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Biological Sciences:

What is Cell?

Cell:

Introduction:

The cell, often regarded as the fundamental unit of life, represents the cornerstone of biological understanding. From the simplest microorganisms to the most complex organisms, cells form the building blocks of all living things.

History:

→ In 17th century Robert Hooke studied thin section of cork under his self-made compound microscope.

→ He observed that the cork is composed of minute honey comb like compartments which he termed as Cells.

→ Lorenz Oken (1805) a German scientist, believed that "all living beings originate from or consists of vesicles or cells".

→ Jean Baptist de-Lamark (1809) expressed similar idea and said "no body can have life if its constituent parts are not cellular tissues or not formed by cellular tissues".

→ A German zoologist Theodar Schwann (1839) and a German botanist Schleiden (1838), working independently, came out with a theory called the cell theory.

→ Robert Remak's discovery of cell division (mitosis) in the 19th century provided evidence for cell continuity.

→ Rudolph Virchow (1855) assertion of "Omnis cellula e cellula" (every cell stems from another cell) consolidated the cell theory.

* Word Cell:

The word cell is derived from a Latin word "cellula" which means "a little room".

* Definition:

"A cell is defined as the smallest, basic unit of life that is responsible for all of life's processes".

* Parts Of Cell: There are three main parts of cell:

i- Outer membrane.

ii- The fluid surrounding the nucleus (Cytoplasm).

iii- Nucleus

Cell Theory:

Cell Theory consists of following three main points:

i- All organisms are composed of one or more cells.

ii- All cells arise from pre-existing cells.

iii- Cell is the basic structural and functional unit for all organisms.

Types Of Cells:

With the discovery of the electron microscope in 1940, it was possible to observe and understand the complex structure of the cell and its various organelles. Based on the cellular structure, there are two types of cells:

i- Prokaryotic cell

ii- Eukaryotic cell.

Prokaryotic cell	Eukaryotic cell
Organisms:	
The organisms made up of prokaryotic cell are called prokaryotes. e.g; Bacteria.	The organisms made up of eukaryotic cell are called eukaryotes. e.g; animals, plants, protists.

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Meaning:

Prokaryote	Eukaryotes
Prokaryote come from "Greek words" pro → mean "before" and karyon means "nucleus"	word Eukaryotes derived from Greek words. Eu → "true" and karyon → nucleus.

Nucleus:

Prokaryotic cell	Eukaryotic cell
have no nucleus, Instead, some prokaryotes, such as bacteria, have a region within the cell where the genetic material is freely suspended. This region is called the nucleoid.	are characterized by a true nucleus.

Chromosomes:

Chromosomes are present in the cytoplasm and no membrane bounded nucleus is present.	Chromosomes are present in membrane bounded nucleus.

Membrane-Bounded Organelles:

Absent	Present

Ribosomes:

Ribosomes are of small size and freely scattered in cytoplasm.	Ribosomes are of large size and are present on endoplasmic reticulum or free in cytoplasm.

Size:

The cell size ranges from 0.1 to 0.5μm in diameter.	The size of the cells ranges b/w 10-100μm in diameter.

Mode Of Reproduction:

Prokaryotes reproduce by binary fission, a form of sexual reproduction.	They reproduce sexually as well as asexually.

Origin:

Evolved 3.5 billion years ago.	Evolved 1.5 billion years ago.

Examples:

Bacteria and Cyanobacteria	Animals, protists, plants and fungi.

★ Similarities b/w Prokaryotes and Eukaryotes:

1 **Genetic Material:**
Both contain genetic material (DNA) that carries instructions for the organism's structure and function.

2 **Cell membrane:**
Both have a cell membrane that separates the interior of the cell from its external environment and regulates the passage of molecules in and out of the cell.

3 **Ribosomes:**
Both have ribosomes, which are responsible for protein synthesis.

4 **Cytoplasm:** Both have cytoplasm, a gel-like substance that fills the interior of the cell and houses organelles.

5 **Metabolism:** Both carry out metabolic processes to generate energy and sustain life.

CSS - 2021 :

Explain with examples the relationship b/w cells, tissues and organs.

* Cells: The Building Blocks Of Life:

→ Cells are the smallest structural and functional units of living organisms.

→ They are the basic components of all living things.

Examples:

→ Nerve cells

→ Muscle cells

→ Epithelial cells.

Tissues : A Collection Of Similiar Cells:

→ Tissues are groups of similiar cells that perform a specific function.

→ They are formed when cells specialize and organize together.

Examples:

→ Epithelial tissue (skin, lung, lining)

→ Connective tissue (Bone & Cartilage)

→ Muscle tissue (skeletal, smooth)

→ Nervous tissue (Brain, spinal cord)

Organs: A Functional Unit Of tissues:

→ Organs are structures composed

of two or more types of tissues that work together to perform a specific function.

→ They are responsible for maintaining homeostasis and regulating body functions.

* **Examples:**

→ Heart (muscle and connective tissues)

→ Lungs (epithelial and connective tissue)

→ Brain (Nervous tissues)

→ Kidneys. (epithelial and connective tissue)

* **The Hierarchy of Life: Cells to Organs:**

→ Cells → Tissues → Organs → Organ system → Organism.

→ Each level is dependent on the previous one, and damage to one level can affect the entire hierarchy.

* **Example: The Digestive System:**

→ Cells (epithelial cells lining the digestive tract).

→ Tissues (epithelial tissues, connective tissues, muscle tissue).

→ Organs (mouth, esophagus, stomach, small intestine and large intestine).

→ Organ System (Digestive System).
→ Organism (the entire human body).

* Feedback loop:

Within organisms, there are feedback loops that regulate various physiological processes. **For example,** the endocrine system uses feedback loops involving hormones to regulate blood sugar levels, body temperature, and many other internal conditions essential for health and survival. These feedback loops involve communication b/w cells, tissues, organs and organ systems to maintain balance and respond to changes in the internal and external environment.

CSS 2018.

Describe the "cell structure". Write down at least three differences b/w an animal cell and plant cell.

Cell Structure:

The cell structure comprises individual components with specific functions essential to carry out life's processes. These components

include:

→ Cell wall
→ Cell membrane
→ Cytoplasm
→ Nucleus
→ Cell organelles.

* CSS 2021

* Cell wall:

→ The outermost boundary in most of the plant cells is cell wall. The cell wall of plant cell is different from that of prokaryotes, both in structure and chemical composition.

* **Definition:** The cell wall is a rigid, semi-permeable membrane that surrounds the cell membrane.

* Composition Of cell wall:

*. Bacterial cell wall:
→ Peptidoglycan (also called murein)
→ Techoic acids.

*. Fungal cell wall:
→ Chitin
→ Glucans.

*. Plant cell wall:
→ Cellulose
→ Hemicellulose
→ Pectin

* Functions of Cell wall :-

1 Support and Protection:
- → Mechanical strength.
- → Protection against external factors (temperature, PH, osmotic pressure).

2 Cell Shape:
- → Maintain cell shape.
- → Prevents cell collapse.

3 Cell Division:
- → Forms new cell plate during cytokinesis.

4 Cell Signaling :-
- → Platform for cell signaling and communication.

* Types Of Cell wall:

2 Types :

i Prokaryotic Cell wall:
- → Found in bacteria.
- → Composed of peptidoglycan.

ii Eukaryotic Cell wall:
- → Found in plants, fungi, and protists.
- → Composed of various components (cellulose, chitin, pectin).

* Importance Of Cell Wall:

* Survival:
  → Essential for cell survival.
  → Provides protection and support.
* Growth and Development:
  → Maintain cell shape.
  → Allows for cell expansion.

* Conclusion:

The cell wall is a vital component of cells, provide structural support, protection, and maintaining cell shape.

→ Its composition and functions vary among different organisms, but its importance remains crucial for cell survival and growth.

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* Cell MemBrane: (CSS-2021)

* Introduction:

It is outermost layer in animal cell while in plant cell it is covered by cell wall.

→ It forms the wall like structure b/w two cells as well as b/w the cell and its surrounding.

Definition: The cell membrane, also known as plasma membrane, is a thin, semi-permeable membrane that surrounds the cell.

→ It regulates what enters and leaves the cell, maintains cellular homeostasis.

Structure Of Cell membrane:

* Phospholipid Bilayer:

→ Hydrophilic (water-loving) head face outwards.

→ Hydrophobic (water-fearing) tails face inwards.

* Embedded Proteins:

→ Integral proteins (transmembrane proteins)

→ Peripheral proteins (lipid-anchored proteins).

Composition of cell membrane:

The composition of cell membranes vary depending on the cell type and organism but the general components are:

→ Protein (60-80%)

→ 20-40% Lipids.

→ Small quantity of carbohydrates.

Protein molecules are embedded in lipid bilayer; This model is called Fluid mosaic model.

★ Functions Of Cell membrane:

★ Transportation:

Transport of materials is one of the vital roles it play for the cell. It offers a barrier b/w the cell contents and their outer environment.

→ Transport of materials occur either by active transport (carrier protein, pumps) or by passive transport (Diffusion, Osmosis)

★ Differentially permeable membrane:

The plasma membrane allows only selective substance to pass through it. So it is called differentially permeable or selective permeable membrane.

★ Cell signaling:-

→ Provide receptors for hormones, neurotransmitter, and other signaling molecules.

→ Ligands bind receptor present in plasma membrane, activating G-protein, second messengers, and protein kinase, propagating signals to regular cellular responses.

* Cell Adhesion:

Cell Adhesion Molecules (CAMs) are proteins that are present on the surface of cell membrane and play important role in cell-cell interactions, adhesion, and communication.

e.g of CAMs: Integrins, Cadherins and Selectins.

* Cellular Homeostasis:

Maintain cellular environment, regulate PH, ions and molecule Transport.

* Endocytosis:

The intake of food material by in-folding the membrane in the form of vacuole is called Endocytosis.

*** Types of Endocytosis:**

1- Phagocytosis:

The process by which solid particles are engulfed by infolding membrane.

→ Also called cellular eating or cellular engulfment.

2- Pinocytosis:

The process by which liquid material is taken inside by infolding.

→ Also called "cellular drinking".

★ Transmission of nerve impulses:

The cell membrane of the neuron transmit the nerve impulses from one part of the body to the other part. It take's coordination in the body.

★ **Types Of Cell membrane:**

2 types:

i **Plasma membrane:** It surrounds the cell, regulates external environment.

ii **Organelle membrane:** It surrounds organelles, regulates internal environment.

★ **Importance:**

★ Survival

→ Essential for cell survival, regulates cellular homeostasis.

★ Cellular communication:

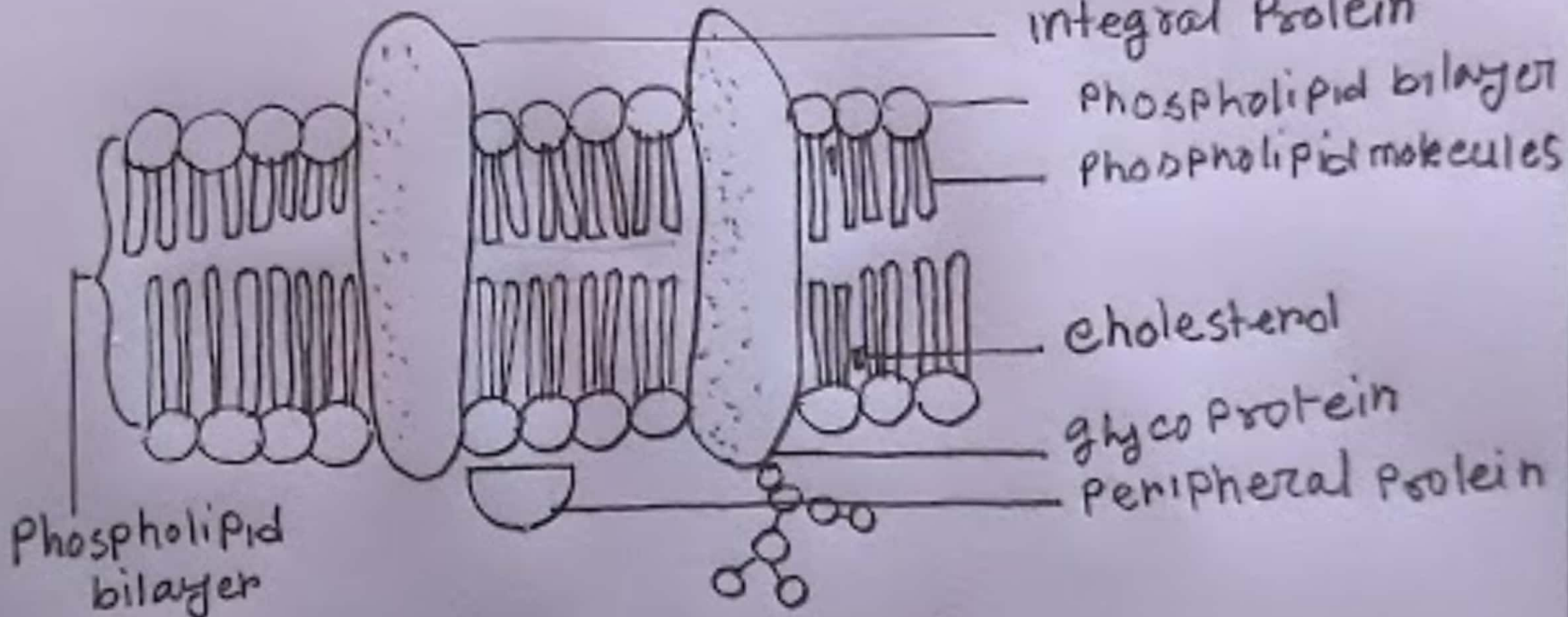
↳ Facilitates cell signaling, adhesion & recognition.

★ **Conclusion:**

The cell membrane is a vital component of cells, regulating what enters & leaves the cell, and maintaining cellular homeostasis.

→ It's structure & functions are crucial for cellular survival, communication and recognition.

cell membrane



cell Membrane

* Cytoplasm:

The living content of the protoplasm b/w plasma membrane and nucleus is cytoplasm.

→ Cytoplasm is the jelly like substance present inside the cell membrane.

→ It's a dynamic, semi-fluid environment where many cellular activities take place.

→ The cytoplasm has two parts:

i- Cytoplasmic organelles.

ii- Cytoplasmic inclusions.

* Cytoplasmic organelles:

Cytoplasm contain different cell organelles like: Mitochondria, Endoplasmic reticulum, Ribosomes, Lysosomes, Centrioles, Golgi bodies etc.

* Cytoplasmic Inclusions:

Cytoplasm also contains insoluble inclusions like: Glycogen granule, Lipid droplets, pigment granules, crystals (e.g; calcium oxalate) and waste products (e.g; melanin).

* Composition:

The cytoplasm is made of 70-90% water and is colorless usually. It also contain other fundamental

molecules of the cell which includes:
→ Salts (ions), Sugars, Amino acid, Nucleotides, Proteins (enzyme, structural, transport), Lipids (fats, oils), Pigments (carotenoids, melanin) and waste products.

★ Cytosol:

The soluble part of the cytoplasm is called cytosol. It forms the ground substance of the cytoplasm. In the cytosol, molecules are present in two forms:

★ True solution:

The small molecules and ions form true solution e.g; vitamins, mineral

★ Colloidal solution:

Large molecules present in cytosol form colloidal solution e.g; protein, lipids.

→ Colloidal solution is present in two forms:

i Sol:

The inner portion of cytoplasm i.e; toward the nucleus is less viscous and is called sol.

ii Gel:

The peripheral part of cytoplasm i.e; toward the plasma membrane is more viscous and is called gel.

* Functions of Cytoplasm:

→ Cytoplasm is the site of many biochemical rxns that are vital and crucial for maintaining life. e.g.; protein biosynthesis, Glycolysis etc.

→ The cytoplasm is the place where the cell expands and growth of the cell take place.

→ The cytoplasm provides a medium for the organelles to remain suspended.

→ Cytoplasm acts as storehouse of a cell. Most of important compounds like starch & glycogen are stored for energy and cellular functions.

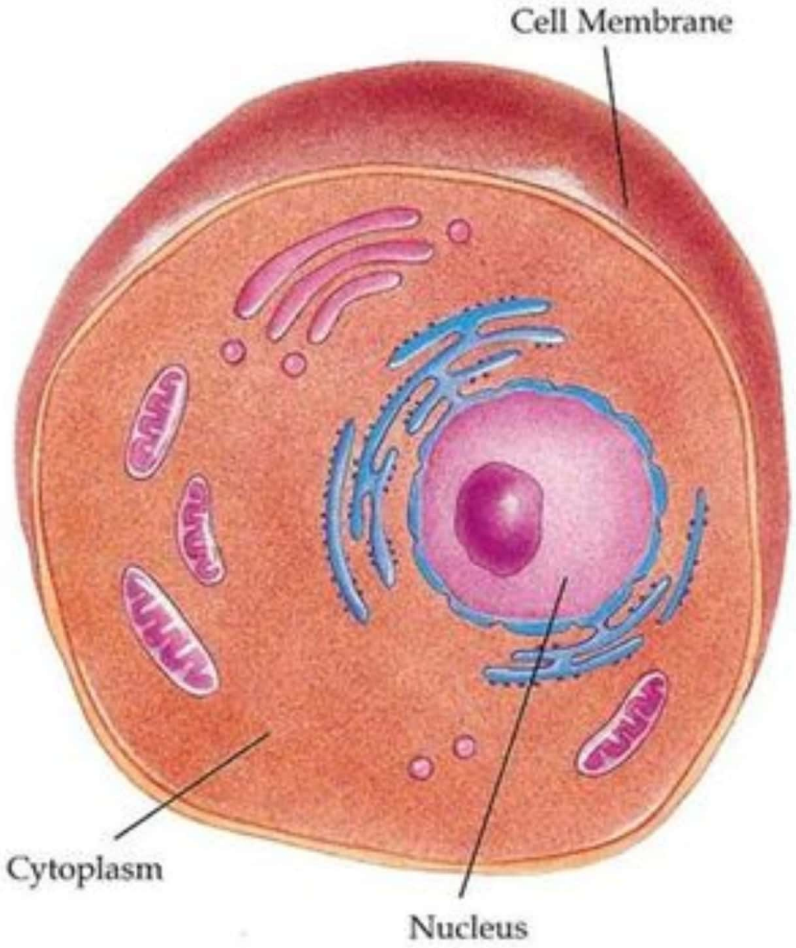
→ Cytoplasm facilitates the transport of molecules & organelles within the cell. e.g.; mitochondrial transport in nerve cell.

→ Cytoplasm helps to remove waste products, like urea, from the cell.
e.g.; Urea removal in Kidney cell.

→ It also aids in the movement of the different cellular elements.

→ It also transports the products of cellular respiration.

Image of Cytoplasm



★ Nucleus:

→ Nucleus was discovered by Robert Brown in 1831.

→ Nucleus is the most prominent and the most important part of the cell.

→ Location: In animal cells, it generally occupied the central space while in the case of plant cell it is pushed towards periphery due to presence of a large vacuole.

→ Shape:

Nucleus maybe irregular or spherical in shape.

→ Numbers:

No. of nucleus is different in different cells.

i- Mononucleate:

The cells having one nucleus are called mononucleate.

e.g; Parenchyma cell → in plants.
Epithelial cell → in animals.

ii- Binucleate:

The cells with two nuclei are binucleate.

e.g; Sclerenchyma cell → plants
Liver cell → Animals.

iii- Multinucleate or Coenocytic cells:

cells have more than two nuclei are multinucleate

(Plants) (Animals)

e.g.s: Collenchyma and Bone cell.

Structure Of Nucleus: The structure of nucleus consists of:

i Nuclear Envelope:

→ Also called nuclear membrane.
→ It's a double membrane structure surrounding the nucleus.
→ It regulates the movement of molecules in and out of the nucleus.

ii Nucleoplasm:

→ It form soluble nuclear sap inside the nucleus.
→ The sap contain Transparent semifluid ground substance formed of a mixture of protein, enzymes, free nucleotides and some metal ions for the synthesis of DNA and RNAs.

iii Nucleolus:

It is darkly stained body within the nucleus and is without any membraneous boundary to separate it from the rest of nuclear materials.
→ There maybe one or more nucleoli in the nucleus.
→ Nucleolus consist of 2 regions:
i- Peripheral granular area → contain ribosomal subunits.
ii- Central fibrillar area → Contain rRNA and rDNA.

→ Due to these regions, nucleolus are involved in the construction of ribosomes.

iv **Nuclear matrix:**

→ Network of fibers and proteins.
→ Provide structural support and regulates DNA replication and Transcription.

v **Chromatin and chromosomes:**

★ **Chromatin:**

Chromatin is a network of thin thread like structure made up of DNA and associated protein molecules (histones and non-histone protein)
→ It forms chromosome during cell division.

★ **Chromosome:**

During cell division chromatin fibres begin to condense and coil up into separate structure called chromosome.
→ Chromosome is made up of 2 arms and centromere
→ Each chromosome has two identical chromatids at the beginning of cell division. The chromatids are exact replica of each other.

→ These chromatids are attached with each other at a point known as centromere.

★ The centromere lies within a thinner segment of chromosome called primary constrictions.

★ Some chromosomes may also have another point of union along the length of chromatid called Secondary constrictions.

★ Do all living things have same ~~types~~ number of chromosomes?

The number of chromosomes varies. Many bacteria have one or two circular chromosomes.

→ Humans, along with other animals and plants have linear chromosomes that are arranged in pairs within the nucleus of the cell.

→ All the individual of the same species have constant no of chromosomes. These chromosomes remain constant generation after generation.

Species	Chromosome pairs	No of chromosomes.
★ Human	23	46
★ Fruit fly	4	8
★ Rice	12	24
★ Dog	39	78
★ Onion	8	16

★ Functions Of Nucleus:

→ It controls all the activities of cell.

→ The nucleus stores genetic information in the form of DNA, which contains the instructions for cellular growth, reproduction, and function. This information is passed from parents to offspring.

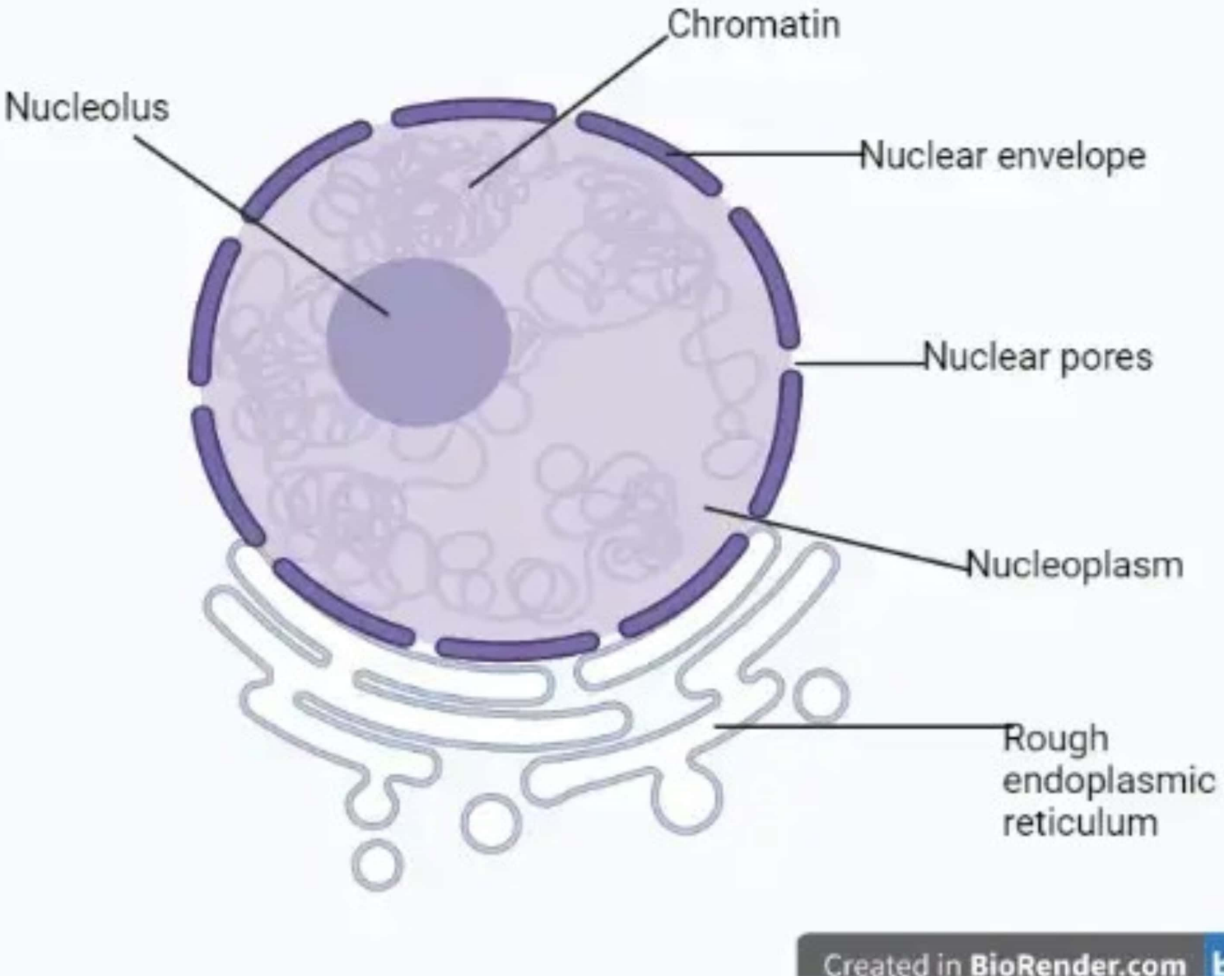
→ The nucleus regulates cell division, ensuring that cell divide correctly and at the right time. This is crucial for growth, development, and tissue repair.

→ The nucleus regulates protein synthesis which is essential for cellular growth, reproduction, and function.

→ The nucleus responds to external stimuli, such as stress or growth factors, by regulating cellular activities.

→ The nucleus replicates DNA before cell division, ensuring that each new cell receives a complete set of genetic instructions.

Nucleus



* Mitochondria:

Mitochondria are very important organelles of eukaryotic cell, bcz they are involved in the manufacture and supply of energy to the cell.

→ They are also known as Powerhouse of the cell.

→ Mitochondria contain DNA and ribosomes so that's why also called self-replicating organelle (synthesize their own proteins).

* Structure of Mitochondria:

Mitochondrial structure may vary depending on the cell type and organism. Some of the main components of its structure are:

i Outer membrane:

→ Phospholipid bilayer, porous structure allowing certain substances to pass through.

→ Contains proteins and lipids, regulating transport of molecules into and out of mitochondria.

ii Inner membrane:

→ Phospholipid bilayer, folded into cristae, increasing surface area for cellular respiration.

→ Help in energy production.

iii **Intermembrane Space:**

→ Region b/w outer and inner membrane containing mitochondrial DNA and regulating transport.

→ Involved in energy production, cellular metabolism and signaling pathways.

iv **Matrix:**

→ Region inside the inner membrane, containing enzymes and regulating cellular respiration.

→ Involved in energy production, ATP synthesis, and regulating cellular respiration.

v **Cristae:**

→ folded inner membrane, increasing surface area for cellular respiration and energy production.

vi **Mitochondrial DNA (mtDNA):**

→ Circular in shape.

→ Regulates mitochondrial function, energy production and cellular respiration.

vii **Mitochondrial ribosomes:**

→ Protein synthesis machinery, producing proteins for energy production and metabolism.

viii **Mitochondrial Protein:**

→ Regulate transport of molecules, energy prdction and help in metabolism.

★ Formation Of New mitochondria:

Mitochondria are self replicating organelles. It means new mitochondria are formed by the division of the old mitochondria.

★ Functions Of Mitochondria:

→ Generate energy for the cell through the process of cellular respiration, producing ATP and NADH.

→ Produce energy for the cell in the form of ATP, essential for cellular processes such as muscle contraction and nerve conduction.

→ It maintain cellular homeostasis by regulating calcium ion levels.

→ Initiate programmed cell death (appoptosis) regulating cellular growth and development and preventing cancer. Ensure damaged cells are removed, maintaining tissue health.

→ It regulate hormone production and secretion, controlling cellular metabolism and energy production.

→ It also involved in cellular signaling pathways regulating cellular processes.

→ Maintain cellular homeostasis, preventing oxidative stress and damage.

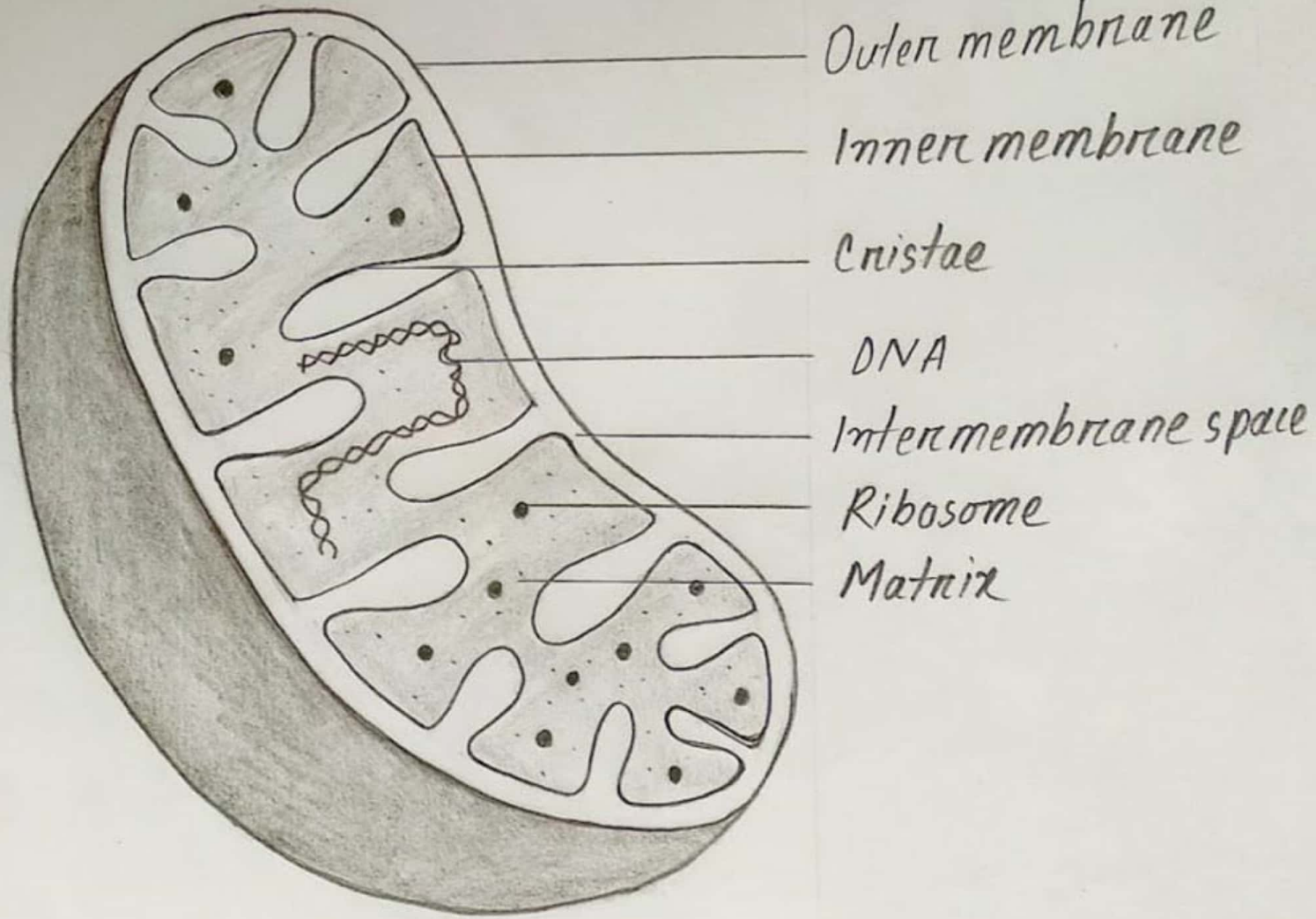


Figure: Mitochondria

* Endoplasmic Reticulum (ER):

→ Found in Eukaryotic cell.
→ Discovered by Porter in 1945.
→ The organelle that form the interconnected flattened sacs (cisternae) called ER.
→ Like other eukaryotic organelle it is also enclosed in membrane.

* Structure Of ER:

→ Composed of a network of membraneous tubule and cisternae, ribosomes, ER lumen, ER membrane and its connection to other organelles.

i Membraneous Structure:

→ Composed of phospholipid bilayer.
→ Similar in composition to the plasma membrane.

ii Tubules and Cisternae:

i- Tubules: narrow and winding structure
ii- Cisternae: flattened and sac-like structure.

→ Both tubules and cisternae are connected and form a continuous network.

iii **Ribosomes:**
→ Rough endoplasmic reticulum (RER) has ribosomes attached to surface.
→ Smooth endoplasmic reticulum (SER) lacks ribosomes.

iv **ER Lumen:**
→ The space inside the ER.
→ Contains protein and lipids being synthesized and transported.
→ Has a higher PH than the cytosol.

v **ER Membrane:**
→ Surround the ER.
→ Regulates the movement of molecules in and out of the ER.

* **Connection to other Organelles:**
→ Nuclear Membrane: ER is continuous with the nuclear membrane.
→ Golgi apparatus:
ER transport proteins and lipids to the Golgi apparatus for further processing and modification.
→ Plasma membrane:
ER can fuse with the plasma membrane, releasing proteins and lipids outside the cell.

* **Types Of ER:** 2 types
i- RER ii- SER.

i- **RER:**

→ Has ribosomes attached to surface.
→ Ribosomes are the site of protein synthesis.
→ RER is involved in protein synthesis and transport.

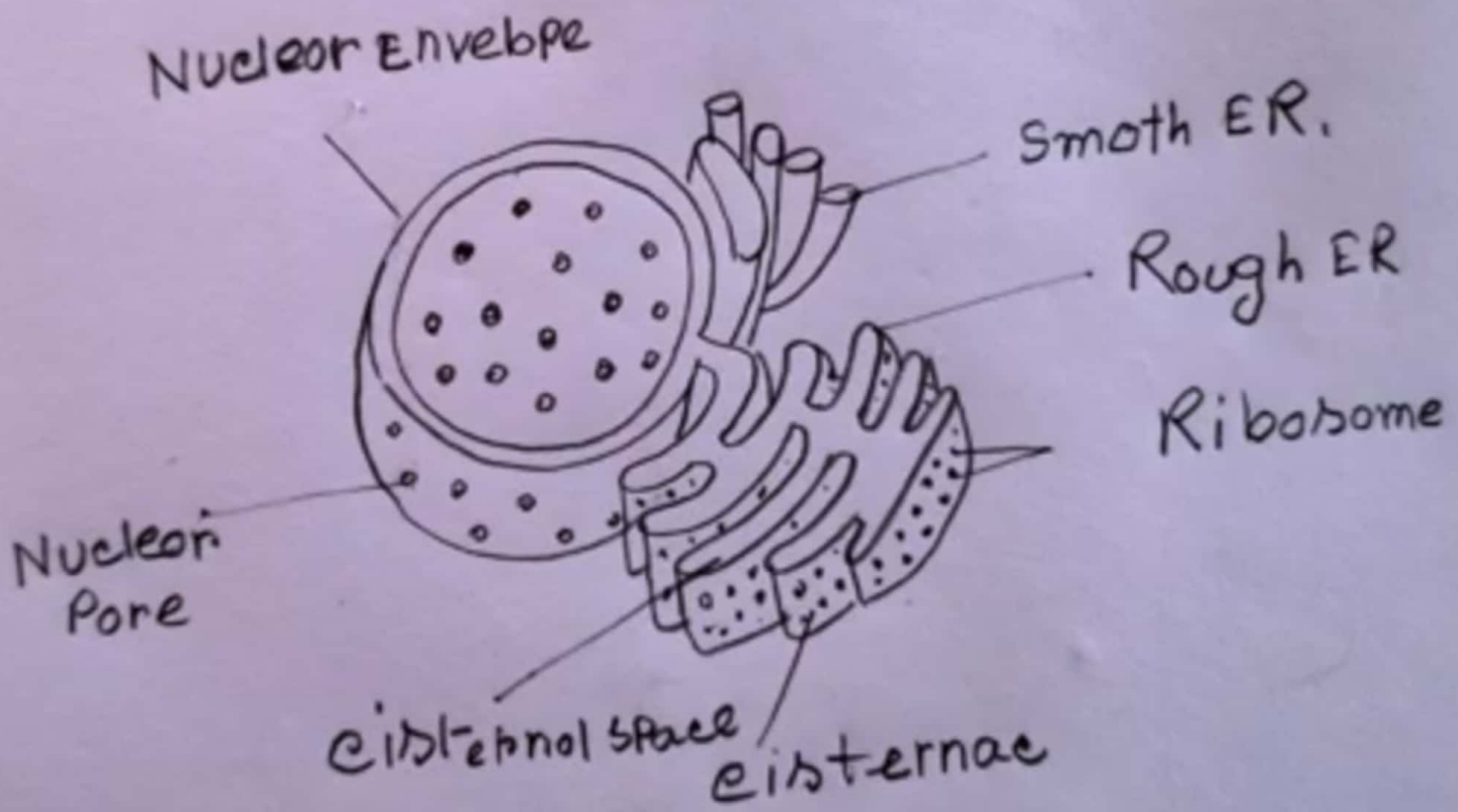
ii **SER:**

→ lacks ribosomes.
→ Involved in lipid metabolism and detoxification.
→ Contains enzymes for lipid synthesis and degradation.

* Functions Of ER:

→ It provide mechanical support to the cell so that shape of cell is maintained.
→ SER involved in transport of material from one part of cell to other parts.
→ RER is site of protein synthesis and transport protein to other organelle (e.g.; Golgi apparatus).
→ SER involved in lipid synthesis. It also regulates cholestrol metabolism.
→ SER detoxifies harmful drugs and toxic materials.
→ SER regulates intracellular calcium level and involved in transmission of nerve impulse in muscles and nerve cells.

ENDOPLASMIC RETICULUM



* Golgi Apparatus:

→ It was discovered by Camillo Golgi in 1898.

→ Golgi apparatus are present only in eukaryotic cells.

* Structure:

The structure of Golgi apparatus consists of:

i Cisternae:

→ Flattened sacs that make up the Golgi body.

→ Each cisternae has a unique set of enzymes and proteins.

ii Tubules:

→ Connect adjacent cisternae.

→ Involved in the transport of molecules b/w cisternae.

iii Golgi Stacks:

→ Multiple cisternae stacked Together.

→ Each stack has a specific function.

→ Stacks are connected by tubules.

iv Golgi matrix:

→ The regions b/w the cisternae contain enzymes and proteins that facilitate transport and modification.

v Golgi Vesicles:

→ Small membrane-bound sac that bud from the Golgi body.

→ Contain proteins and lipids for transport to other organelles or outside the cell.

★ Types Of Golgi Bodies: 3 types

i Cis Golgi Network:
→ Receives proteins and lipids from the ER (Endoplasmic reticulum).
→ Modifies and packages protein for transport.

ii Medial Golgi:
→ Modifies and transports proteins and lipids.
→ Involved in glycosylation and phosphorylation.

iii Trans Golgi Network:
→ Packages proteins and lipids into vesicles for transport.
→ Regulates protein secretion and cell signaling.

★ Functions Of Golgi apparatus:

→ Golgi apparatus help in protein modification by adding carbohydrates to protein (glycosylation) which increase stability of protein.
→ Golgi apparatus package proteins into vesicles for transport.
→ Vesicles bud from the Golgi ep

fuse with other organelles or plasma membrane.

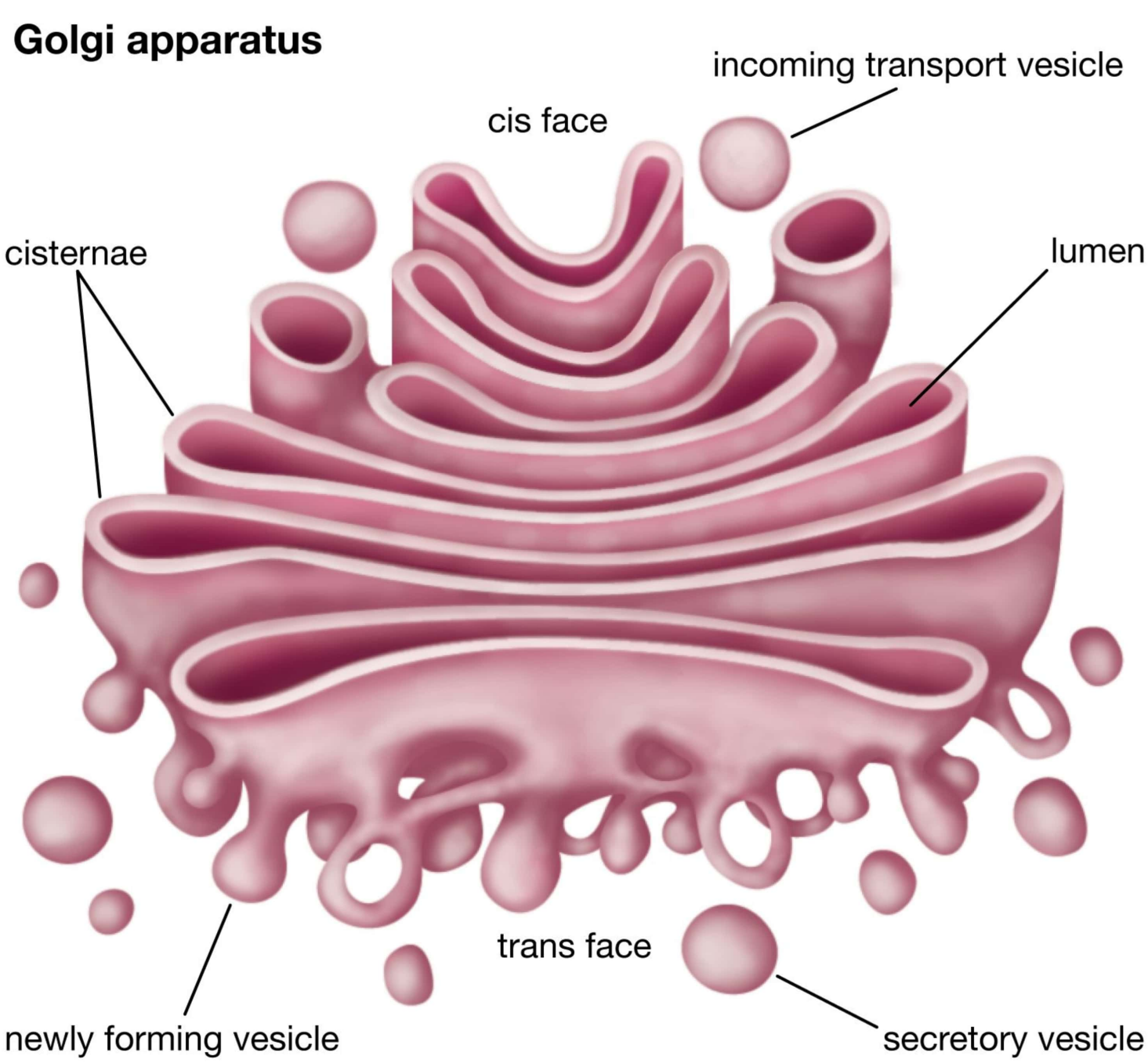
→ Golgi apparatus also help in the secretion of proteins outside the cell which help in cellular communication, signaling and regulate cellular response to stimuli.

→ Golgi apparatus regulates cellular communication and signaling.

→ Golgi apparatus add phosphate groups to proteins through phosphorylation, activating or inhibiting protein function.

→ Synthesize and modifies lipids, such as cholesterol and phospholipids, for membrane structure and function.

→ Formation of glycolipids is the most important function of golgi apparatus. They add carbohydrates to protein and lipids form glycolipids and glycoproteins.



★ Lysosomes:

→ Lysosomes were isolated by De Duve in 1949.

→ Lysosomes are secreted by Golgi complex.

→ The word Lysosomes is formed of two words:

i- "Lyso" means splitting.

ii- Soma means Body.

→ That's why lysosomes are also known as splitting Bodies.

→ They are found only in eukaryotic cells.

★ Definition:

Lysosomes are membrane-bound organelles found in eukaryotic cell that contain digestive enzymes and play a crucial role cellular digestion and recycling.

★ Structure Of Lysosomes:

→ single membrane bounded organelle.

→ Contain digestive enzymes e.g.; acid hydrolases and acid phosphatases.

→ Has a acidic interior (PH 4.5 - 5.5).

★ Types Of Lysosomes:

2 types.

i.

★ Primary Lysosomes:

→ Formed from the fusion of vesicles from the Golgi apparatus.
→ Contain digestive enzymes (acid hydrolases) such as:
→ Lysozyme
→ Lipases
→ Amylases
→ Have a PH of around 4.5-5.5
→ It digest and recycle cellular waste and debris.

ii.

★ Secondary Lysosomes:

→ Formed from the fusion of lysosomes with:
★ L→ Phagosomes (containing engulfed pathogen or debris.
★ L→ Autophagosomes (containing damaged cellular organelles or proteins).
→ Contain digestive enzymes & cellular waste.
→ Have a PH of around 4.5-5.5
→ It digest and eliminate pathogens, recycle damaged cellular organelles and proteins.

★ Functions Of Lysosomes:

→ Any foreign object which tries to enter into cell is engulfed by

lysosomes. It is broken into digestable pieces. The process is known as phagocytosis (cell eating).

-> Phagocytosis is important for:

i- Cellular defense

ii- Cellular recycling.

iii- Tissue repair.

→ Lysosomes involved in intracellular digestion in which lysosomes break down and degrade engulfed materials, such as proteins, lipids, carbohydrates and other cellular debris into smaller molecules that canbe reused by the cell or excreted.

↳ Intracellular digestion is crucial for:

→ Cellular recycling.

→ Cellular homeostasis.

→ In extracellular digestion the lysosomes release their digestive enzymes outside the cell to break down extracellular materials, such as: Dead cells, pathogens and Extracellular matrix.

↳ Extracellular digestion is important for:

→ Tissue repair and Tissue homeostasis

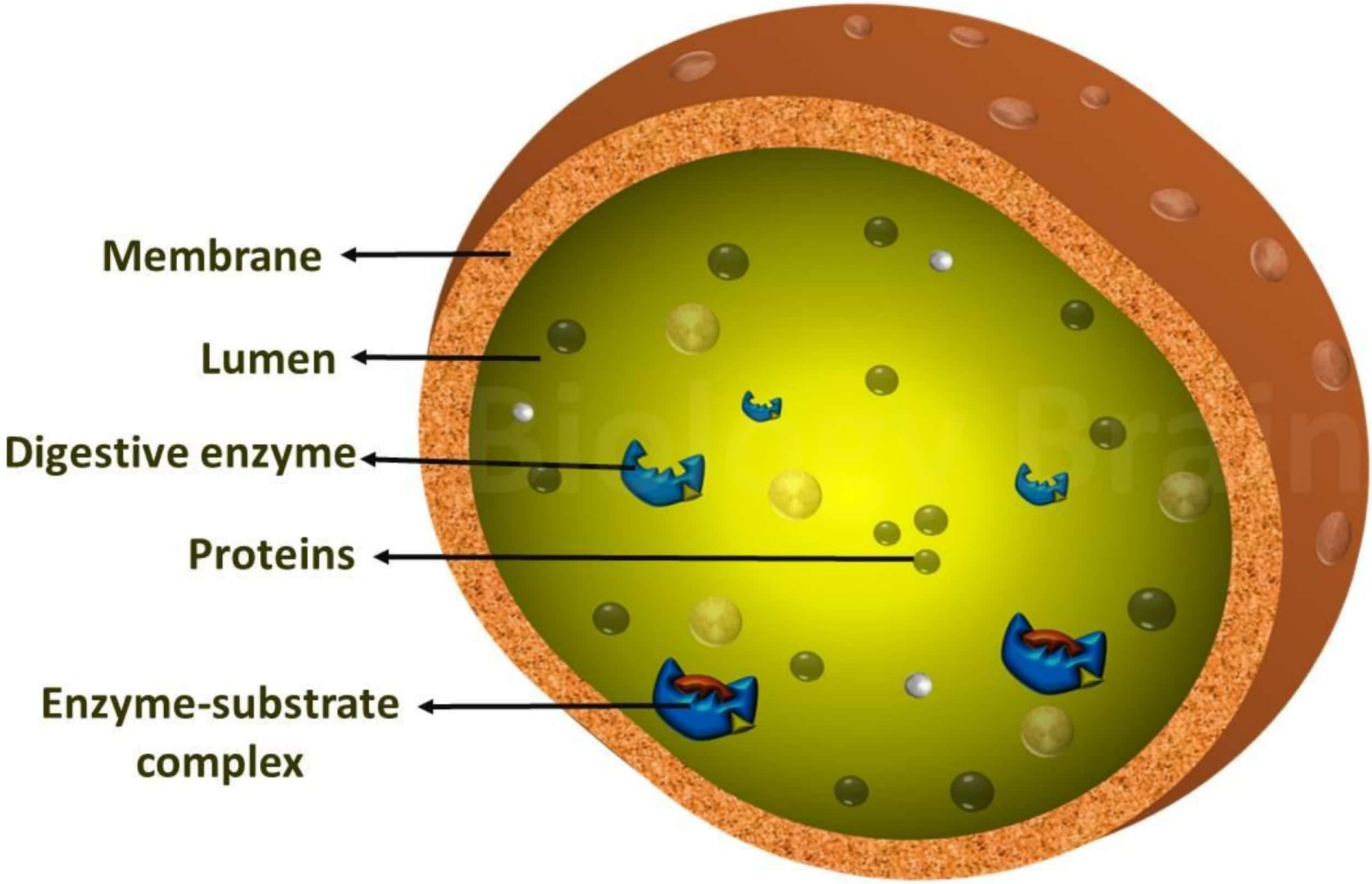
→ The process by which unwanted structures within the cell are

engulfed and digested within the lysosomes is called autophagy. This is the self eating of cell in which some old, broken part of the cell are digested by lysosomes. In this way material of the cell is recycled.

→ During developmental phases when a particular cell is required to be disintegrated, a type of cell death is committed with the help of enzymes of lysosomes, called autolysis. e.g; sperm or tail in the development of frog larvae is degenerated.

→ Lysosomal storage diseases are group of approximately 50 rare inherited metabolic disorders that results from defects in lysosomal functions.

→ The excess of vitamin A causes cell poisoning. It disrupts the lysosomal membrane, causing release of enzymes into the cell and producing autolysis in cartilage and bone tissue.


Membrane
Lumen
Digestive enzyme
Proteins
Enzyme-substrate complex

★ Ribosomes:

→ Cell contains many tiny granular structures known as ribosomes.

→ Palade (1955) was the first person to study them.

★ Chemical Composition :

Eukaryotic ribosomes contain equal amount of RNA and protein, hence they are ribonucleo-particles.

→ The RNA present in ribosomes is called ribosomal RNA and protein present is called ribosomal proteins.

★ Structure Of Ribosome:

The structure of ribosomes consists of 2 subunits:

i- Small subunits

ii- Large subunits.

★ Small subunits:

→ 30S in prokaryotes, 40S in eukaryotes.

→ Contain 16S rRNA → prokaryotes

→ " 18S rRNA → Eukaryotes

→ Has a binding site for messenger RNA.

→ Responsible for recognizing and binding to mRNA.

* Large Subunit:
  - → 50S in prokaryotes, 60S in eukaryotes.
  - → Contains 23S rRNA → Prokaryotes
  - → " 28S rRNA → Eukaryotes.
  - → Has a binding site for transfer RNA.
  - → Responsible for peptide bond formation and protein synthesis.
- → The small and large subunits combine to form a functional ribosome (70S in prokaryotes, 80S in eukaryotes).
- → The attachment of two subunits is controlled by the presence of Mg^{2+} ions.
* Total diameter of ribosomes is approximately 20-30nm.

* Occurence Of Ribosomes:

Ribosomes are present in two forms:
- → Freely dispersed form in cytoplasm, synthesize proteins for the cytoplasm.
- → Attached to RER synthesize proteins for ER and other organelles.

* Types Of Ribosomes: 2 Types:

i- Prokaryotic ribosome → 70S
↓
Found in bacteria and archaea.

ii- Eukaryotic ribosome → 80s
↓
found in fungi, protists, plants and animals.

* Polysome:

A group of ribosomes attached to same mRNA is known as polysomes.

* Formation of ribosomes:

The formation of ribosomes occur in nucleolus, where ribosomal RNA & proteins are synthesized and assembled into a large and small subunits. The subunits are then transported out of nucleolus and assembled into a complete ribosome in the cytoplasm.

* Functions Of Ribosomes:

i- Protein synthesis:

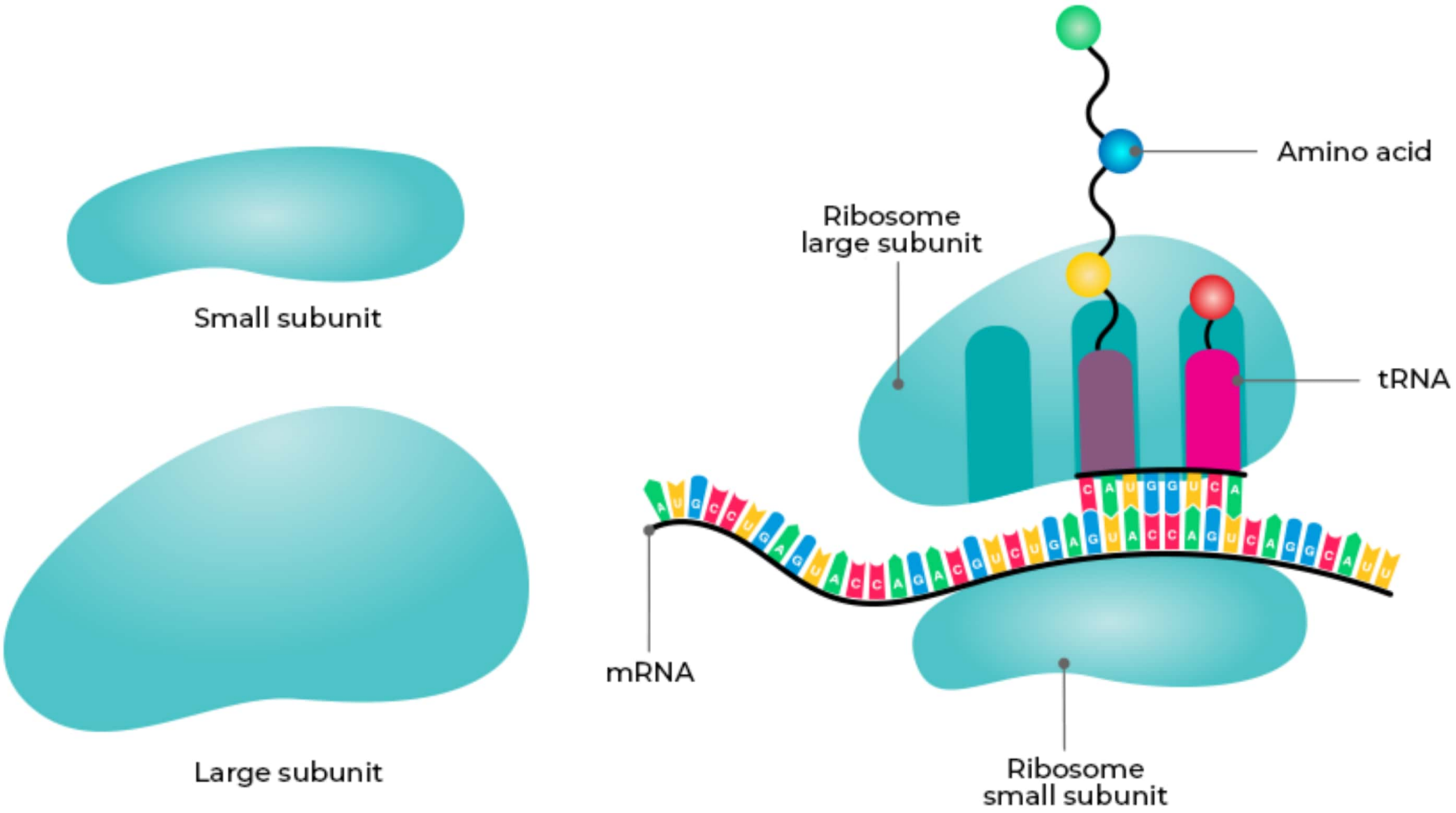
Ribosome translate mRNA into a specific sequence of amino acids from which protein synthesis occurs during a process called translation.

ii Peptide bond formation:

Ribosomes form covalent bonds b/w amino acids

iii Protein folding:

Ribosomes help to fold newly synthesize protein into


Small subunit
Large subunit
Amino acid
Ribosome
large subunit
tRNA
mRNA
Ribosome
small subunit

their correct shape.

→ Ribosomes can interact with other cellular components such as chaperones and proteases, to regulate protein synthesis.

★ Centrioles:

Centrioles are small, cylindrical structure present in animals cell but absent in plant cell.

→ They are typically found in pairs and are located near the outer surface of nucleus.

→ Two centrioles are present at right angle to each other

★ Structure:

→ Centriole are composed of 9 triplets of microtubules, surrounded by a protein called centrin.

→ Each triplet is composed of 3 microtubules: A, B and C.

→ The A microtubule is the longest and most stable, while the C microtubule is the shortest and most dynamics.

★ Microtubule Organization:

The microtubule triplets are connected to each other through protein bridges.

→ The A-tubules are connected to the

Central hub of the centriole.
→ The C-Tubules are connected to the periphery of the centriole.
* Associated Proteins:
Centriole are associated with various proteins, such as:
→ Tubulin (alpha and beta)
→ Centrin
→ Centriolin.

* Types Of Centrioles: 2 types:

i Mother Centriole:
The older, larger centriole that give rise to a new daughter centriole.
→ It has a more complex structure & is more stable.
→ It acts as a Template for the formation of the daughter centriole.

ii Daughter Centriole:
It is smaller, newly formed centriole.
→ It is less complex and more dynamic than the mother centriole.
→ It will eventually mature into a mother centriole.

* Functions Of Centriole:

→ Centrioles act as basal bodies, giving rise to cilia and flagella, essential for cell movement and sensing.

→ The centriole are involved in cell division. The two centriole duplicate just before cell division and forms two pairs. Each pair moves to the opposite side of the nucleus. The spindle is formed b/w them, separating chromosomes during mitosis and meiosis.

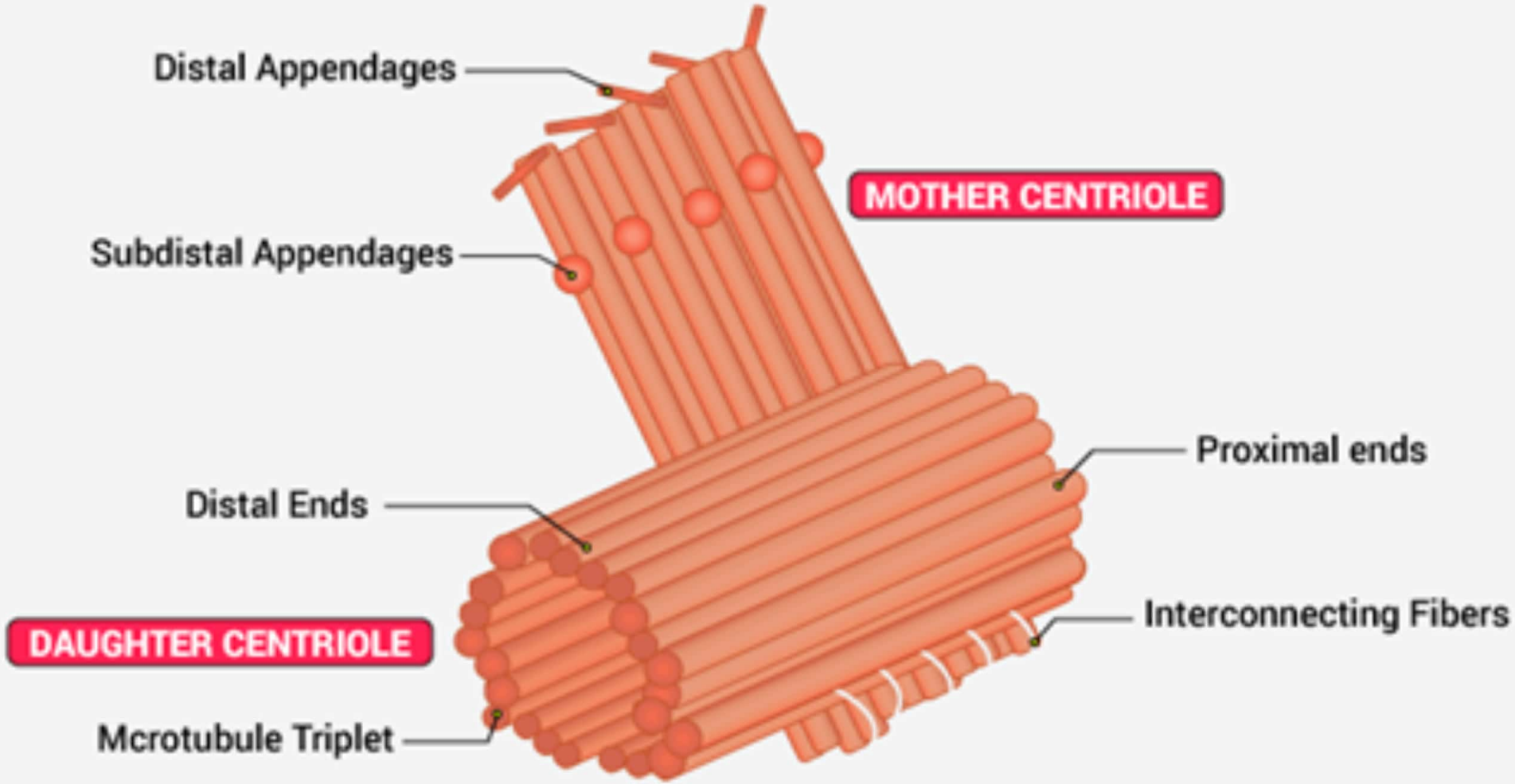
→ Centriole assist in the movement of vesicles and organelles along microtubule. They help in transport of materials and maintain cellular organization.

→ Centrioles regulate microtubule dynamics, influencing cytoskeletal structure and function. They maintain cellular, shape, organization and mechanical properties.

→ Centrioles help regulate cell migration by organizing microtubule and interacting with cytoskeleton. They facilitate cell movement and adhesion.

→ Centrioles help in the formation of furrowing during cell division.

CENTRIOLE



★ Vacuoles:

→ Vacuoles are found in eukaryotic cell, bounded by a single membrane and are formed by the coalescene of smaller vacuoles during the plant's growth and development.

→ In animals cell vacuole is formed by phagocytosis.

→ Vacuole are large in plant cell and present in the centre of cell, while smaller in animal cell and distributed in the cell.

★ Structure:

→ Membrane that separate the vacuole from the cytoplasm is called Tonoplast

→ Tonoplast surrounding the vacuole is semi-permeable, allowing certain substances to pass through.

→ Vacuoles have a lumen (inner space) that canbe acidic or alkaline, depending on the cell's needs.

→ The membrane and lumen of vacuoles canbe modified with proteins and lipids to perform specific functions.

★ Types Of Vacuoles:

i Lysosomal vacuole: This vacuole contain digestive enzymes and help break down cellular waste and foreign substances.

ii **Food Vacuoles:** This vacuole store food and digest them, releasing nutrients into the cytosol.

iii **Contractile vacuole:**

It help in removal of excess water from the cell.

→ Contractile vacuole found in protists, which help to maintain osmotic balance and regulate cell volume.

iv **Central Vacuole:**

Large, membrane-bound compartment in plant cell, involved in storage, recycling and cellular maintenance.

v **Autophagic Vacuole:**

Autophagic vacuoles forms around damaged cellular components and recycles them through autophagy.

* Functions Of Vacuole:

i Function in plant cells:

→ Vacuole play important role in maintaining cell turgor pressure, which helps plants to maintain their shape and structure.

→ They help store water and ions, which is essential for plant growth and development.

→ Vacuoles help in expanding of plant cell without diluting its cytoplasm.

→ They store water, cell products or metabolic intermediate.

ii Functions in animals cell:

→ In animal cells, vacuoles play a subordinate role in the process of endocytosis and exocytosis.

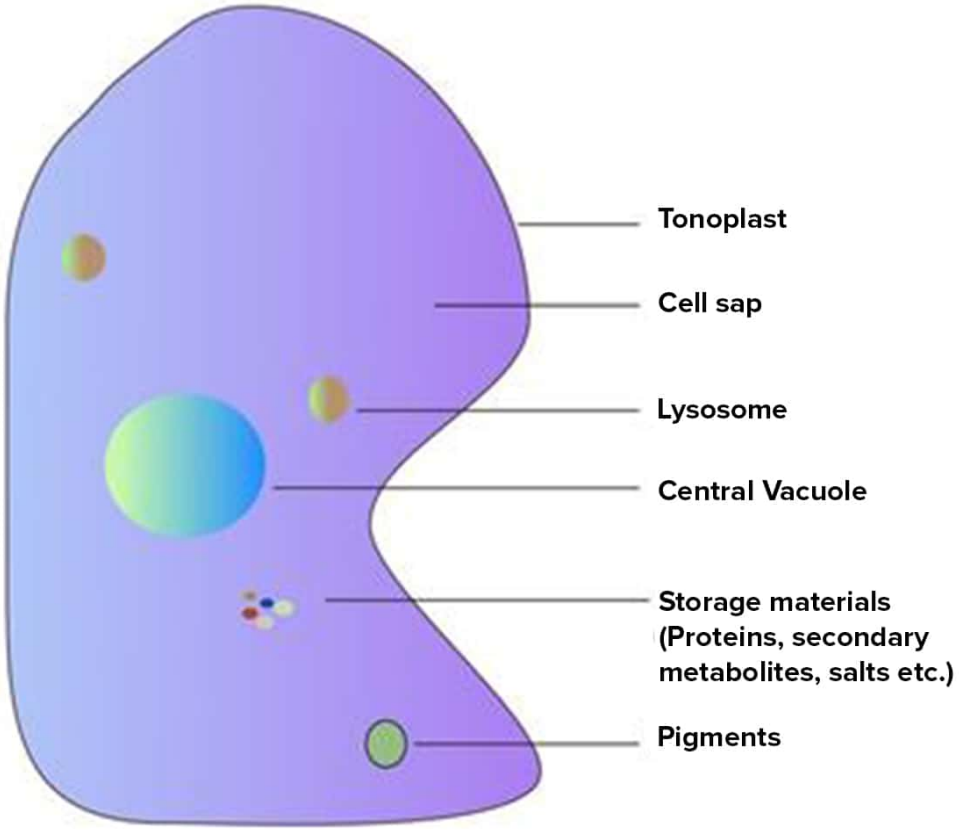
→ In exocytosis, proteins and lipids are expelled from cells.

→ These protein and lipids molecules release into extracellular spaces to communicate with other cells.

→ In endocytosis, vacuoles form around engulfed particles; such as bacteria, dead cell or debris, and fuse with lysosomes for degradation.

iii Function in fungal cells:

Vacuole play a crucial role in maintaining cellular homeostasis and regulating cellular processes, including storage and recycling of nutrients, waste management, and PH regulation.



Vacuole

★ Plastids:

The membraneous bound and pigment containing bodies present in the cytoplasm of plant cell are called plastids.

→ Plastids are found in plant and algal cells, and they are necessary for essential life processes, like photosynthesis and food storage.

★ Types Of Plastids: 3 Types

i- Chloroplast
ii- Chromoplast
iii- Leucoplast

★ Chloroplast:

Chloroplasts are membrane bound structure that presents in the green parts of the plant and act as a site of photosynthesis.

→ Found in leaves and other green parts of the plants.
→ Contain the pigment chlorophyll, which absorbs light energy for photosynthesis.
→ Chloroplast are self replicating organelle.

★ Shape and Size of Chloroplast:

→ Discoid shape.
→ Size range from 2-10 μm in diameter.

* Structure Of Chloroplast:

i Envelope:

→ Chloroplast is surrounded by a smooth double membrane called envelope

i → Outer membrane → is freely permeable to small molecules.

ii- Inner membrane: → is semi-permeable and rich in protein.

→ It separate chloroplast from rest of the cell.

ii Stroma:

→ Ground mass of chloroplast is called stroma.

→ It is colourless proteinaceous substance which contains a small circular DNA, all kind of RNA, ribosome (70S) and various enzymes.

→ Site of light independent rxns. (calvin cycle).

→ Synthesis of sugar (Glucose) occur in stroma.

iii Thylakoid:

→ Flattened membrane-bound stoucture.

→ Form grana (stacks of thylakoids)

→ Contain pigments (chlorophyll, carotenoids)

→ Site of light-dependent rxn.

iv Grana:

→ Stacks of thylakoids.

→ Each granum consists of

25-50 thylakoids.
→ 40-60 grana found in each chloroplast.
→ It increase surface area for photosynthesis.

* **Intergranum:**
The grana are connected with each other by the non-green part called intergranum.

* **Chloroplast DNA (cpDNA)**
→ Present in stroma.
→ Responsible for chloroplast inheritance (maternal inheritance).

* **Ribosome:**
→ 70S ribosomes
→ Present in stroma
→ Involved in protein synthesis.

* **Chloroplast Movement:**
Chloroplasts can move within cells in response to light and other stimuli.

* **Chromoplast:**
→ It synthesize and store different pigments other than green.
→ They are found in coloured parts of the plant such as flower petals and fruit wall where they attracts insects & thus help in pollination.

→ Contain pigments like carotenoids and anthocyanins, which give colour to plants.
→ Have a simple structure than chloroplast, with a single membrane and no thylakoids.

* Leucoplasts:

→ Found in roots, stems and other non-photosynthetic parts of the plants.
→ Colourless.
→ Maybe triangular, tubular or some other shape.
→ Storage organelles
→ Involved in starch and lipid synthesis and storage.

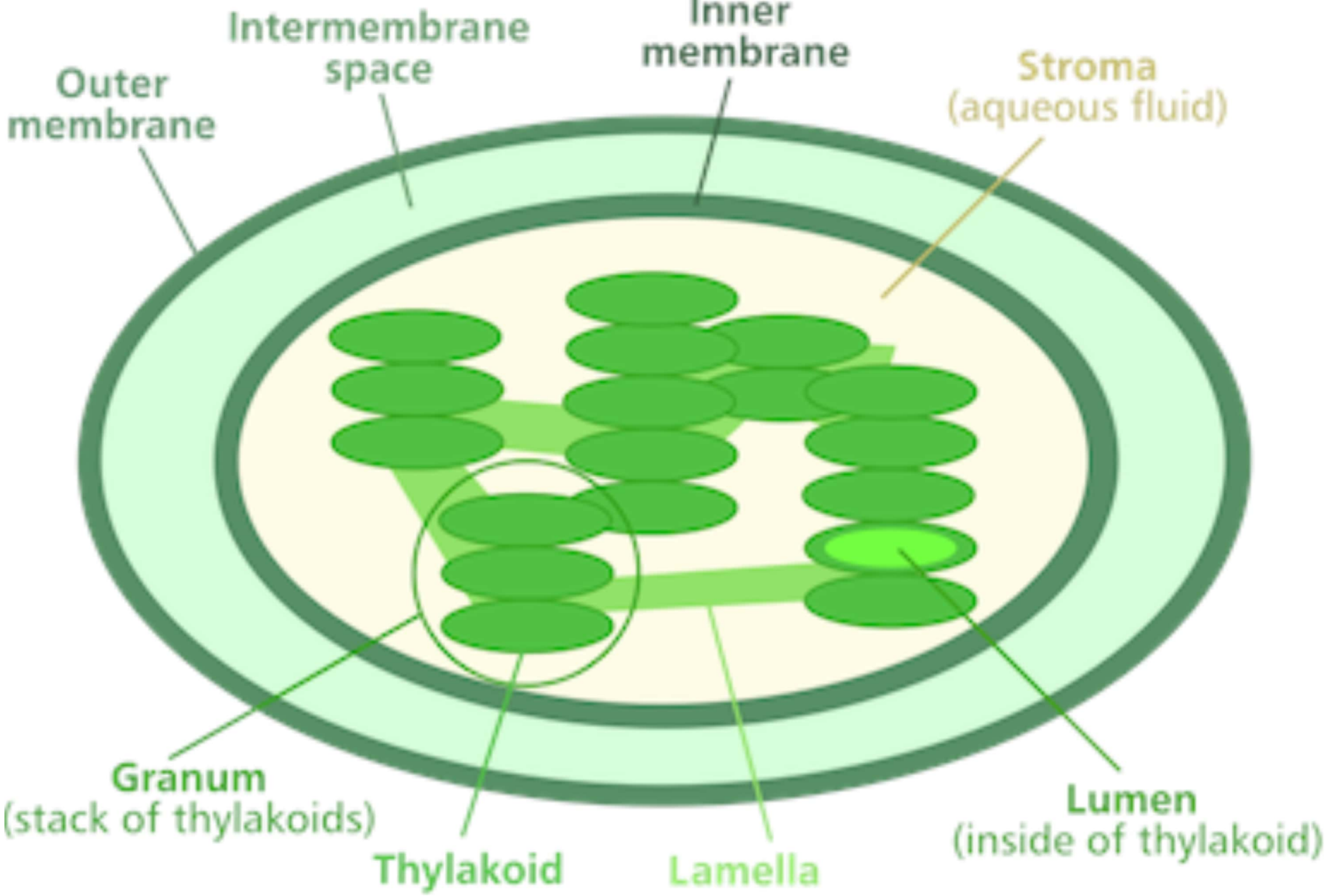
Types of leucoplast:

Based on the kind of substance they store.
Their are Three Types of leucoplasts:

i- Amyloplast: store starch
ii- Elaioplasts: store lipids.
iii- Proteinoplast: store proteins.

* Functions of Plastids:

i- Chloroplasts convert light energy into chemical energy.
→ Produce glucose and oxygen.


Outer membrane
Intermembrane space
Inner membrane
Stroma (aqueous fluid)
Granum (stack of thylakoids)
Thylakoid
Lamella
Lumen (inside of thylakoid)

ii Chromoplast synthesize pigments like carotenoid and anthocyanins.
→ Give plants their color and protect them from excessive light.

iii Leucoplast synthesize starch and lipids.
→ Store energy and nutrients for the plant.

iv Amyloplasts and elaioplasts store starch and lipids, respectively.
→ Provide energy and nutrients for the plant.

Difference b/w plants and Animals cell:

Animal Cell	Plant cell
Shape	
Do not have fixed shape.	Have fixed shape.
Cell wall	
Do not have cell wall	Have cell wall
Vacuole	
Smaller vacuoles present in periphery	Large vacuole present in centre.
Chloroplast	
No chloroplast	Have chloroplast
Food storage	
Glycogen	Starch
Nucleus	
Nucleus is present at the centre.	Nucleus is not at centre due to large sized vacuole.

Centriole

Have centriole	Centriole absent

Cilia

Cilia present in animal cells.	Cilia are rarely present in plant cells.

Size

Smaller in size	Larger in size

Lysosomes

Animal cells have Lysosome.	Lysosomes are very rare in plant cells.

Plant cell

Animal cell