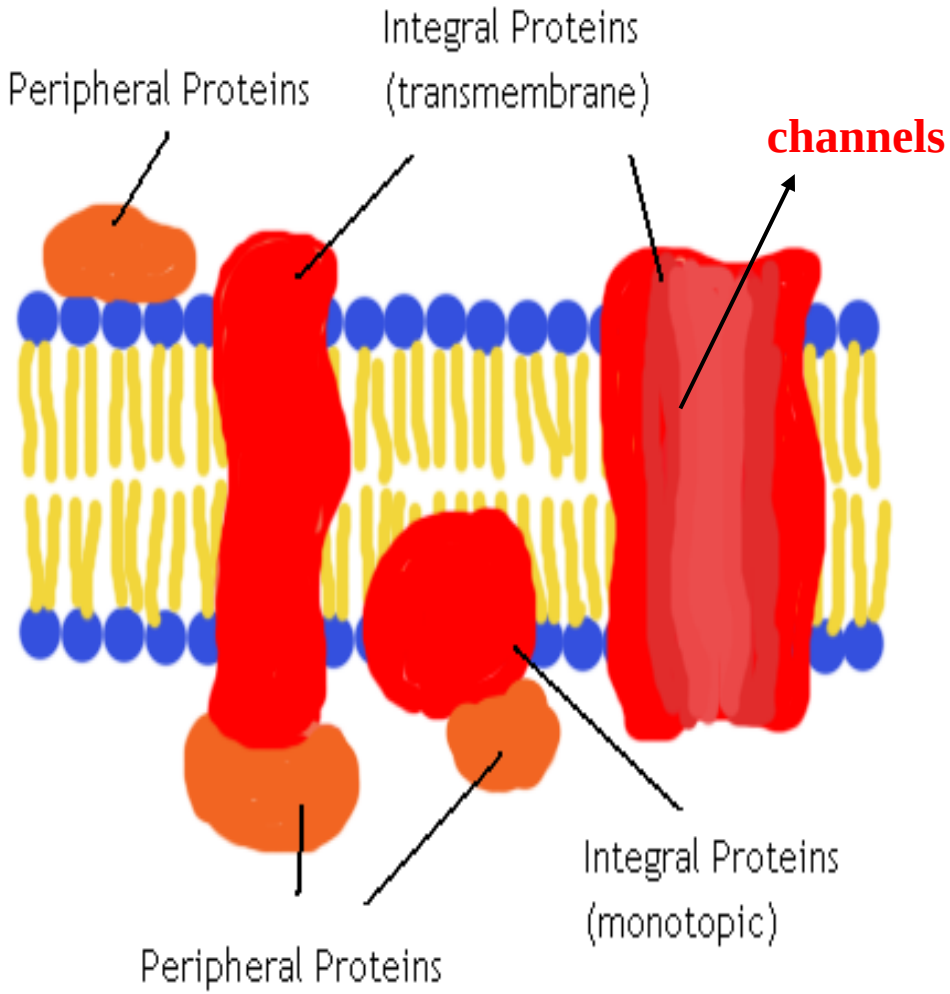
Phospholipids Molecules

- The membrane is partially made up of molecules called **phospholipids**, which spontaneously arrange themselves into a double layer with **hydrophilic** ("water loving") heads on the outside and **hydrophobic** ("water hating") tails on the inside.
- The **phospholipids** molecules are arranged in a way that **polar heads** are always attached to the i**ntracellular and intercellular water molecules**, while the **nonpolar** tails avoid water and **lie in the center of the membrane**.
- The head attached to the tail by a **cholesterol** molecules.
- The cholesterol form 20% of the lipid membrane acts in keeping the flexibility and stability of the plasma membrane.



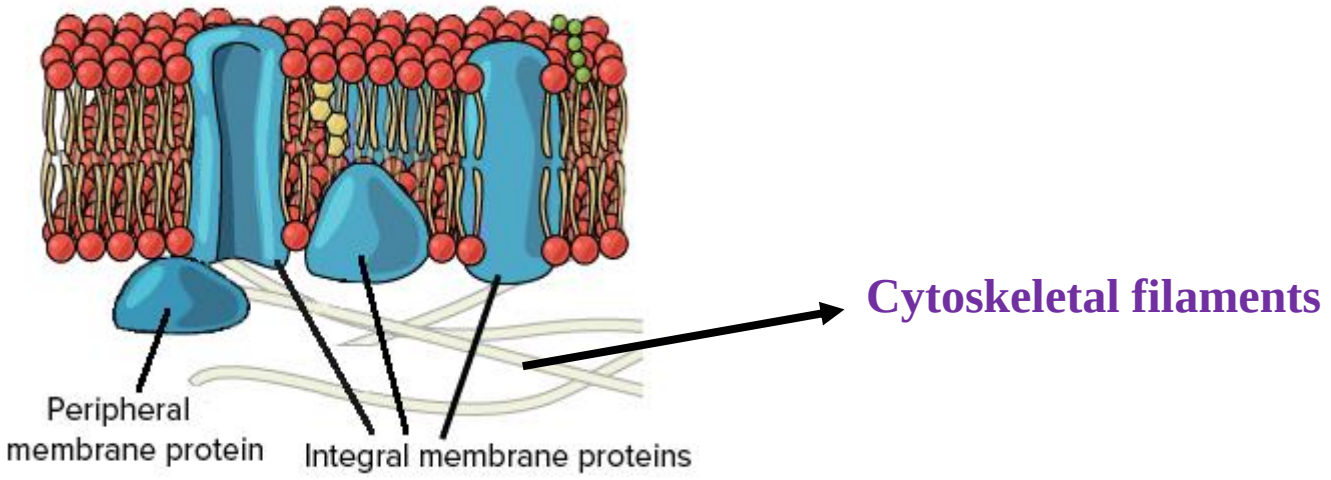
Protein Molecules

- **Membrane proteins** represent about a third of the proteins in living organisms. Based on their structure, there are main two types of membrane proteins: **integral membrane and peripheral membrane protein**.
- Most of **integral protein** molecules are found to be inserted and cross the entire width of the lipid bilayer and called **transmembrane protein**, while some of them are located attached to one side of the membrane.
- The **transmembrane proteins** mainly involved in transport of large molecules, others are clustered together to form **channels**, or **pores**, through which water and small molecules or ions can cross the membrane.

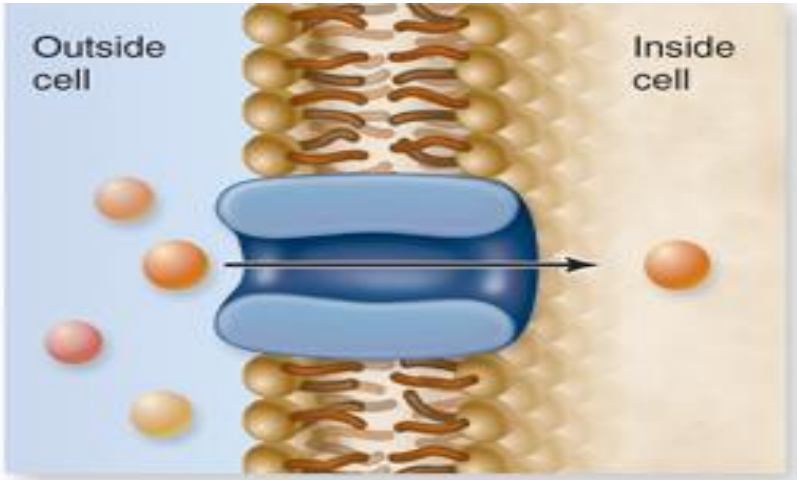


Protein Molecules

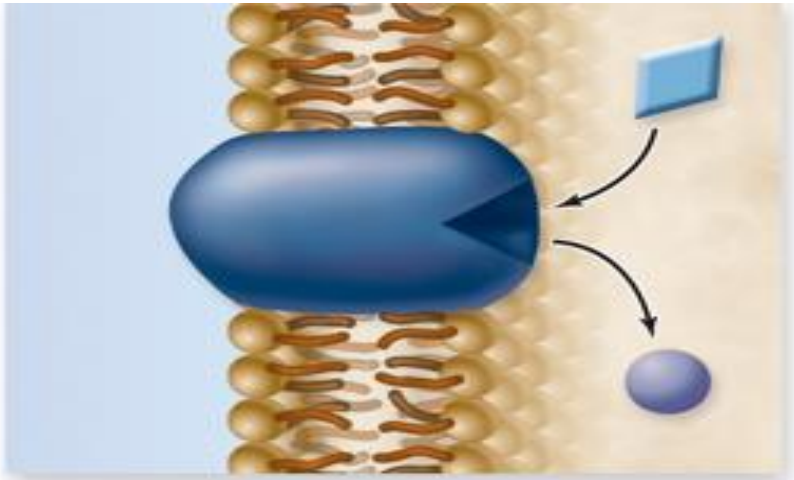
- **Peripheral membrane proteins** are found on the outside and inside surfaces of membranes, attached either to integral proteins or to phospholipids. Unlike integral membrane proteins, peripheral membrane proteins do not stick into the hydrophobic core of the membrane, and they tend to be more loosely attached.
- The **peripheral proteins** incorporate with the **cytoskeletal filaments** from its cytoplasmic side to maintain the shape of the cell.
- Some peripheral proteins act as **enzymes**, and others are **involve in mechanical functions** changing the shape of the cell during **cell division, muscle contraction, or linking cells together**.

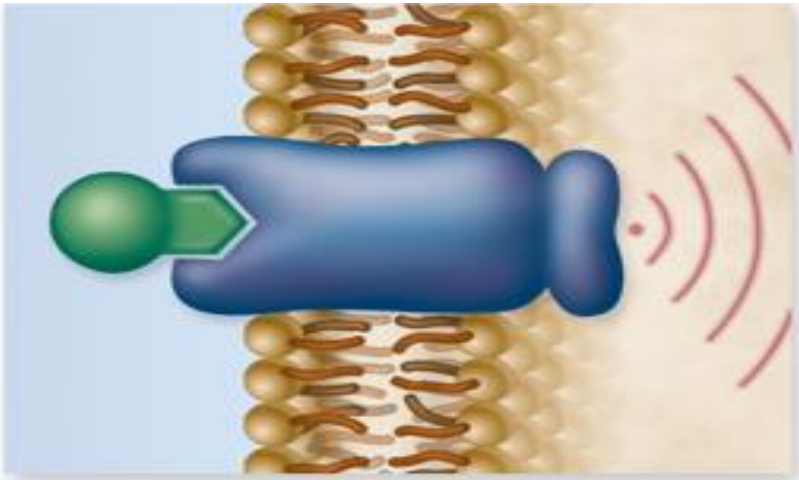


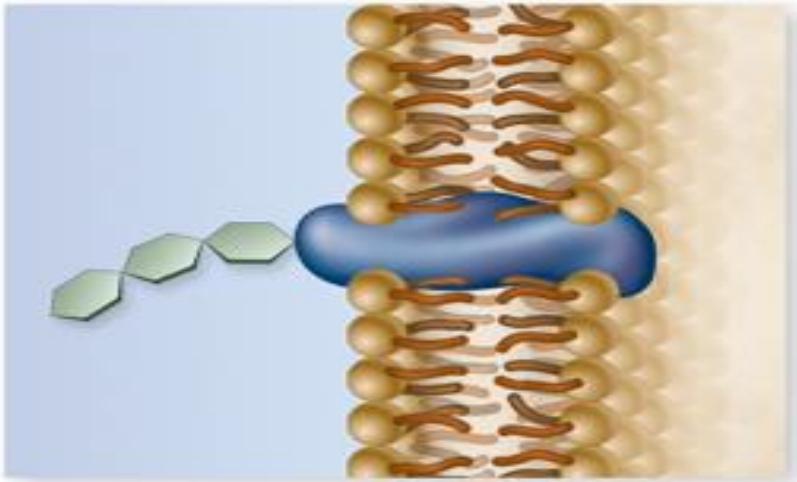
Protein Molecules Functions

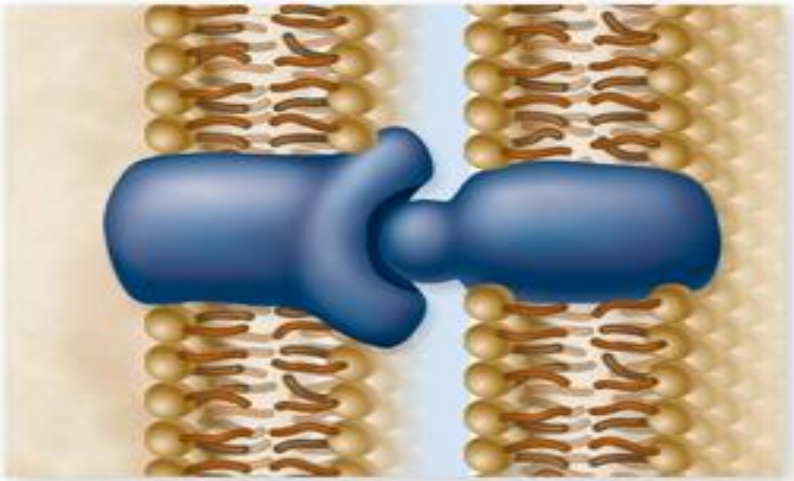


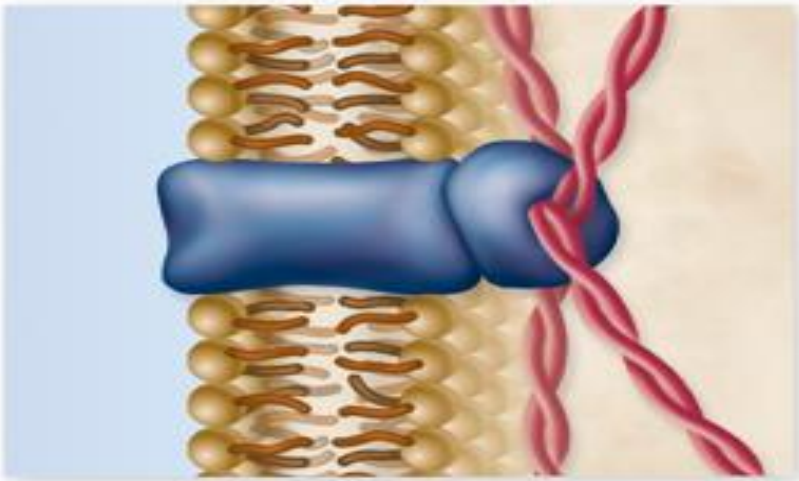
Transporter


Enzyme


Cell surface receptor


Cell surface identity marker


Cell-to-cell adhesion

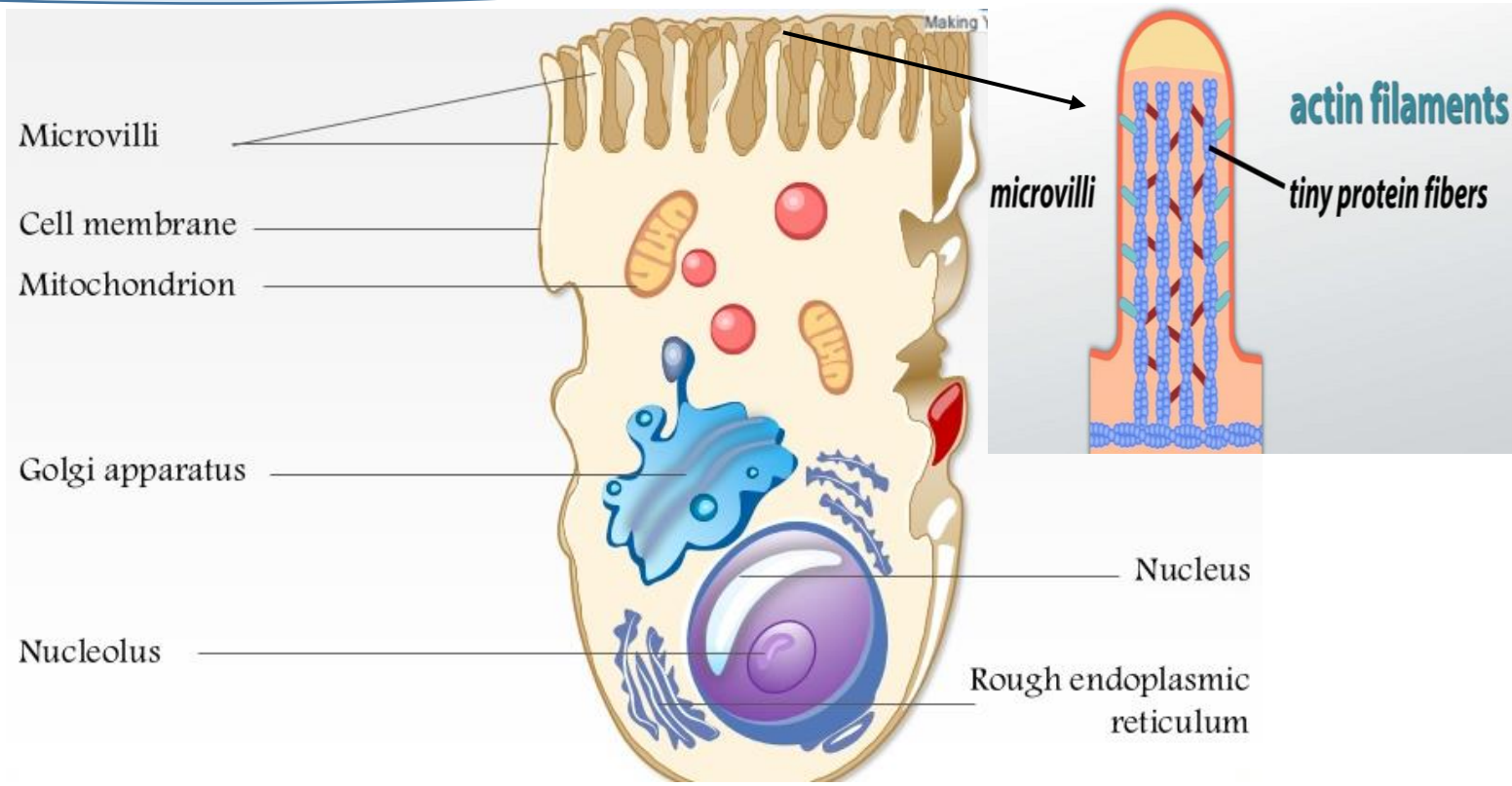

Attachment to the cytoskeleton

Modification of plasma membrane

- The plasma membrane of some cells show some modifications to accommodate different functions that maintain the cellular integrity and includes all the surfaces, **upper, lower, and lateral** sides of the membrane.

1. Upper surface modification

- The plasma membrane of the free surface in-folded to form finger-like closely packed uniform projections called **microvilli** to increase the surface area of absorption. Found in epithelial cells of intestine, kidney tubules, gall bladder and hepatic cells.
- The core of the **microvilli** contain microtubules and microfilaments (actin) in their cytoplasm to provide support and rigidity that maintain morphology and parallel extension of the microvilli.

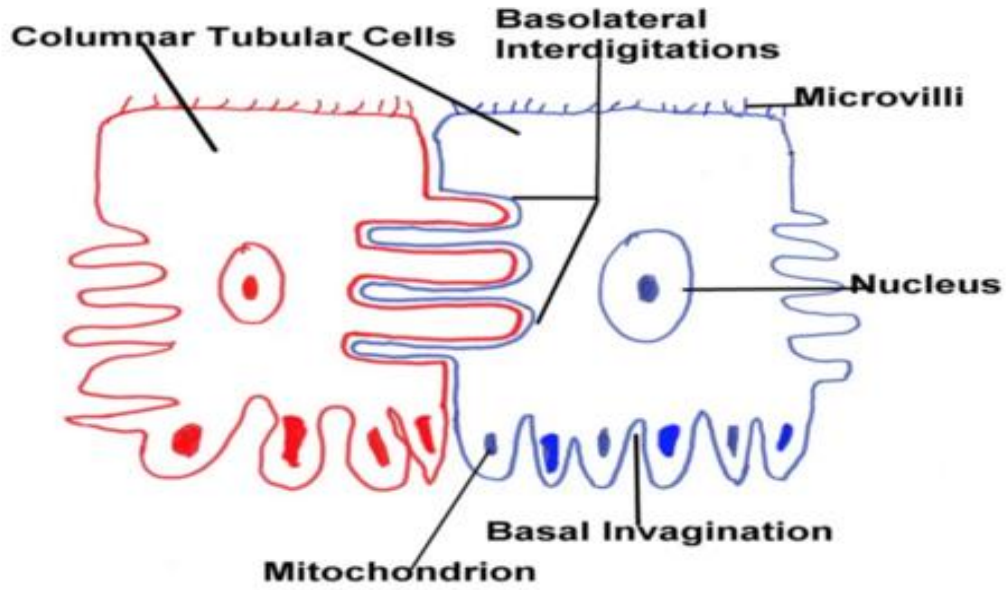


2. Lateral surface modifications (membrane junctions)

- Cell adhesion is one of the functions of the cell membrane, modified to provide attachment and exchange processes between the epithelial cell.
- This membrane junctions link the adjacent cells on their lateral surfaces to form a continuous cohesive layer of cells.
- The lateral surface modifications are 5 types: **Inter digitations, tight junction, desmosome, plasmodesmata, and gap junction**.

Inter digitations

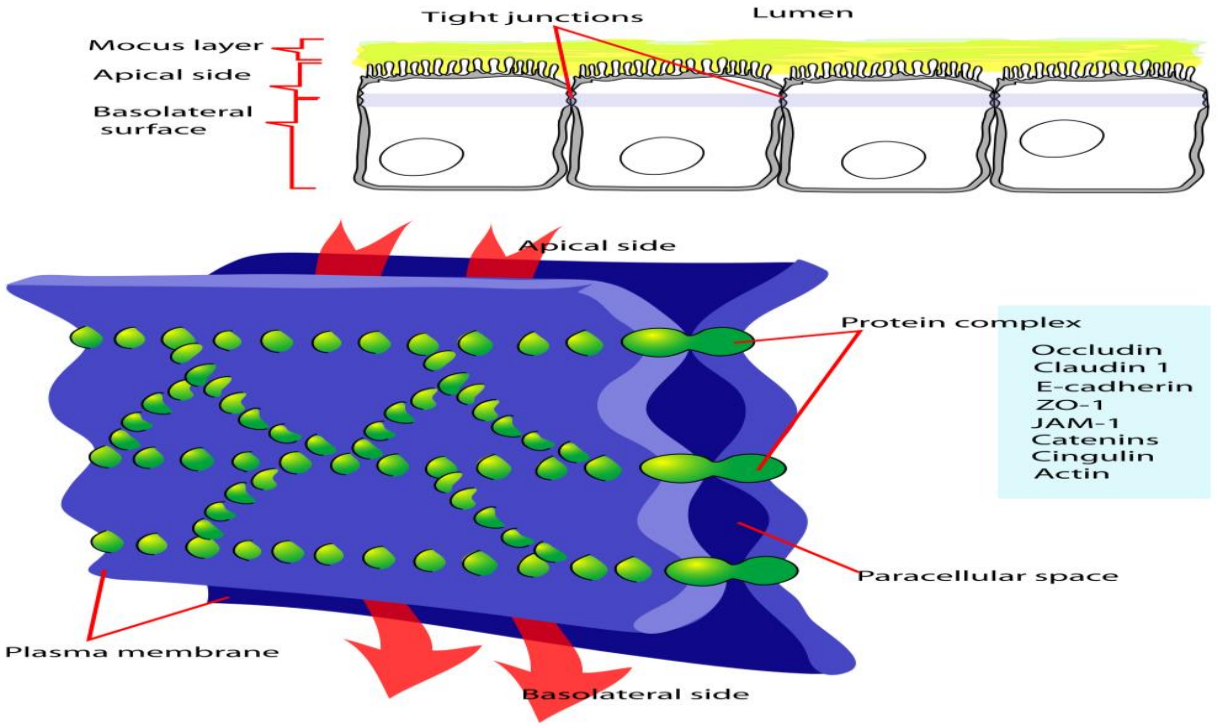
- Plasma membrane of adjacent cells project into cytoplasm as finger-like projections
- Found in lymph nodes and lymphoid tissues
- Function: increase surface area for exchange of substance between the cells



2. Lateral surface modifications (membrane junctions)

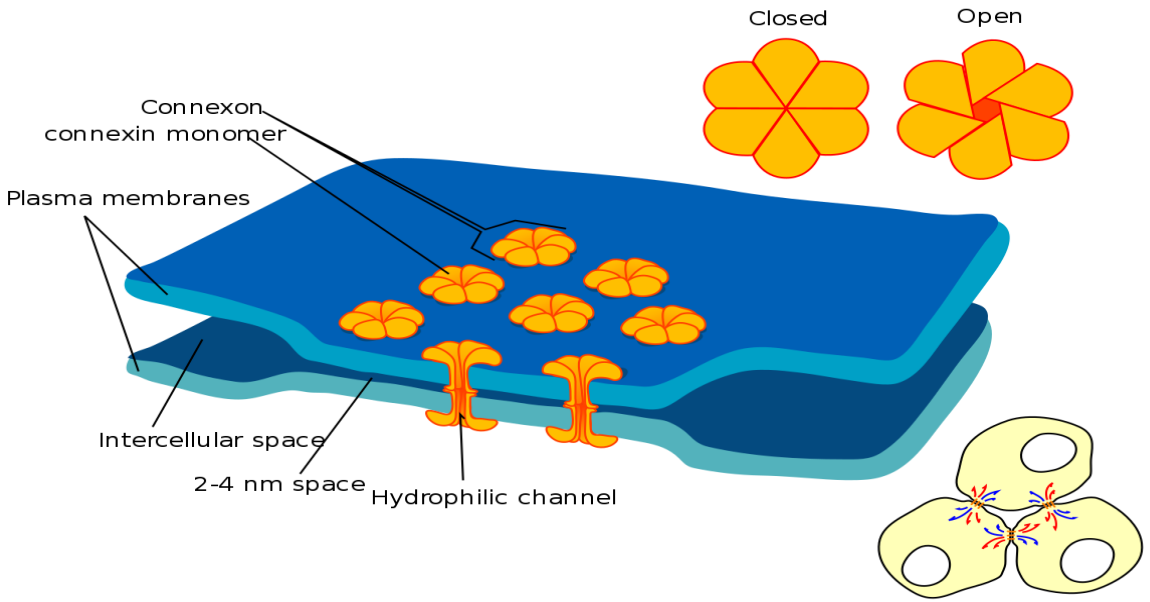
Tight junction

- Plasma membrane of adjacent cells fuses by extrinsic proteins
- Found in brain cells, gall bladder and intestinal cells
- Function: adhesion, no substance can be exchanged.



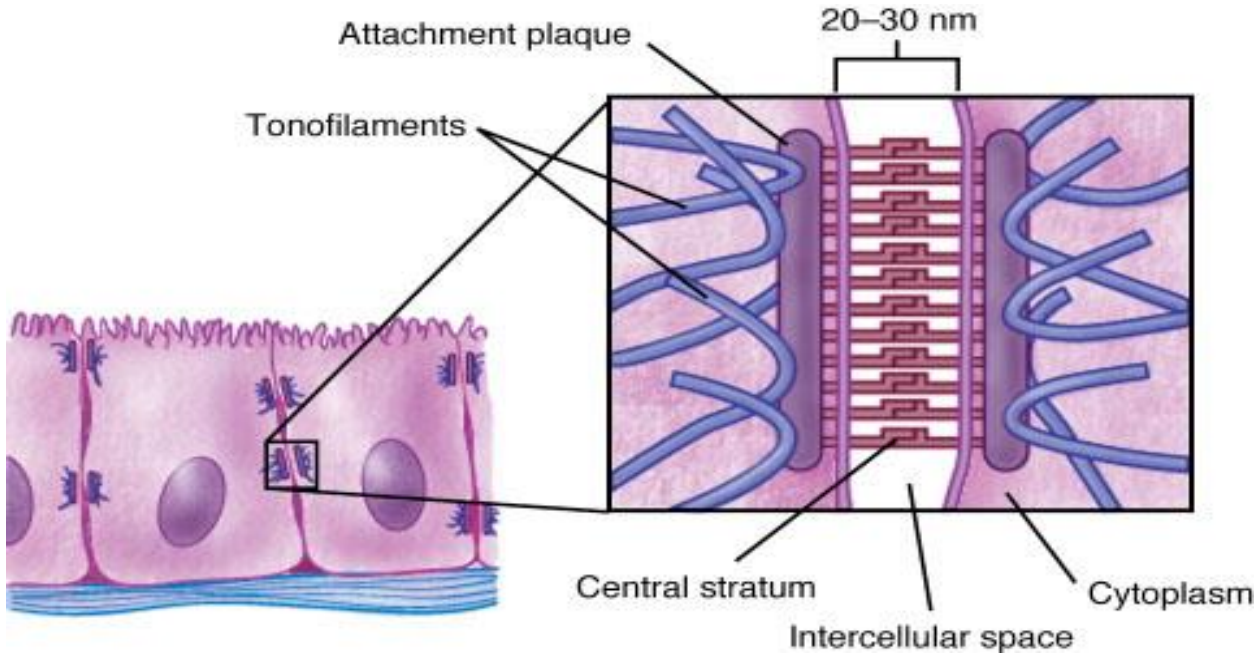
Gap junction

- Gap junction is channel through two cell membranes across the intercellular space between two adjacent cells.
- Found in cardiac muscles
- Function: conduct electrical signals & passage of ions, sugar, vitamin and metabolites.



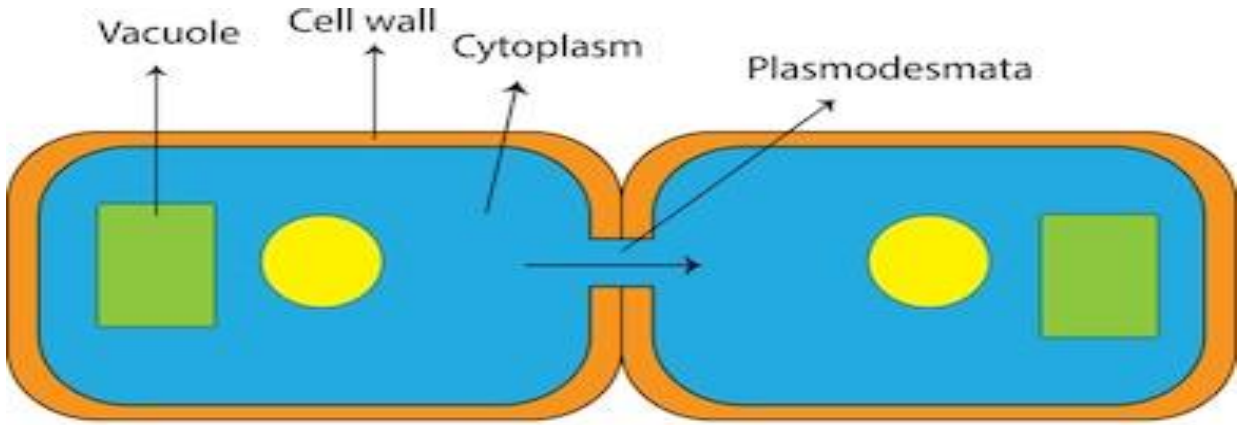
Desmosomes

- Desmosomes are thickened areas of plasma membrane of two adjacent cells.
- Found in cardiac muscle and skin cells.
- Function: help to glue the cells together



Plasmodesmata

- Cytoplasm of adjacent cell connected with cytoplasmic strands.
- Found in plant cells.
- Function: exchange of materials between two cells



Plasmodesmata in Plant cells

3. Basal surface modifications

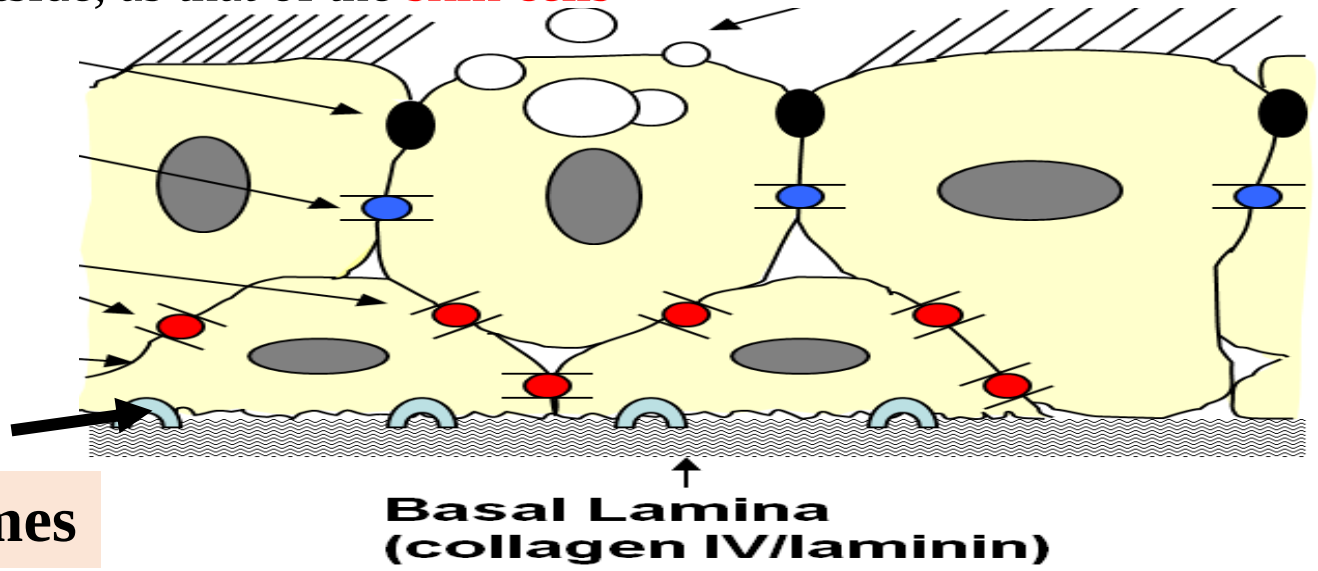
- **The basal surface** modifications of a plasma take place on the base of an epithelial cell to achieve certain function (s) and its two type: **Hemidesmosomes** and **Basal infolding**

Hemidesmosomes

- Connect the cell to its basement membrane.
- This achieved by intermediated filaments called **tono** anchor the cell to the underneath reticular connective tissue of the basement membrane to resist abrasion power from the outside, as that of the **skin cells**

Basal infolding

- Folding of the basal surface of the plasma membrane to increase the surface area of the cell.
- Found in **cuboidal epithelium of kidney.**



Hemidesmosomes

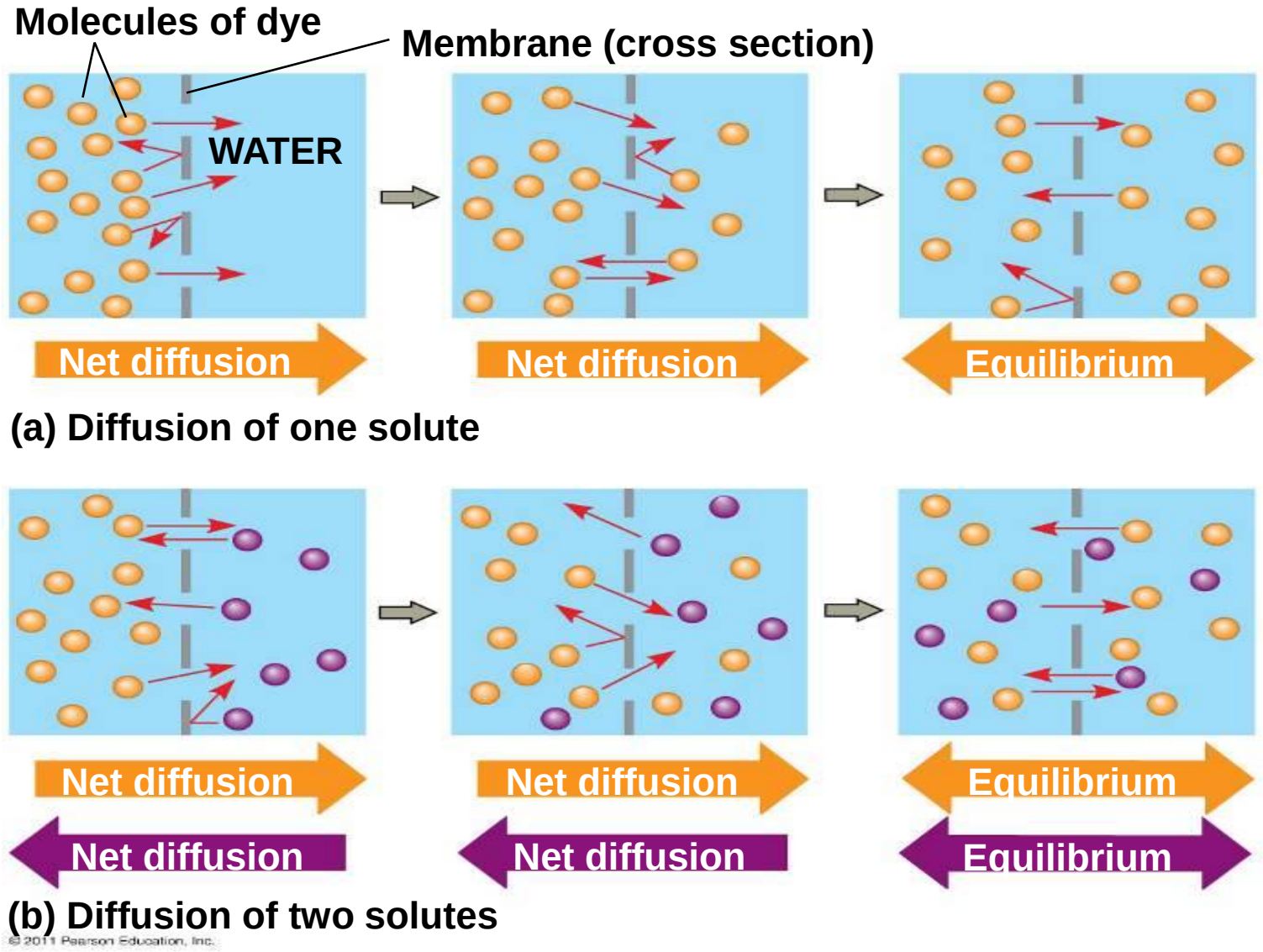
Membrane transport

- Cell membranes are **selectively permeable**
- Some substances readily pass through, others do not
- Most permeable to small molecules and lipid-soluble substances
  - Water and other small molecules like CO_2 and O_2 can pass through easily
  - Some examples of molecules that do not pass through easily: amino acids, sugars, ions
- The substances that are cross the membrane either by passive or active mechanism transport, but in different ways:

1. **Diffusion**
2. **Osmosis**
3. **Mediated transport, facilitated transport, and active transport**
4. **Bulk transport**

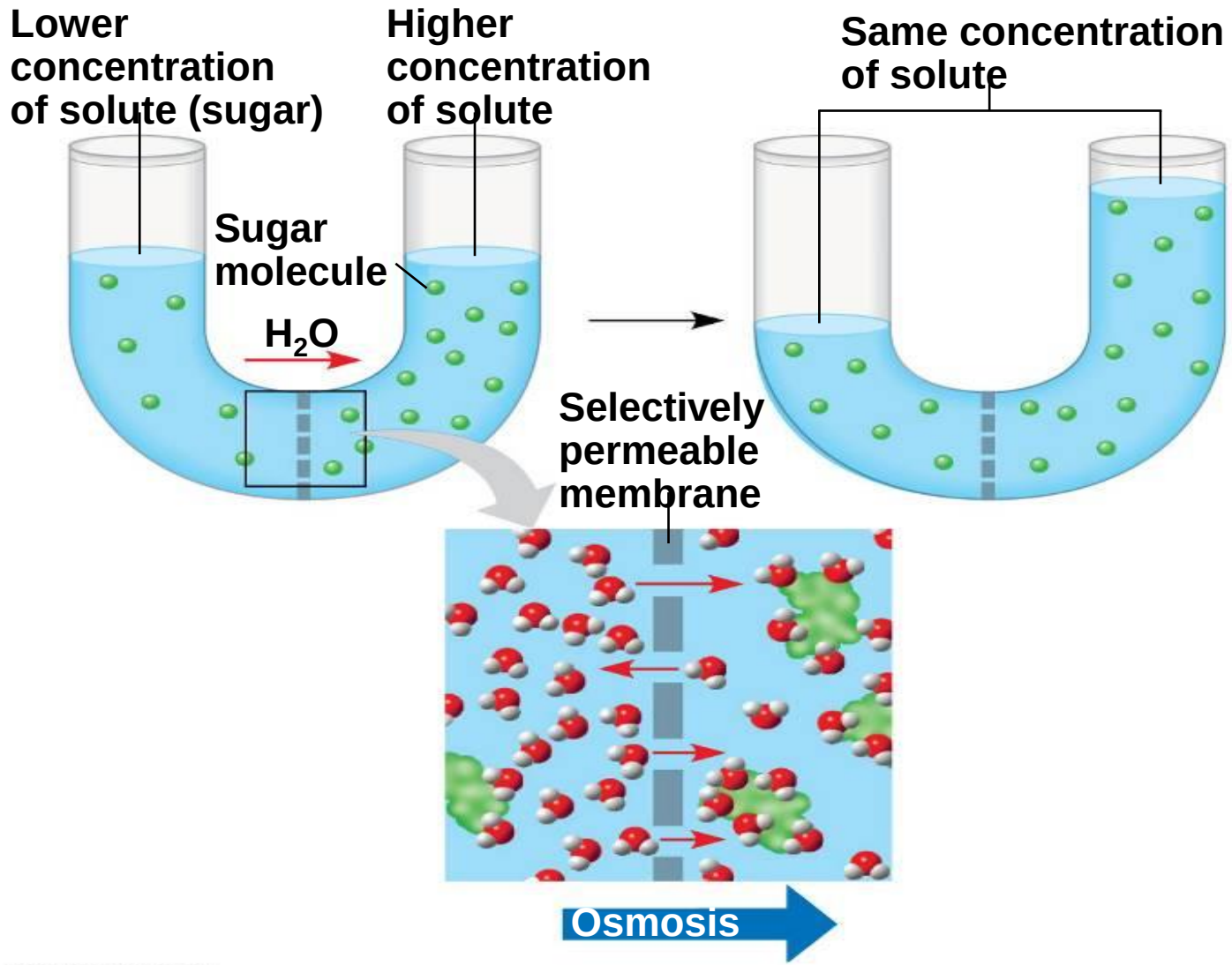
1. Diffusion

- **Diffusion** is the random movement of particles from an area of high concentration to an area of low concentration untie the solute reaches a state of **equilibrium**.
- The process initiated depending on **their kinetic energy** and exaggerated by the **temperature, size of molecule, area of the container and nature of substances**



2. Osmosis and osmolality

- **Osmosis** is the diffusion of water through a selectively permeable membrane
- Water diffuses across a membrane from the region of **lower solute concentration** to the region of **higher solute concentration** until the solute concentration is **equal** on both sides.
- **Osmosis pressure** is determined by the amount of dissolved substances in a solution; it is the tendency of water to move into the solution
- Diffusion of **water molecules**, but not the **solute**

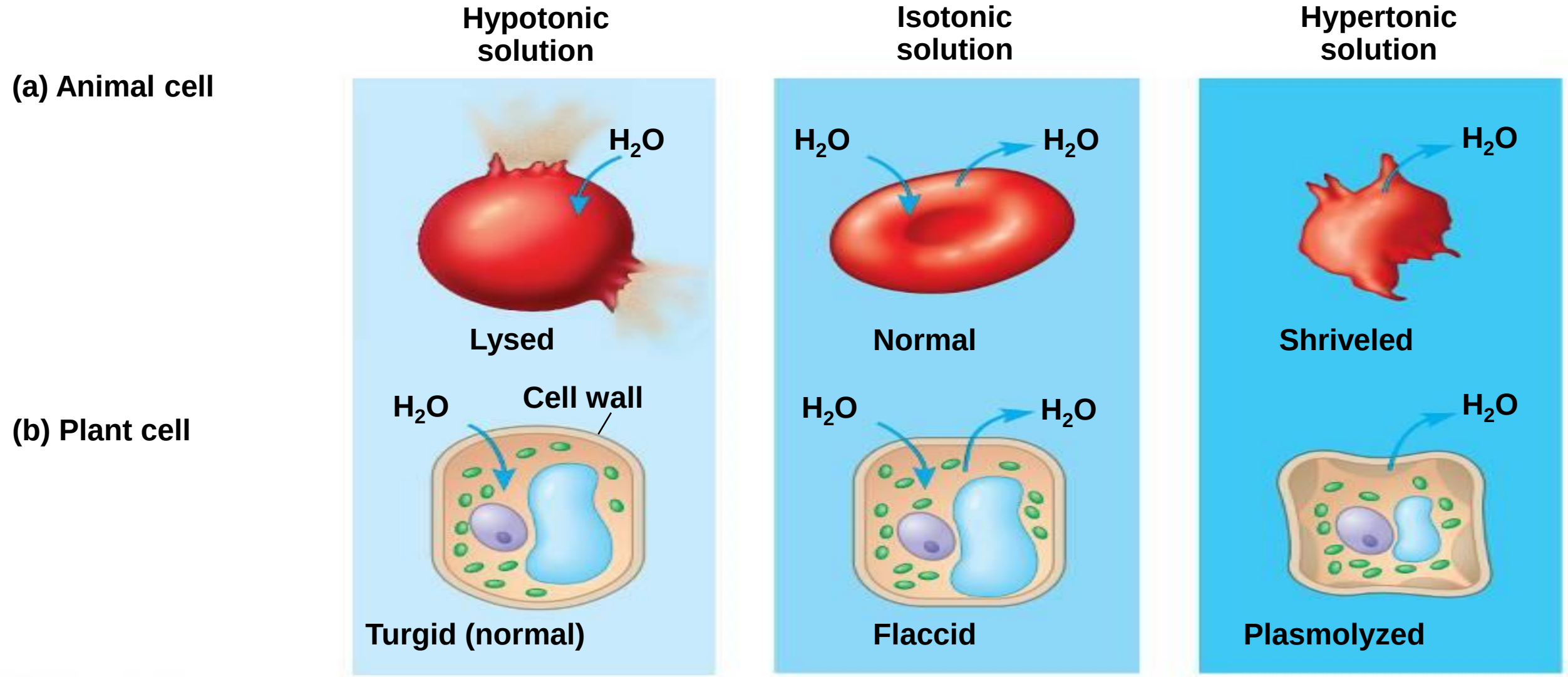


Tonicity

- **Tonicity** is a phenomenon by which a solution change the shape or tone (tono=tention) of a living cell by altering its internal water volume.
- Such phenomenon may occur in animal cells under the action of osmotic imbalance and lead to swell or shrink of the cell by gain or loss of water. Three types of changes are described in the cells:

- **Isotonic solution:** The concentration of solutes in the solution is equal to the concentration of solutes inside the cell. The cell retain its shape and shows equal water molecules exchange, no swell or shrink shown in the solution.
- **Hypotonic solution** : The solution has a lower concentration of solutes and a high concentration of water than inside the cell. When a cell is placed in a such solution (water), water will diffuse to the cell to reach the equalization state, cause **swelling** and then bursts or lyses of the cell.
- **Hypertonic solution** The solution has a higher concentration of solutes and a lower concentration of water than inside the cell. When a cell placed in a solution concentrated more than the cell protoplasm, water diffusion from the cell to the solution lead to loss of water and **shrinkage** of the cell

Tonicity

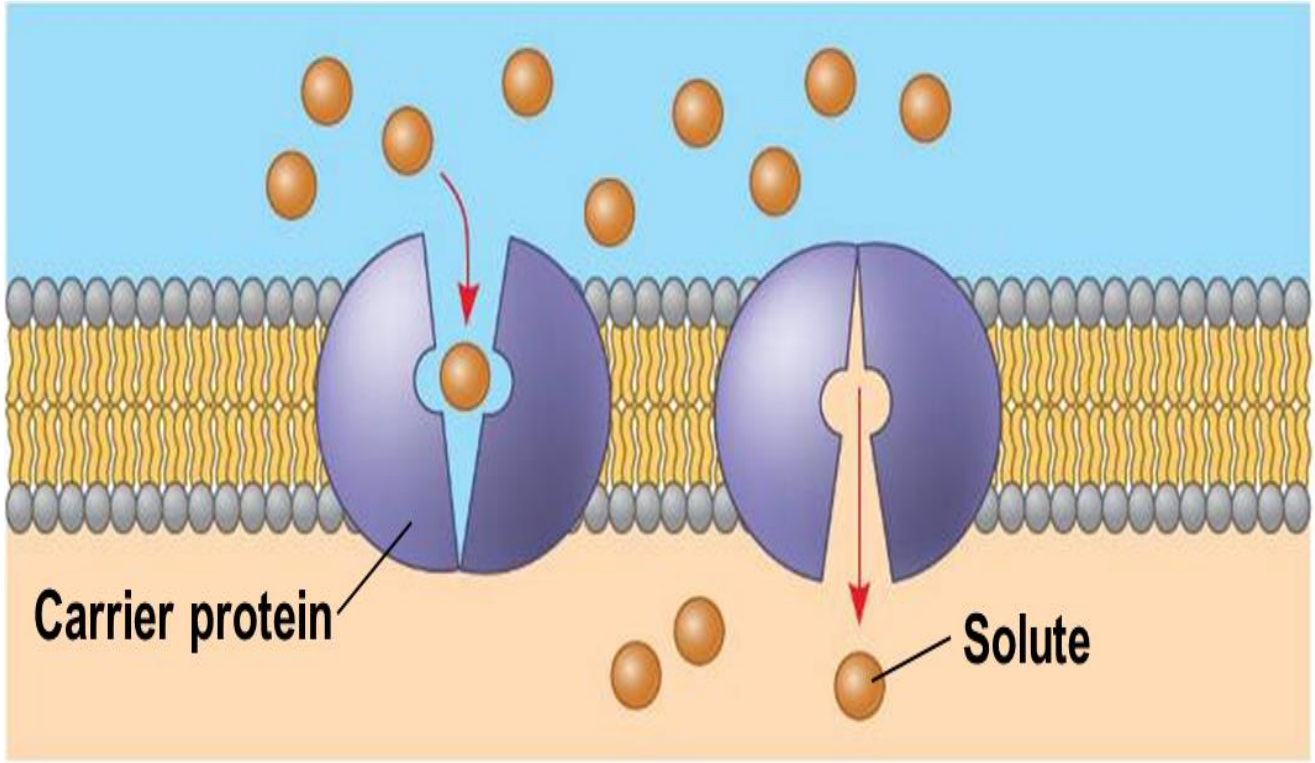


3. Mediated transport

- The **mediated transport** is a type of transport specialized to carry the large or too charged molecules through channels of cell membrane.
- Two types of mediated transport are applied in a living cell: **Facilitated and Active transport**

Facilitated transport

- In this type of diffusion the large molecules **(sugar, amino acids)** are captured by a **carrier protein** (**integral protein**) and carried from higher concentration to a lower one across the cell membrane until equilibrium state is reached.
- No energy is required for such mechanism as in the absorption of food particles by **epithelial cell of the small intestine**.



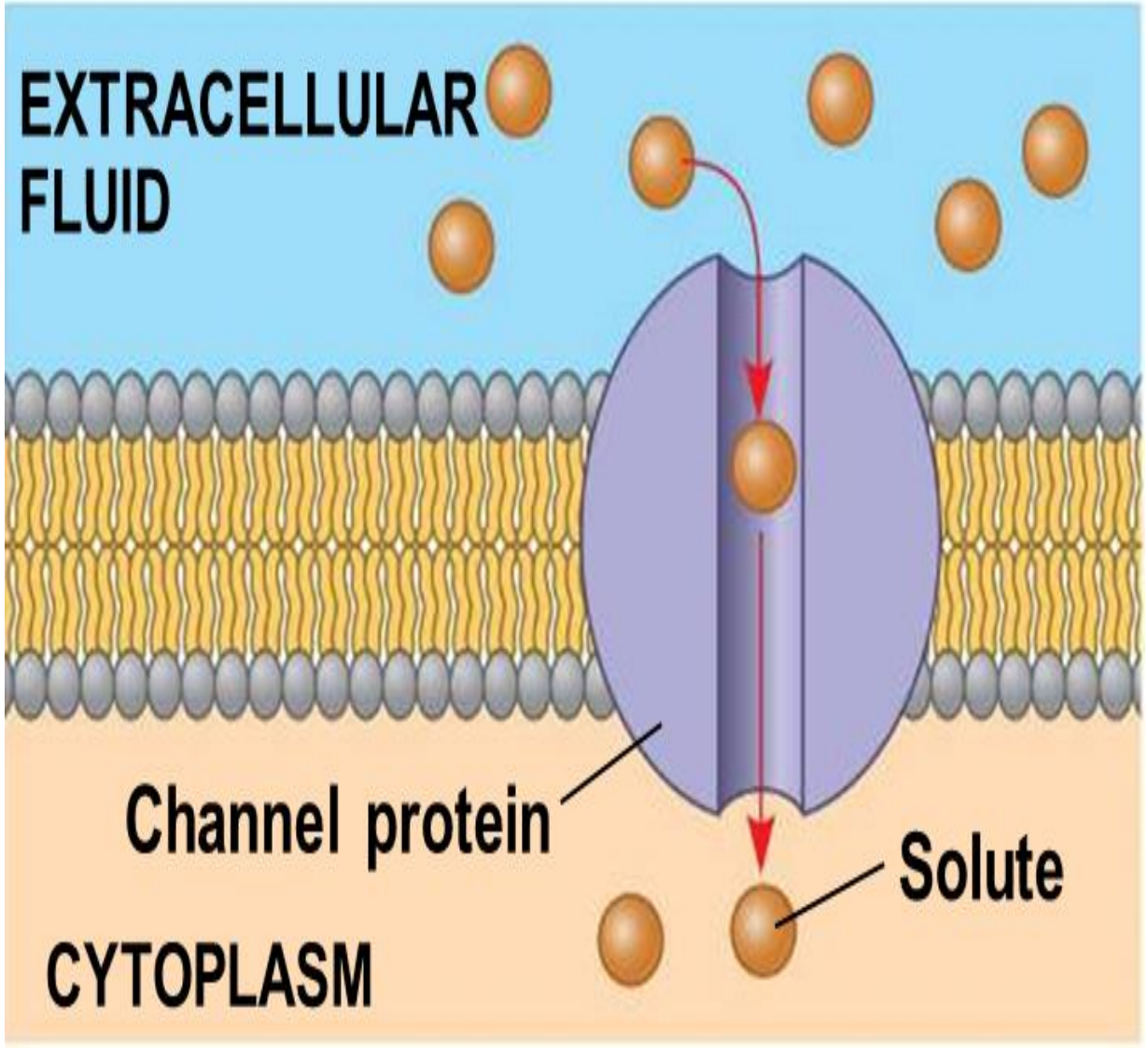
Facilitated transport

- **Channel proteins** provide corridors that allow a specific molecule or ion to cross the membrane

- Channel proteins include:

-**ion channels** allow the passage of ions (charged atoms or molecules) which are associated with water

-**gated channels** are opened or closed in response to a stimulus, the stimulus may be chemical or electrical



Active transport

- **Active transport** is the movement of substances against a concentration gradient (from a region of low concentration to a region of higher concentration) across a plasma membrane.
- This process **requires energy**. This energy is provided by **mitochondria in the form of ATP** and cells performing active transport on a large scale contains numerous mitochondria.
- Active transport is performed by specific proteins embedded in the membranes.
- Carrier proteins used in active transport include:

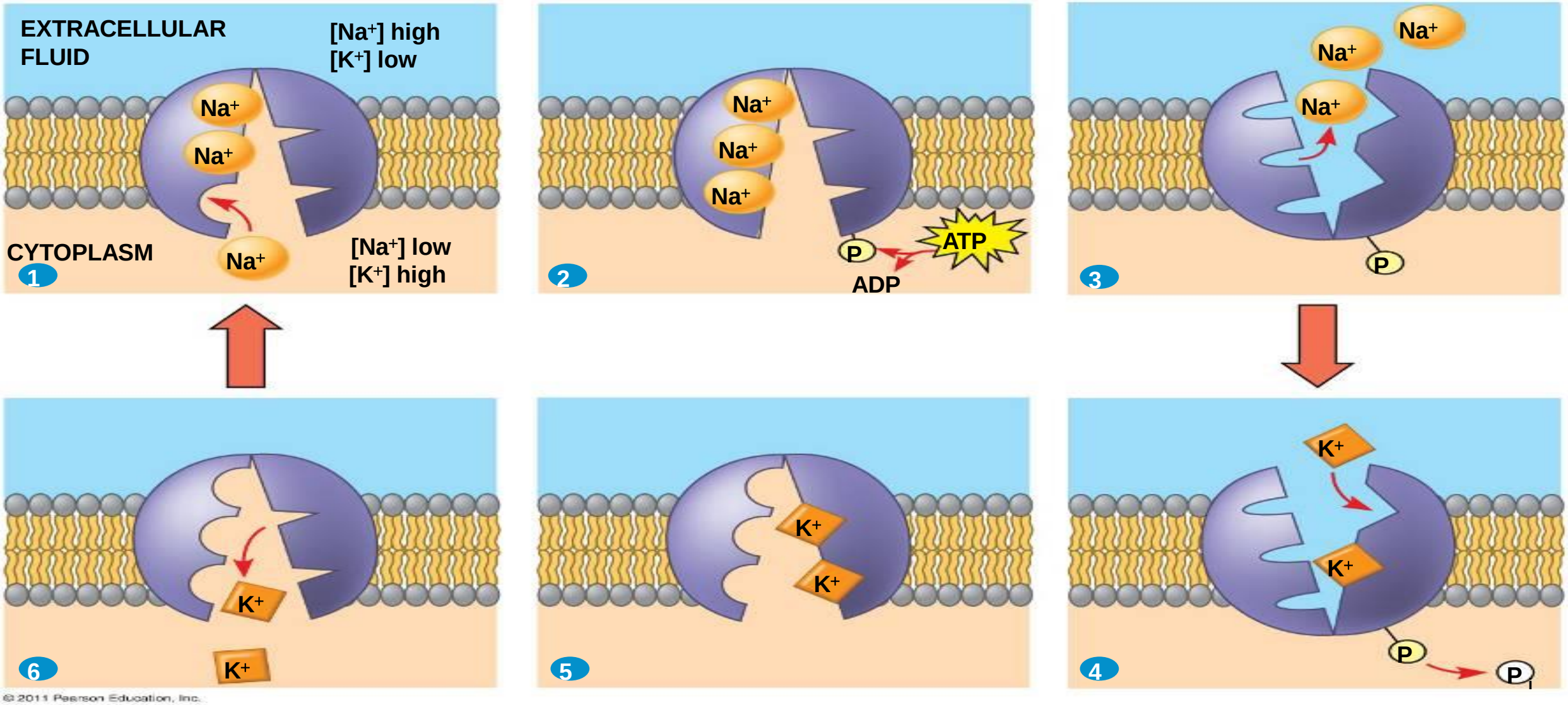
1. One substance in one direction (**uniport carriers**)
2. Two substances in one direction (**symport carriers**)
3. Two substances in opposite direction (**antiport carriers**)

- The **sodium-potassium pump** is one type of active transport system
- uses an **antiporter** to move 3 Na+ out of the cell and 2 K+ into the cell

-ATP energy is used to change the conformation of the carrier protein

-the affinity of the carrier protein for either Na+ or K+ changes so the ions can be carried across the membrane

Active transport



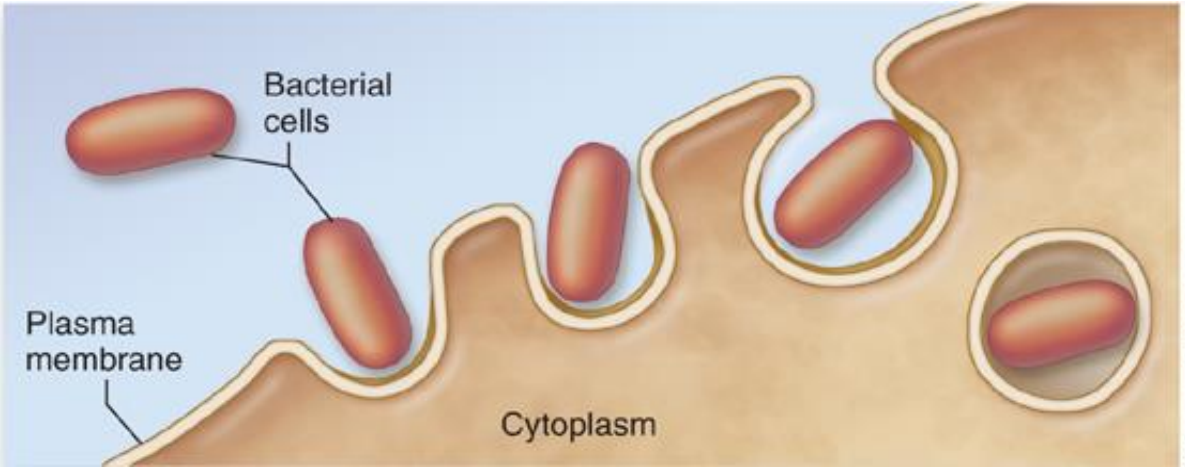
3. Bulk transport

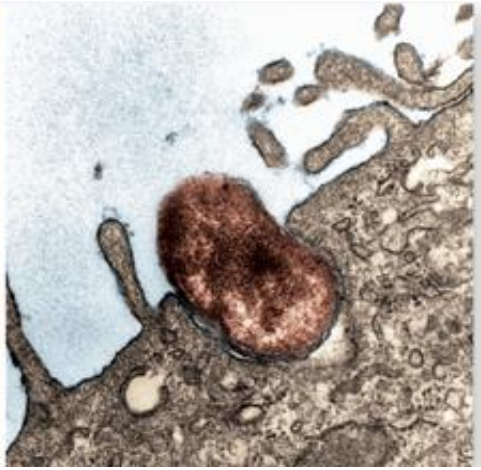
- Its is a process by which the macromolecules and fluid molecules picked up a cross the plasma membrane to or from the cell and its two types: **Endocytosis and Exocytosis.**

Endocytosis

- **Endocytosis** occurs when the plasma membrane envelops food particles and liquids, and its three types.

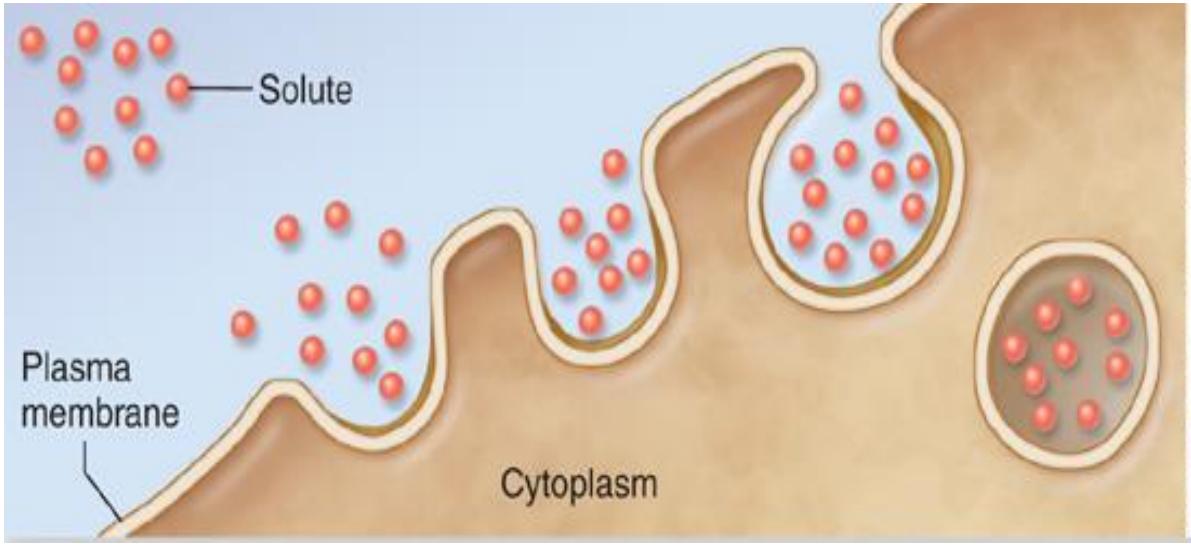
1. **phagocytosis** – by which the large solid molecules engulfed
2. **pinocytosis** – by which the fluid molecules get in the cell
3. **receptor-mediated endocytosis** – specific molecules are taken in after they bind to a receptor

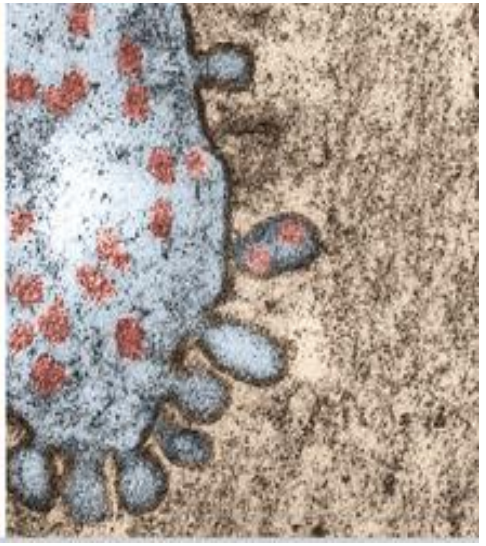




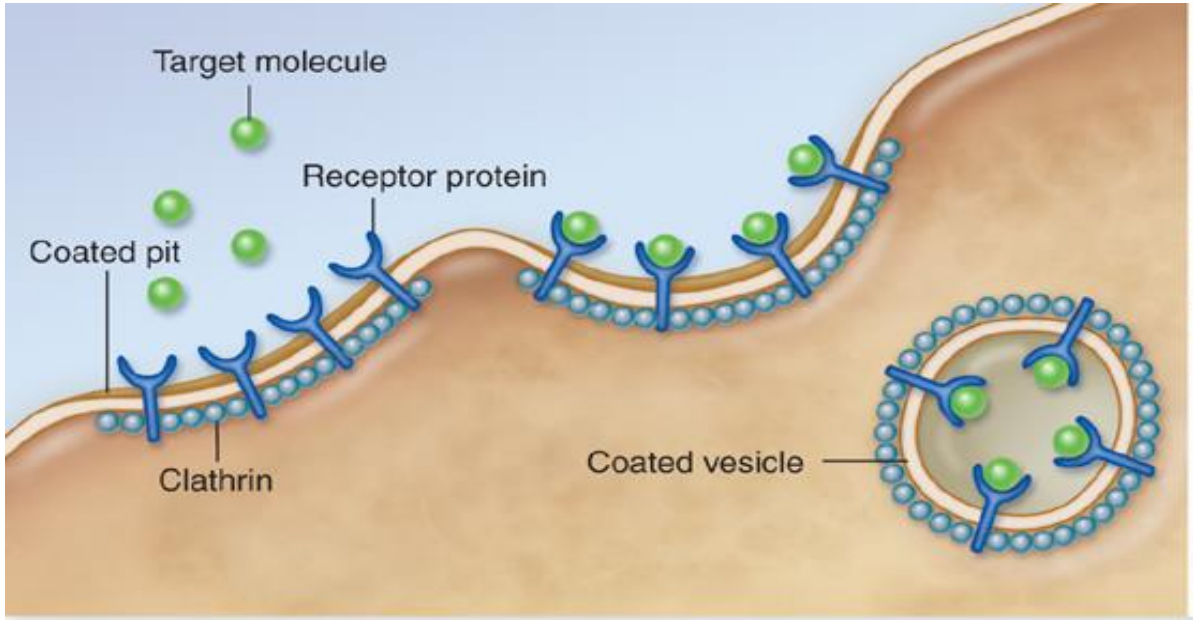
Phagocytosis

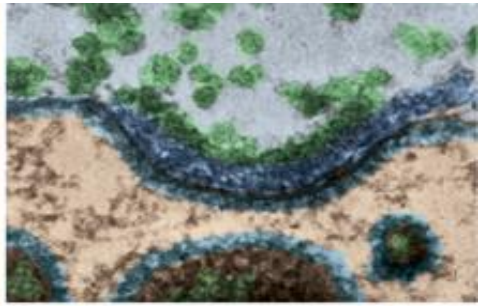
3. Bulk transport

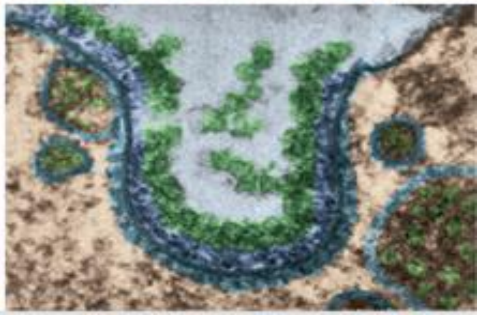




Pinocytosis







Receptor-mediated endocytosis

3. Bulk transport

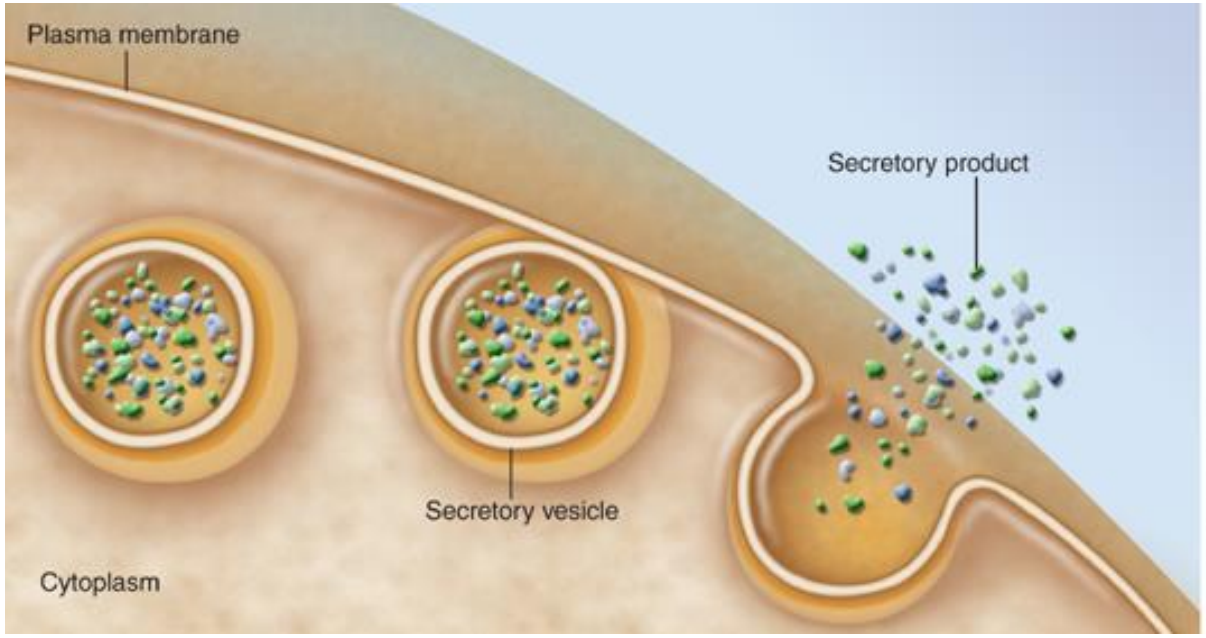
Exocytosis

➢ **Exocytosis** occurs when material is discharged from the cell.

-vesicles in the cytoplasm fuse with the cell membrane and release their contents to the exterior of the cell

-used in plants to export cell wall material

-used in animals to secrete hormones, neurotransmitters, digestive enzymes



Recap

- **Cell membrane and plasma membrane.**
- **Plasma membrane structure.**
- **Plasma membrane modifications**
- **Active and passive transport**
- **Osmolality of the cell**
- **Tonicity of the cell**