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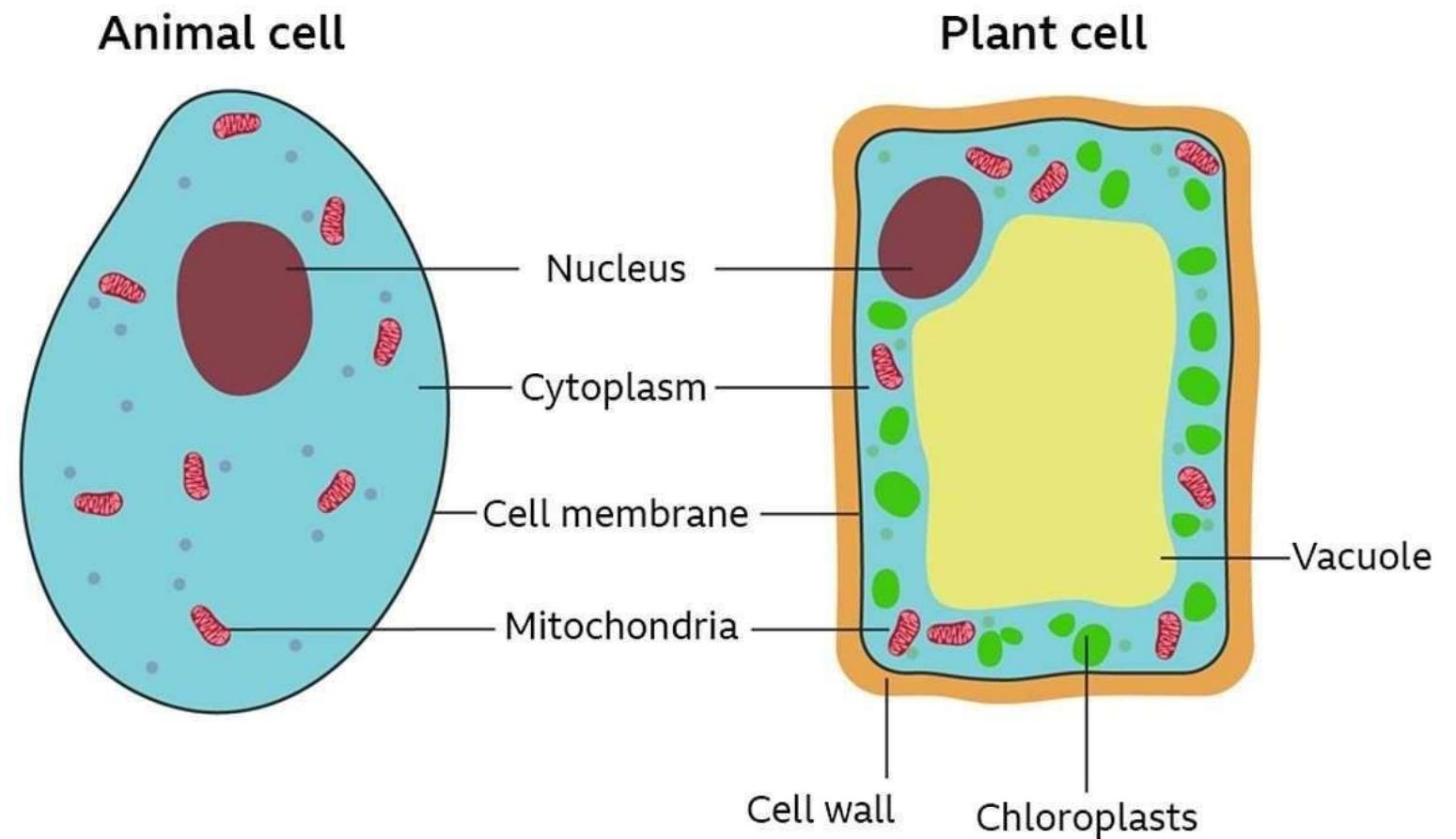
Department of Biomedical Engineering

Course Name: 23BMT201 Human Anatomy & Physiology

I Year : II Semester

Topic : UNIT 1- Cell Structure and Organelles

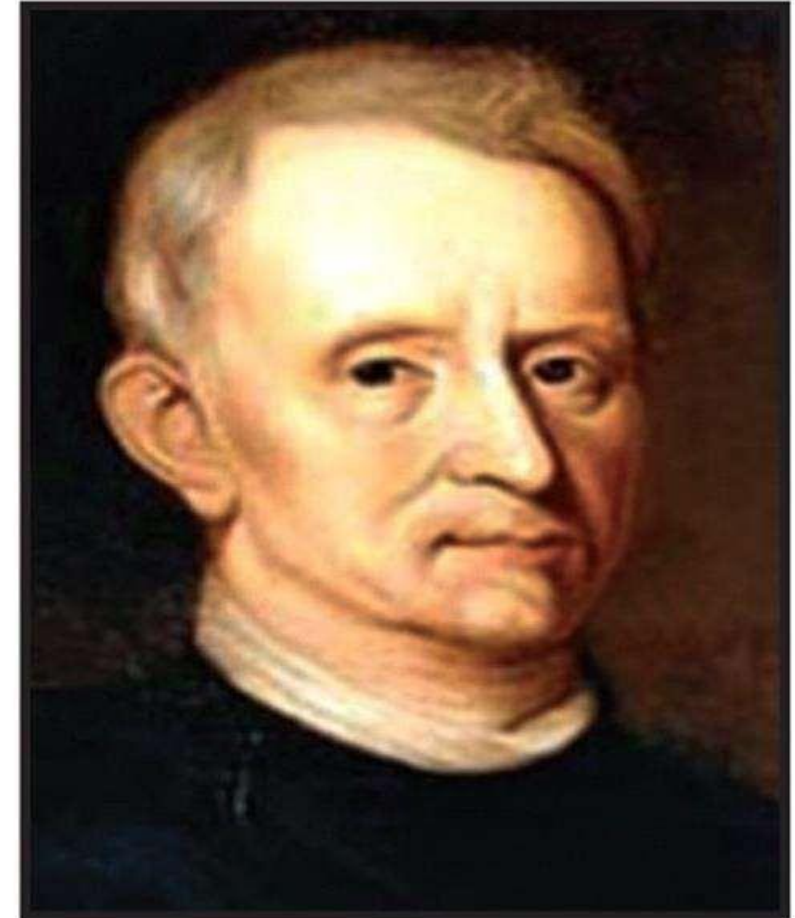
CELL: STRUCTURE AND FUNCTION





INTRODUCTION

- **Fundamental unit of life.**
- Self replicating structure
- The first cells were observed and named by **Robert Hooke** in **1665** from **slice of cork**.
- Some organisms consist of a unicellular organism, others are multicellular.
- **Diameter- 2-120 μ m.**





Nucleus
Cell's control center

Mitochondrion
Produces energy for cells to use by breaking down substances during oxidative metabolism.

DNA
Contains coded information that passes on every single inherited characteristic.

Golgi complex
Collects, packages and distributes molecules made in the cell.

Endoplasmic reticulum
Smooth and rough tubes that move and store materials made by the cell.

Ribosome
Tiny protein producing factories. Proteins produce chemical messages that run a cell.

Lysosome
Where digestion of cell nutrients takes place.

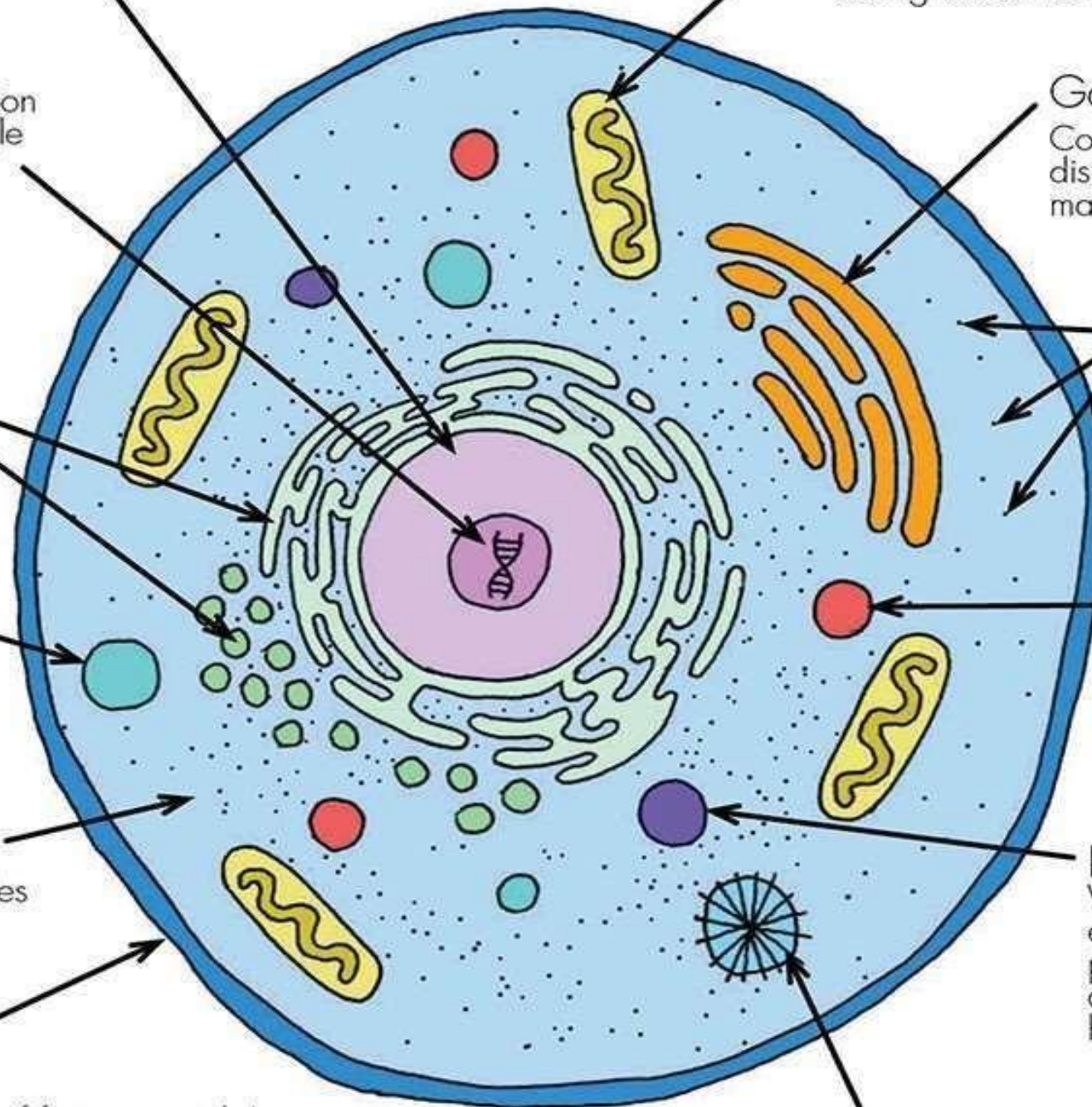
Vacuole
Storage area from fats and other substances.

Cytoplasm
Jelly-like fluid between cell membrane and the nucleus. This is where all the organelles (little organs) are found.

Peroxisome
Vesicle that contains enzymes that carry out particular reactions, such as detoxifying potentially harmful molecules.

Cell membrane
Made up of a double layer of fatty material. It allows some materials to pass into and out the cell at thousands of places across the surface. It allows foods to pass into the cell and waste to pass out of the cell.

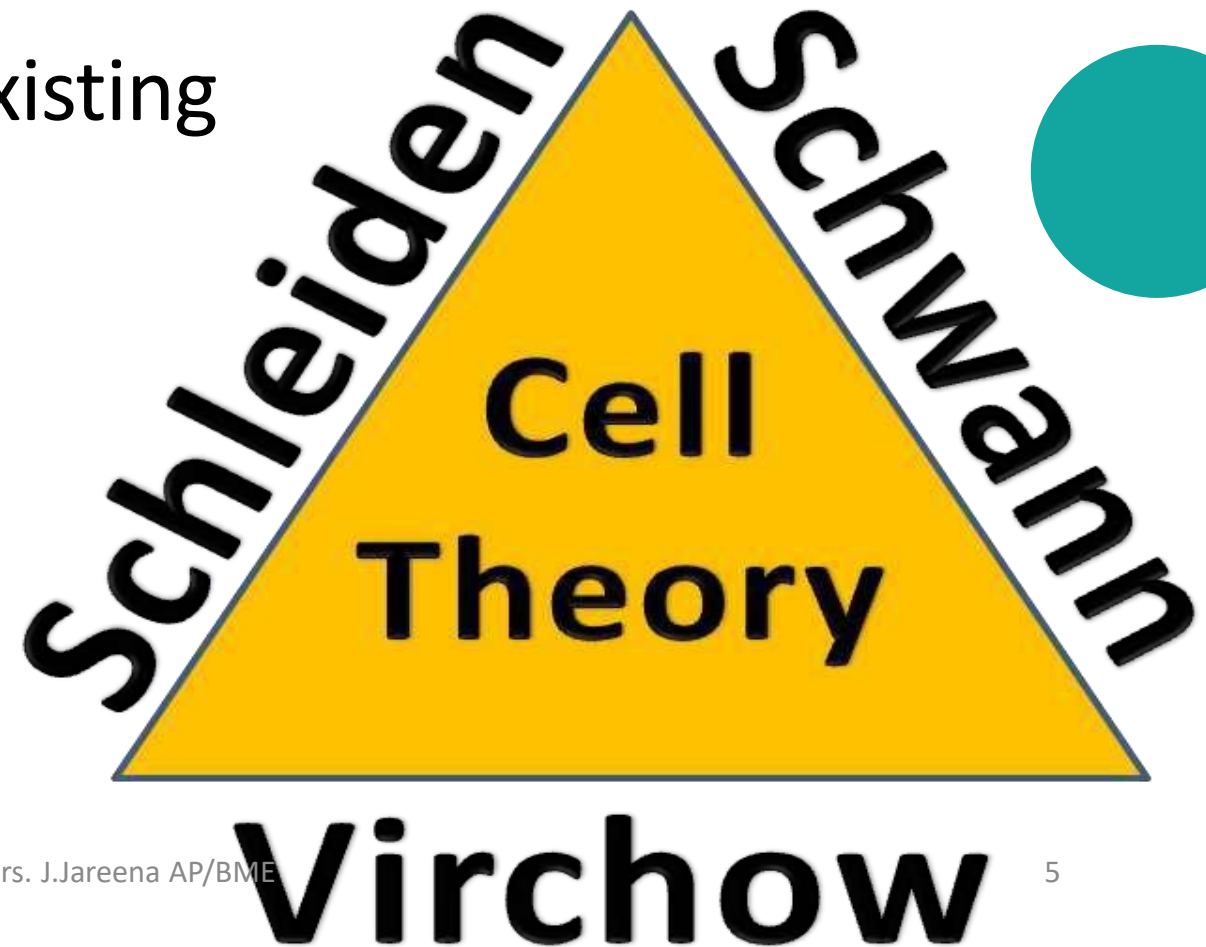
Centriole
Tiny organs that help the cell divide.





CELL THEORY

- Proposed by **Matthais Schleiden** and **Theodor Schwann** in **1839**:-
 - All living things are made up of cells.
 - Cells are the smallest working unit of all living things.
 - All cells come from pre-existing cells through cell division.





CONSTITUENTS

- Different substances that make a cell are collectively called **Protoplasm.**

- Protoplasm is composed of :-
 - 1) Water - **70-80% Water** is present in cell.
 - 2) Carbohydrates
 - 3) Lipids
 - 4) Proteins
 - 5) Electrolyte - Sodium (Na^+), Potassium (K^+), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Phosphate, Chloride (Cl^-), and Bicarbonate (HCO_3^-).



SUBCELLULAR STRUCTURES

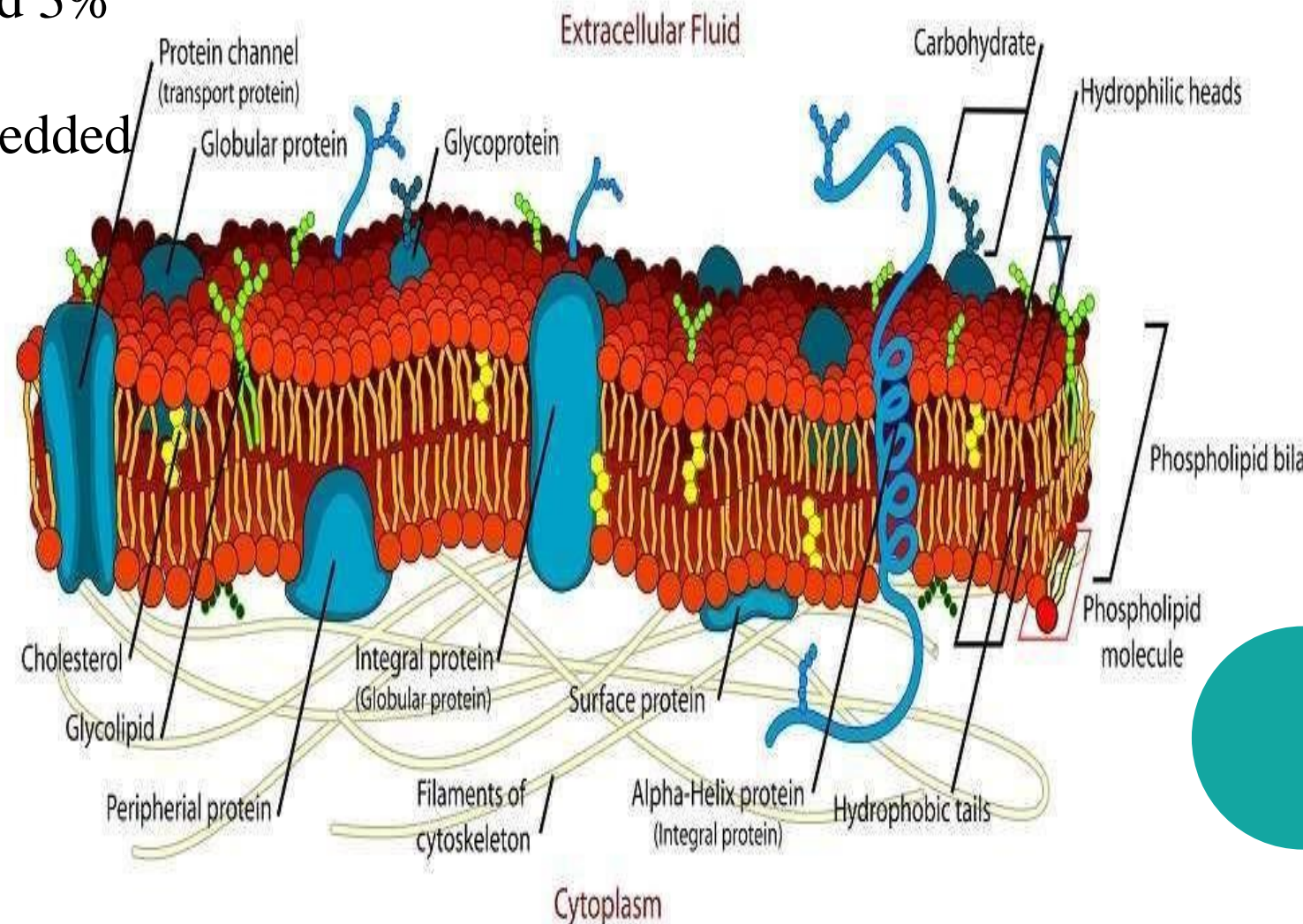
Major Structures Present in a cell are :-

- Cell Membrane
- Cytoplasm and its Organelles
 - Nucleus

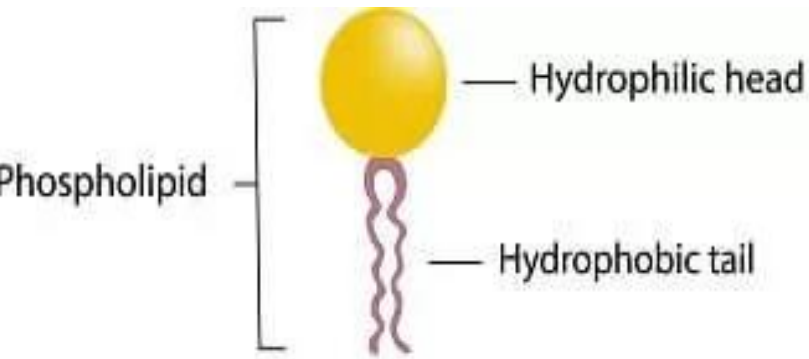


CELL MEMBRANE

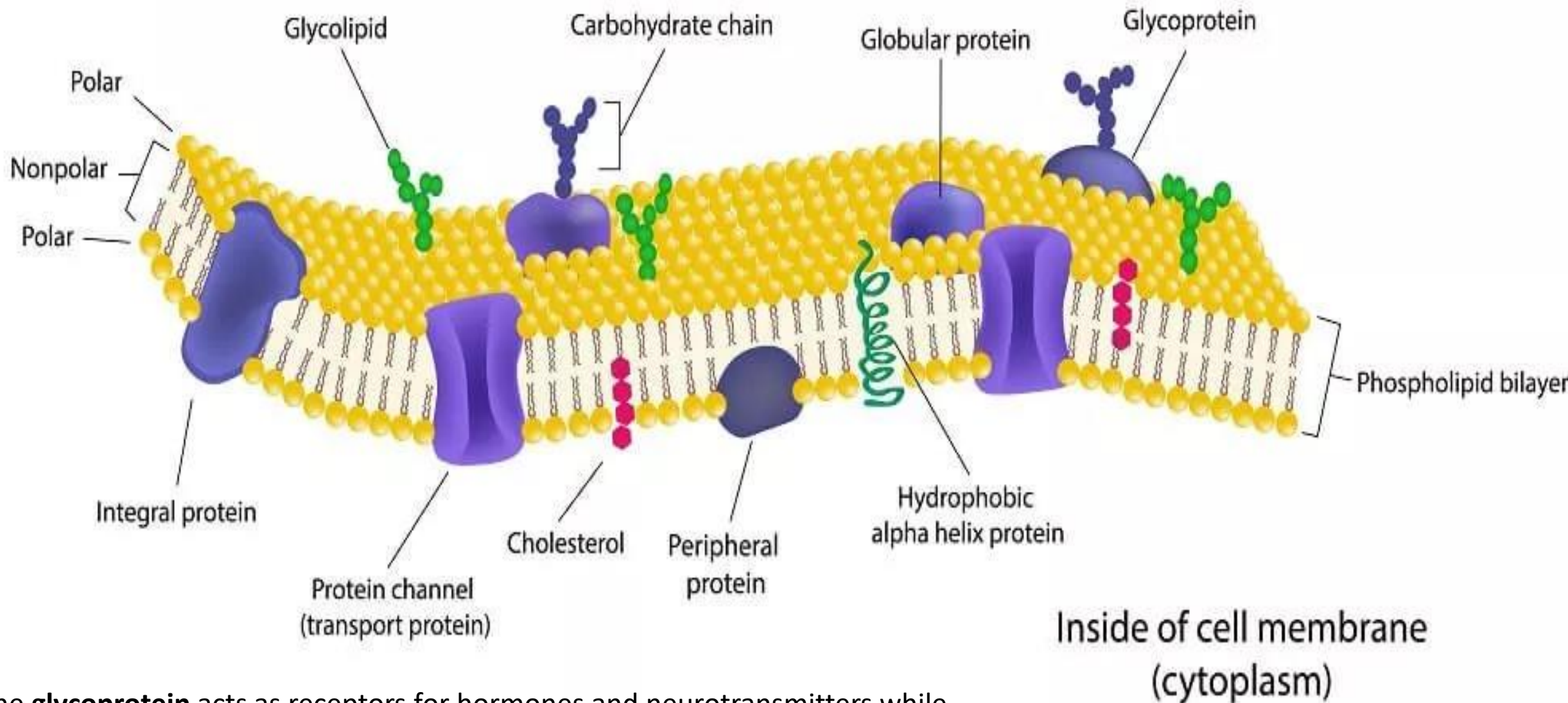
- Thin pliable elastic **outermost** structure which envelops the cell.
- Cell membrane comprises approximately 55% of proteins, 25% phospholipids, 13% cholesterol, 4% of other lipids and around 3% carbohydrates
- It consists of **bilipid layer** with embedded **proteins** that are-
 - **Integral Proteins** - receptors for water-soluble chemical such as peptide and hormone
 - **Peripheral proteins** - enzymes and coenzymes (Metabolic activities)
 - **carrier proteins** - actively move substances across the membrane(use ATP)
 - **channel proteins** - movement of molecules that are normally too large to pass through the membrane (tube)



Phospholipids are lipid molecules made up of a phosphate group head and two fatty acid tails.



Outside of cell membrane



The **glycoprotein** acts as receptors for hormones and neurotransmitters while **lipoprotein** functions as ion channels and enzymes.

Fluid mosaic model

- The fluid mosaic model states that cell membranes are composed of a phospholipid bilayer with admixed protein molecules freely floating around it.
- fluid -individual phospholipids and proteins move side-to-side within the layer like it is a liquid
- Mosaic - because of the topographic pattern produced by the scattered protein molecules.



FUNCTIONS OF CELL MEMBRANE

- **Protective**:- Forms outermost boundary of the cell organelles.
- **Digestive**:- Takes in food and excretes waste products.
- **Selective Permeability**:-
a) Non-Polar Molecules- Gases (like O_2 , CO_2 , N_2), Lipids, Steroid Hormones, Alcohols can dissolve in the non-polar regions of the membrane and move rapidly across the membrane.
b) Polar molecules:- H_2O soluble ions, Glucose, urea etc. have much lower solubility. Therefore Penetrate the membrane much more slowly.
- **b) Chemical and Physical Properties** of membrane control the free passage of ions in and out of cell. This property helps in maintaining components in ICF and ECF.



- Links adjacent cells together by junctional complexes to form tissues.
- **Insulating Properties**:- It acts as **dielectric material** of a charged condenser, thus cell membrane have very high insulating value

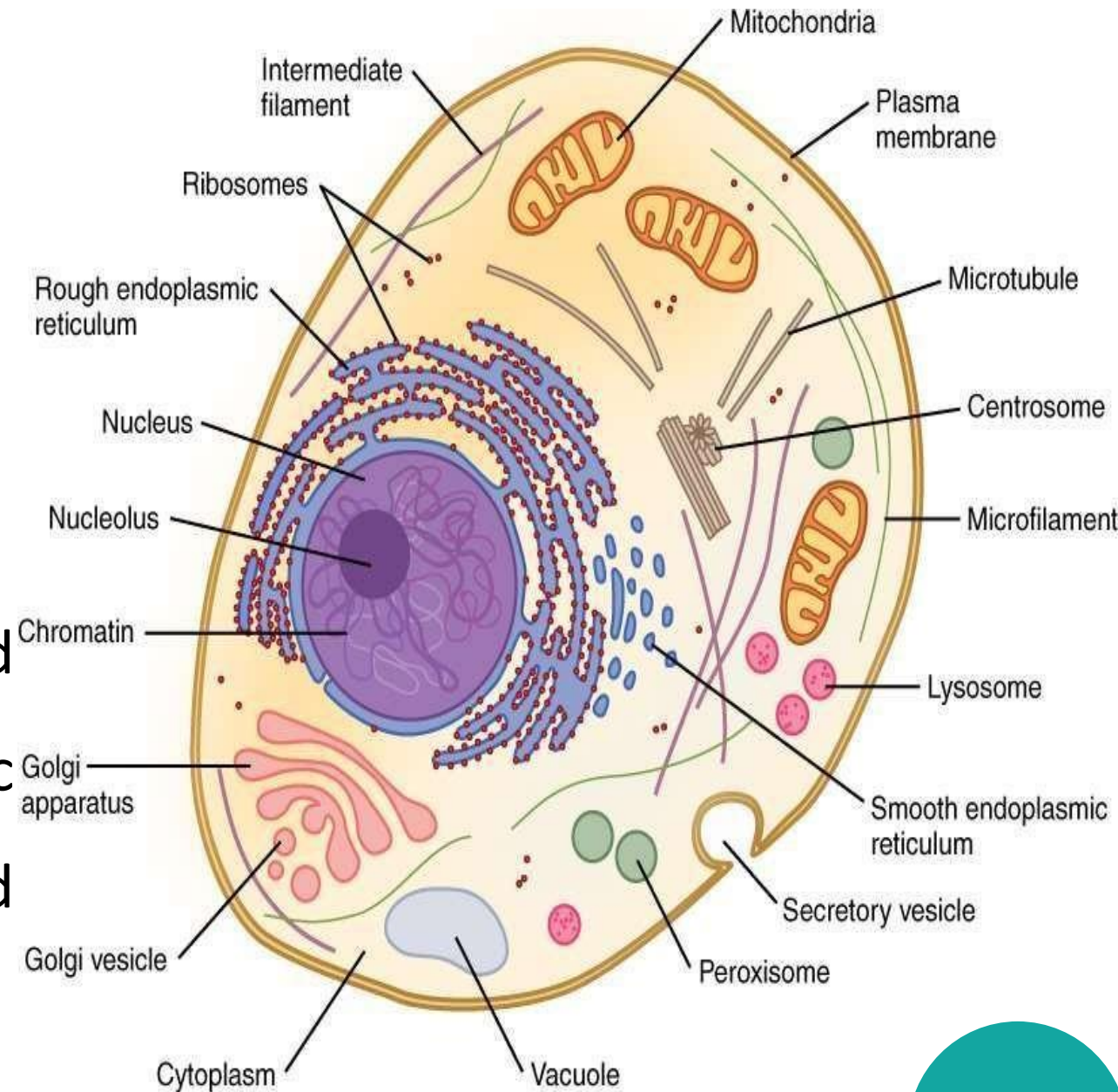


CYTOPLASM AND ITS ORGANELLES



CYTOPLASM

- **Thick, gel-like semitransparent fluid** that is found in both plant and animal cell.
- The constituent parts of cytoplasm are **cytosol, cell organelles and cytoplasmic inclusions.**
- Bounded by the plasma membrane, and contains many organelles in a eukaryotic cell (cell containing membrane bounded nucleus).





CYTOSOL

- **The cytosol**, the aqueous part of the cytoplasm outside all of the organelles, also contains its own distinctive proteins.
- It accounts for almost 70% of the total cell volume.
- **Gelatinous substance** consisting mainly of cytoskeleton filaments, organic molecules, salt and water.
- Chemically, the cytoplasmic matrix is composed of many chemical elements in the form of atoms, ions and molecules.



ORGANELLES

- Following organelles are present in the Cytoplasm:-
 - i) Mitochondria
 - ii) Endoplasmic Reticulum
 - iii) Lysosomes
 - iv) Golgi Apparatus
 - v) Peroxisomes
 - vi) Vacuole
- Each organelle is bounded by a lipid membrane, and has specific functions.

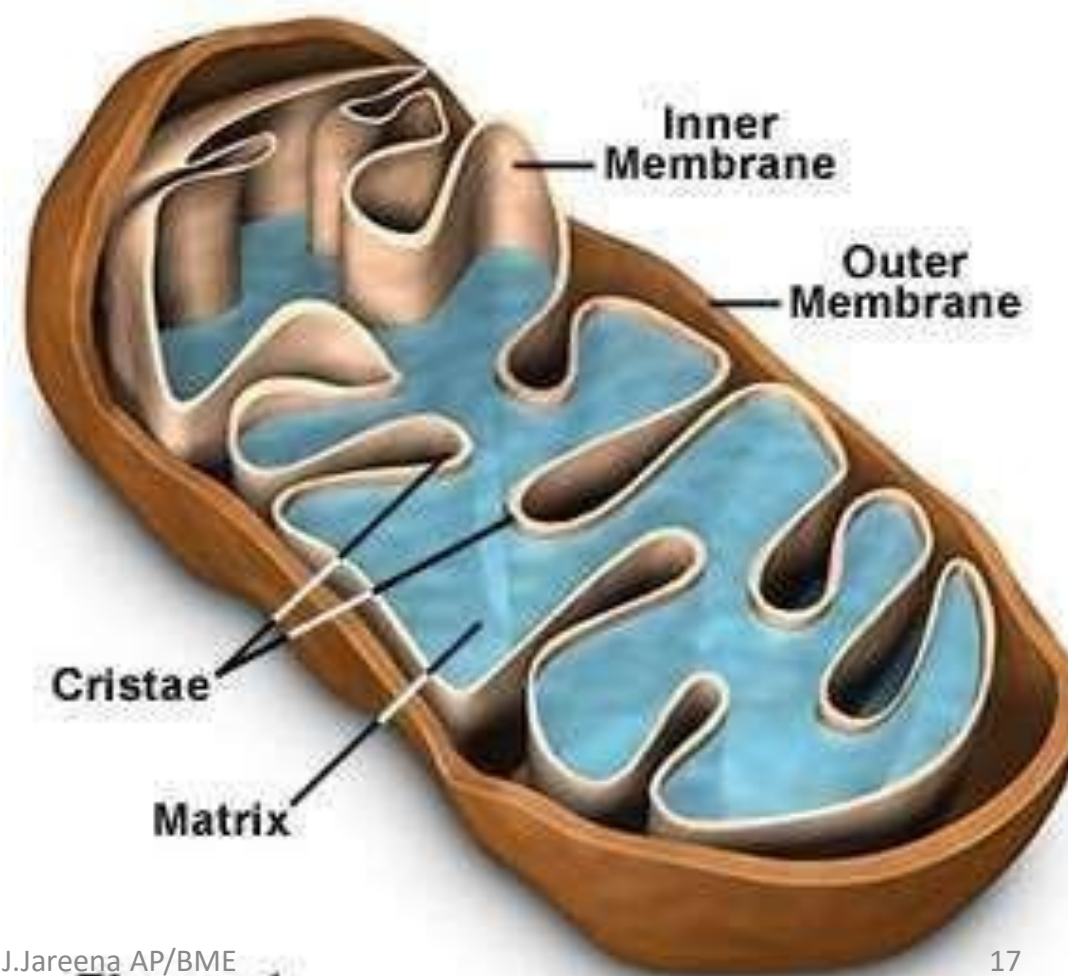


MITOCHONDRIA

- The mitochondria were first observed by **Kolliker** in **1850** as granular structures in the striated muscles.
- Mitochondria are called the '**powerhouse of the cell**'.

STRUCTURE-

- **Length-** 5-12 μm
- **Diameter-** 0.5-1 μm
- Filamentous or globular in shape.





○ Components of Mitochondria are -

i) Outer Membrane

ii) Inner Membrane

iii) Intermediate Space- space between outer and inner membranes

iv) Cristae- Infoldings of inner membrane

v) Matrix- The space enclosed by inner membrane

○ The membranes are made up of phospholipids and proteins



- **Outermost Membrane-**

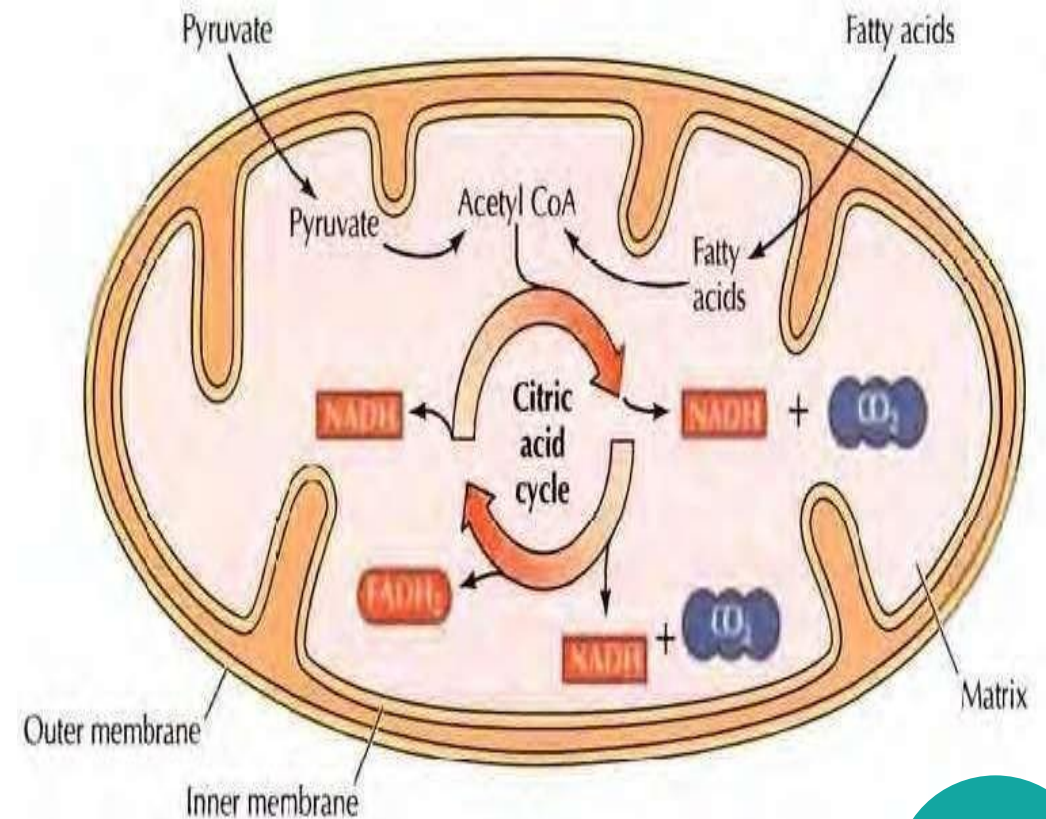
a) It contains large numbers of integral membrane proteins called **Porins**.

These porins form channels that allow molecules of 5000 daltons or less to pass.

b) Studded with enzymes concerned with biological oxidation .

- **Interior (Matrix)** of the Mitochondria contains enzymes concerned with '*citric acid cycle*' and '*respiratory chain oxidation*'.

- Major metabolic pathways involved in oxidation of carbohydrates, lipids and amino acids and part of special biosynthetic pathways involving urea and heme synthesis are located in inner matrix.





- **Inner Membrane :**

It contains ATPase and other enzymes concerned with synthesis and metabolism of ATP.

Contains enzymes of Electron Transport Chain.

- The ultimate purpose of these mechanisms is *oxidative phosphorylation* and *synthesis of ATP*.

- Mitochondria has some protein synthesised by Mitochondrial DNA.



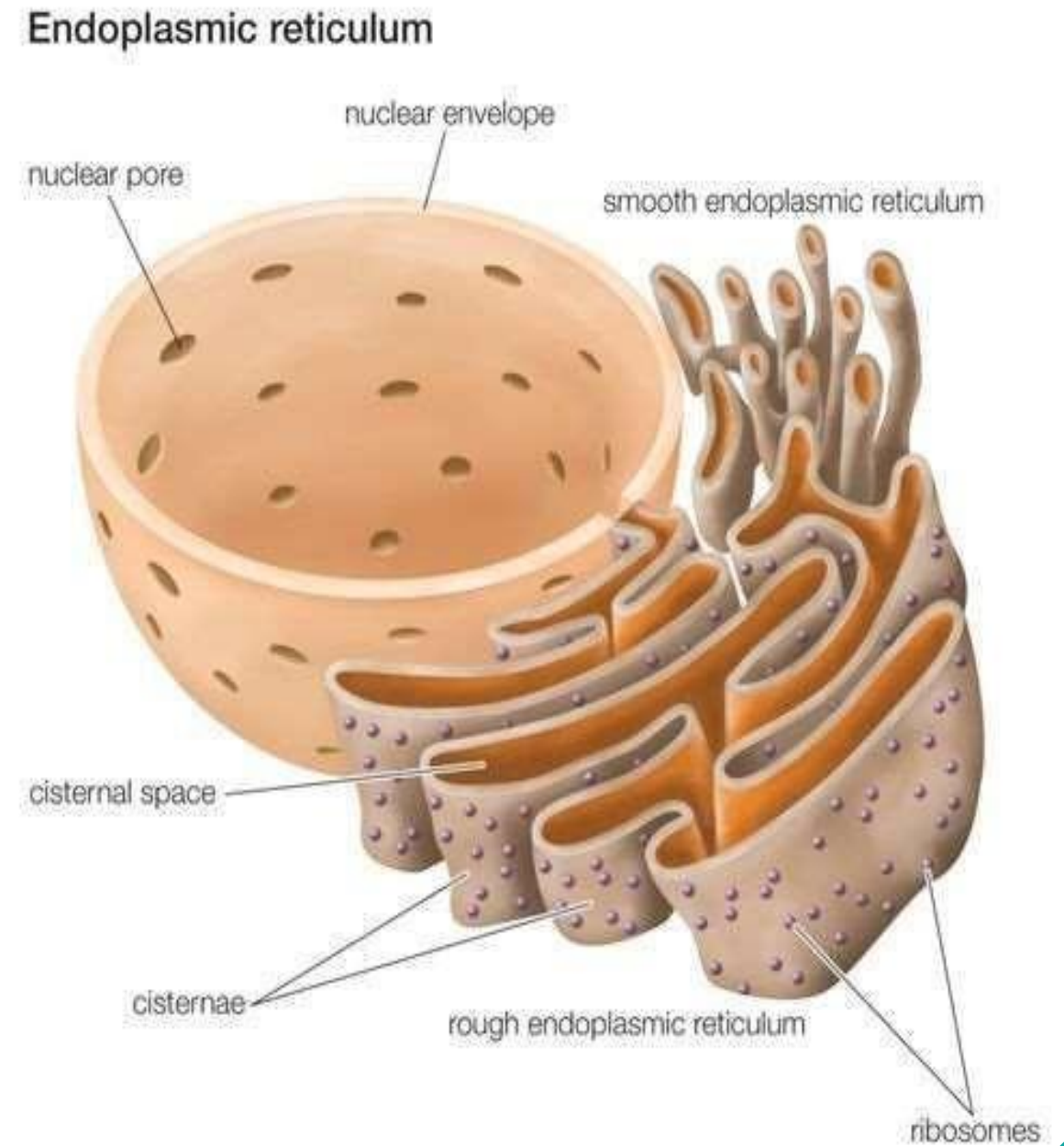
FUNCTIONS

- Power generating units of the cells.
- Important to maintain proper concentration of calcium ions within the various compartments of the cell.
- Energy transduction through respiration.
- Responsible for thermogenesis.



ENDOPLASMIC RETICULUM

- Network of **tubular and flat vesicular structures** in the cytoplasm.
- An extensive network of closed, flattened membrane-bounded sacs called **cisternae**.
- Space inside the tubules is filled with Endoplasmic Matrix.





○ TWO TYPES-

Smooth Endoplasmic Reticulum

- Ribosomes absent
- Site of synthesis of lipid and steroid hormones.
- Mainly present in lipid forming cells such as adipocytes, interstitial cells of testis, glycogen storing cells of liver, adrenal cortex cells, muscle cells, leucocytes etc.

Rough Endoplasmic Reticulum

- Contains ribosomes
- Site of protein synthesis, processing and packaging.
- Mainly present in protein forming cells such as pancreatic acinar cells, Goblet cells, antibody producing plasma cells, Nissl's granules of nerve cells etc.



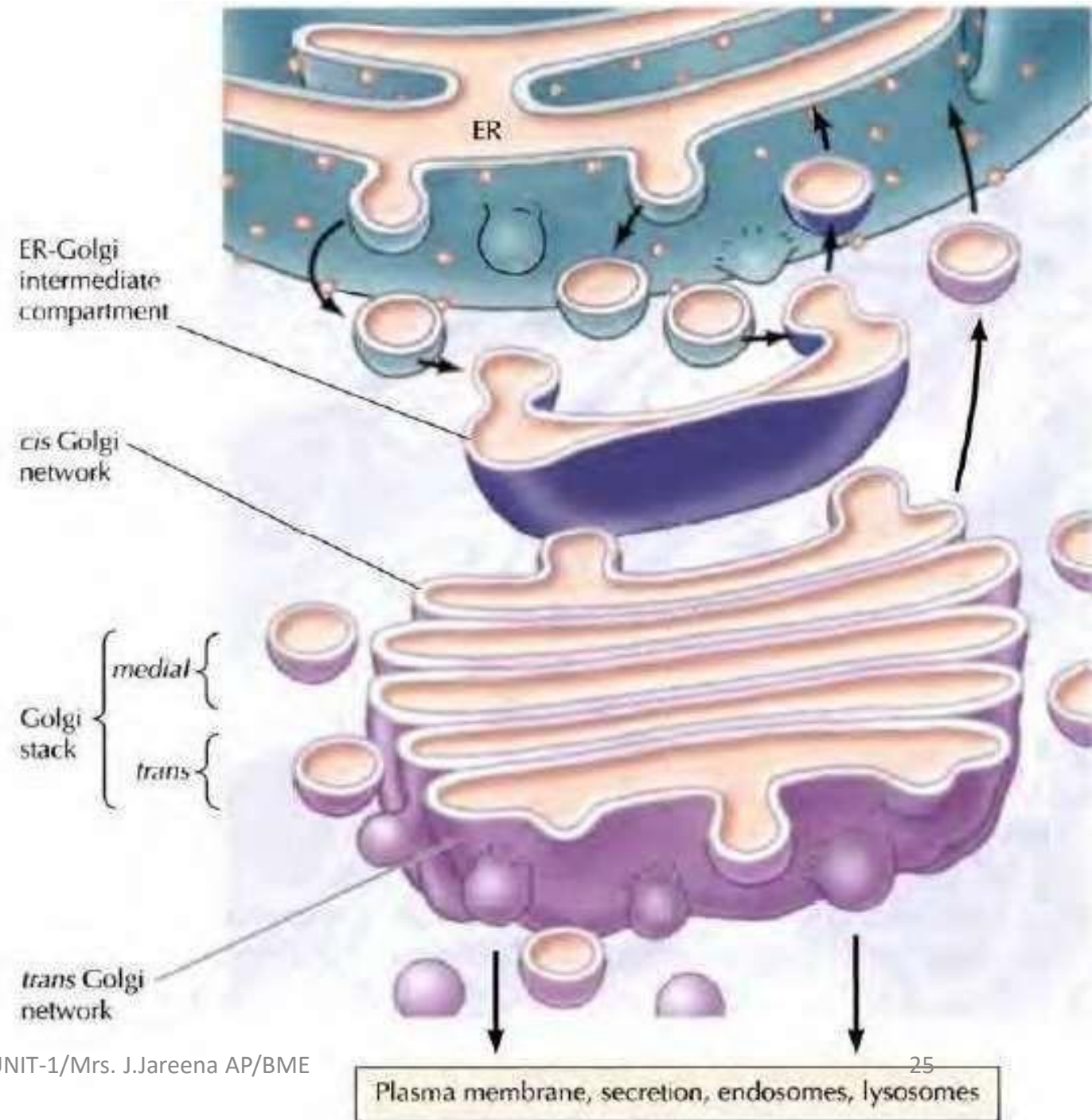
FUNCTION

- Synthesis of proteins.
- Protein segregation.
- Unsaturation of fatty acid.
- Muscle contraction. ER is commonly known as Sarcoplasmic Reticulum in muscle fibers.



GOLGI BODIES

- Golgi Bodies is a collection of membrane enclosed sacs composed of four or more stacked layers of thin, flat enclosed vessels lying near the side of the nucleus.
- Consist of multiple discrete compartments.
- Consist of four functionally distinct regions:
 - i) The cis Golgi network
 - ii) Golgi stack –which is divided into
 - a) The medial and
 - b) Trans sub compartments
 - iii) The trans Golgi network.





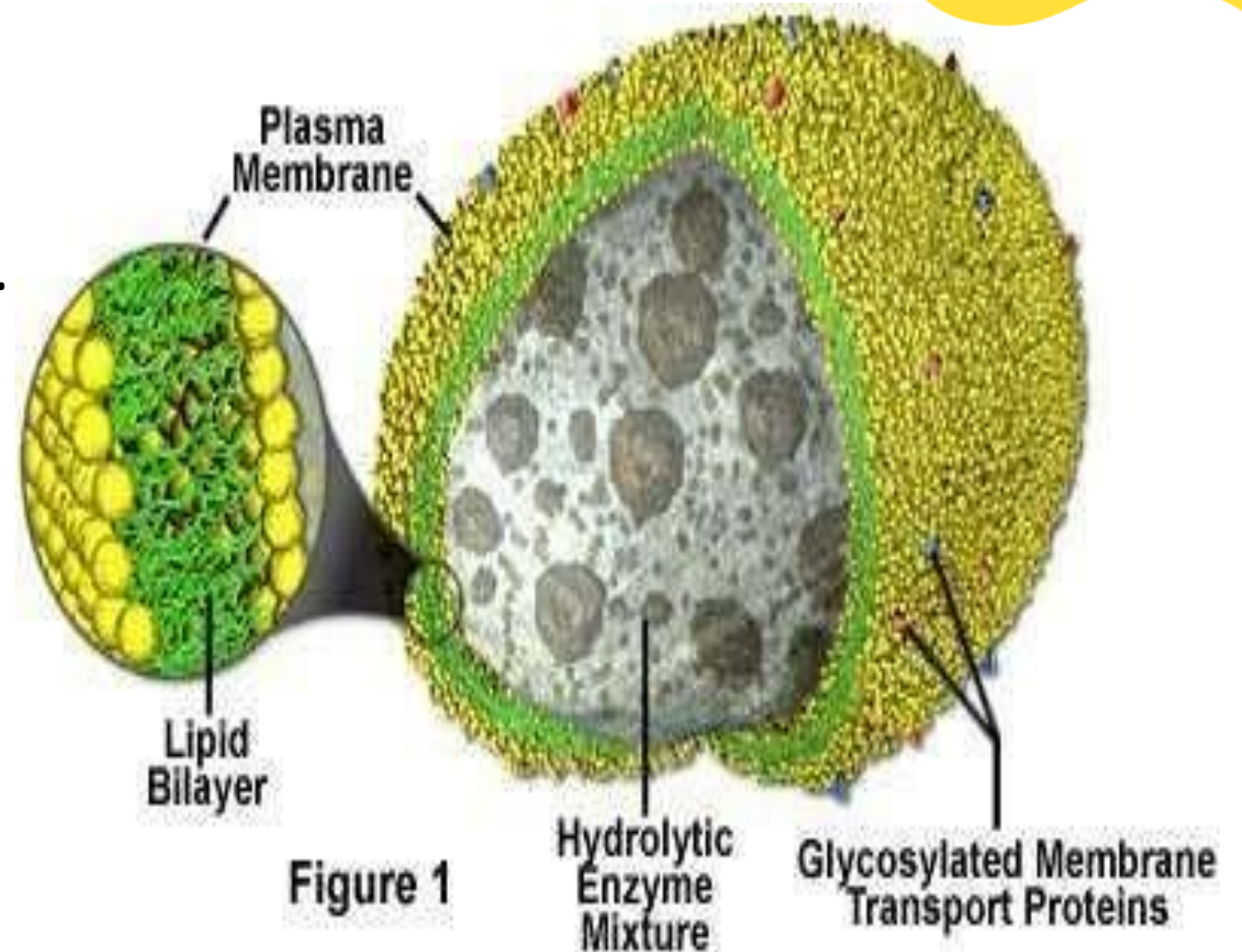
FUNCTION

- Wrapping and Packaging department of the cell.
- Produces secretion granules i.e. membrane enclosed complexes, which store hormones and enzymes in the protein secreting cells, it packages proteins.
- Site of formation of lysosomes i.e. large irregular structures surrounded by membrane which are present in the cytoplasm.
- It adds certain carbohydrates to form glycoproteins, which play an important role in the association of the cells to form tissues



LYSOSOMES

- **Diameter-** 250 -750nm
- These are the irregular structures surrounded by the unit membrane.
- More acidic than rest of the cytoplasm and external bacteria as well as worn out cell components are digested in them.
- The interior is kept acidic(near pH 5.0) by the action of proton pump or H^+ or ATPase.
- Lysosomes are cell hydrolases and they function best at the acidic pH.





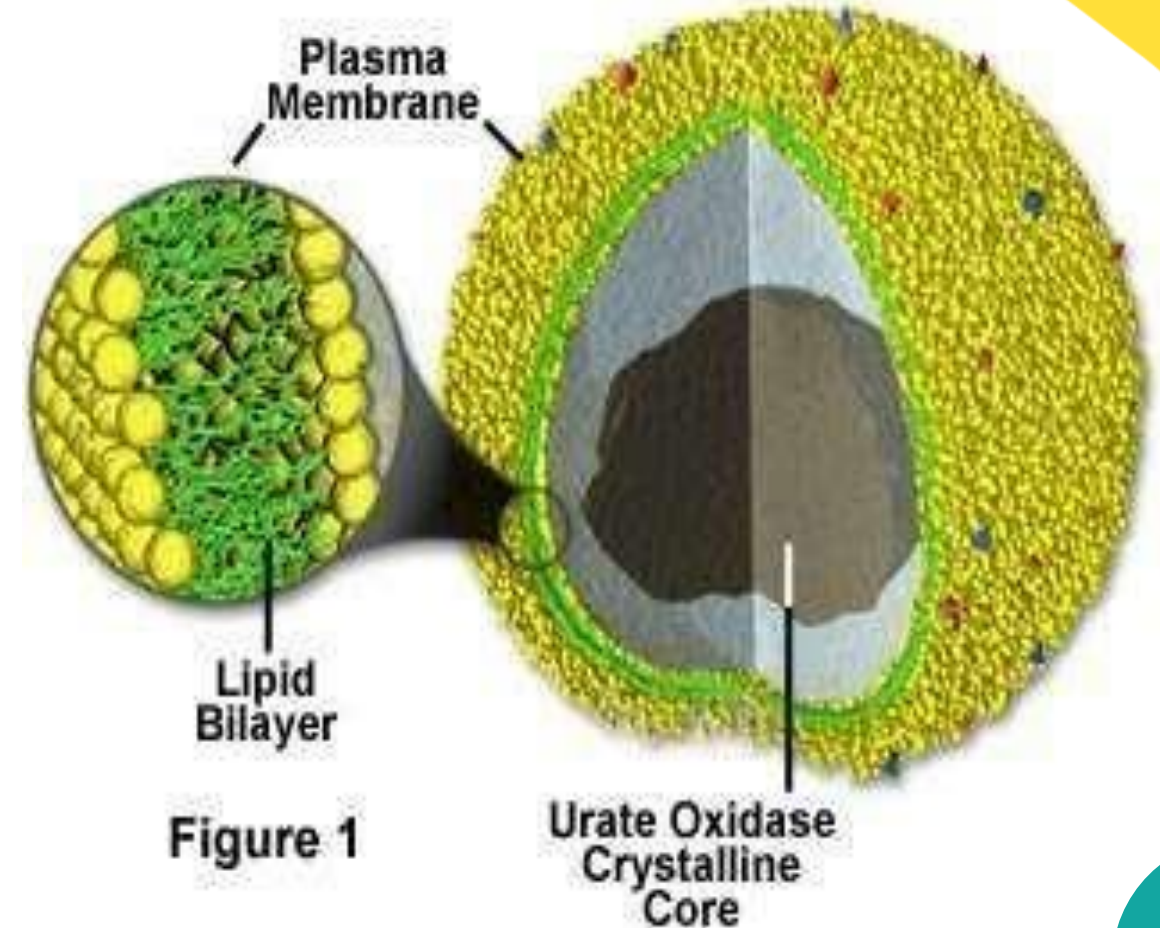
FUNCTIONS

- Acts as a form of digestive (lytic) system or the cell, because enzymes present in it can digest essentially all macromolecules.
- Engulf worn out components of the cells in which they are located.
- Engulf exogenous substances e.g. bacteria and degrade them.
- When a cell dies ,lysosomal enzymes causes autolysis of the remanant .
Thats why lysosomes are called as ***Suicidal Bags***.



PEROXISOMES

- **Diameter-** $0.5\mu\text{m}$
- A lipid bilayer membrane surrounds which regulates what enters or exits the peroxisomes.
- Urate oxidase crystalline core.
- Structure is similar to that of the lysosomes but with a different composition .



- Peroxisomes can be formed by the budding of ER, or by division



CONTD.

- Contains oxidases that produces H_2O_2 .
- Catalases degrades hydrogen peroxide to yield water and oxygen
- Proteins are directed to the Peroxisomes by a unique signal sequence with the help of protein chaperones, **Peroxins**.



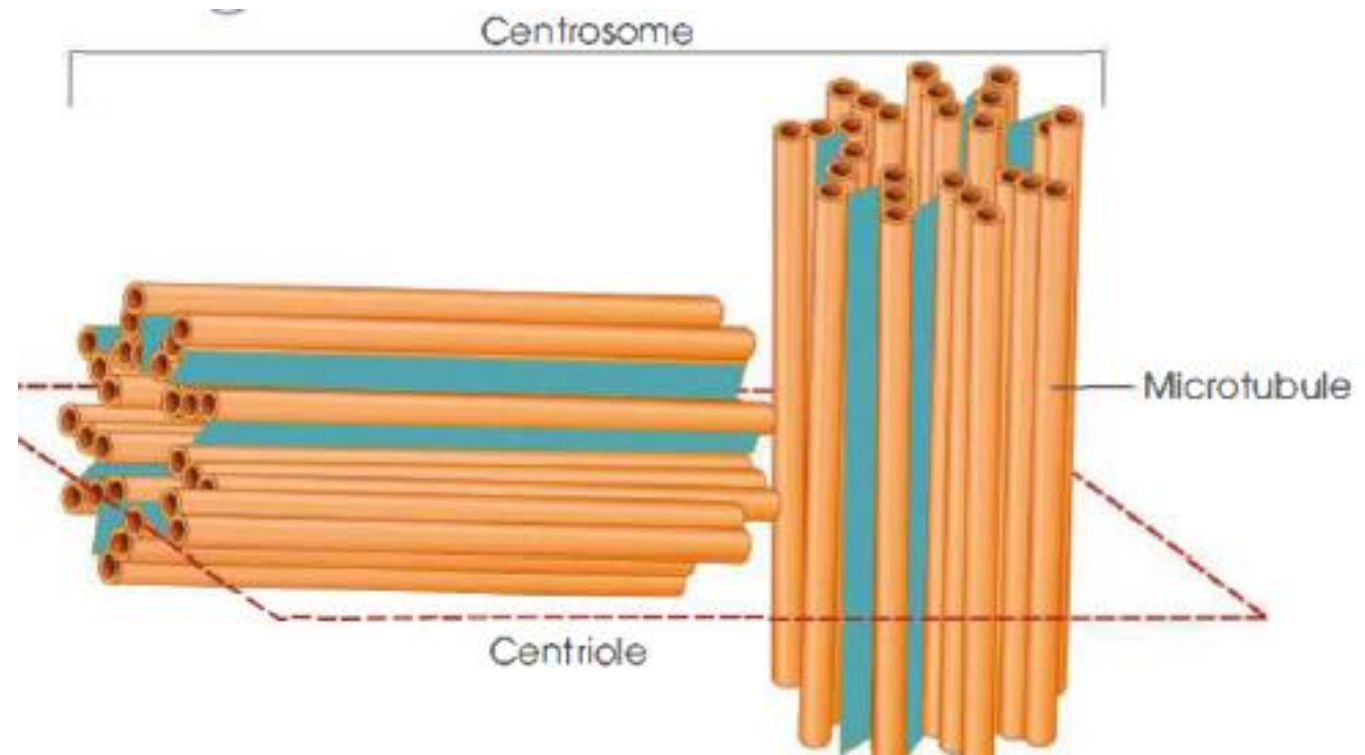
FUNCTION

- H_2O_2 metabolism and detoxification
- Helps in Photorespiration in plants
- Biosynthesis of lipids .
- Cholesterol and dolichol are synthesized in animals.
- Synthesis of bile acids in liver.
- Synthesis of plasmalogens (myelin sheath).



Centrosome

- Dense region of cytoplasm surrounding the nucleus.
- Plays a major role in cell division (mitosis).
- Made of a pair cytoskeletal structure called **centriole**, arranged perpendicular to each other. *Centriole is closely related to spindle formation during mitosis (normal cell division)*





Vacuoles

- Hollow capsules that are **spherical** or **irregular**
- Plant vacuoles are **larger** than animal vacuoles and are bound by well defined membrane called **tonoplast**.
- The space of the vacuole is filled with **cell liquids cell sap**.
- Vacuole plays a role in the **maintenance of the internal pressure of the cell**.



CYTOSKELETON

- System of fibers that not only maintains the structure of the cell but also permit it to change shape and move.

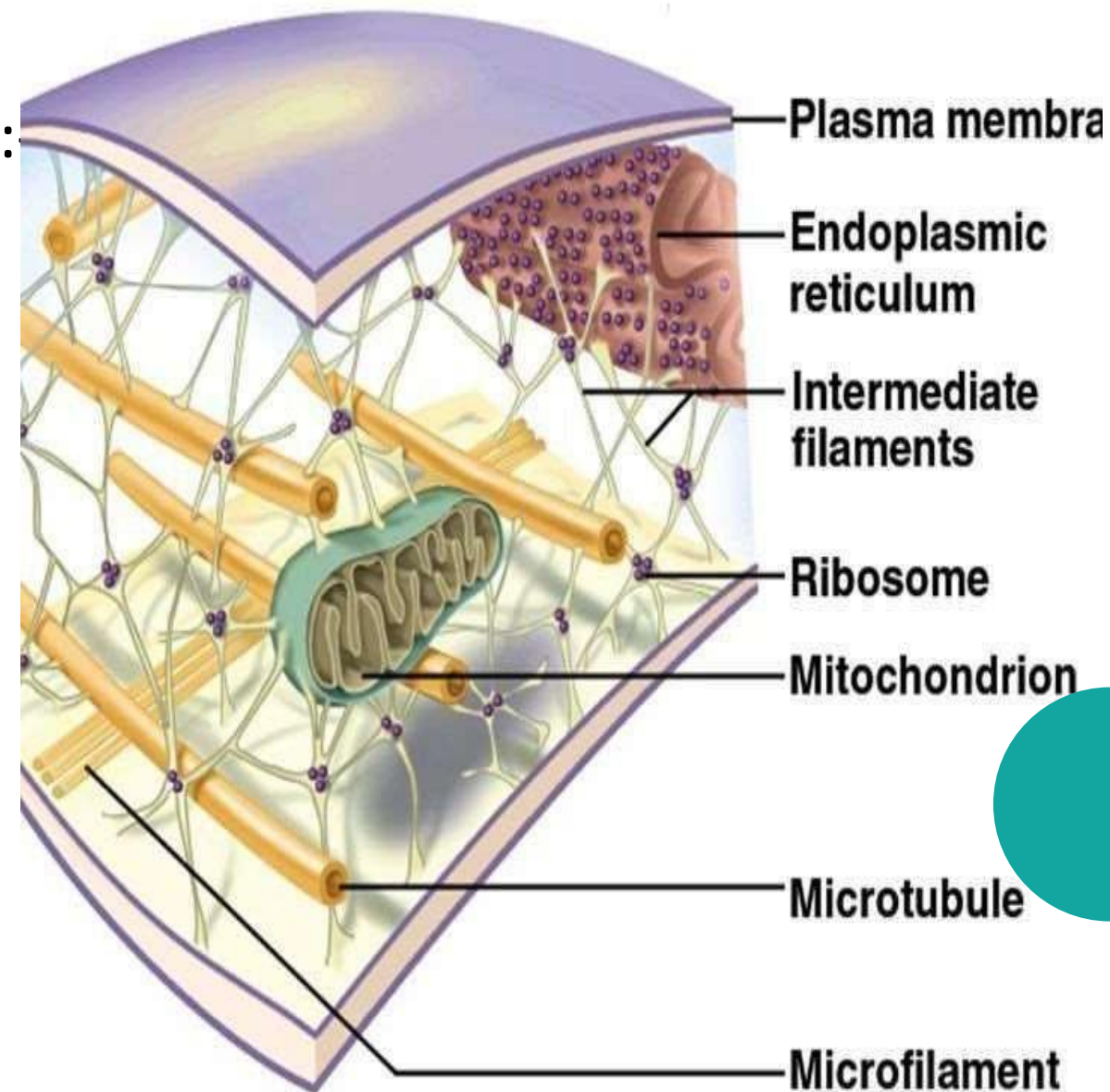
- The cytoskeleton is made up primarily of:

i) Microtubules

ii) Intermediate Filaments

iii) Microfilaments

along with protein that anchor tie them together.



- **Microtubules**- These are long hollow structures approx. 25nm in diameter. Determine shape of the cell, role in the contraction of the spindle and movement of chromosomes and centrioles as well as in ciliary and flagellar motion.
- **Intermediate Filaments**- They are 8-14nm in diameter and are made up of various subunits. They form a flexible scaffolding or cell and help it resist external pressure.
In their absence cell ruptures more easily and when they are abnormal in human, blistering is common.
- The proteins that make up intermediate filament are cell types specific and are thus frequently used as cellular markers.
- **Microfilaments**- They are long solid fibers 4-6 nm in diameter. They comprise the contractile protein actin and are responsible for the cell motion.



FUNCTION

They are involved in the:-

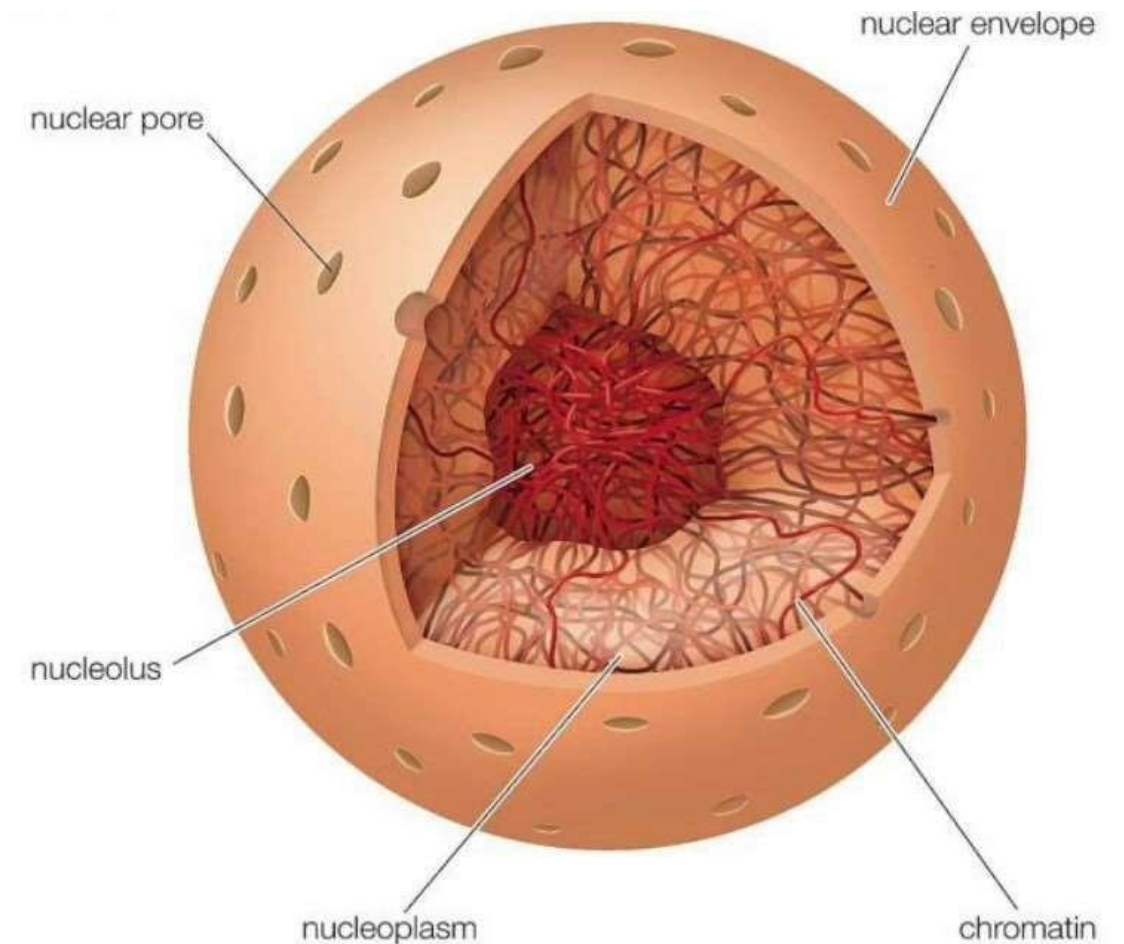
- Movement of the chromosomes
- Cell movement
- Processes that move secretion granules in the cell
- Movement of proteins within the cell membrane.

NUCLEUS



THE NUCLEUS

- The nucleus contains chromatin, RNAs, and nuclear proteins move freely in aqueous solution.
- Nucleus has an internal structure that organizes the genetic material and localizes nuclear functions.
- A loosely organized matrix of nuclear lamins extends from the nuclear lamina into the interior of the nucleus.





CONTD.

- These lamins serve as sites of chromatin attachment and organize other proteins into functional nuclear bodies.
- Chromatin within the nucleus is organized into large loops of DNA, and specific regions of these loops are bound to the lamin matrix by lamin-binding proteins in the chromatin.



NUCLEAR ENVELOPE

- Complex structure consisting of two nuclear membranes, an underlying nuclear lamina, and nuclear pore complexes.
- Two concentric membranes, called the inner and outer nuclear membranes .
- The outer membrane is continuous with the endoplasmic reticulum, so the space between the inner and outer nuclear membranes is directly connected with the lumen of the endoplasmic reticulum.

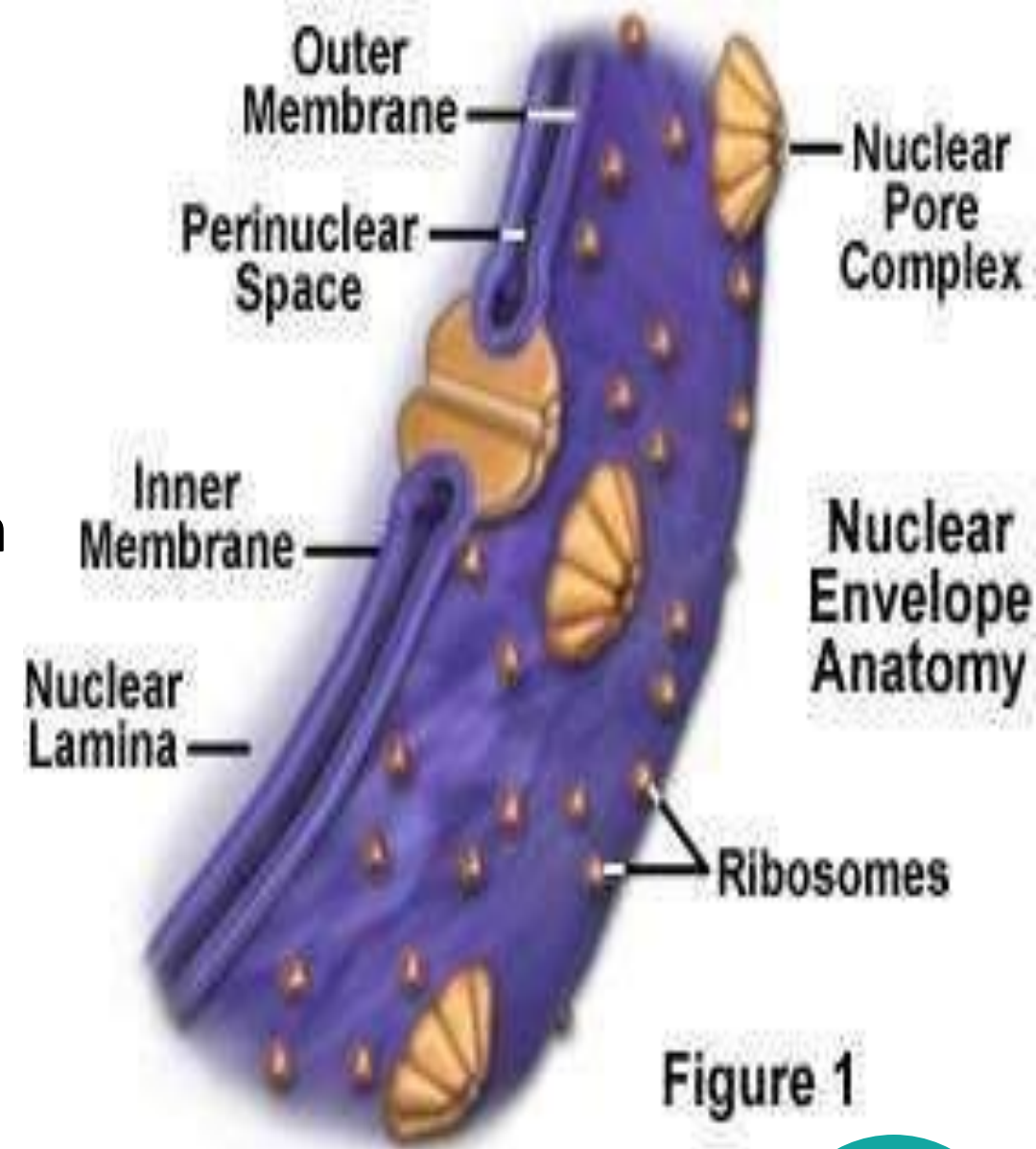


Figure 1

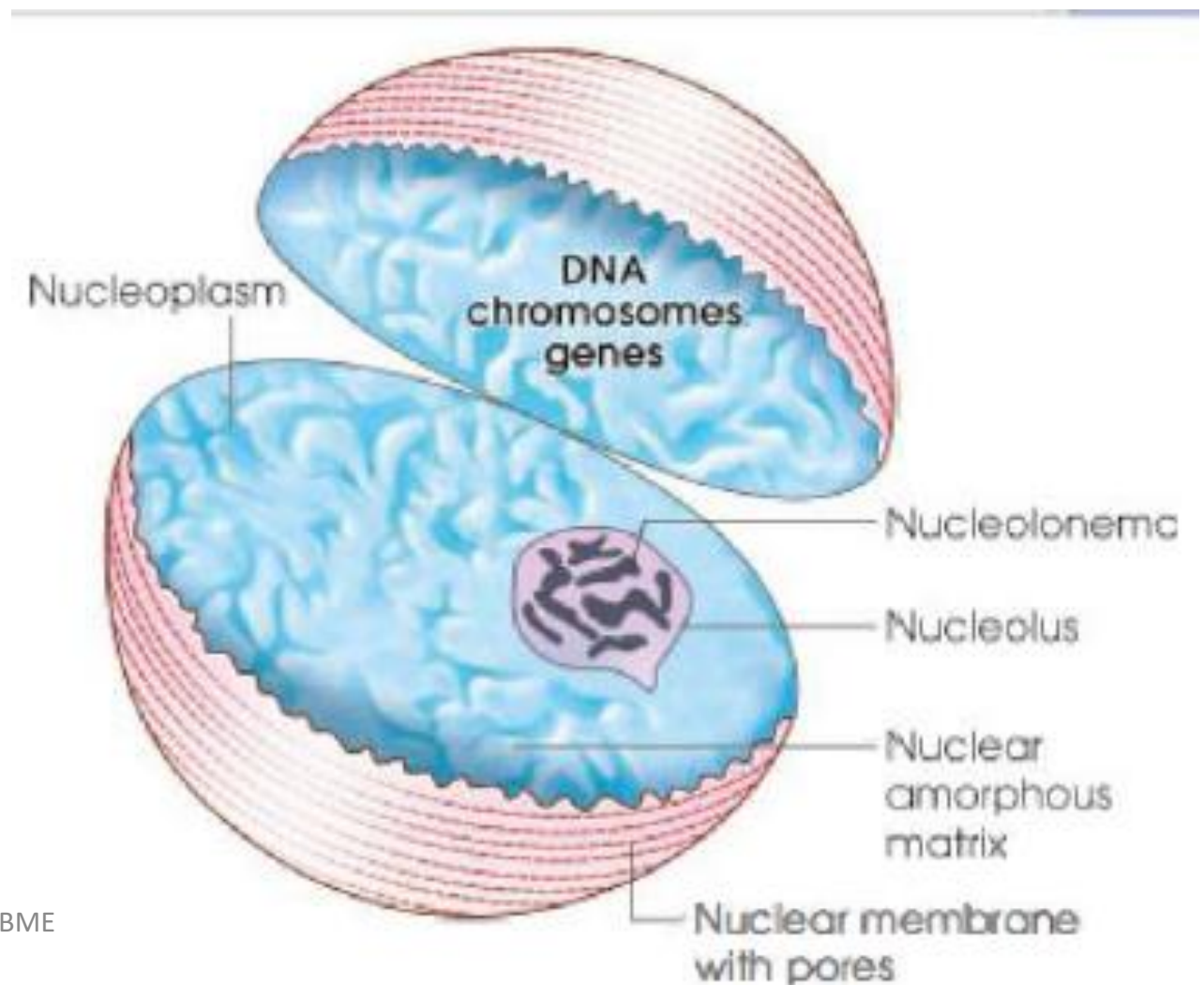


CONTD.

- Nuclear membrane is permeable only to small nonpolar molecules.
- Underlying the inner nuclear membrane is the nuclear lamina, a fibrous meshwork that provides structural support to the nucleus.

Nucleous

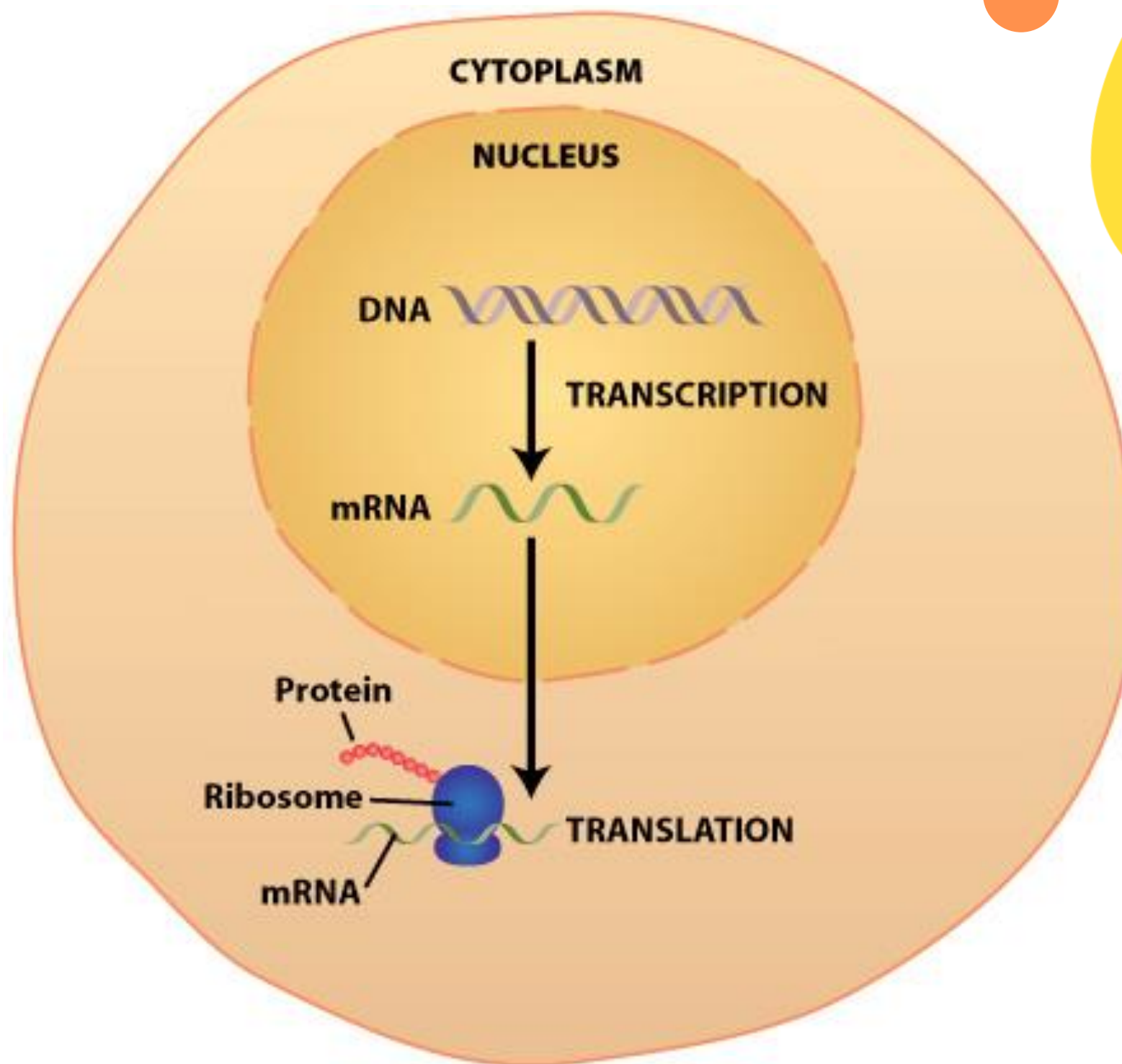
- Inside a nucleus there is usually single or may be from two to five smaller bodies known as nucleolus
- The nucleolus comprises the irregular network or rows of fine granules, nucleolonema as seen in EM.
- The nucleolus loses its identity during cell division.
- The nucleolus contains still smaller nucleus known as nucleololus or nucleolinus or nucleolonucleus





FUNCTION

- Serves both as the repository of genetic information and as the cell's control center. **(Protein Synthesis)**
- The presence of a nucleus thus allows gene expression to be regulated by posttranscriptional mechanisms, such as alternative splicing.
- The nuclear envelope provides novel opportunities for the control of gene expression at the level of transcription.



- <https://www.youtube.com/watch?v=gG7uCskUOrA>



SUMMARY

COMPARTMENTS

- Plasma Membrane
- Cytosol

- Mitochondria
- Endoplasmic Reticulum
- Golgi apparatus
- Lysosomes
- Peroxisomes
- Cytoskeleton
- Nucleus

MAJOR FUNCTIONS

- Transport of ions and molecules
- Metab. of carbohydrate, lipids and amino acids

- Energy production
- Synthesis of proteins and lipids
- Modification and sorting of proteins
- Cellular digestion
- Utilisation of H_2O_2
- Cell Morphology and cell motility
- DNA synthesis and Repair



THANK YOU