DEPTH OF BIOLOGY

Unit - I

Introduction to human body

Definition and scope of anatomy and physiology, levels of structural organization and body systems, basic life processes, homeostasis, basic anatomical terminology.

Cellular level of organization

Structure and functions of cell, transport across cell membrane, cell division, cell junctions. General principles of cell communication, intracellular signaling pathway activation by extracellular signal molecule, Forms of intracellular signaling: a) Contact-dependent b) Paracrine c) Synaptic d) Endocrine

Tissue level of organization

Classification of tissues, structure, location and functions of epithelial, muscular and nervous and connective tissues.

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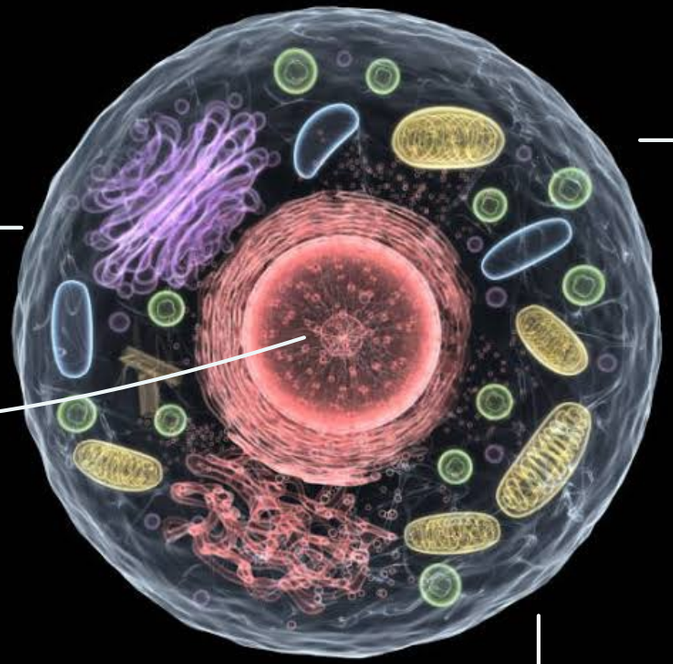
Characteristics of Cell.

→ Provide Structure & Support to Organism.

Available in different Shape & Sizes.

Structural, Functional & Biological Unit of Life.

1665.
Discovered by Robert Hooke.



Cell Can replicate Itself

Nucleus Contain genetic Information for Growth & Reproduction.

Study of Cell Called Cell Biology.

Smallest Cell.
↓
Mycoplasma.

Unicellular → ●

Or

Multicellular → 

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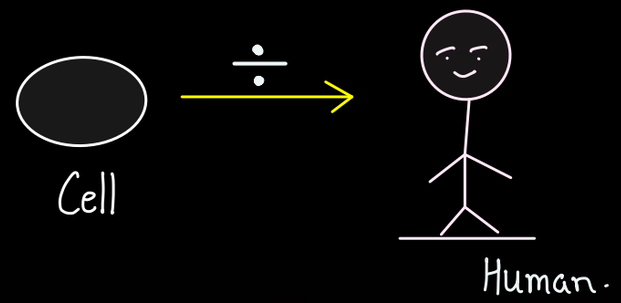
Cellular level of organization

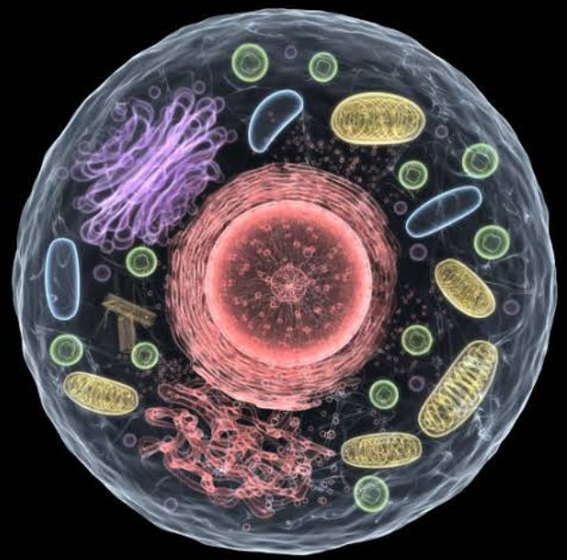
The cellular level of organization refers to the basic structural and functional unit of life, where cells, the smallest units capable of reproducing themselves, are the fundamental building blocks of all living organisms

Structure & Function of cell → Discovered by Robert Hooke.



Cells are the structural, functional, and biological units of all living beings.

A cell can replicate itself independently. Hence, they are known as the building blocks of life. A cell is the structural and fundamental unit of life.



The study of cells from its basic structure to the functions of every cell organelle is called Cell Biology.

Robert Hooke was the first Biologist who discovered cells.

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All organisms are made up of cells. They may be made up of a single cell (unicellular), or many cells (multicellular). Mycoplasmas are the smallest known cells.

Each cell contains a fluid called the cytoplasm, which is enclosed by a membrane. Also present in the cytoplasm are several biomolecules like proteins, nucleic acids and lipids. Moreover, cellular structures called cell organelles are suspended in the cytoplasm.

They provide structure to the body and convert the nutrients taken from the food into energy. They are of different shapes and sizes

In 1665, Robert Hooke, while examining a thin slice of cork under a microscope, observed tiny, box-like structures and coined the term "cell" to describe them, marking the beginning of cell discovery

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Characteristics of Cells

Following are the various essential characteristics of cells:

Cells provide structure and support to the body of an organism.

The cell interior is organised into different individual organelles surrounded by a separate membrane.

The nucleus (major organelle) holds genetic information necessary for reproduction and cell growth.

Every cell has one nucleus and membrane-bound organelles in the cytoplasm.

Mitochondria, a double membrane-bound organelle is mainly responsible for the energy transactions vital for the survival of the cell.

Lysosomes digest unwanted materials in the cell.

Endoplasmic reticulum plays a significant role in the internal organisation of the cell by synthesising selective molecules and processing, directing and sorting them to their appropriate locations.

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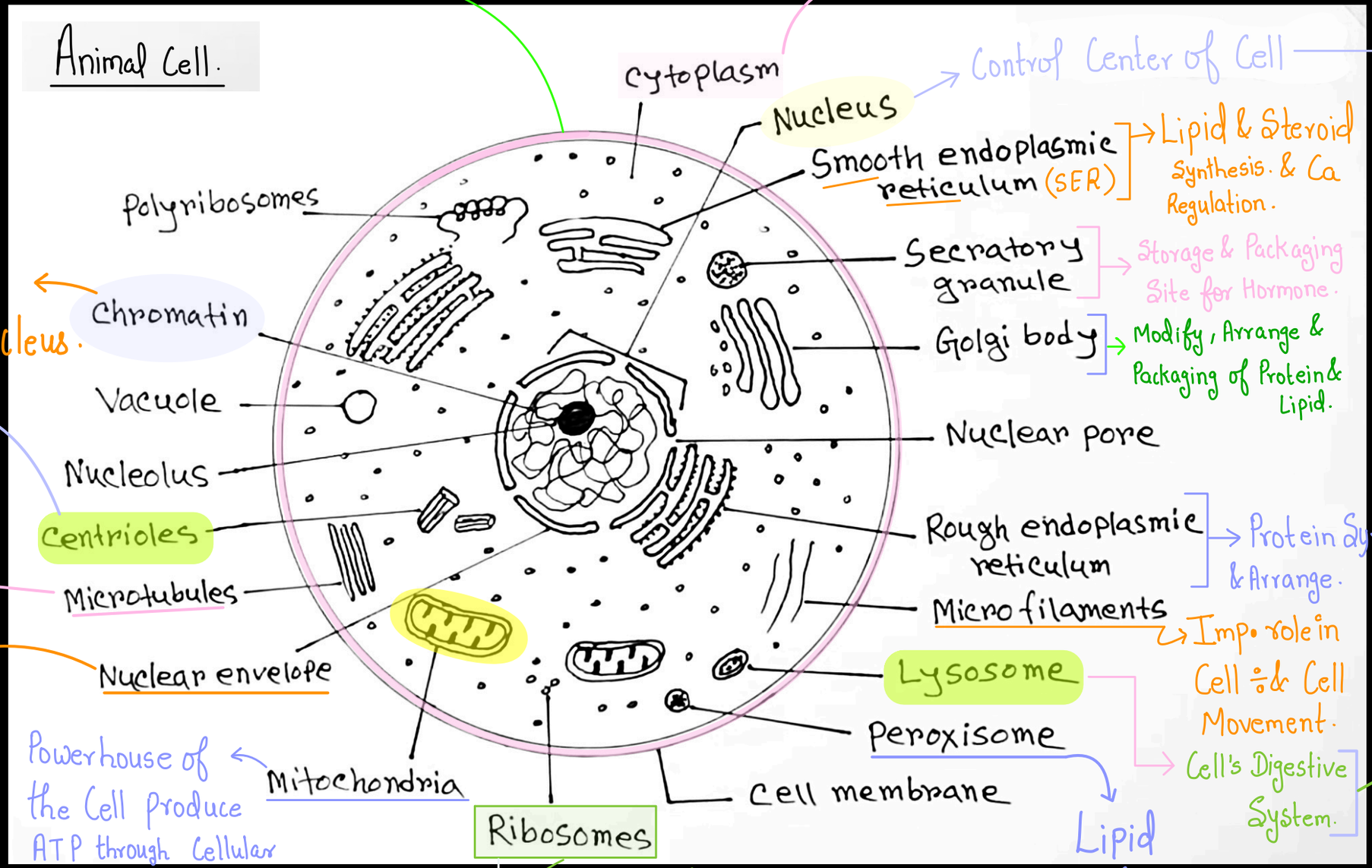

Semipermeable Membrane ↔ Protect the Cell & Control In/out of Molecule.

Jelly like Substance, Contain all Cell Organele

Control Center of Cell → Contain DNA. → Surrounded by Nuclear Membrane. Which Has pore for In/Out Molecule

Pore Diameter = 100 to 150 nm.

Lipid & Steroid Synthesis. & Ca Regulation.

Storage & Packaging Site for Hormone.

Modify, Arrange & Packaging of Protein & Lipid.

• Pack DNA for fit in Nucleus.

Cilia & Flagella formation. & Cell ÷

Imp. role in Cell ÷ & Motility.

Separate the Cytoplasm & Nucleoplasm.

Protein Synthesis, Modification & Arrange.

& ensure that protein are Correctly folded before release into Cell.

Imp. role in Cell ÷ & Cell Movement.

Cell's Digestive System. → Break down Waste & Cellular debris & Virus Bacteria.

Powerhouse of the Cell produce ATP through Cellular Respiration.

Protein factory of Cell.

→ May be free floating or attached with ER.

Metabolism.

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Structure of Cell

The structure of a cell consists of various components, each serving a specific function. Here's an overview of the key parts of a typical eukaryotic cell:

Cell Membrane (Plasma Membrane):

A semi-permeable membrane that surrounds the cell, protecting it and controlling the movement of substances in and out.

Cytoplasm:

The jelly-like substance inside the cell that contains all the organelles. It is the site for most cellular processes.

Nucleus:

The control center of the cell that contains DNA. It regulates cell activities, such as growth and reproduction.

It is surrounded by the nuclear membrane (or envelope), which has pores to allow molecules to move in and out.

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Mitochondria:

Known as the powerhouse of the cell, mitochondria generate energy in the form of ATP (adenosine triphosphate) through cellular respiration.

Ribosomes:

Small structures responsible for protein synthesis. They can be free-floating in the cytoplasm or attached to the rough endoplasmic reticulum.

Endoplasmic Reticulum (ER):

A network of membranes involved in protein and lipid synthesis. It comes in two types:
Rough ER: Studded with ribosomes and involved in protein synthesis and modification.
Smooth ER: Involved in lipid synthesis and detoxification processes.

Golgi Apparatus:

Involved in modifying, sorting, and packaging proteins and lipids for delivery to other parts of the cell or secretion outside the cell.

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Lysosomes:

Contain digestive enzymes that break down waste materials, cellular debris, and foreign invaders.

Peroxisomes:

Organelles involved in the breakdown of fatty acids and detoxifying harmful substances.

Cytoskeleton:

A network of fibers (microtubules, actin filaments, and intermediate filaments) that provide structural support, shape, and assist in cellular movement.

Centrosome (and Centrioles in animal cells):

Involved in organizing microtubules and regulating cell division.

Vacuoles:

Membrane-bound sacs used for storage, waste disposal, and maintaining the cell's shape, particularly prominent in plant cells.

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Cell Wall (in plant cells, fungi, and some bacteria):
A rigid outer layer that provides structural support and protection, made primarily of cellulose in plants.

These are the primary structures in a typical eukaryotic cell. Prokaryotic cells, like bacteria, have fewer organelles and lack a nucleus.

Functions of Cell

Cells perform a variety of essential functions to sustain life. These functions are coordinated to maintain the cell's integrity, energy production, growth, and communication with other cells. Here's a breakdown of the key functions of a cell:

1.Metabolism:

The cell carries out chemical reactions necessary for life. These include processes like breaking down nutrients to release energy (catabolism) and building complex molecules (anabolism), which are vital for growth, maintenance, and energy storage.

2. Energy Production:

Cells produce energy primarily in the form of ATP (adenosine triphosphate) through processes like cellular respiration (in mitochondria) and photosynthesis (in plant cells via chloroplasts).

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3. Protein Synthesis:

Cells synthesize proteins based on genetic instructions stored in DNA. Ribosomes, along with the rough endoplasmic reticulum (ER), help in translating the genetic code into functional proteins that are essential for structure and function.

4. Growth and Development:

Cells divide and grow to form new cells, which allows organisms to develop and repair tissues. This includes the cell cycle, which leads to mitosis (for growth or repair) or meiosis (for sexual reproduction).

5. Reproduction:

Cells reproduce either sexually (through meiosis) or asexually (through mitosis), ensuring the continuation of genetic material and the survival of the organism.

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6. Homeostasis:

Cells maintain a stable internal environment (homeostasis) by regulating factors like temperature, pH, and ion concentrations. The cell membrane plays a crucial role in this by controlling the movement of substances into and out of the cell.

7. Transport:

Cells transport substances across the membrane and within the cell. This includes active transport (requiring energy) and passive transport (like diffusion or osmosis) to maintain proper concentrations of molecules.

8. Communication:

Cells communicate with each other through signaling molecules (such as hormones or neurotransmitters) and receptor proteins on the cell surface. This communication is crucial for coordinating cellular functions, growth, and immune responses.

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9. Defense and Protection:

Cells, especially those in the immune system, play a role in defending the body against harmful microorganisms, foreign substances, and damaged cells. This can involve processes like phagocytosis (cellular eating) or apoptosis (programmed cell death).

10. Waste Disposal:

Cells remove metabolic waste products (such as carbon dioxide, urea, or ammonia) through processes like exocytosis or via the lysosomes, which break down waste materials and cellular debris.

11. Structural Support:

The cytoskeleton gives the cell its shape, supports its internal structure, and aids in cellular movement and transport. It also helps with cell division.

12. Storage:

Cells store nutrients, ions, and other substances in organelles like vacuoles or lysosomes (in animal cells) for future use, or to keep harmful substances isolated until they can be dealt with.

Transport across Cell membrane

Transport across the cell membrane is crucial for maintaining the cell's internal environment, acquiring nutrients, and removing waste products.
The cell membrane is selectively permeable, meaning it controls which substances can enter and exit the cell.
There are several mechanisms for transport, which can be categorized into passive and active processes.

1. Passive Transport (Does not require energy):

In passive transport, molecules move from areas of high concentration to areas of low concentration, down their concentration gradient.

Diffusion:

The movement of small or nonpolar molecules (like oxygen or carbon dioxide) directly across the lipid bilayer of the cell membrane, from high to low concentration.

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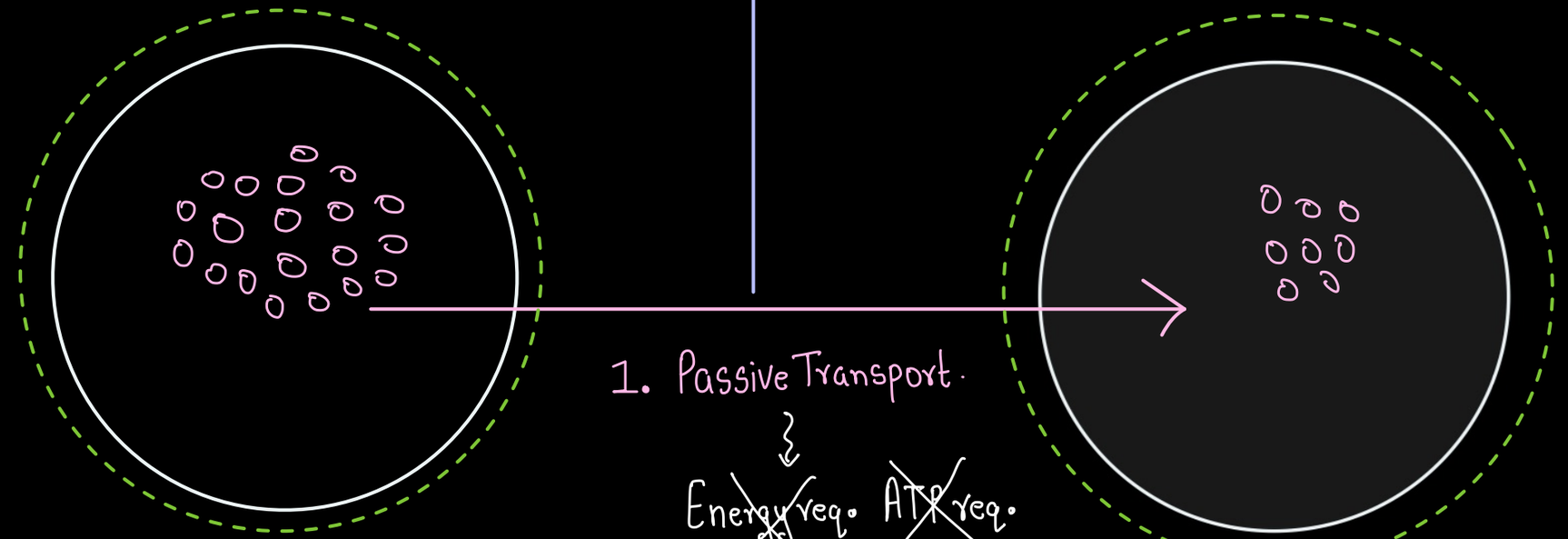
c). Osmosis → H_2O moves from Low Solute Conc. to High

→ Transport across Cell Membrane is Crucial for Nutrient Transport, Waste product removal



Cell Memberane (Selective permeable).

1. Passive Transport.
   ↓
   Energy ~~req.~~ ATP ~~req.~~

a). Diffusion → Movement of Small Non-polar Molecule. (O_2, CO_2).
   ↓
   High ⇝ Low.

b). Faciliated Diffusion. → It Use Membrane Protein.
   ↓
   High → Low.

eg → Channel protein or Carrier Protein

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Facilitated Diffusion:

Involves the use of membrane proteins (like channel proteins or carrier proteins) to help larger or polar molecules (such as glucose or ions) move across the membrane. This also occurs from high to low concentration but requires the help of a protein.

Osmosis:

The diffusion of water molecules across a selectively permeable membrane. Water moves from an area of lower solute concentration to an area of higher solute concentration. Osmosis is crucial for maintaining cellular water balance.

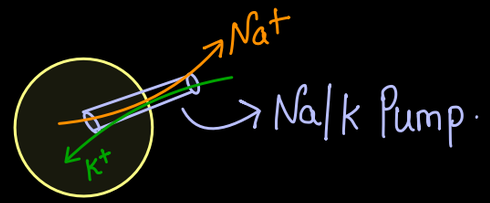
2. Active Transport (Requires energy):

Low ⟶ High.

Active transport involves the movement of substances **against their concentration gradient** (from low to high concentration), and it **requires energy, usually in the form of ATP.**

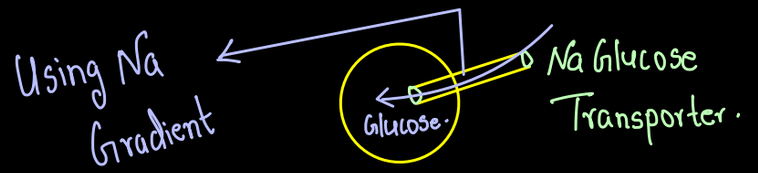
Primary Active Transport:

Direct use of energy to move ions across the membrane. A common example is the sodium-potassium pump, which moves sodium (Na+) out of the cell and potassium (K+) into the cell, both against their concentration gradients.



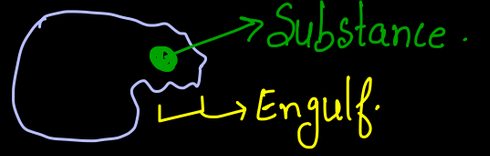
Secondary Active Transport:

This process **indirectly uses energy.** It relies on the gradient created by primary active transport. For example, symporters or antiporters use the movement of one molecule down its concentration gradient to move another molecule against its gradient. An example is the sodium-glucose transporter, which moves glucose into the cell using the sodium gradient established by the sodium-potassium pump.



3. Bulk Transport (Vesicular Transport)

Bulk transport, also called vesicular transport, involves the movement of large particles, liquids, or even entire cells across the cell membrane. This process requires the formation of vesicles (small membrane-bound sacs) and typically requires energy.



a) Endocytosis

Definition: Endocytosis is the process by which cells engulf external substances to bring them into the cell.

Mechanism: The cell membrane wraps around the substance and pinches off, forming a vesicle that enters the cytoplasm. There are different types of endocytosis, including:

Phagocytosis: "Cell eating," where the cell engulfs large particles like debris or microorganisms. Typically carried out by immune cells like macrophages.

Pinocytosis: "Cell drinking," where the cell engulfs extracellular fluid and dissolved substances.

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b) Exocytosis

Definition: Exocytosis is the process by which cells expel substances to the external environment.

Mechanism: The cell uses vesicles that contain materials (such as waste products or secretory proteins) that fuse with the cell membrane, releasing their contents outside the cell. Exocytosis is essential for the secretion of substances like hormones, neurotransmitters, and digestive enzymes.

Example: The release of insulin from pancreatic cells or the secretion of neurotransmitters at synapses.

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Importance of Transport Across the Cell Membrane-

The various transport mechanisms help maintain cellular homeostasis by controlling the internal environment of the cell. These processes allow cells to:

Regulate ion concentrations (e.g., sodium, potassium, calcium) to create electrochemical gradients that are critical for functions like nerve signaling and muscle contraction.

Take up nutrients (e.g., glucose, amino acids) and expel waste products (e.g., urea, carbon dioxide).

Communicate with other cells through the release of signaling molecules and receptors.

Control the volume of water and maintain osmotic balance.

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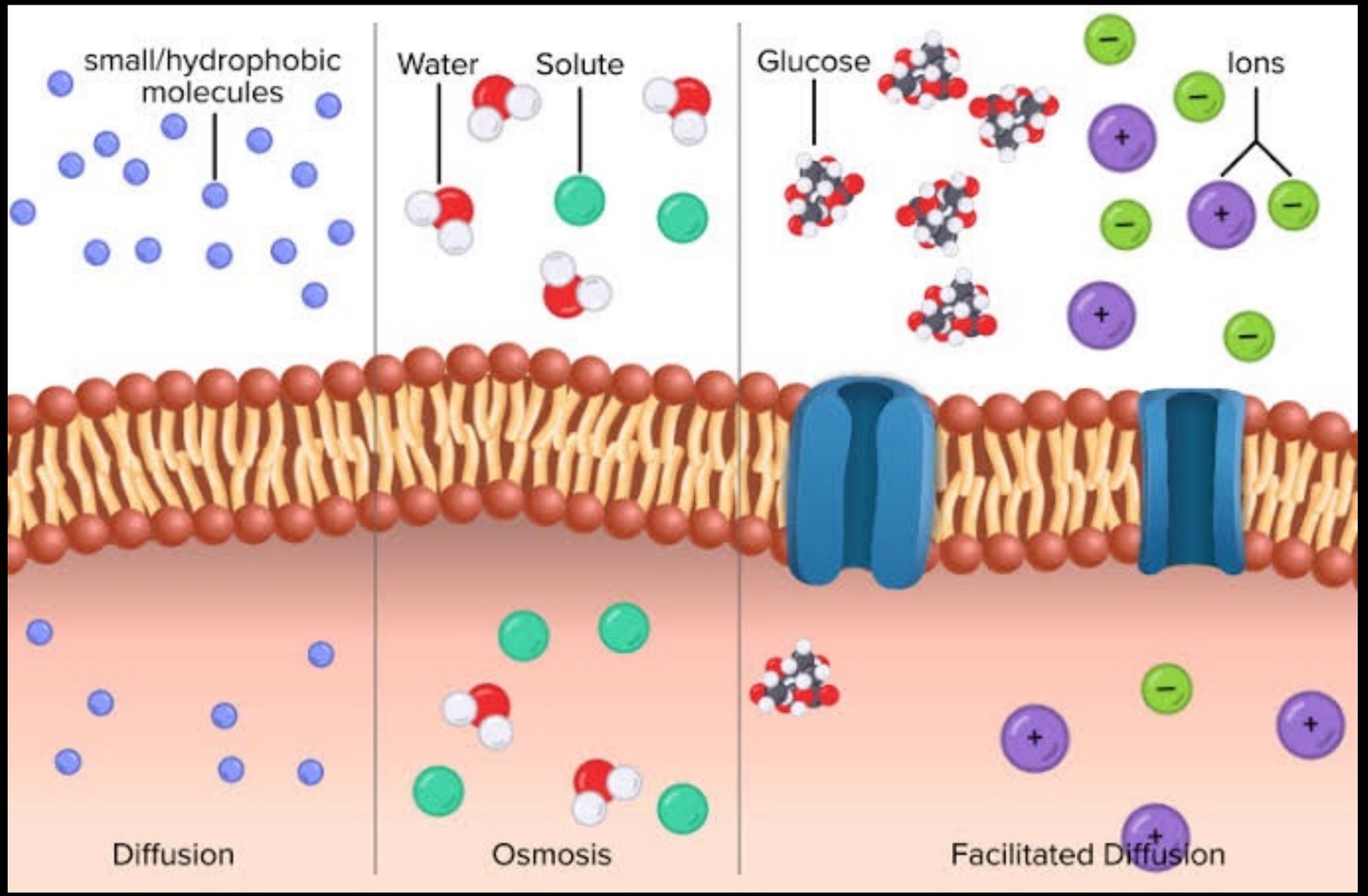
1. Passive Transport



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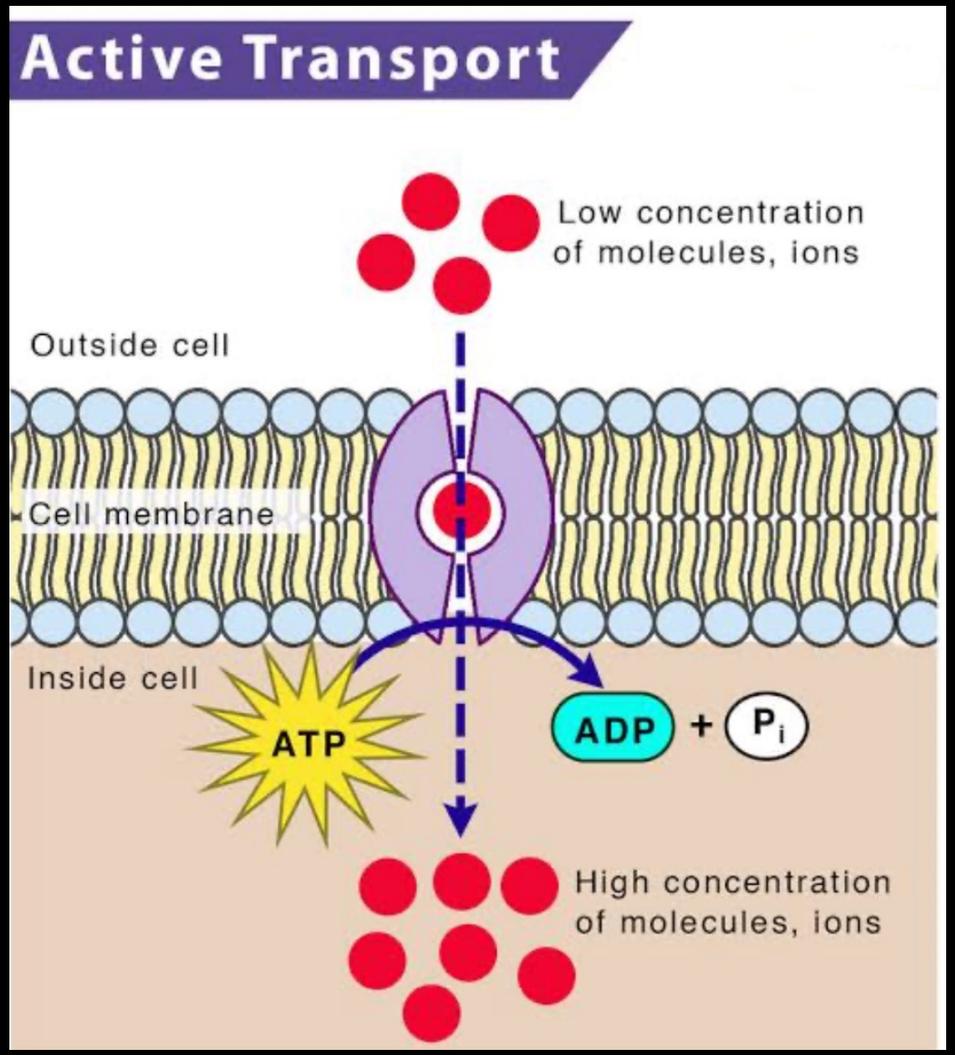
2. Active Transport



3. Bulk Transport