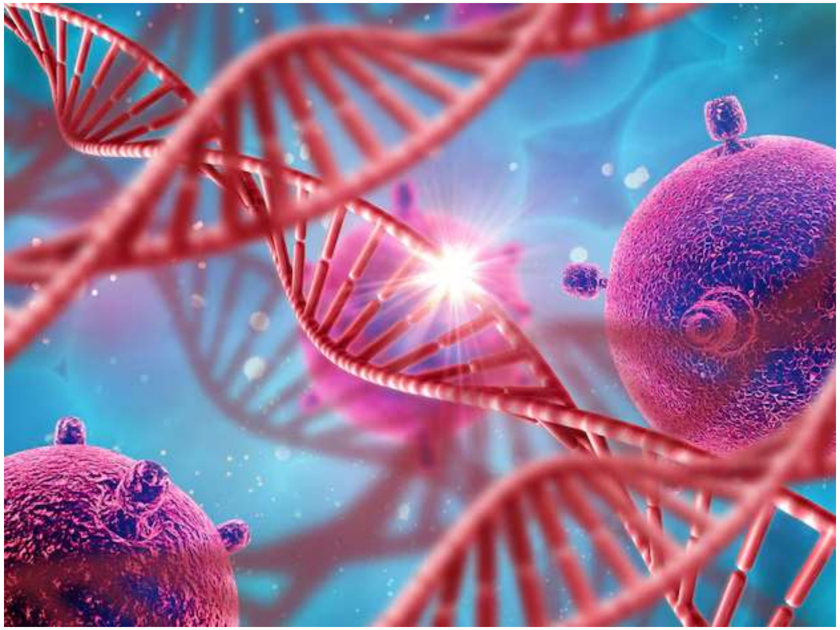
Lecture 9

General Biology & Cytology Course 2301130



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Review

Q1: Which of the following best describes how high levels of cholesterol affect the cell membrane at certain temperatures?

(A) At high temperatures, high amounts of cholesterol decrease the fluidity of the cell membrane.
(B) At high temperatures, high amounts of cholesterol decrease the rigidity of the cell membrane.
(C) At low temperatures, high amounts of cholesterol increase the rigidity of the cell membrane.
(D) At low temperatures, high amounts of cholesterol decrease the fluidity of the cell membrane.

Facilitative Diffusion

diffusion of specific particles (**high** to **low** concentration)

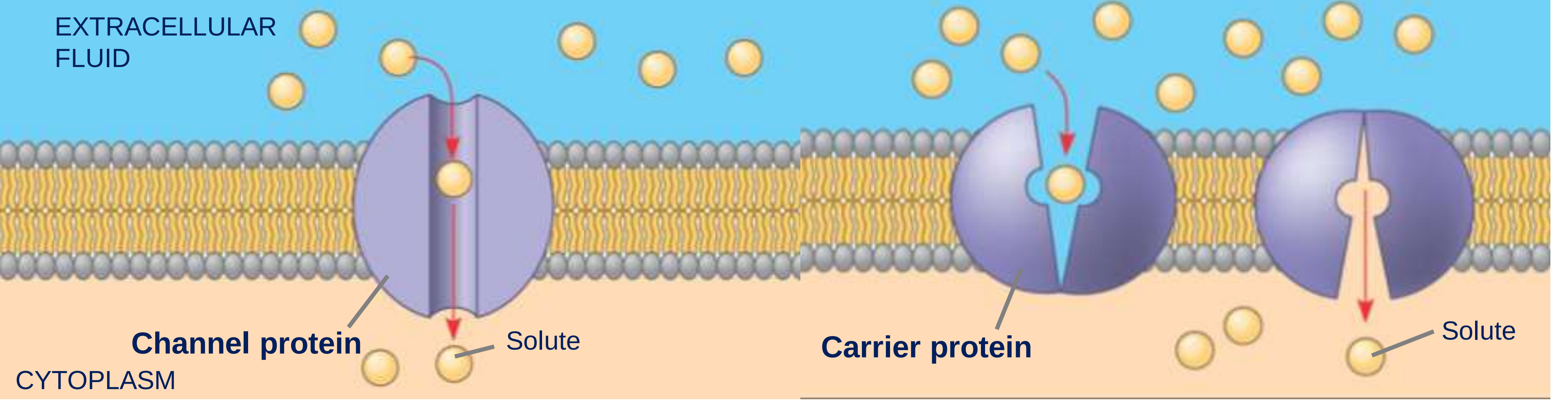
- **Diffusion through protein channels**
- **No energy** needed.
- **Diffusion of polar, hydrophilic molecules**

Two types of transport proteins can help ions and large polar molecules diffuse through cell membranes:

1. **Channel proteins** – provide a narrow channel for the substance to pass through.
2. **Carrier proteins** – physically bind to the substance on one side of membrane and release it on the other.

- Some diseases are caused by malfunctions in specific transport systems, for example the kidney disease cystinuria

Examples: **Glucose** or **amino acids** moving from blood into a cell.



Osmosis

Osmosis is the **diffusion of water** across a semi-permeable membrane from a hypotonic solution to a hypertonic solution

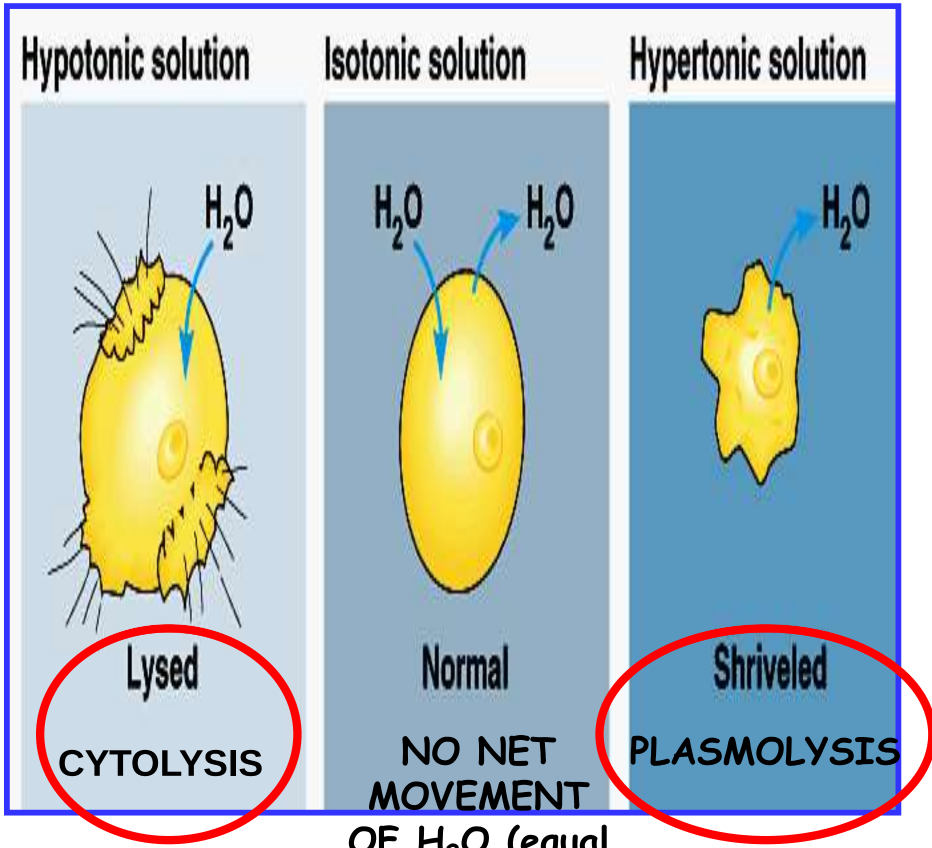
Direction of osmosis is determined by comparing total solute concentrations (Tonicity)

- **Hypertonic - more solute, less water**
- **Hypotonic - less solute, more water**
- **Isotonic - equal solute, equal water**

Water can diffuse across plasma membrane--- Moves from HIGH water potential (low solute concentration) to LOW water potential (high solute concentration)

Aquaporins (water channels) are proteins embedded in the cell membrane that regulate the flow of water only.

Homeostasis (equilibrium)



NO NET MOVEMENT OF H_2O (equal amounts entering & leaving) **e.g. Normal saline 0.9%NaCl**

Water Balance of Cells Without Walls

- **Tonicity** is the ability of a solution to cause a cell to gain or lose water
- **Isotonic** solution: Solute concentration is the same as that inside the cell; no net water movement across the plasma membrane
- **Hypertonic** solution: Solute concentration is greater than that inside the cell; cell loses water
- **Hypotonic** solution: Solute concentration is less than that inside the cell; cell gains water

-Active Transport

- **Protein Pumps** -transport proteins that require **energy** to do work (**low to high** concentration) **AGAINST concentration gradient**

2 types:

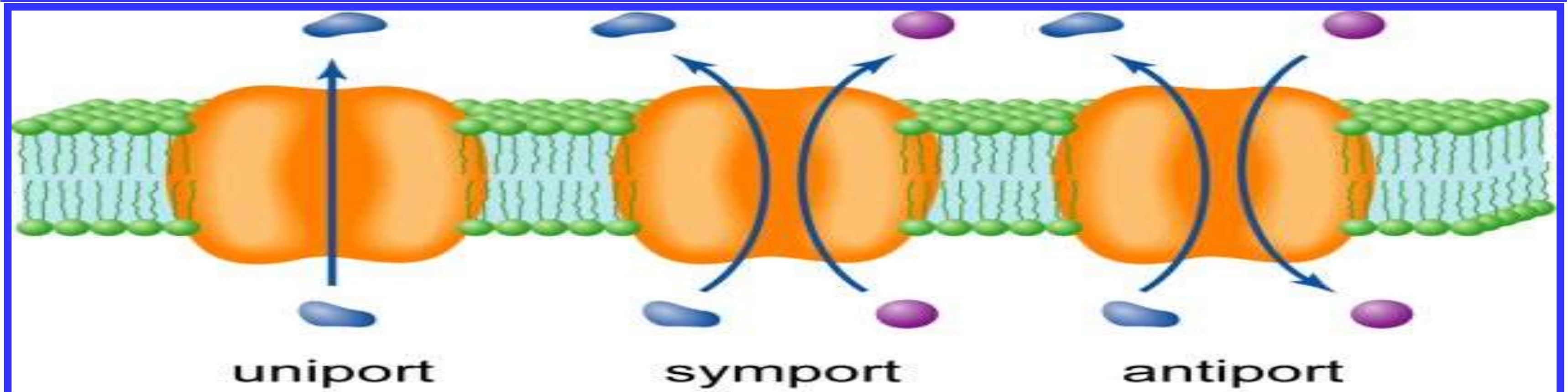
I. **Primary active transport (** directly uses metabolic energy/ energy is derived directly from the breakdown of ATP)**: Membrane pump** (protein-mediated active transport) example **Na+/K+ Pump (Shown in figure)**

II. **Secondary active transport**: (electrochemical potential difference created by pumping/ energy is derived secondarily from energy that has been stored in the form of ionic concentration differences between the two sides of a membrane.)

Coupled transport (cotransport)

-**symport** transport two substances simultaneously in the same direction example **glucose symporter** (glucose and sodium)

-antiport transport two substances in opposite directions example **sodium-calcium exchanger** or **antiporter**



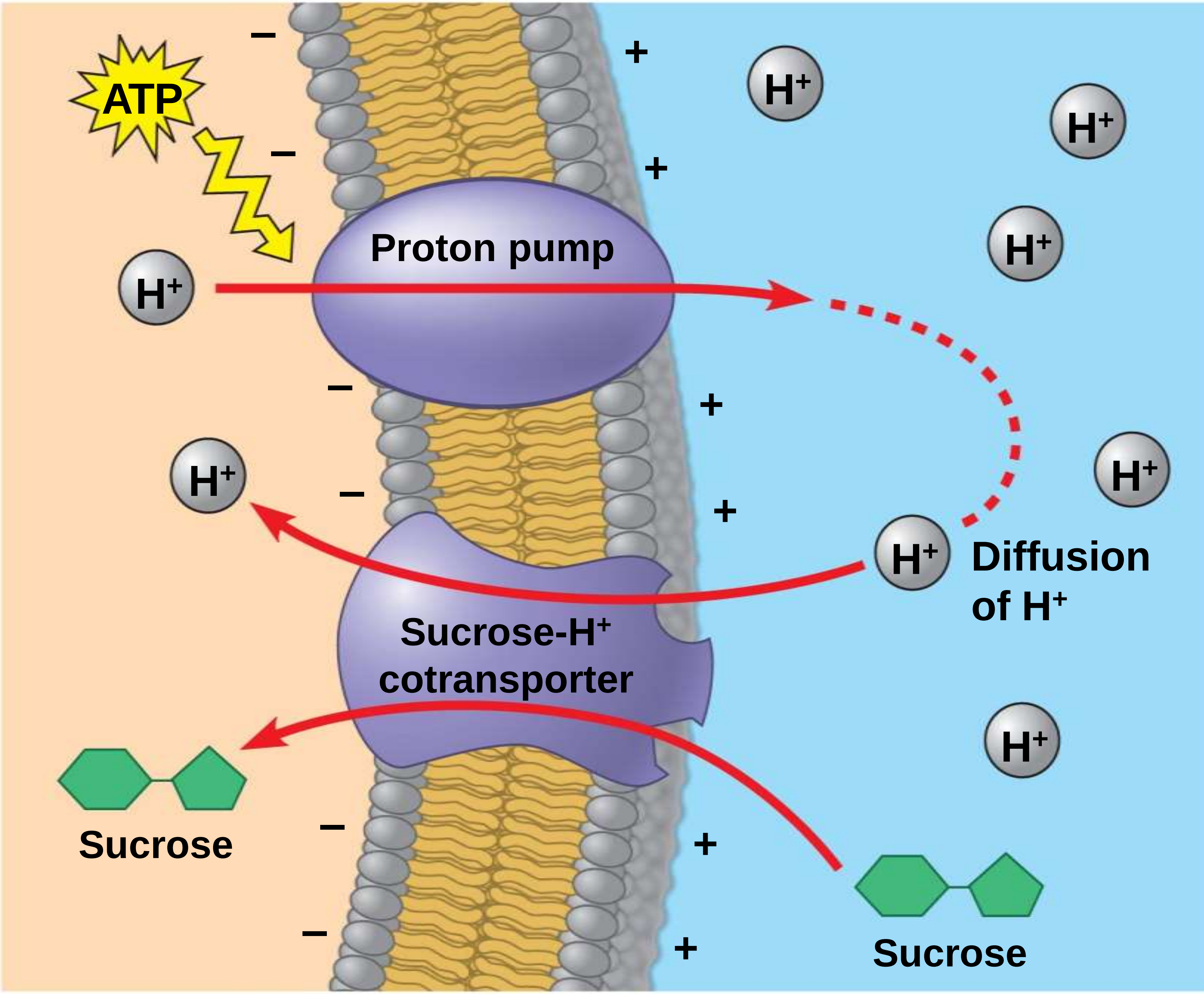
How Ion Pumps Maintain Membrane Potential

- **Membrane potential** is the voltage difference across a membrane

- Voltage is created by differences in the distribution of positive and negative ions

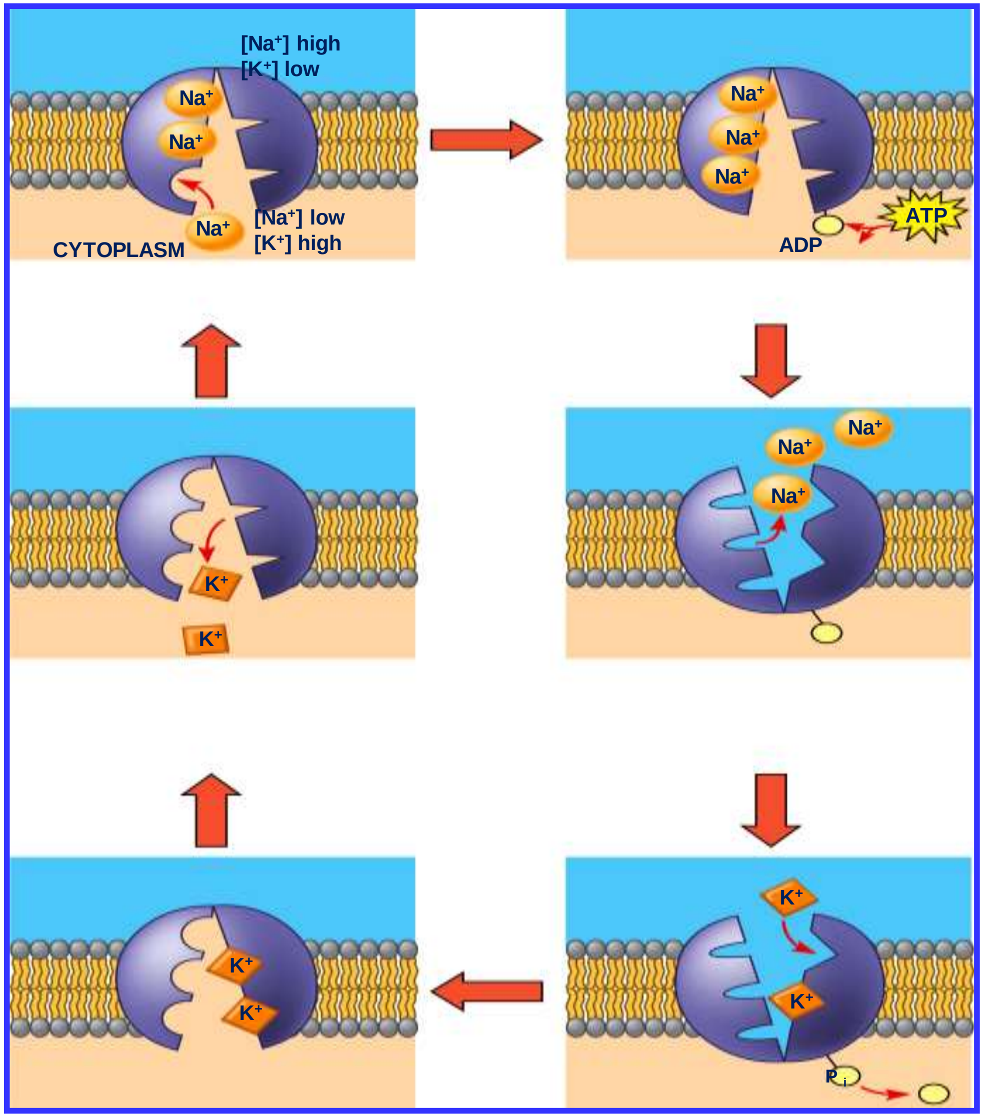
- Two combined forces, collectively called the **electrochemical gradient**, drive the diffusion of ions across a membrane:
  1. A chemical force (the ion's concentration gradient)
  2. An electrical force (the effect of the membrane potential on the ion's movement)

- An **electrogenic pump** is a transport protein that generates voltage across a membrane
- The **sodium-potassium pump** is the major electrogenic pump of animal cells
- The main electrogenic pump of plants, fungi, and bacteria is a **proton pump.**
- **Cotransport** occurs when active transport of a solute indirectly drives transport of another solute


ATP
Proton pump
H+
H+
H+
H+
H+
H+
H+
H+
Diffusion of H+
Sucrose-H+ cotransporter
Sucrose
Sucrose

The Sodium-potassium Pump

1. Cytoplasmic Na^+ binds to the sodium-potassium pump.



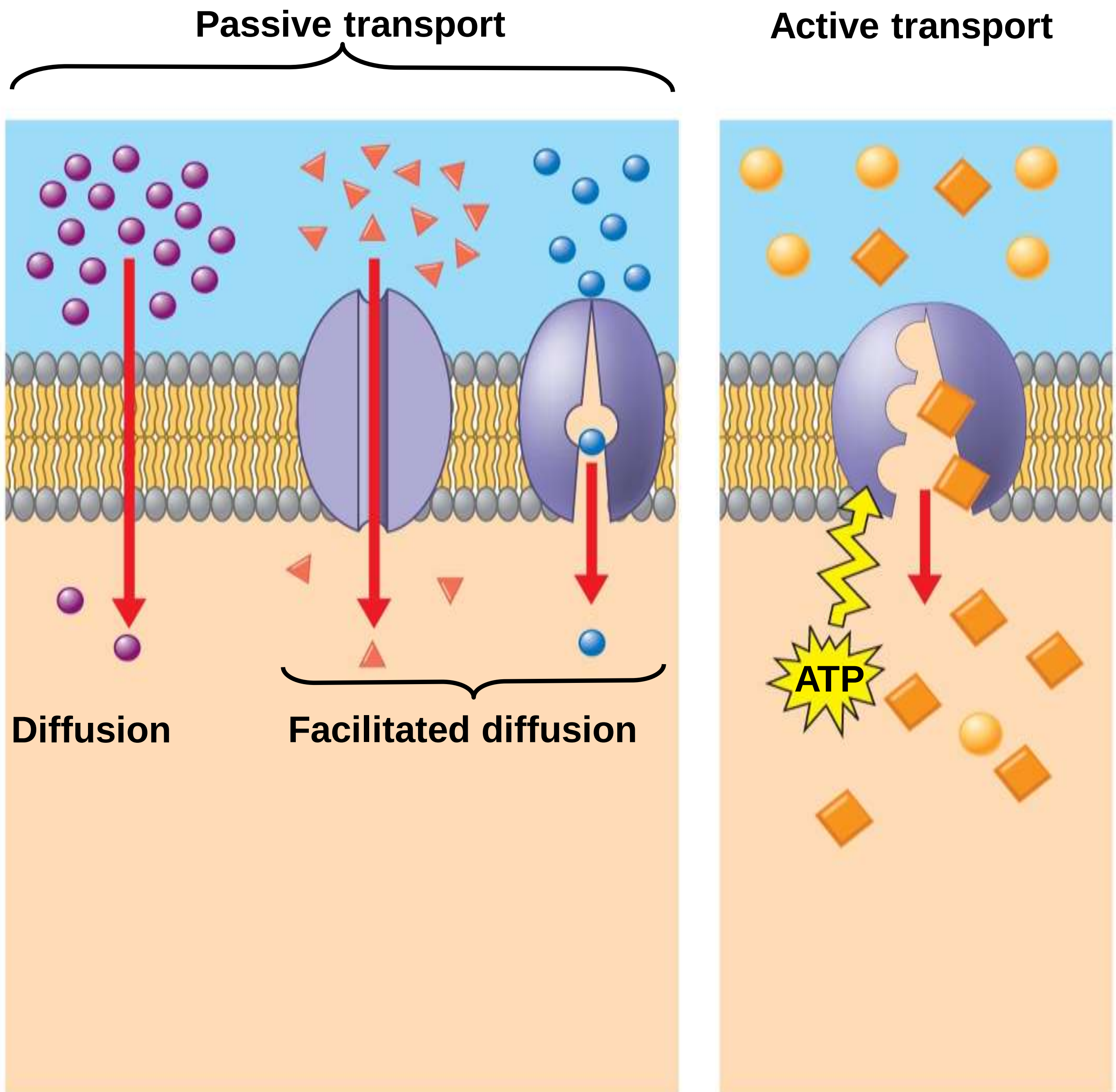
2. Na+ binding stimulates phosphorylation by ATP.

3. Phosphorylation causes the protein to change its conformation, expelling Na^+ to the outside.

4. Extracellular K^+ binds to the protein, triggering release of the Phosphate group.

5. Loss of the phosphate restores the protein's original conformation.

6. K^+ is released and Na^+ sites are receptive again;
the cycle repeats.

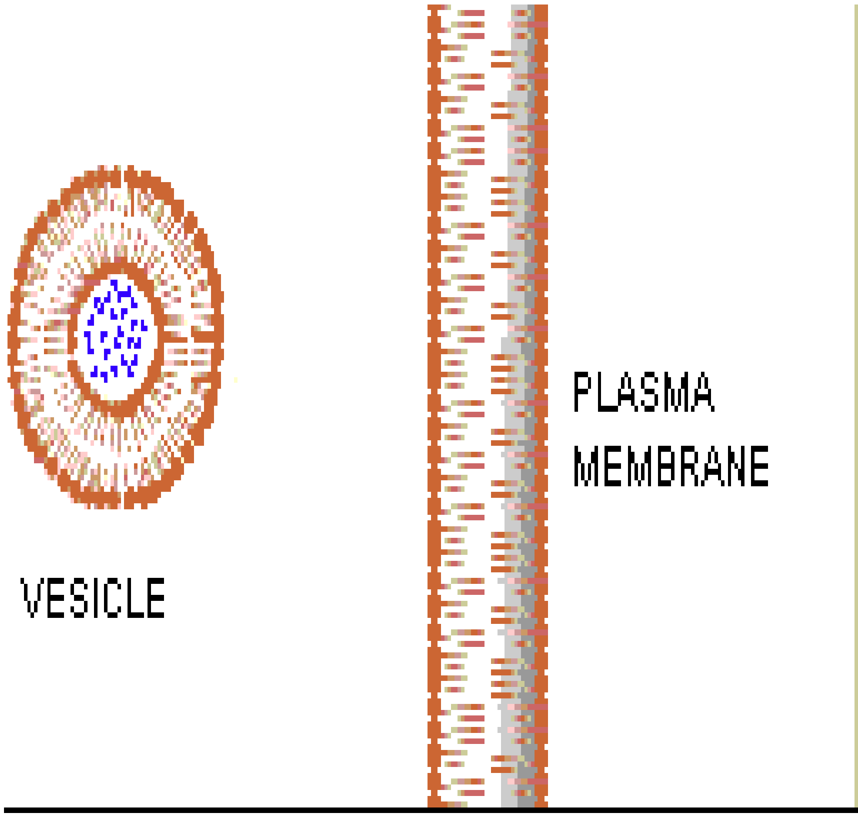

Passive transport
Active transport
Diffusion
Facilitated diffusion
ATP

Bulk Transport

- Allows small particles, or groups of molecules to enter or leave a cell without actually passing through the membrane.
- **2 mechanisms of bulk transport**: **endocytosis** and **exocytosis**
- Both endocytosis and exocytosis involve motor proteins and **require energy**

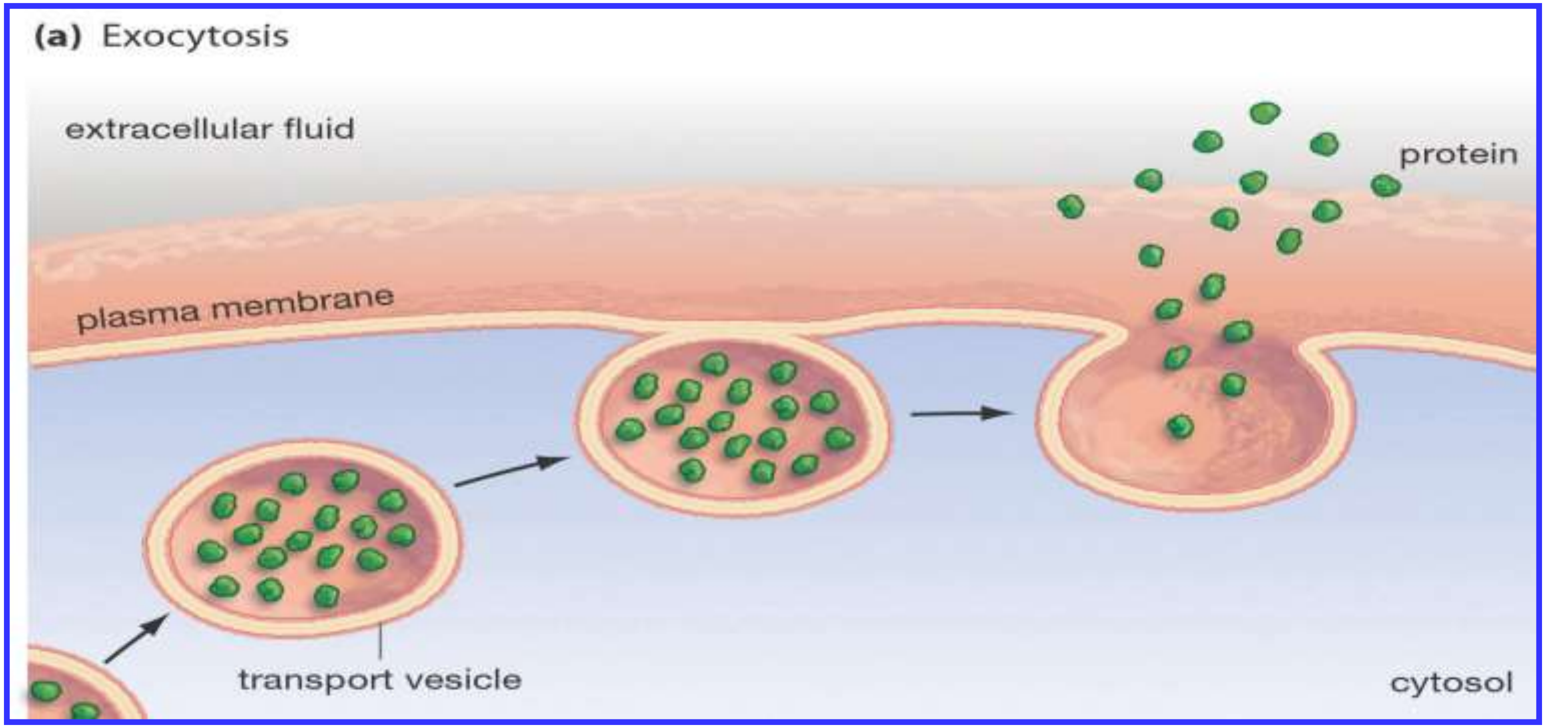
Endocytosis

- **Phagocytosis** large particles
- **Pinocytosis** fluids and small particles
- **Receptor-Mediated Endocytosis**



Exocytosis

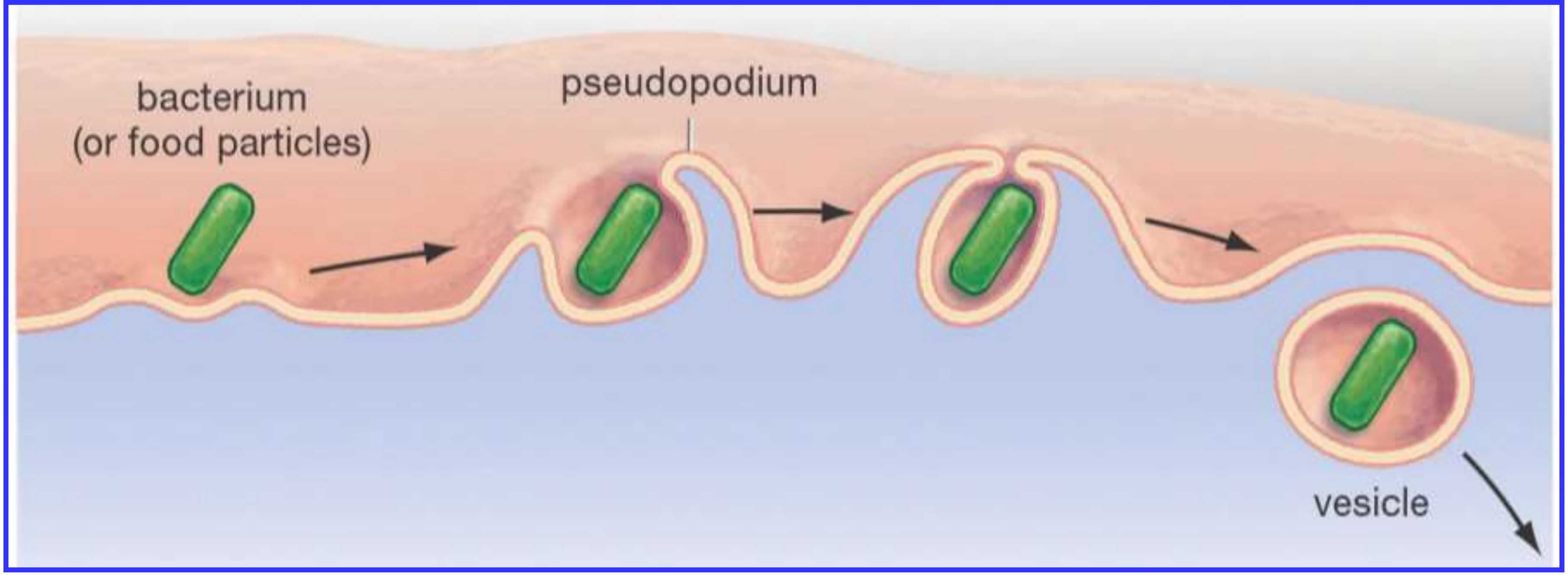
- **Moving things out**
- Molecules are moved out of the cell by **vesicles** that fuse with the plasma membrane, **waste** and **secretory products**
- This is how many **hormones** are secreted and how nerve cells communicate with one another (**neurotransmitters**)



Endocytosis

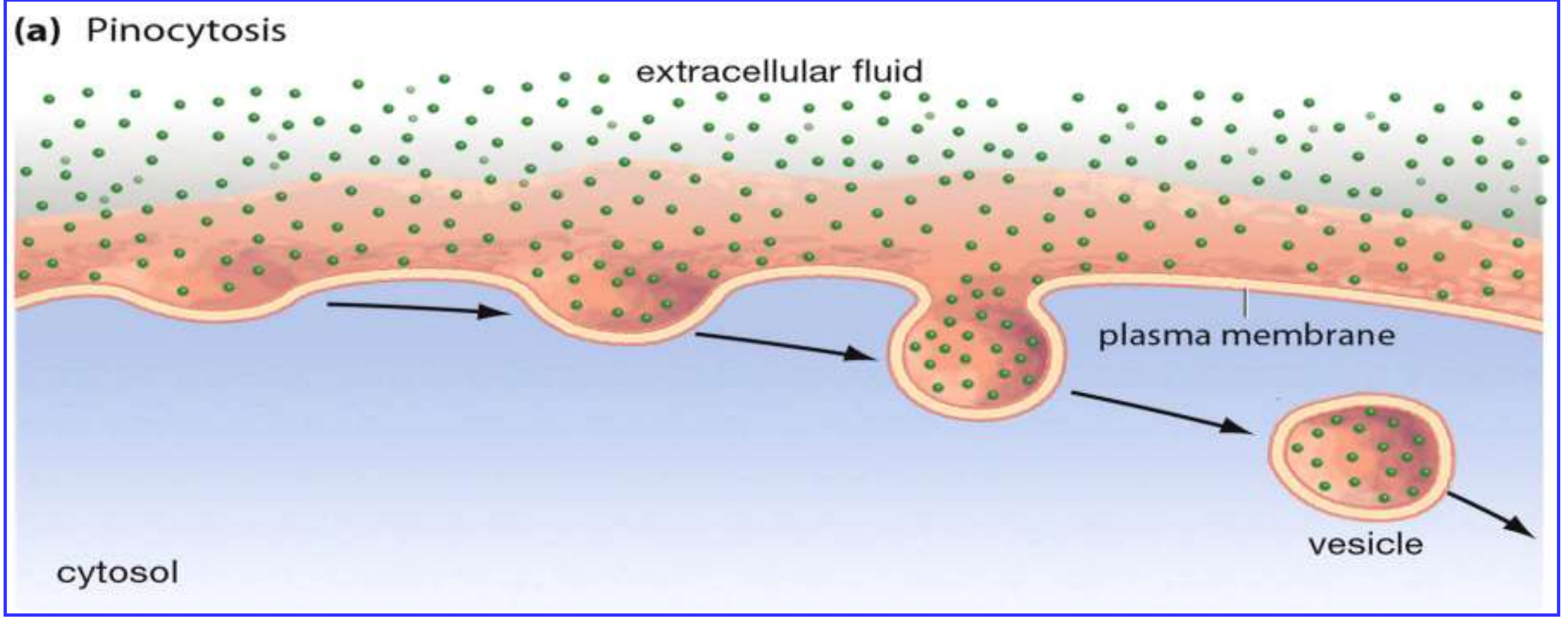
❖ **Phagocytosis**

- Transports large particles**,** a cell engulfs a particle by **wrapping pseudopodia** around it and packaging it within a membrane-enclosed sac as a vesicle or vacuole.
- The particle is digested after the vacuole fuses with a lysosome containing hydrolytic enzymes.



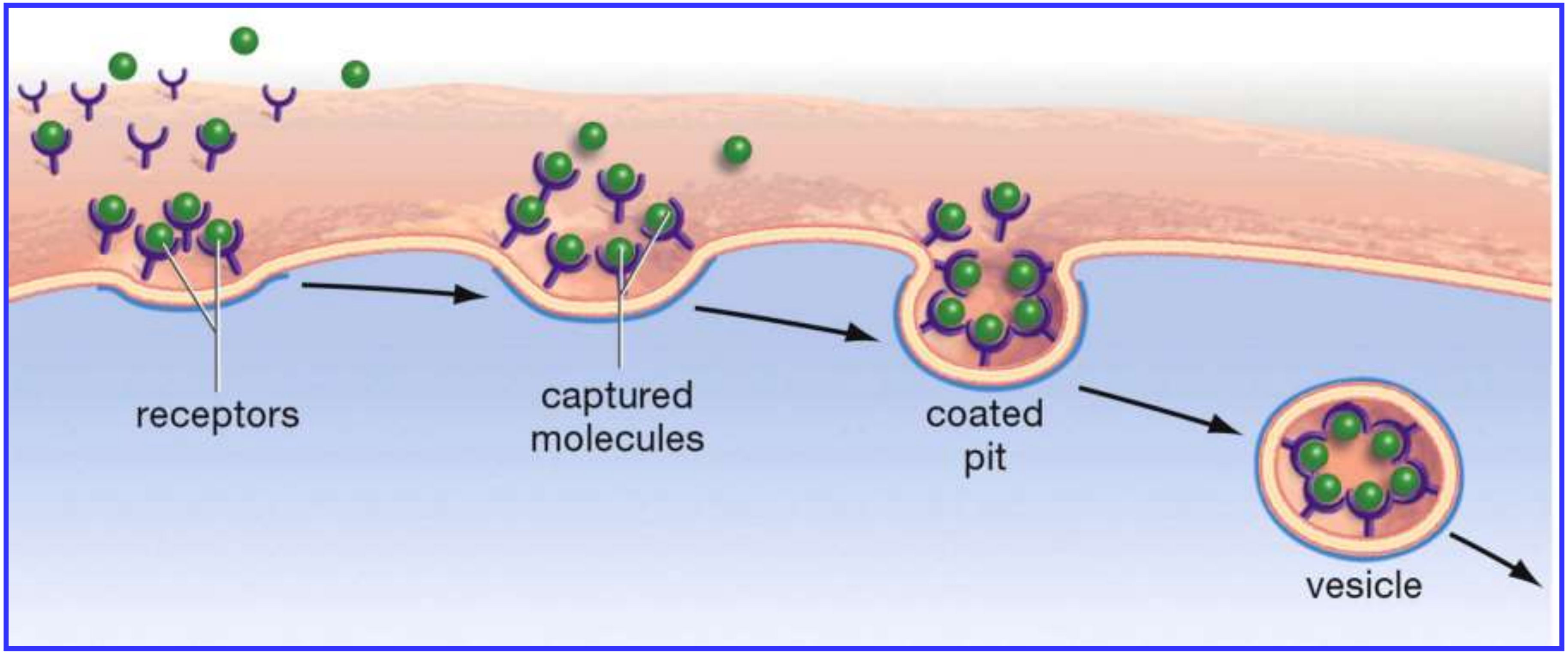
❖ **Pinocytosis**

- Transport **fluids** and **small** particles **(Cell Drinking)**
- This is the **most common** form of endocytosis
- In **pinocytosis,** the cell "gulps" droplets of extracellular fluid into tiny **vesicles**.
- It is not the fluid itself that is needed by the cell, but the **molecules dissolved** in the droplet.
- Pinocytosis is **nonspecific** in the substances it transports

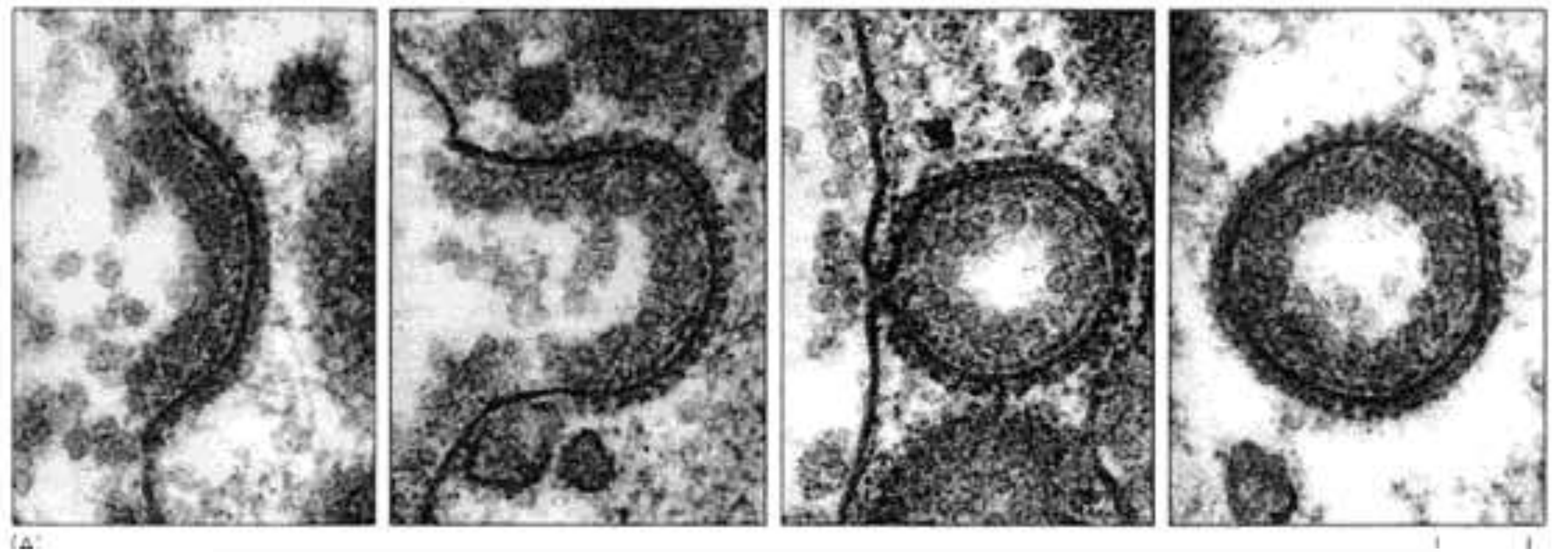


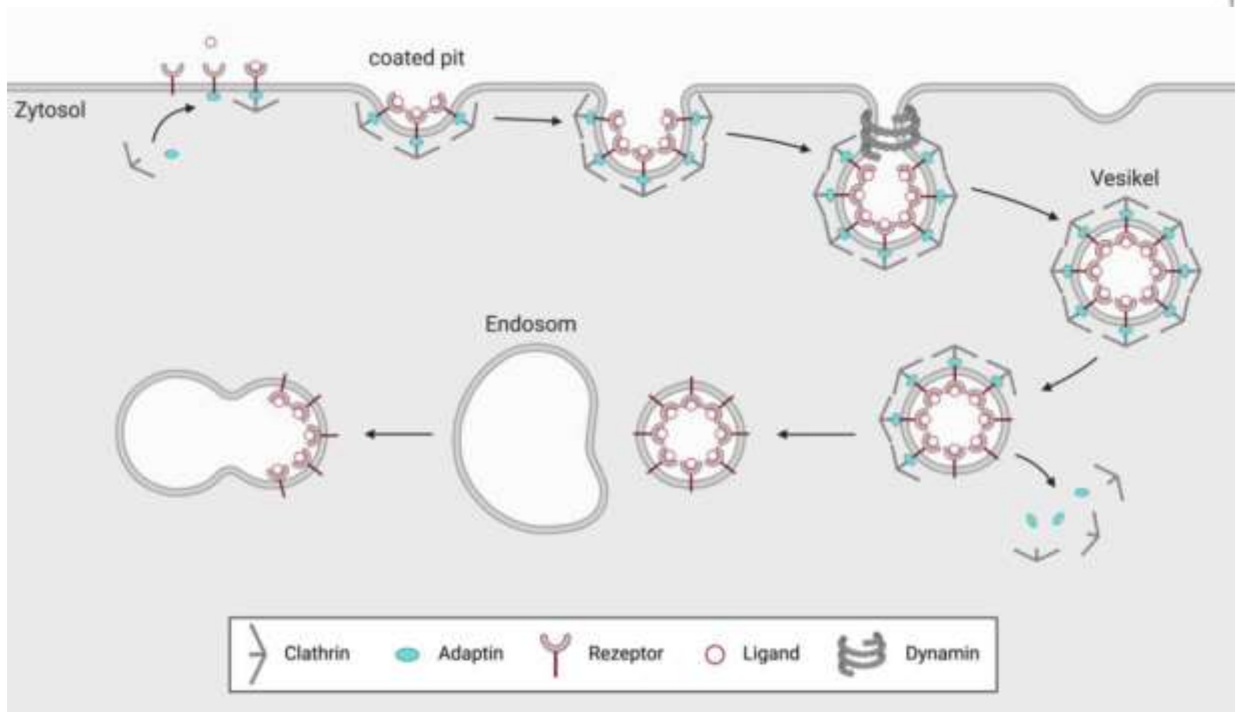
❖ Receptor-Mediated Endocytosis

- **Triggered by molecular signal** Receptor proteins make this a highly **specific** form of transport.
- **Cholesterol** is taken-up this way.



Formation of Clathrin-Coated Vesicles





Extracellular components

- Most cells synthesize and secrete materials that are external to the plasma membrane
- These extracellular structures include:
  - Cell walls of plants
  - The extracellular matrix (ECM) of animal cells
  - Intercellular junctions

The Extracellular Matrix (ECM) of Animal Cells

- Animal cells lack cell walls but are covered by an elaborate **extracellular matrix (ECM)**

- The ECM is made up of glycoproteins such as **collagen fibers**, **proteoglycans**, **Elastin fiber**, and **fibronectin**

- ECM proteins bind to receptor proteins in the plasma membrane called **integrins.**

- **Functions of the ECM:**
  - Support against compressive force.
  - Adhesion (cell to cell) by integrin protein.
  - Movement of cell signals and nutrients.
  - Regulation of cell functions

1. Collagen:

- Plays a key role in giving tissues strength and structural integrity. **Bone**.
- With a class of carbohydrate bearing **proteoglycans** that give flexibility. **Ear cells**
- Human genetic disorders that affect collagen, such as Ehlers-Danlos syndrome, result in fragile tissues that stretch and tear too easily.

2. **Fibronectin:**

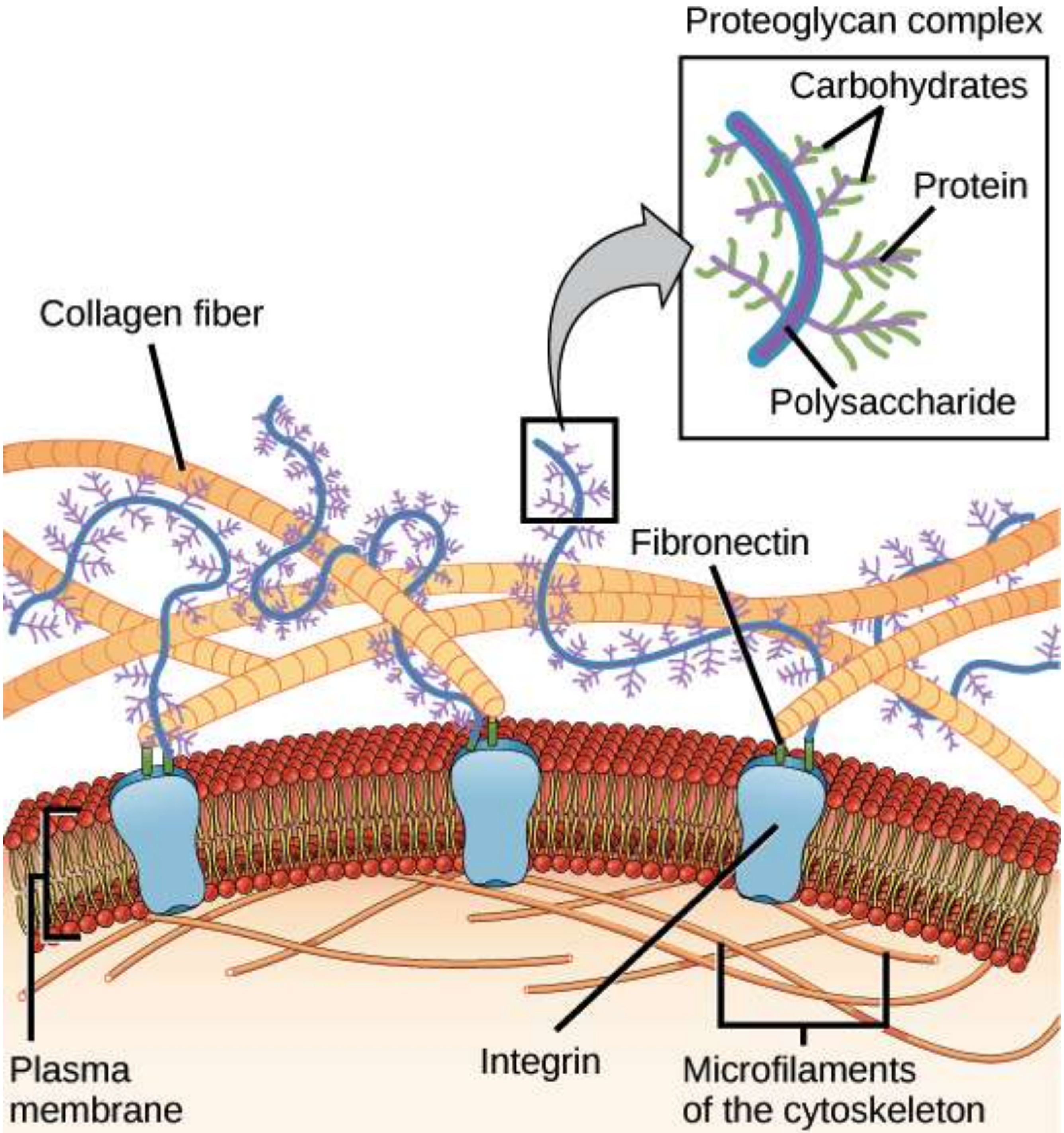
- Proteins in the extracellular matrix, can act as bridges between integrins and other extracellular matrix proteins such as collagen.
- On the inner side of the membrane, the integrins are linked to the cytoskeleton.

3. Polysaccharide chains:

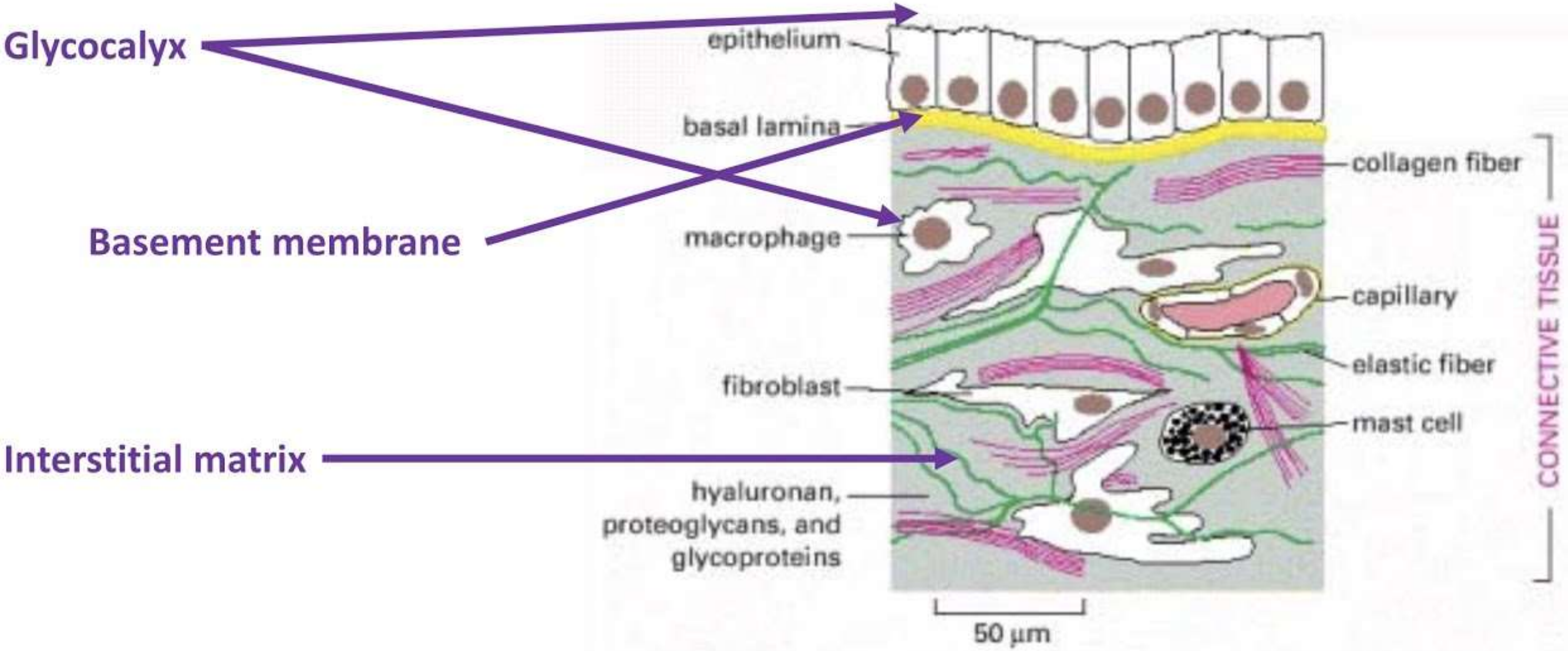
- like glycosaminoglycan(GAGs) link to protein to form proteoglycan like **hyaluronan** that bin to cell receptor protein CD44.

4. Cells of the ECM:

- **Fibrocytes**: secretion fibrous proteins.
- **Plasma cells**: secretion Abs.
- **Macrophages**: immune function.
- **Fat cells**: Source of energy and thermal insulation.
- **Mast cells**: secretion histamine and heparin


Proteoglycan complex
Carbohydrates
Protein
Polysaccharide
Collagen fiber
Fibronectin
Plasma membrane
Integrin
Microfilaments of the cytoskeleton

The major subsets of ECM by location

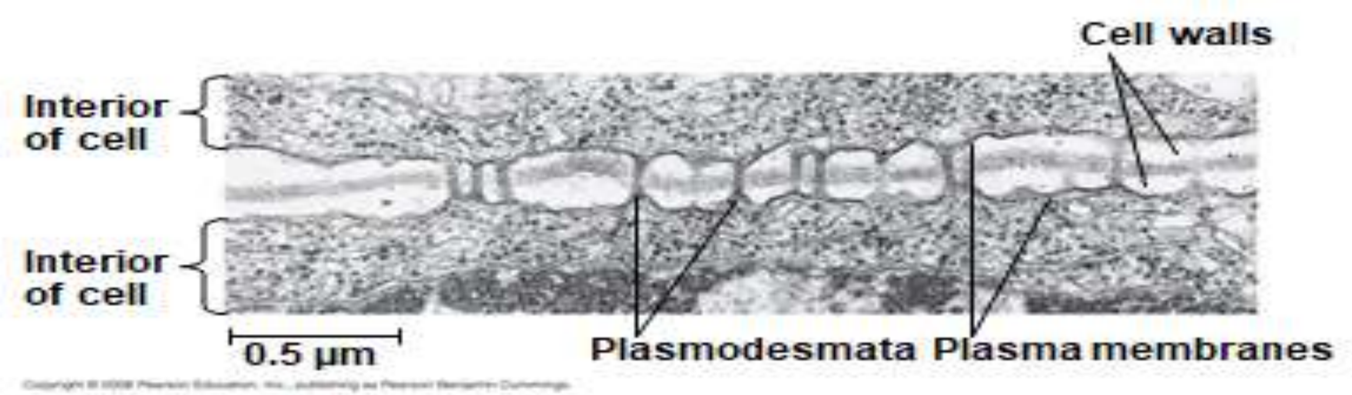


Intercellular Junctions

- Neighboring cells in tissues, organs, or organ systems often adhere, interact, and communicate through direct physical contact.
- Intercellular junctions facilitate this contact.
- There are several types of intercellular junctions
  - Plasmodesmata
  - Gap junctions
  - Tight junctions
  - Desmosomes

Plasmodesmata in Plant Cells

- **Plasmodesmata** are channels that perforate plant cell walls.
- Through plasmodesmata, water and small solutes (and sometimes proteins and RNA) can pass from cell to cell



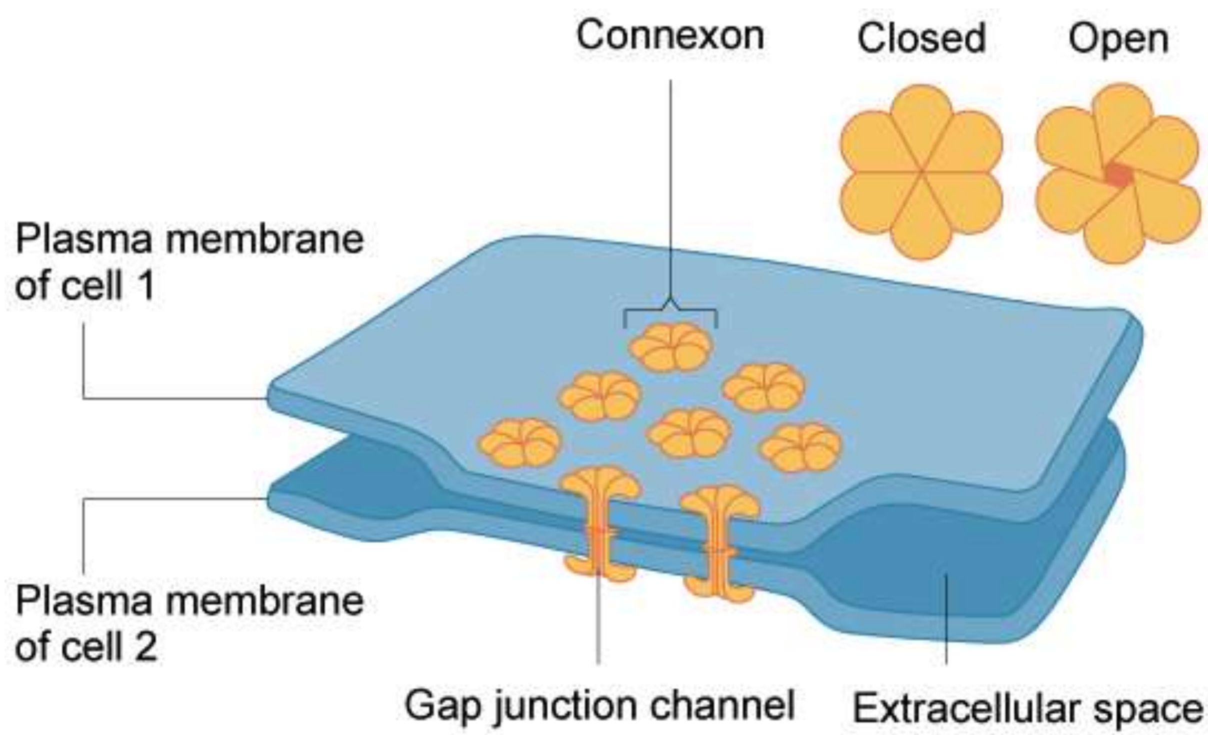
Gap junctions in animal cells

- In animal cells are a lot like plasmodesmata in plant cells, they are channels between neighboring cells that allow for the transport of ions, water, and other substances.

- Structurally, however, gap junctions develop when a set of six membrane proteins called **connexins** form an elongated, donut-like structure called a **connexon**.

- When the pores, or "doughnut holes," of connexons in adjacent animal cells align, a channel forms between the cells.
- **Invertebrates** also form gap junctions in a similar way, but use a different set of proteins called **innexins**.

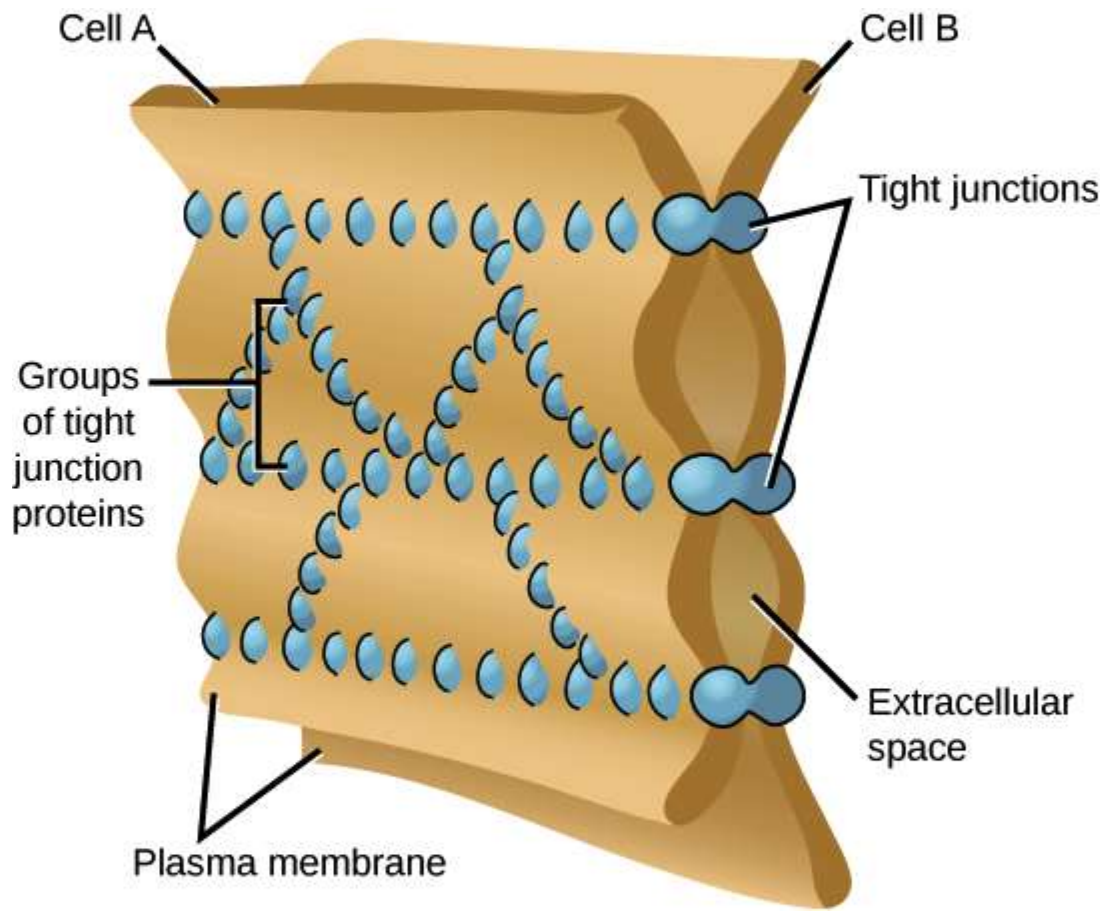
- Gap junctions are particularly important in **cardiac muscle**: the electrical signal to contract spreads rapidly between heart muscle cells as ions pass through gap junctions, allowing the cells to contract in tandem.



Tight junctions

- Not all junctions between cells produce cytoplasmic connections.
- **Tight junctions** create a watertight seal between two adjacent animal cells.
- At the site of a tight junction, cells are held tightly against each other by many individual groups of tight junction proteins called **claudins**.
- Each of which interacts with a partner group on the opposite cell membrane.
- The groups are arranged into strands that form a branching network, with larger numbers of strands making for a tighter seal.

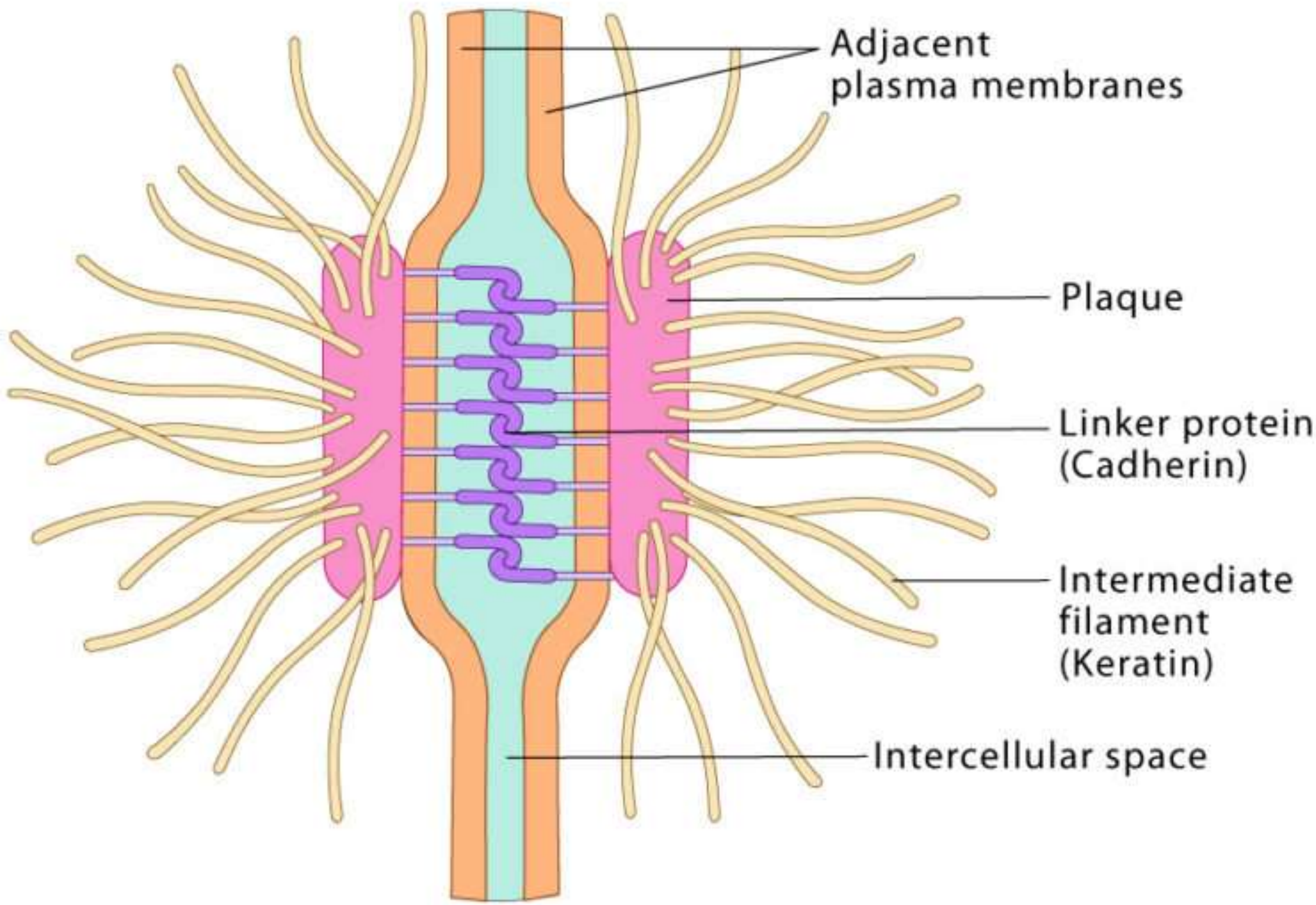
- The purpose of tight junctions is to keep liquid from escaping between cells, allowing a layer of cells (for instance, those lining an organ) to act as an impermeable barrier.
- **For example**, the tight junctions between the epithelial cells lining your bladder prevent urine from leaking out into the extracellular space.



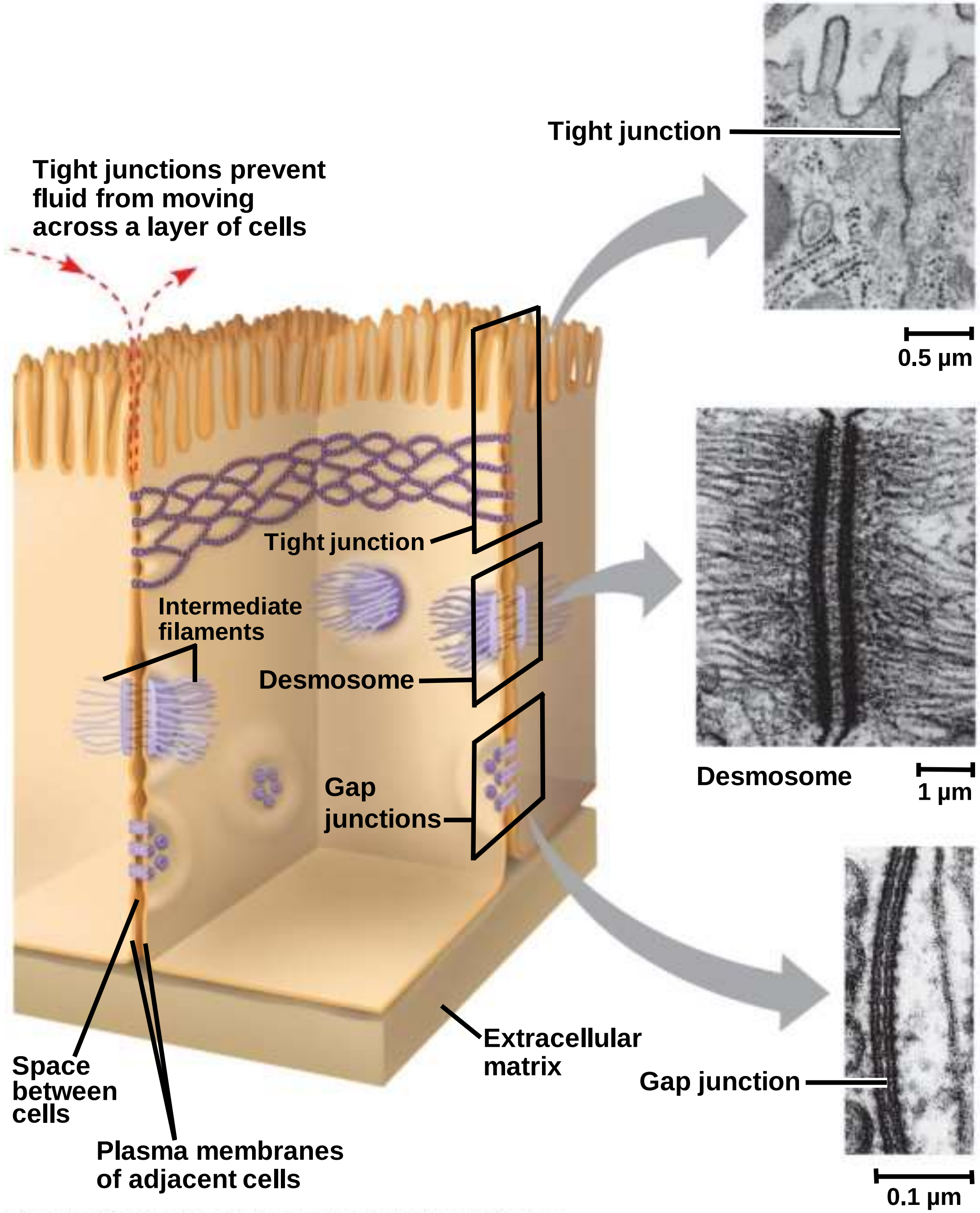
Desmosomes

- Which act like spot welds between adjacent epithelial cells.
- A desmosome involves a complex of proteins. Some of these proteins extend across the membrane, while others anchor the junction within the cell.
- **Cadherins**, specialized adhesion proteins, are found on the membranes of both cells and interact in the space between them, holding the membranes together.
- Inside the cell, the cadherins attach to a structure called the cytoplasmic plaque, which connects to the intermediate filaments and helps anchor the junction.

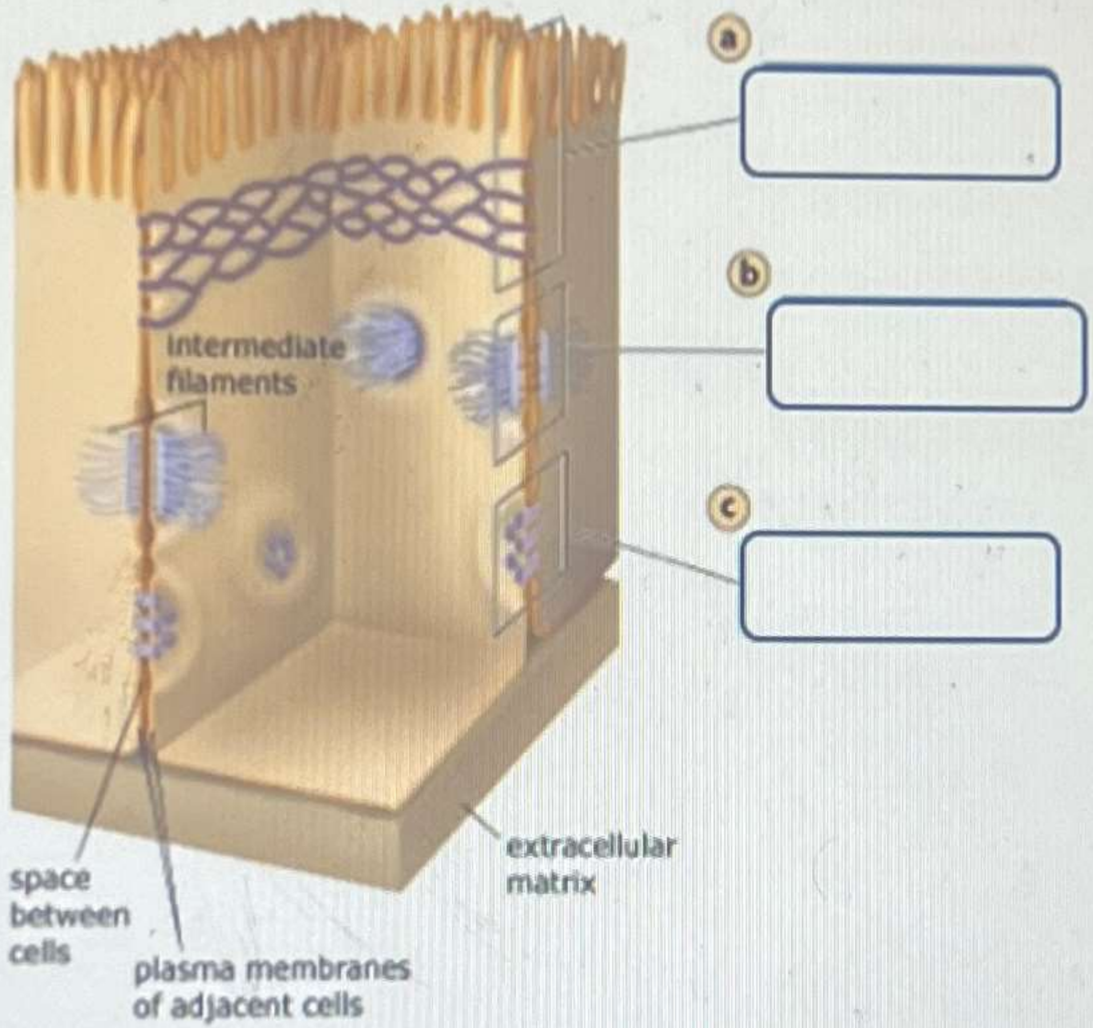
Desmosome

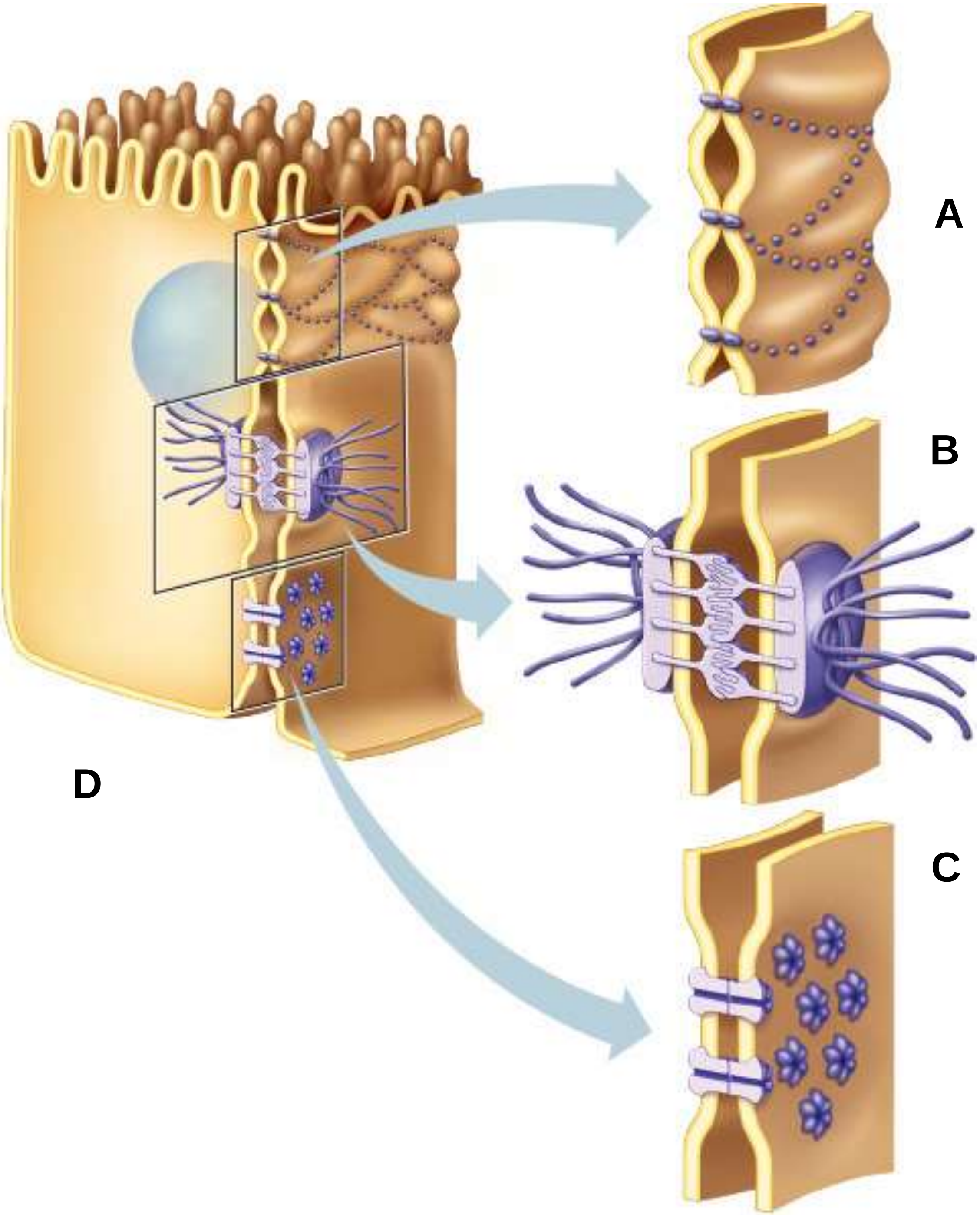


For example, cells in organs and tissues that stretch, such as **skin** and **cardiac muscle**, remain connected in an unbroken sheet.


Tight junctions prevent fluid from moving across a layer of cells
Tight junction
Intermediate filaments
Desmosome
Gap junctions
Space between cells
Plasma membranes of adjacent cells
Extracellular matrix
Tight junction
0.5 µm
Desmosome
1 µm
Gap junction
0.1 µm

Animal cells have three main types of intercellular junctions. The occurrence of these junctions depends on the type of cells you are studying. For example, epithelial cells are rich in all three types of intercellular junctions. Label the different intercellular junctions found in animal tissues.





Match the number with correct Letter

1. **Desmosomes ( )**
2. **Gap junctions ( )**
3. **Tight junctions ( )**
4. **Plasmodesmata ( )**
5. **Tow adjacent cells ( )**