Cell structure & function

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Obejectives

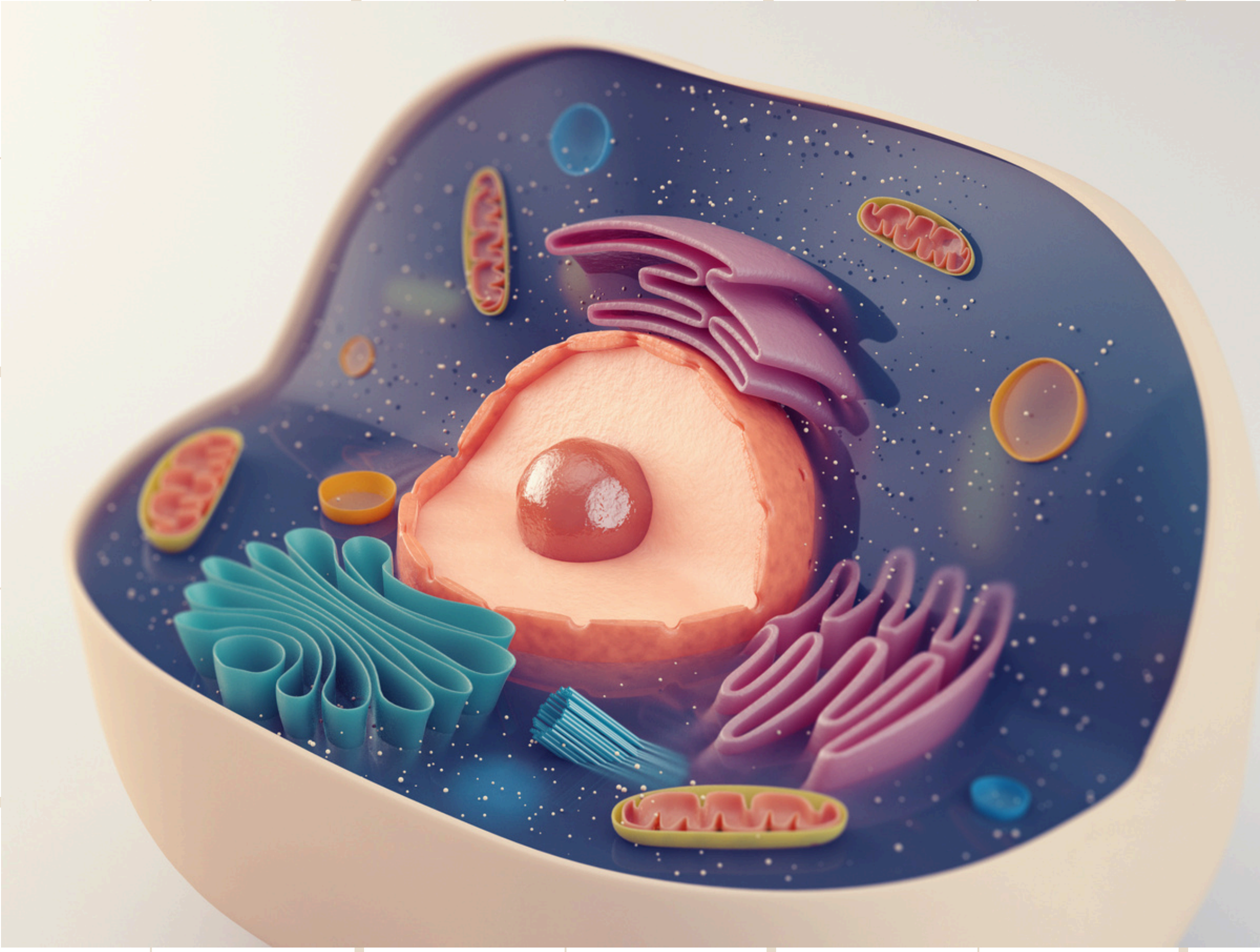
Identify the main structures in animal and plant cells.

Describe the function of each cell organelle.

Describe the structures of each cell organelle.

Cell nucleus

- Usually Spherical in shape
- Surrounded by double nuclear membrane with holes or pores
- Chemicals move in and out of nucleus through these pores
- Inside nuclear membrane (nuclear envelope), are nucleic acids and proteins
- Nucleic acids: DNA and RNA



Nuclear Envelope:

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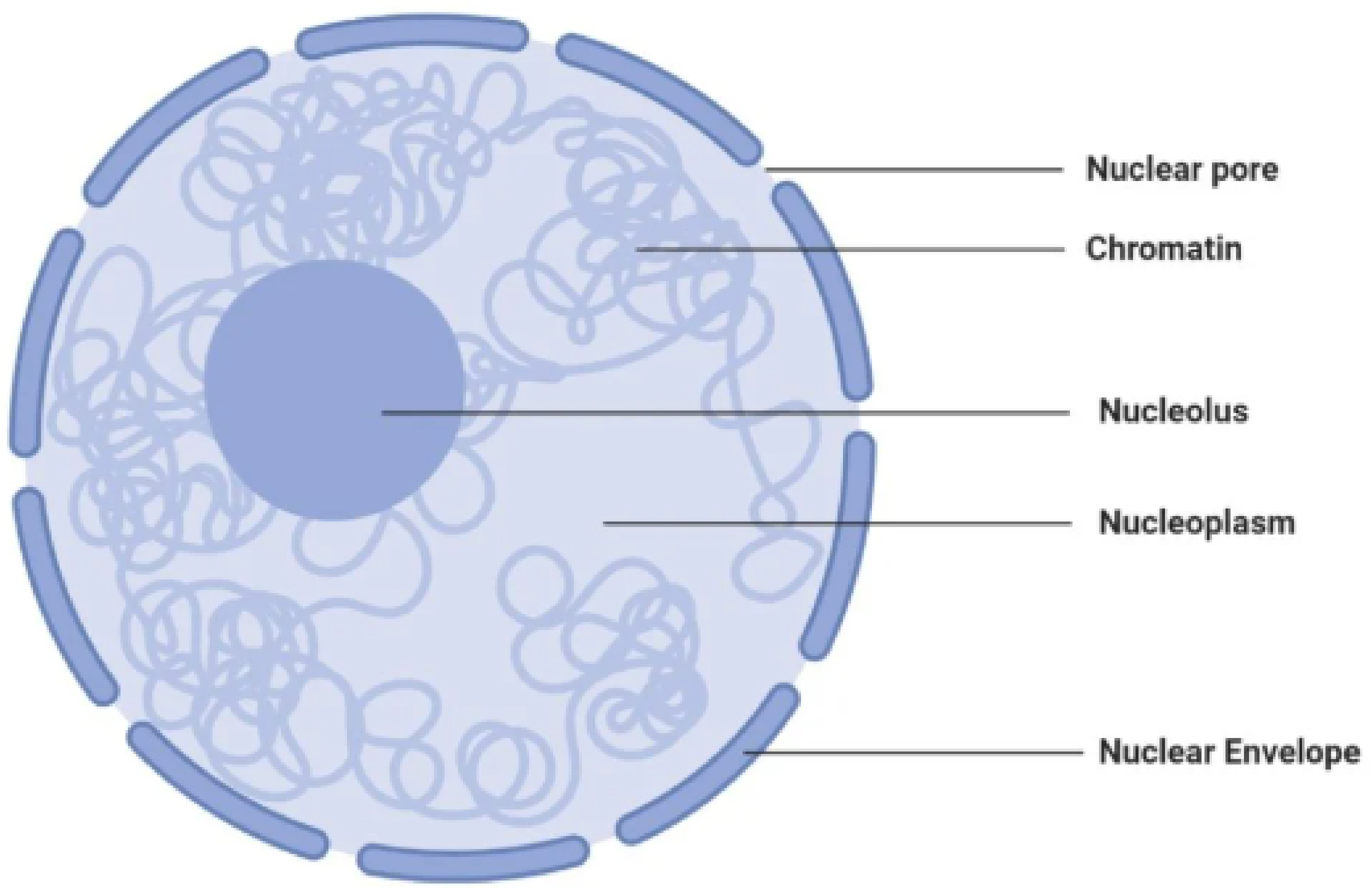
- Nucleus is enclosed by a double membrane called the nuclear envelope
- It separates the contents of the nucleus from the cytoplasm.
- Each membrane of the envelope is a lipid bilayer with associated proteins.
- These two membranes are separated by a gap of 20-40 nm.



Nuclear Pores:

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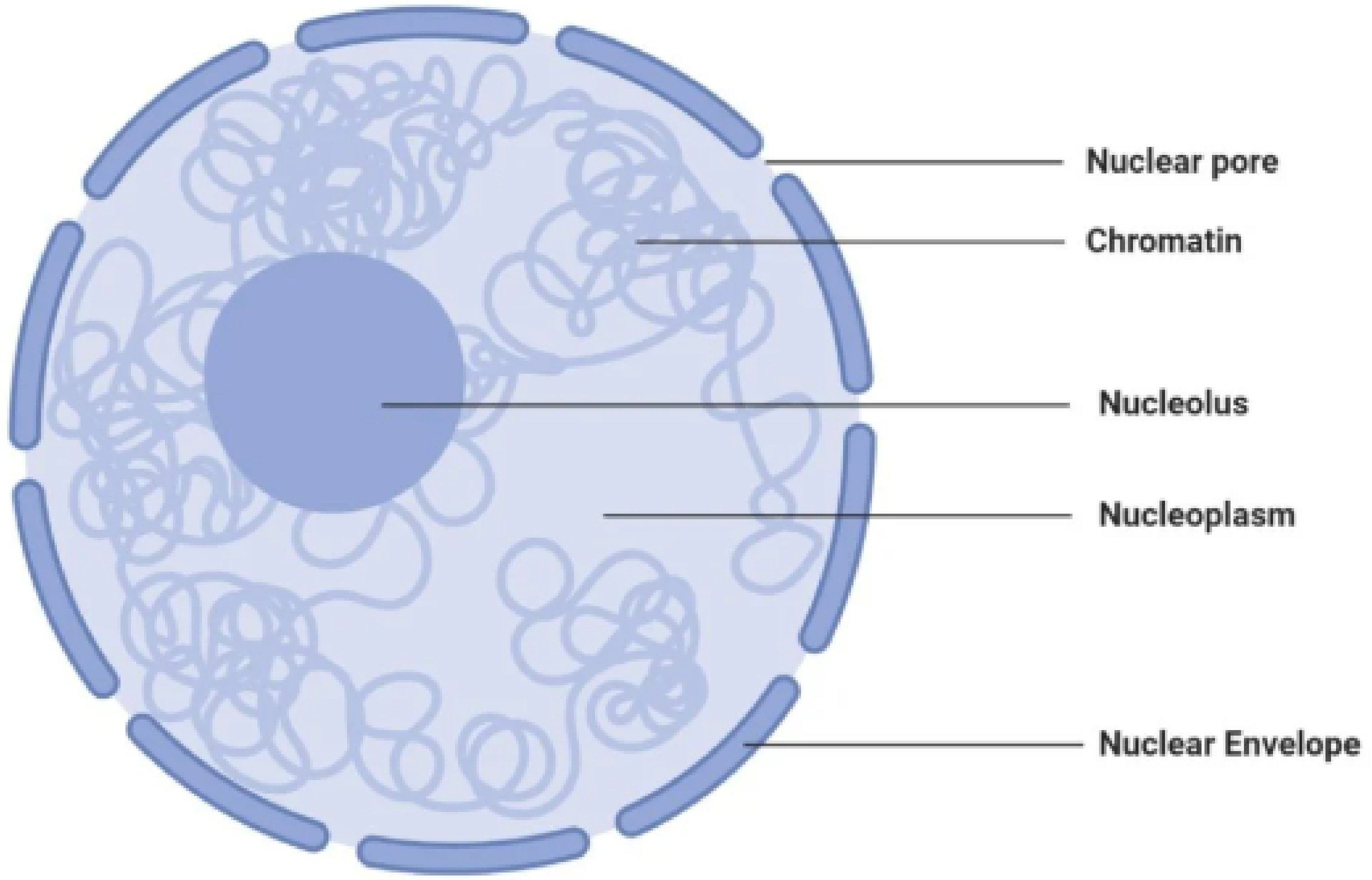
- Nuclear envelope contains pores about 100 nm in diameter.
- Regulate the movement of molecules between the nucleus and the cytoplasm.
- Each pore is lined by a protein complex called the pore complex
- Crucial to regulating the entry and exit of proteins, RNA, and large macromolecular complexes.



Nucleolus:

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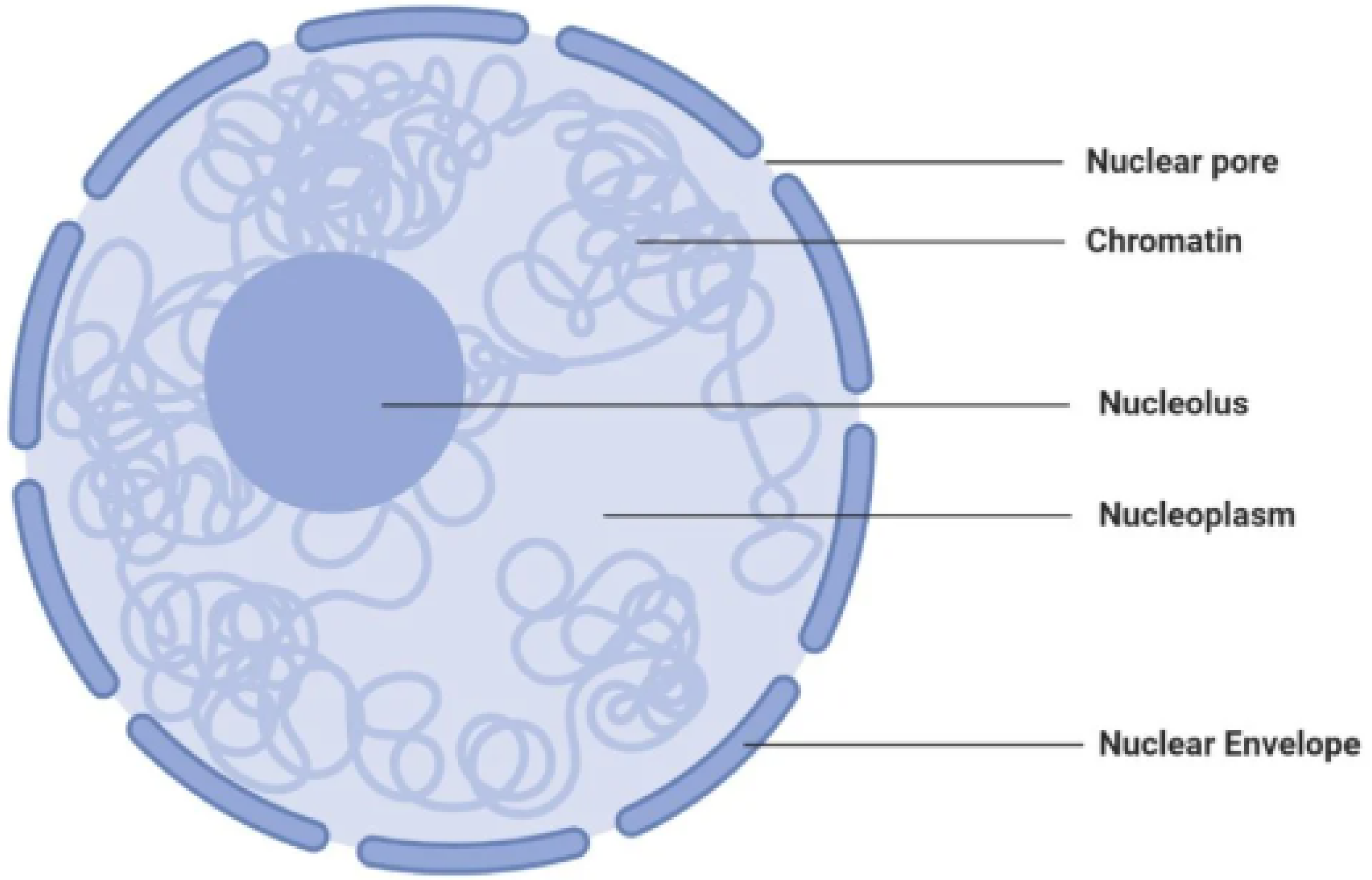
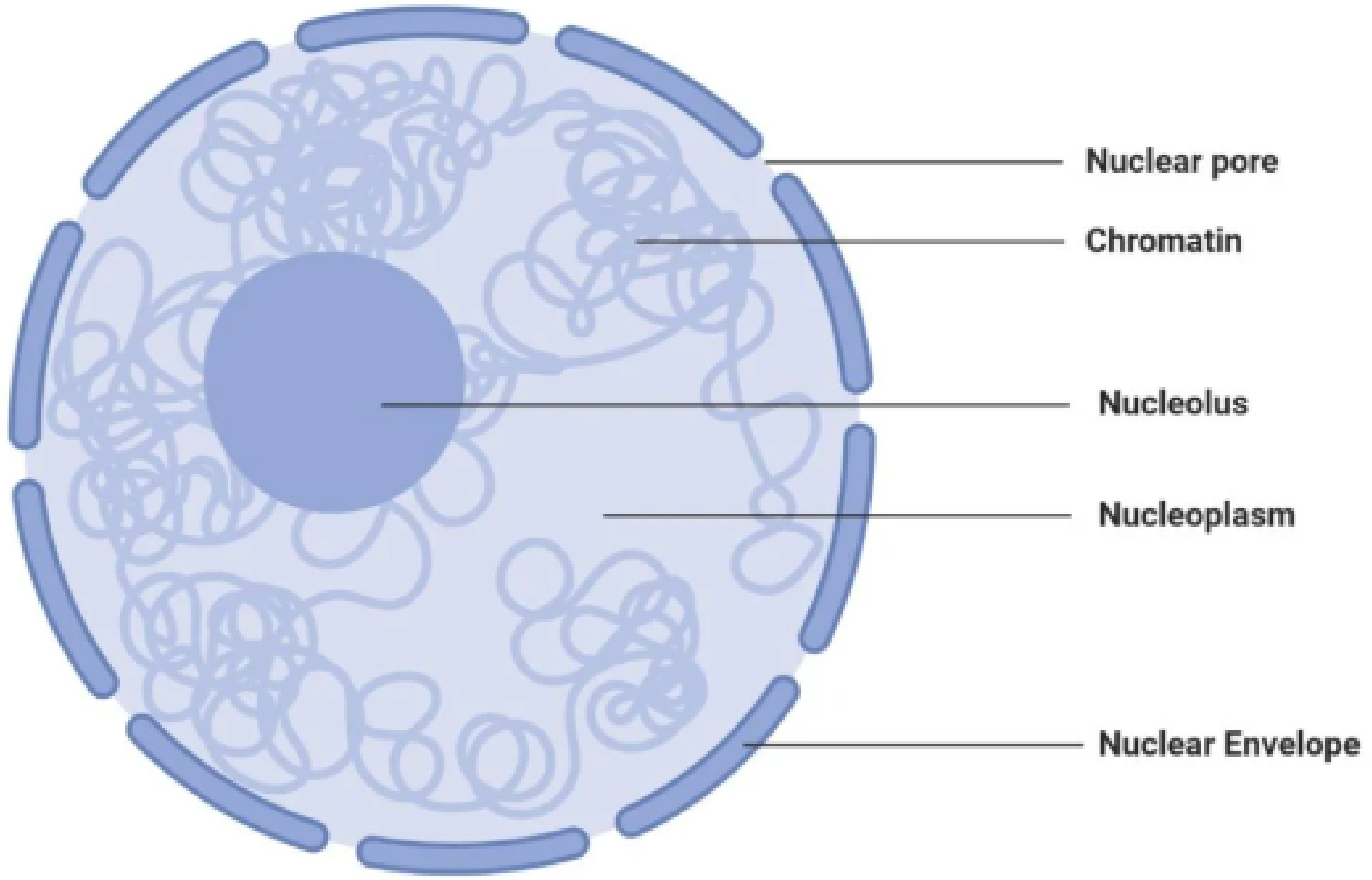
- A prominent structure within the nondividing nucleus.
- It is the site of ribosomal RNA (rRNA) synthesis and the assembly of ribosome subunits.
- These subunits are composed of rRNA and proteins
- They are exported to the cytoplasm via nuclear pores
- They combine to form functional ribosomes.
- Also plays a role in controlling cell division and the lifespan of the cell. The number of nucleoli can vary depending on the species and the cell's stage in the reproductive cycle.



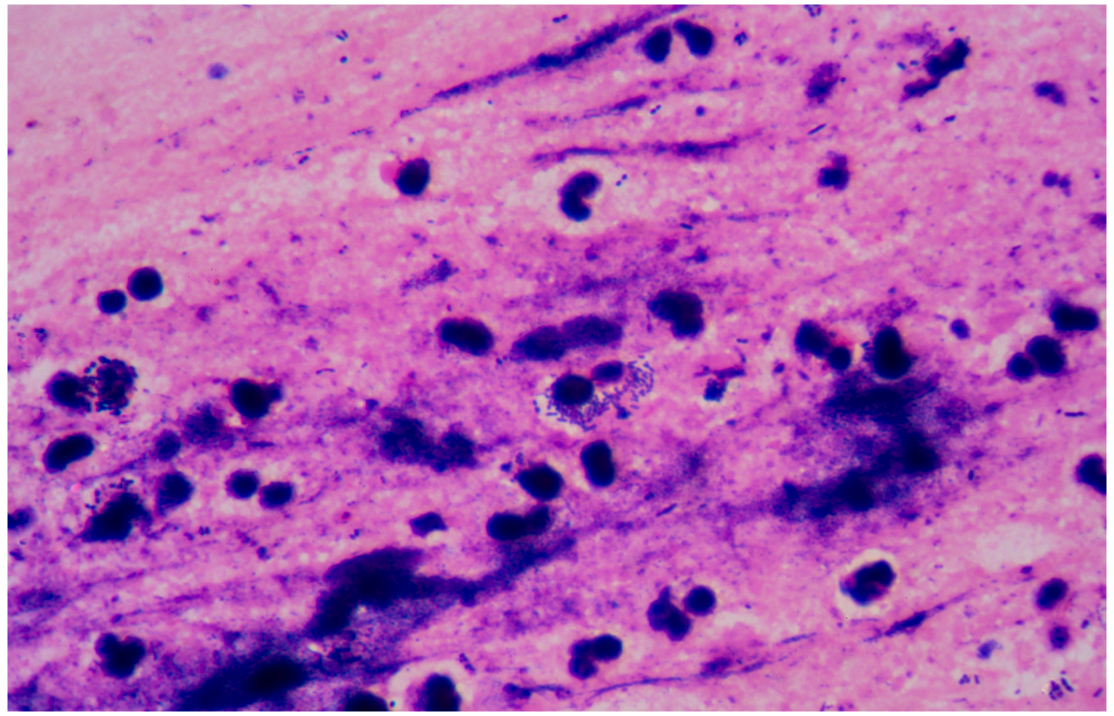
Functions of nucleus:

- Crucial for directing protein synthesis in the cell. It synthesizes messenger RNA (mRNA), which carries genetic information from the DNA.
- This mRNA is transported to the cytoplasm, where it is translated by ribosomes into specific polypeptides.



Ribosomes

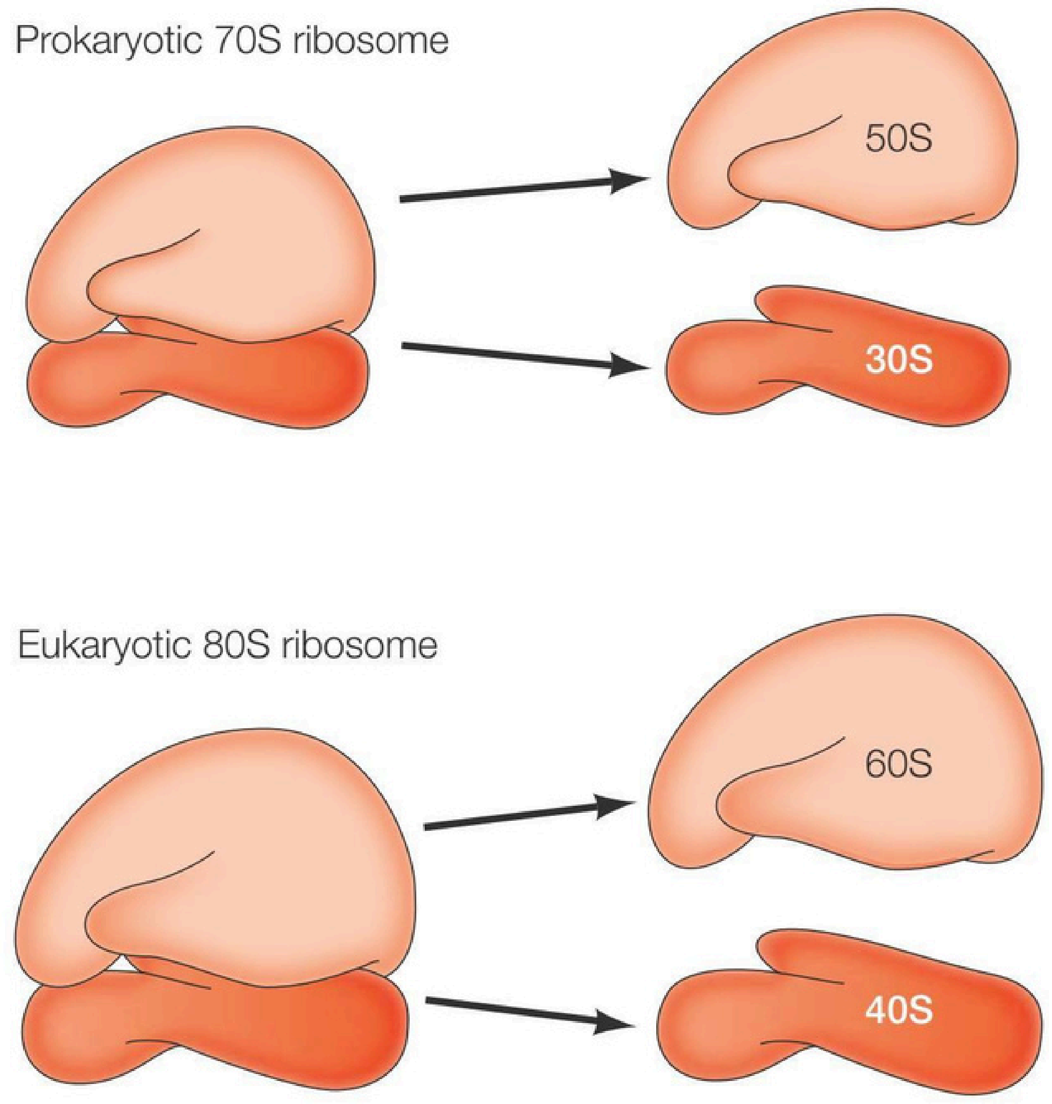
- Ribosomes are essential cellular structures responsible for protein synthesis.
- They are complexes made up of ribosomal RNA (rRNA) and proteins.
- Structure: Ribosomes consist of two subunits; a large subunit and a small subunit. These subunits are assembled in the nucleolus from rRNA and proteins. After synthesis, they are transported to the cytoplasm through the nuclear pores.
- Ribosomes are located in the cytoplasm and the rough endoplasmic reticulum.



Ribosomes

Types:

- 80S Ribosomes: Found in eukaryotes, consisting of a 40S small and 60S large subunit. Primarily involved in protein synthesis.
- 70S Ribosomes

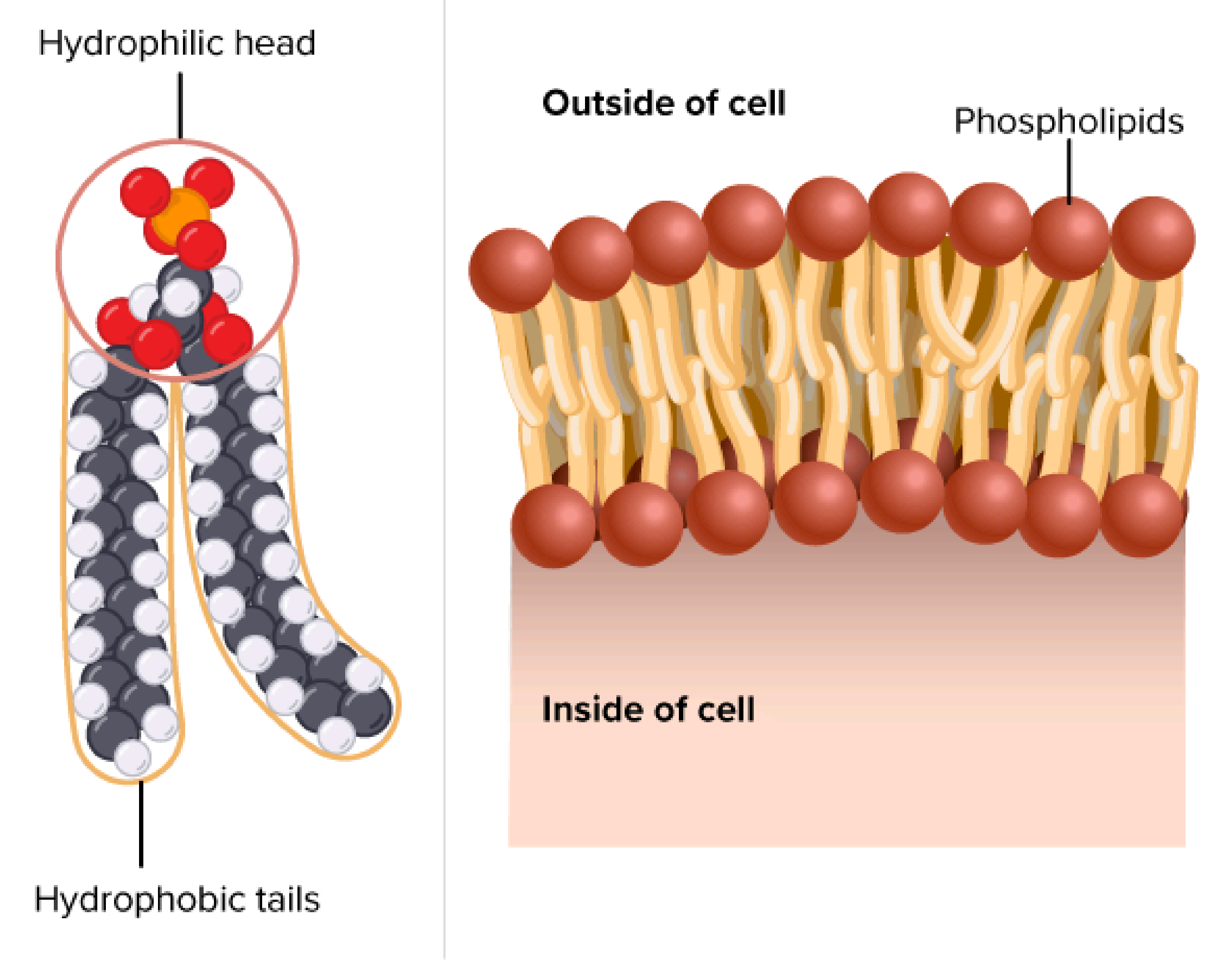


Plasma membrane

- The cell membrane surrounds the cell and is a selective barrier between the interior and the exterior.
- Its primary role: regulating the passage of substances, including nutrients and waste materials.

Structure:

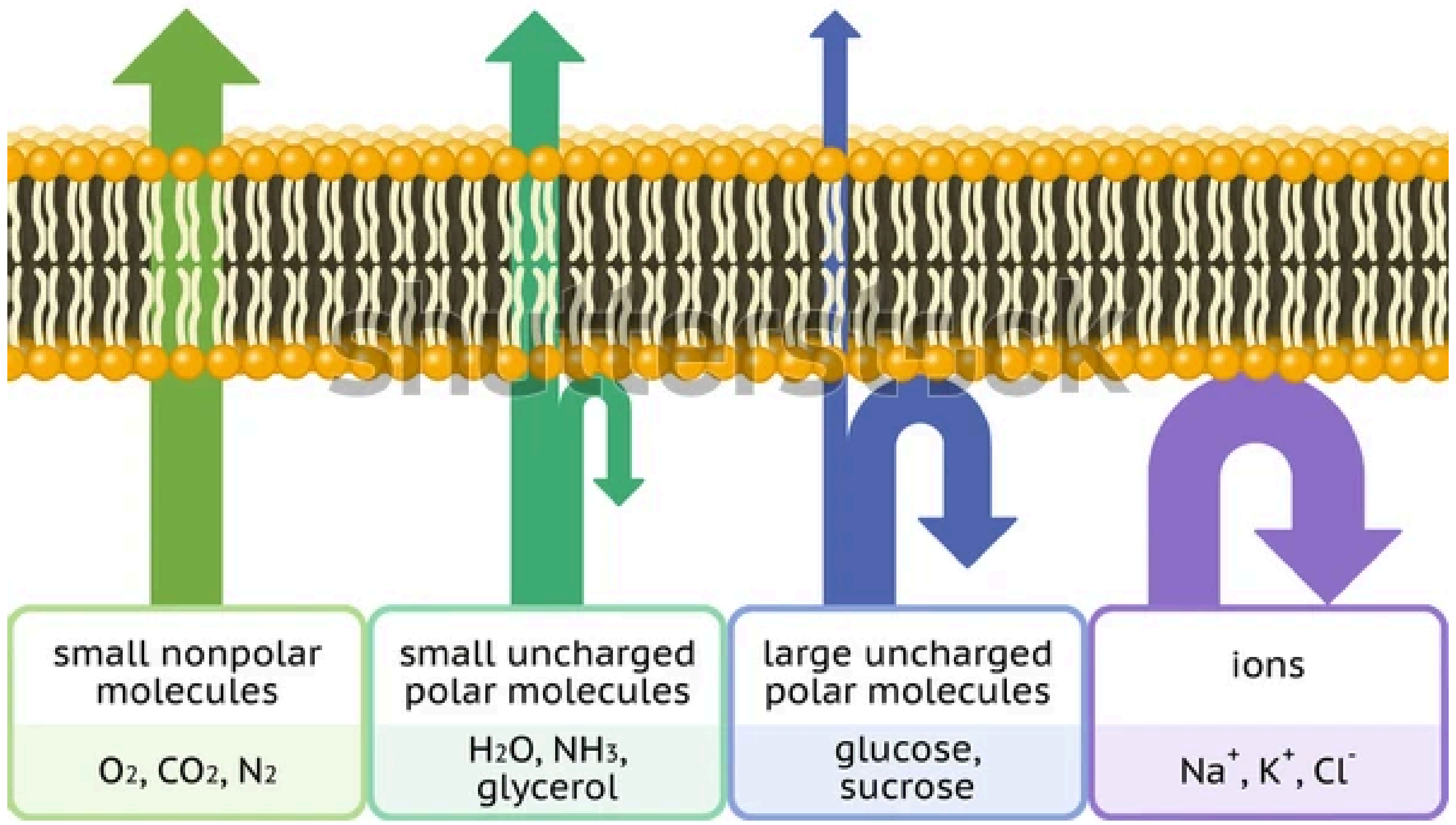
- Composed of lipids and proteins embedded within a phospholipid bilayer.
- Proteins are amphipathic, meaning they have both hydrophobic and hydrophilic regions.



Plasma membrane

Selective Permeability :

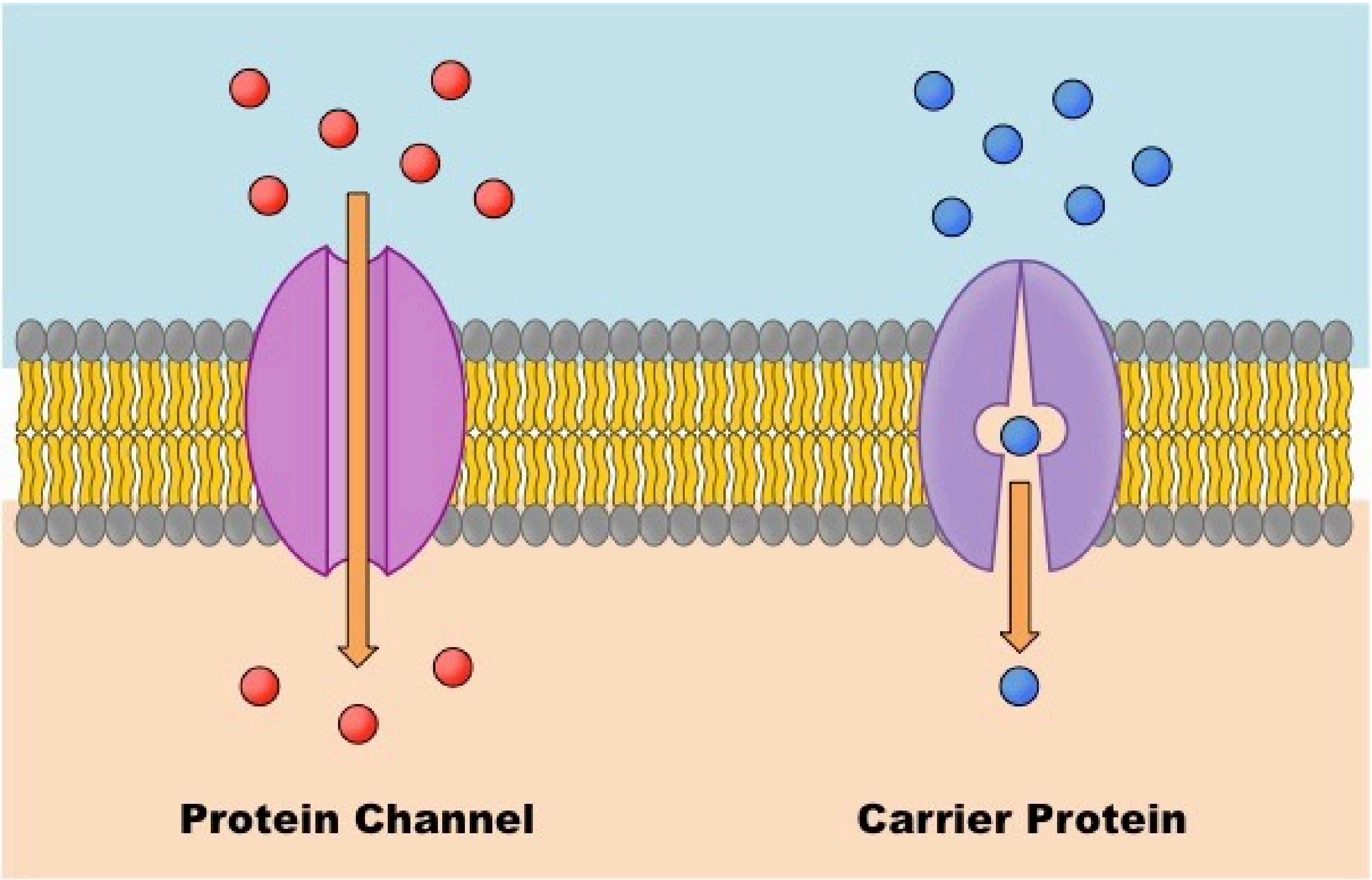
- The plasma membrane regulates the exchange of molecules and ions between the cell and its surroundings.
- The structure of the membrane ensures selectivity:
- Hydrophobic substances (nonpolar molecules) dissolve in the lipid bilayer and cross the membrane rapidly. Examples: Oxygen (O_2), carbon dioxide (CO_2).
- Polar molecules (e.g., water) and ions face difficulty passing through the hydrophobic core of the bilayer.



Plasma membrane

Transport Proteins

- Specific transport proteins facilitate the movement of polar molecules and ions across the membrane.
- Channel Proteins: Create hydrophilic pathways for certain molecules.
- Carrier Proteins: Bind specific molecules and undergo conformational changes to transport them.
- Transport proteins provide both specificity and control in molecular exchange.



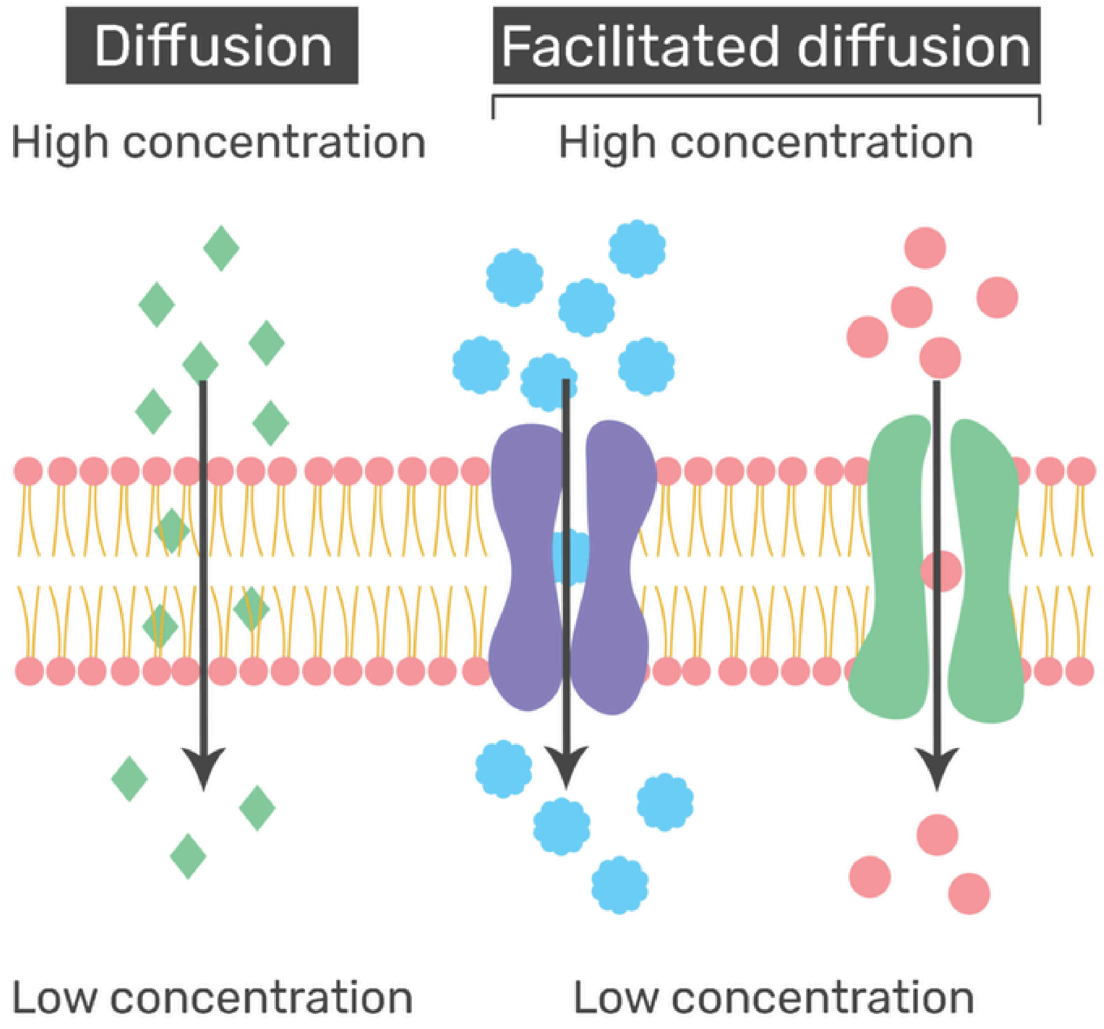
Membrane Transport

1. Passive Transport:

- Movement occurs along a concentration, pressure, or electrochemical gradient without energy (ATP).

o Diffusion:

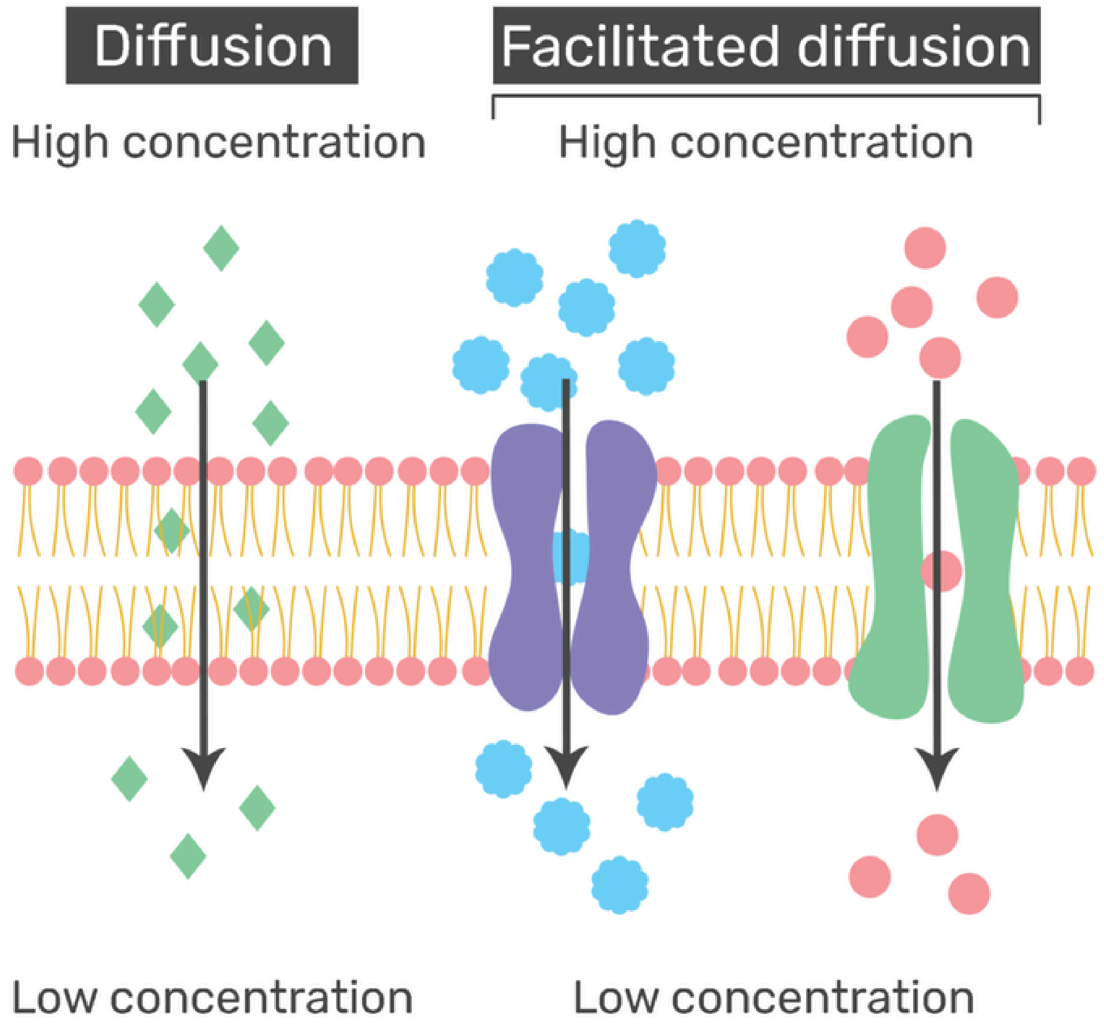
- Random movement of particles from high to low concentration.
- Requires kinetic energy but not ATP.
- Example: Oxygen and CO_2 diffusion.



Membrane Transport

o Facilitated Diffusion:

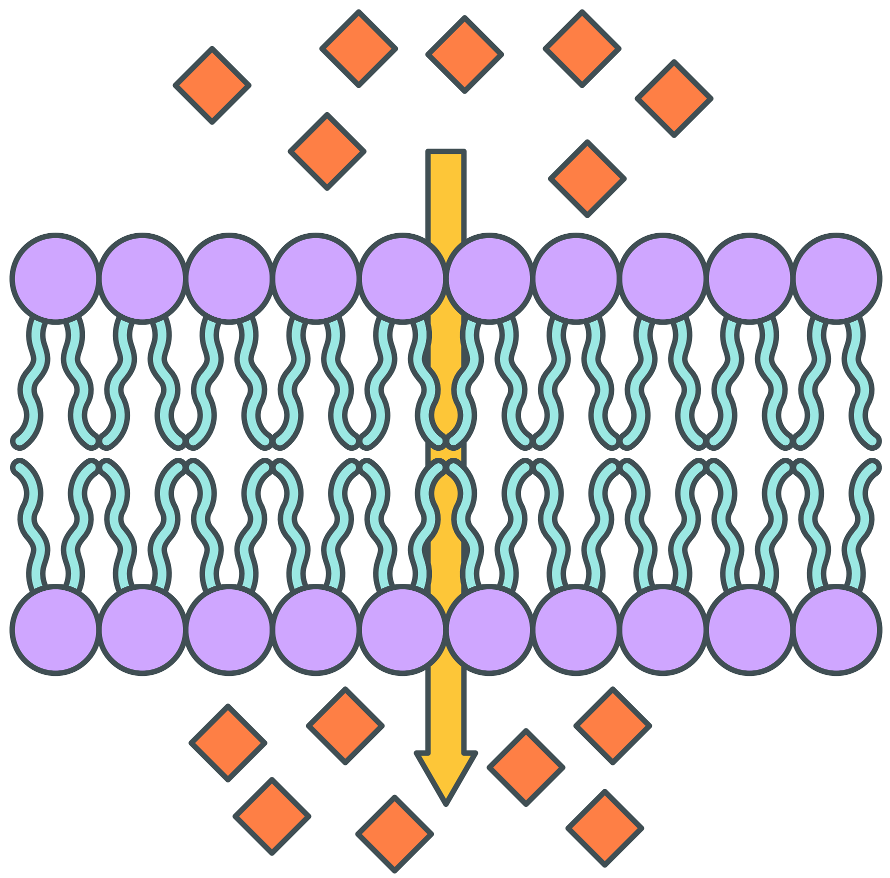
- Specialized proteins (channel or carrier) enable movement down a concentration gradient.
- No ATP is required.
- Example: Glucose transport via carrier proteins.



Membrane Transport

o Osmosis:

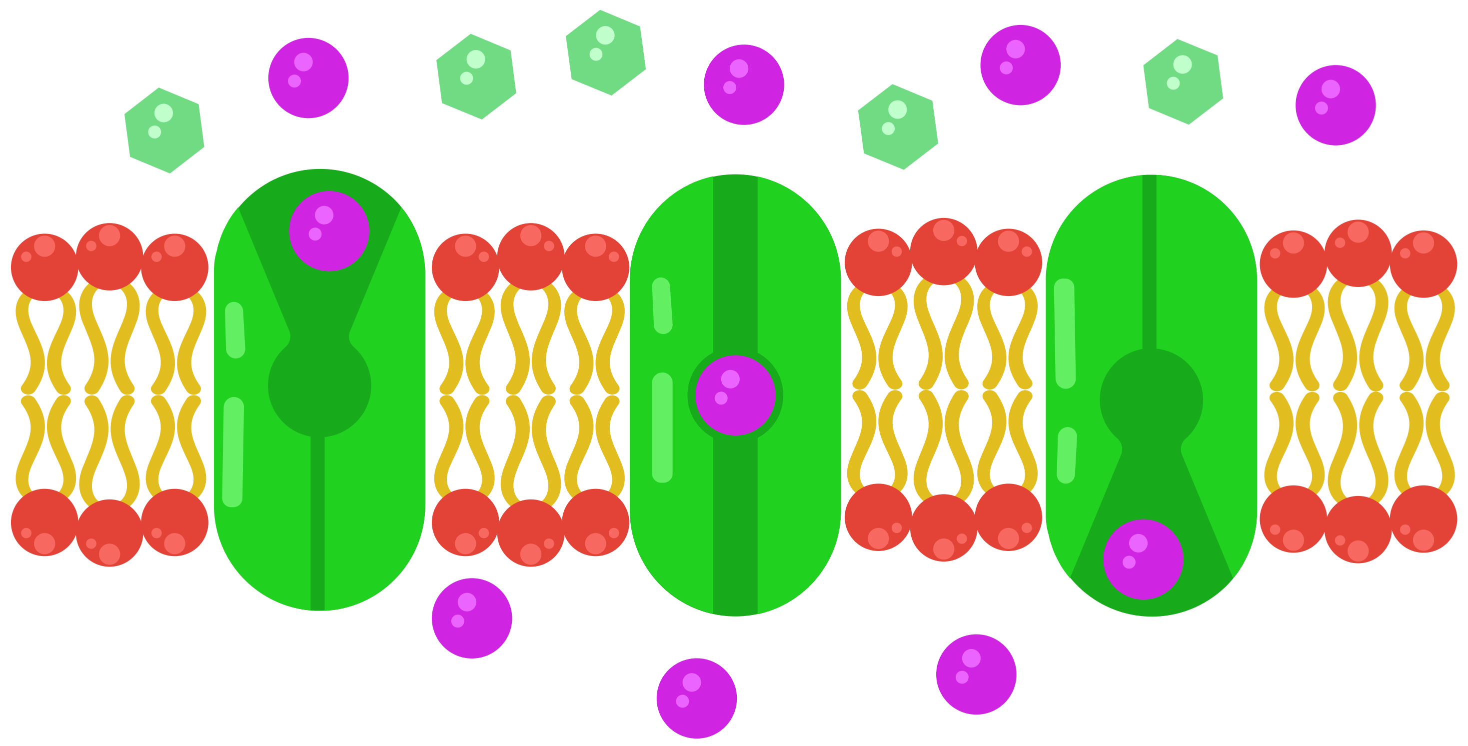
- Movement of water molecules across a partially permeable membrane.
- Driven by a water potential gradient.
- Solutes accumulate on one side, creating osmotic movement.



Membrane Transport

2. Active Transport:

- Movement of substances against a gradient using ATP.
- Mechanism: Carrier proteins bind molecules, using ATP to move them across membranes.
- Examples: Uptake of nutrients in cells or sodium-potassium pumps.



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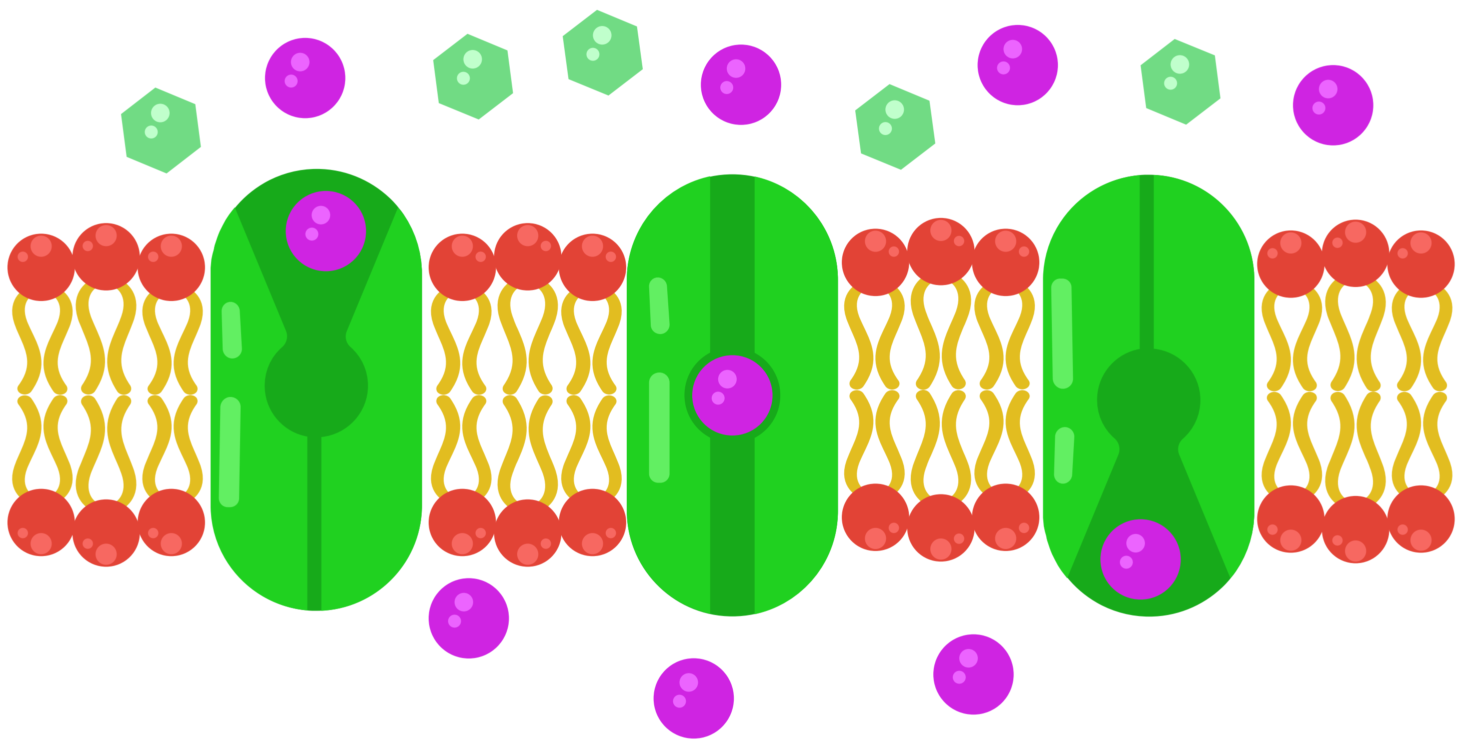
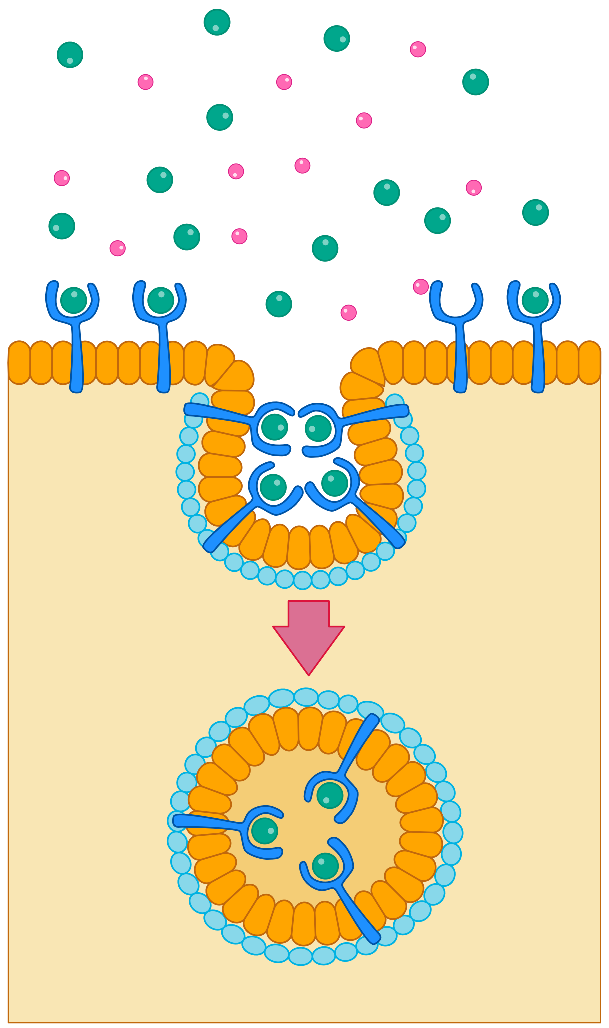


Membrane Transport

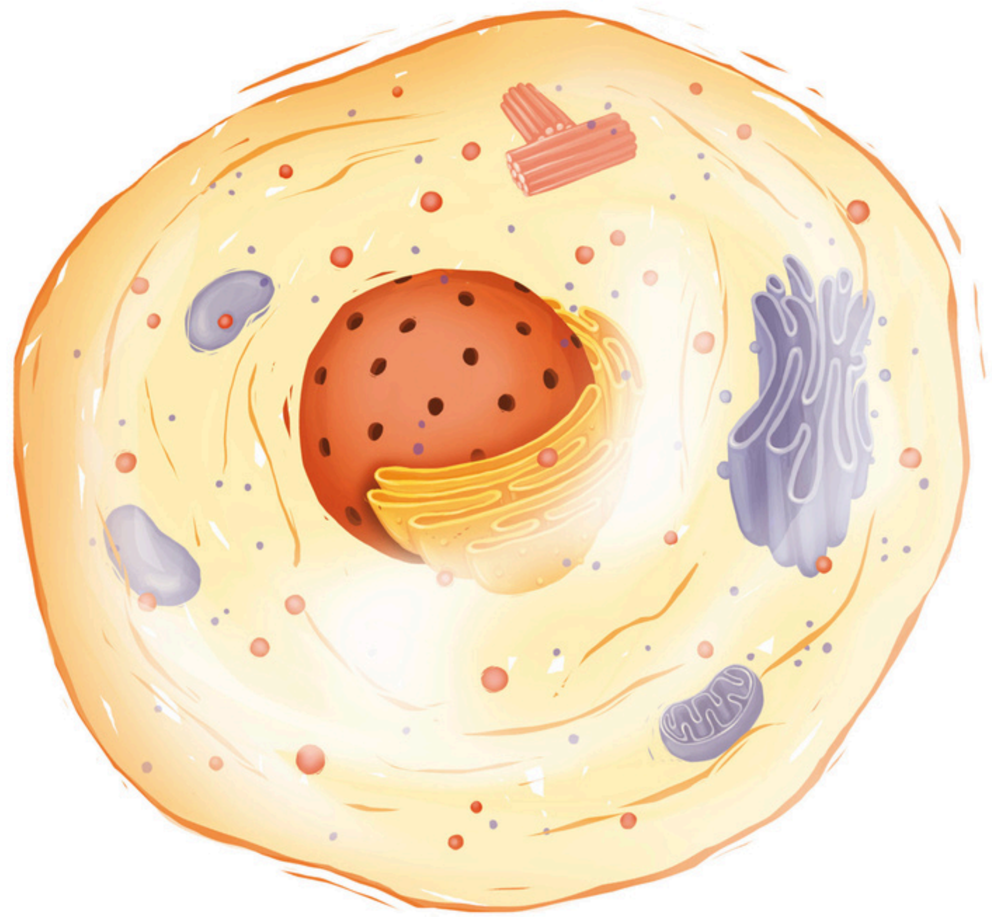
3. Endocytosis & Exocytosis:

- Endocytosis: Internalization of large molecules by vesicle formation.
- Exocytosis: Expulsion of substances (e.g., enzymes, waste) using vesicles.
- Both processes require ATP.



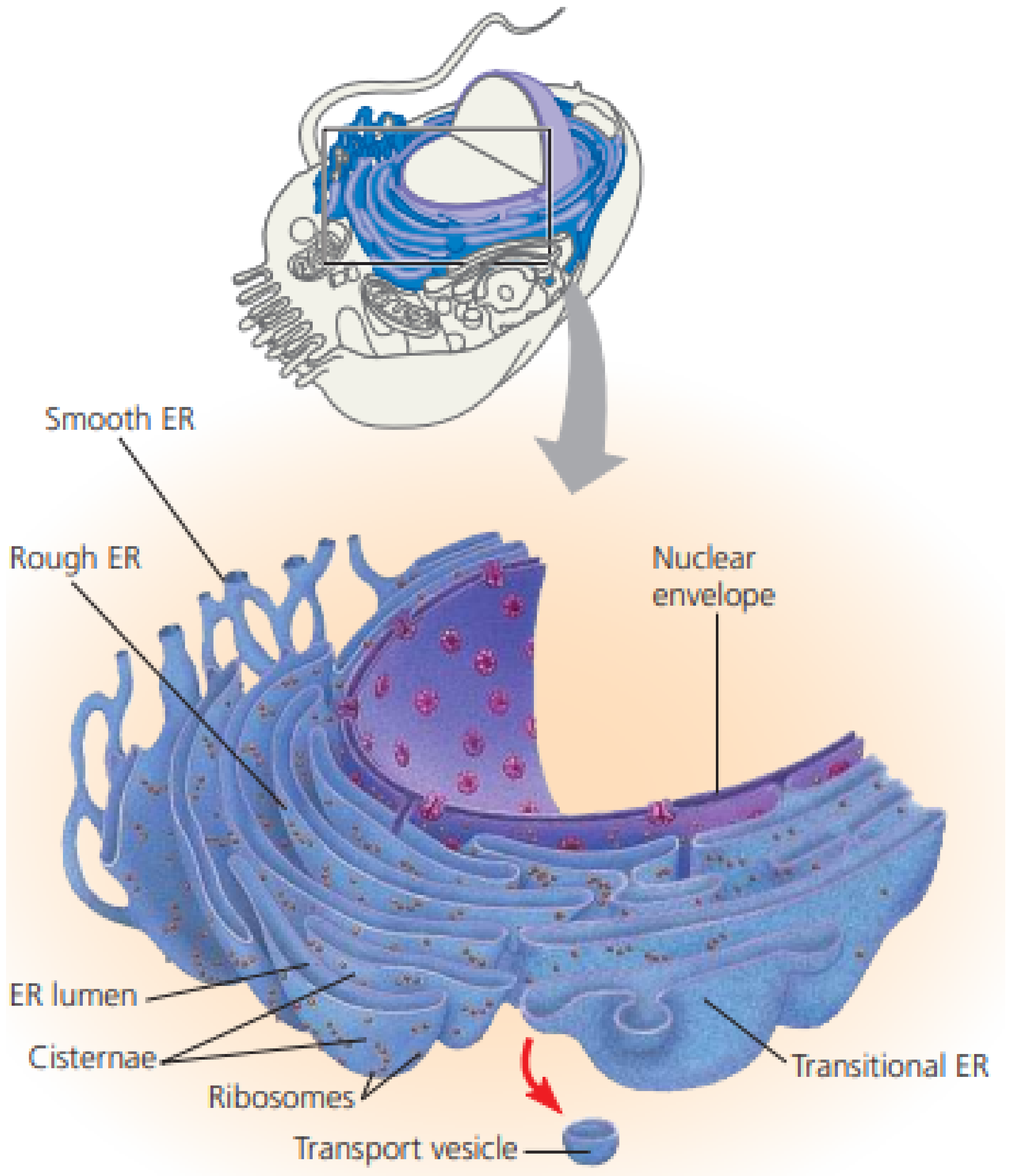
Cytoplasm

- The cytoplasm is a gel-like matrix containing water, salts, proteins, and other molecules.
- It occupies the intracellular space between the cell membrane and the nucleus.
- It plays a crucial role in biochemical reactions, energy production, and substance transport.
- Essential for cellular metabolism, it provides structural support to the cell.



Endoplasmic reticulum

- A network of interconnected membranes that extends from the nuclear membrane to the cell membrane.
- It plays a fundamental role in the transport, processing, and distribution of proteins and lipids within the cell.
- There are two main types of ER:
- Rough Endoplasmic Reticulum (RER) is studded with ribosomes and is involved in the synthesis and modification of proteins.
- Smooth Endoplasmic Reticulum (SER) specializes in lipid synthesis, carbohydrate metabolism, and detoxification.



Rough Endoplasmic reticulum (RER)

Protein Synthesis:

- Ribosomes attached to the rough ER synthesize proteins that are usually destined for secretion or for incorporation into membranes.
- For example, pancreatic cells use the rough ER to synthesize the hormone insulin, which is then secreted into the bloodstream.

Processing and Folding of Proteins:

- As polypeptides are synthesized on ribosomes, they are threaded into the ER lumen through protein complexes in the ER membrane.
- Once inside the lumen, the polypeptides fold into their functional three-dimensional shapes.

Rough Endoplasmic reticulum (RER)

Glycosylation of Proteins:

- Many secretory proteins are glycoproteins, meaning they have carbohydrate groups covalently bonded to them.
- The rough ER enzymes add carbohydrate groups to the proteins inside the ER lumen, a crucial step in glycoprotein formation.

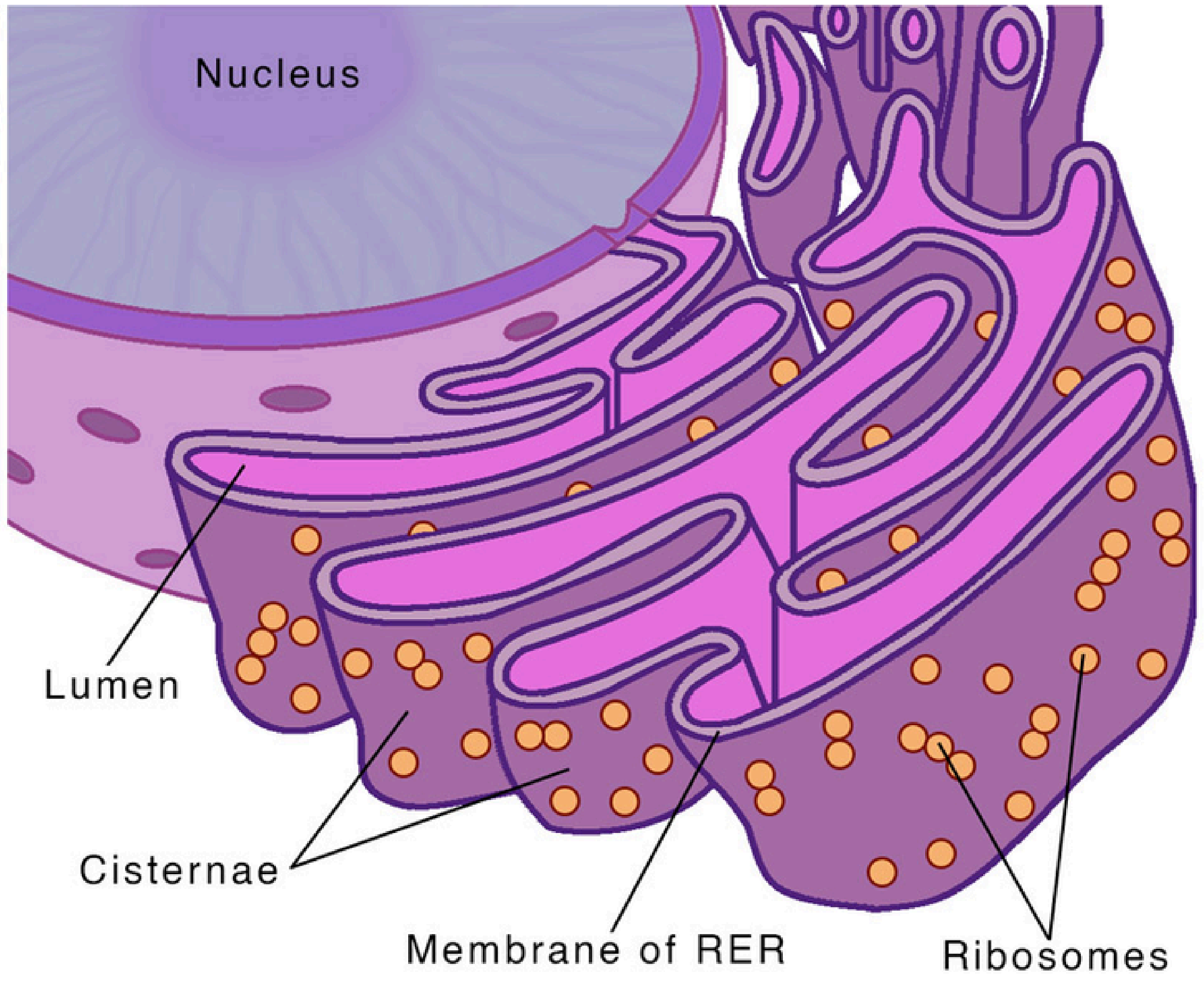
Membrane Protein and Lipid Production:

- The rough ER also serves as a membrane factory, adding membrane proteins and phospholipids to its own membrane.
- Membrane proteins that are destined for the cell membrane are inserted directly into the ER membrane during synthesis.
- The rough ER also synthesizes membrane phospholipids through enzymes embedded in its membrane.

Rough Endoplasmic reticulum (RER)

Transport:

- After processing proteins, the rough ER packages them into transport vesicles that bud off from the transitional ER (a specialized region of the rough ER).
- These transport vesicles carry proteins to other parts of the cell, including the Golgi apparatus.



Smooth Endoplasmic reticulum (SER)

Synthesis of Lipids:

- Smooth ER synthesizes lipids, including oils, steroids, and phospholipids that are essential for membrane formation.
- It is especially abundant in cells that produce steroid hormones, such as cells in the testes and ovaries, which synthesize sex hormones.

Metabolism of Carbohydrates:

- Smooth ER enzymes are involved in carbohydrate metabolism, helping cells process sugars and manage their energy stores.

Smooth Endoplasmic reticulum (SER)

Detoxification:

- Smooth ER helps detoxify drugs and poisons. In liver cells, enzymes in the smooth ER add hydroxyl groups to drugs, making them more water-soluble and easier to excrete from the body.
- Certain drugs, such as barbiturates and alcohol, induce the proliferation of smooth ER, leading to increased detoxification capacity. This can increase drug tolerance, requiring higher doses to achieve the same effect.

Calcium Ion Storage:

- The smooth ER stores calcium ions, which are important for various cellular processes.
- In muscle cells, the smooth ER pumps calcium ions from the cytosol into the ER lumen, and releases them when the muscle cell is stimulated, triggering muscle contraction.
- In other cells, the release of calcium ions can trigger processes such as secretion.

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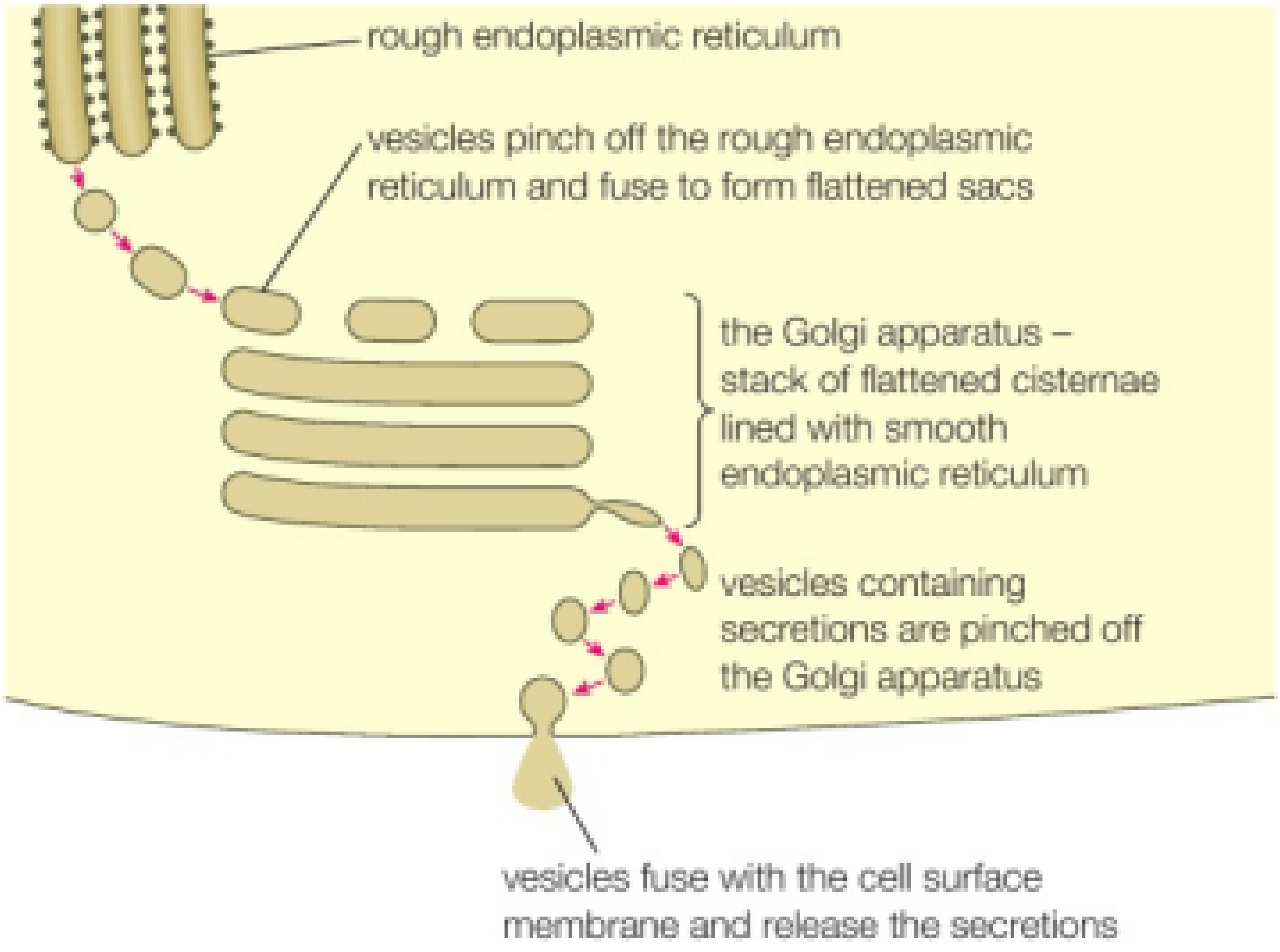
Golgi apparatus

Structure:

- Consists of a series of flattened, membrane-bound sacs known as **cisternae.**
- **It has two faces: the cis face (the receiving side) and the trans face (the shipping side).**
- The cis face is usually located near the ER, and vesicles from the ER deliver materials to the Golgi.
- The trans face is where vesicles bud off to send material to other organelles or the plasma membrane.



Golgi apparatus

Modification of ER Products:

- As materials from the ER move through the Golgi stack (from cis to trans), they are modified. For example, glycoproteins have their carbohydrate chains modified in the Golgi.

Manufacture of Macromolecules:

- The Golgi synthesizes some macromolecules, such as polysaccharides (e.g., pectins in plant cells).

Sorting and Packaging:

- The Golgi apparatus sorts proteins and lipids based on molecular tags (e.g., phosphate groups) and directs them to their proper destinations.

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