

**CELL THEORY
&
ULTRA STRUCTURE OF ANIMAL
CELL**

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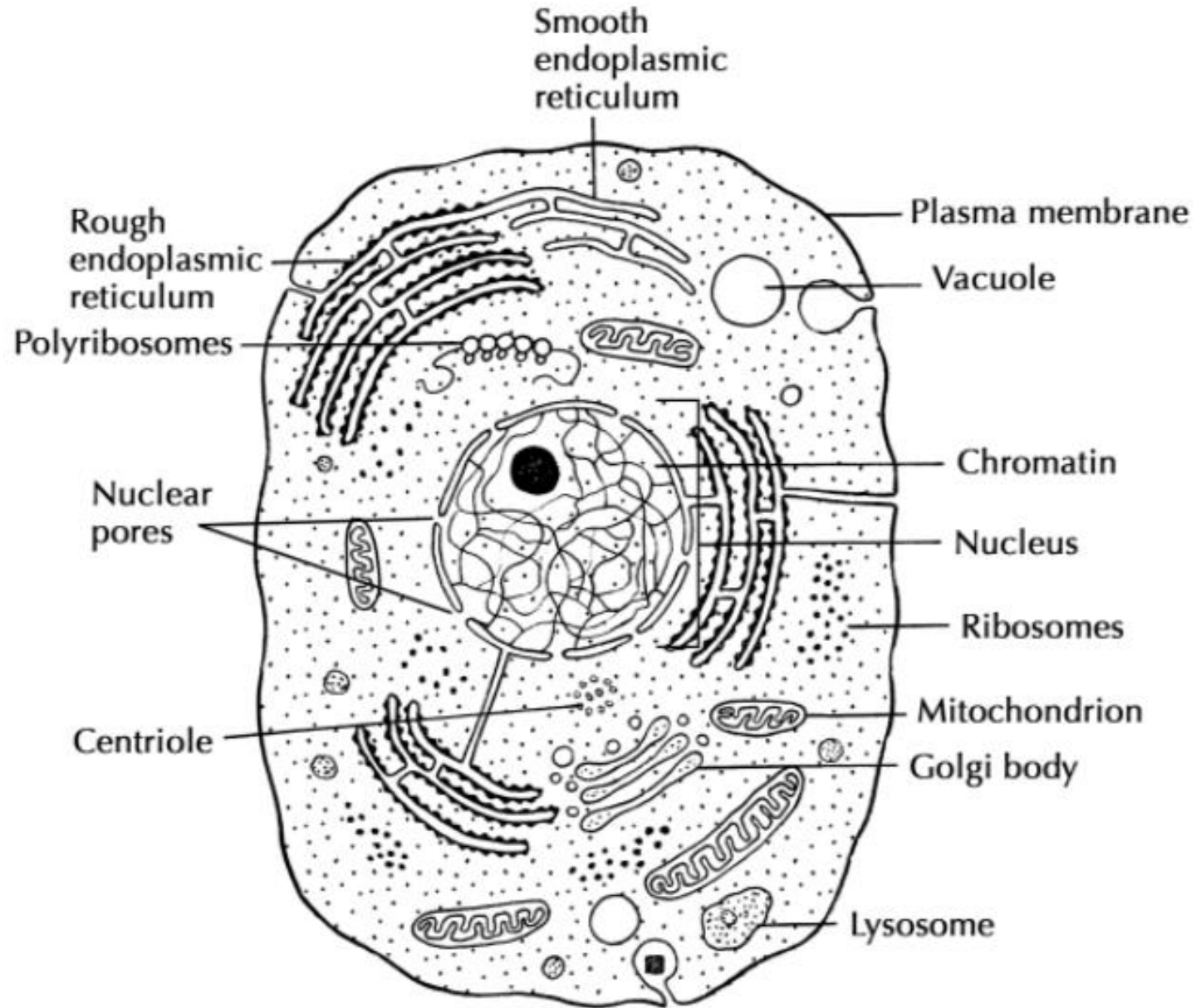
Cell Theory

- The cell theory developed in 1839 by microbiologists Schleiden and Schwann describes the properties of cells. It is an explanation of the relationship between cells and living things. The theory states that:
 - all living things are made of cells and their products.
 - new cells are created by old cells dividing into two.
 - cells are the basic building blocks of life.

- The modern understanding of cell theory extends the concepts of the original cell theory to include the following:
- The activity of an organism depends on the total activity of independent cells.
- Energy flow occurs in cells through the breakdown of carbohydrates by respiration.
- Cells contain the information necessary for the creation of new cells. This information is known as 'hereditary information' and is contained within DNA.
- The contents of cells from similar species are basically the same.

- Cells are the smallest form of life; the functional and structural units of all living things.
- Our body contains several billion cells, organised into over 200 major types, with hundreds of cell-specific functions.
- Some functions performed by cells are so vital to the existence of life that all cells perform them (e.g. cellular respiration).
- Others are highly specialised (e.g. photosynthesis).

The ultrastructure of the cell.



Cell organelles

Plasma Membrane

Cytoplasm

Nucleus

Mitochondria

Endoplasmic Reticulum

Lysosomes

Golgi bodies

Vesicles and lysosomes

Centrioles

cell membrane

- The **cell membrane**, also called the plasma membrane, physically separates the intracellular space (inside the cell) from the extracellular environment (outside the cell).
- All plant and animal cells have cell membranes. The cell membrane surrounds and protects the **cytoplasm**. Cytoplasm is part of the protoplasm and is the living component of the cell.
- The cell membrane is composed of a double layer (bilayer) of special lipids (fats) called **phospholipids**. Phospholipids consist of a **hydrophilic** (water-loving) head and a **hydrophobic** (water-fearing) tail.
- The hydrophilic head of the phospholipid is **polar** (charged) and can therefore dissolve in water. The hydrophobic tail is **non-polar** (uncharged), and cannot dissolve in water.
- The lipid bilayer forms spontaneously due to the properties of the phospholipid molecules. In an aqueous environment, the polar heads try to form hydrogen bonds with the water, while the non-polar tails try to escape from the water.

- The problem is solved by the formation of a bilayer because the hydrophilic heads can point outwards and form hydrogen bonds with water, and the hydrophobic tails point towards one another and are 'protected' from the water molecules
- All the exchanges between the cell and its environment have to pass through the cell membrane.
- The cell membrane is **selectively permeable** to ions (e.g. hydrogen, sodium), small molecules (oxygen, carbon dioxide) and larger molecules (glucose and amino acids) and controls the movement of substances in and out of the cells.
- The cell membrane performs many important functions within the cell such as osmosis, diffusion, transport of nutrients into the cell, processes of ingestion and secretion.
- The cell membrane is strong enough to provide the cell with mechanical support and flexible enough to allow cells to grow and move.

Cytoplasm

The cytoplasm is the jelly-like substance that fills the cell. It consists of up to 90% water.

It also contains dissolved nutrients and waste products. Its main function is to hold together the organelles which make up the cytoplasm.

- It also nourishes the cell by supplying it with salts and sugars and provides a medium for metabolic reactions to occur.
- All the contents of prokaryotic cells are contained within the cytoplasm. In eukaryotic cells, all the organelles are contained within the cytoplasm except the nucleolus which is contained within the nucleus.

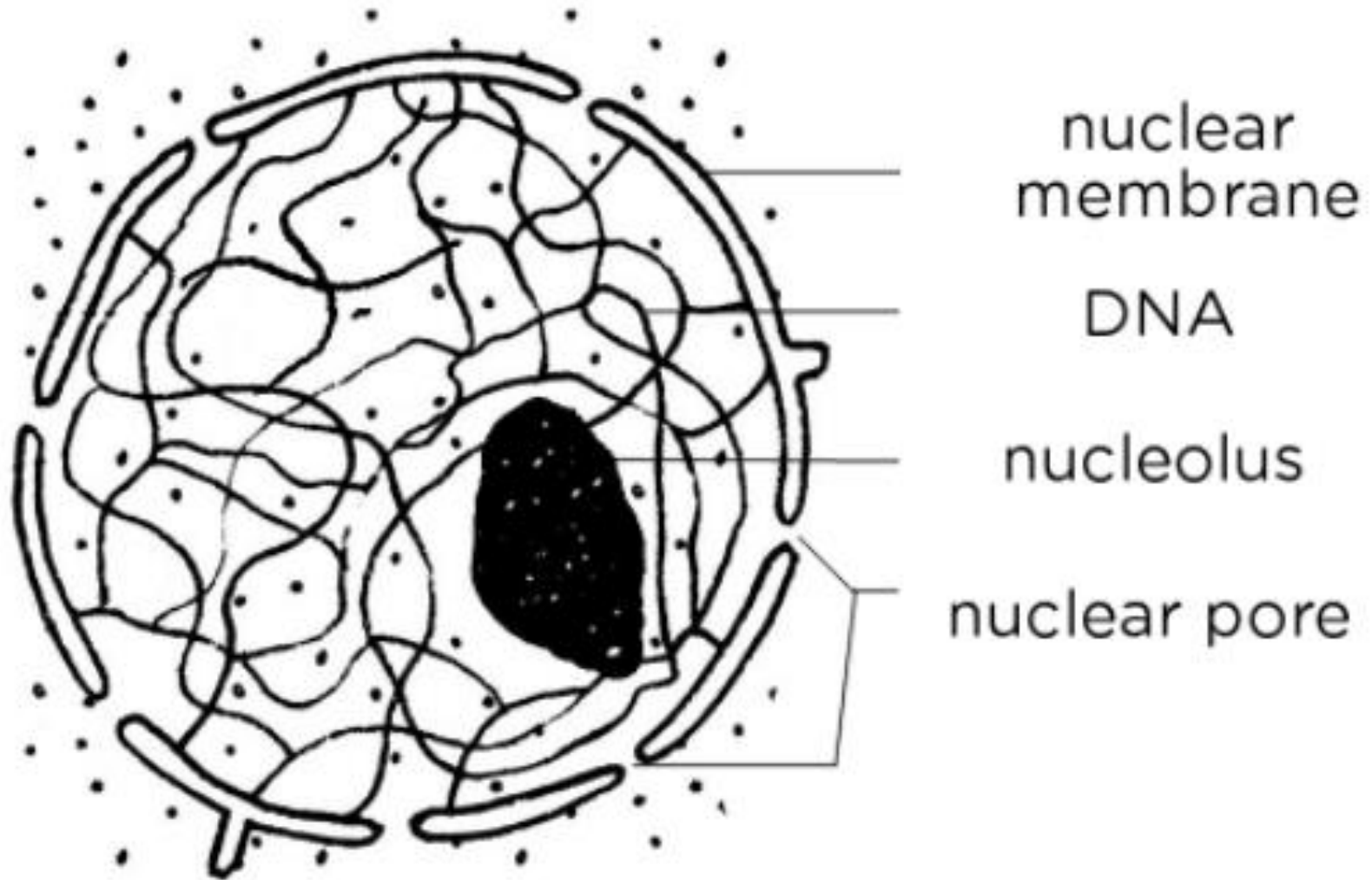
- **Functions of the cytoplasm**

- The cytoplasm provides mechanical support to the cell by exerting pressure against the cell's membrane which helps keep the shape of the cell. This pressure is known as **turgor** pressure.
- It is the site of most cellular activities including metabolism, cell division and protein synthesis.
- The cytoplasm contains ribosomes which assist in the synthesis of protein.
- The cytoplasm acts a storage area for small carbohydrate, lipid and protein molecules.
- The cytoplasm suspends and can transport organelles around the cell.

Nucleus

- The nucleus is the largest organelle in the cell and contains all the cell's genetic information in the form of DNA.
- The presence of a nucleus is the primary factor that distinguishes eukaryotes from prokaryotes. The structure of the nucleus is described below:
- **Nuclear envelope:** two lipid membranes that are studded with special proteins that separates the nucleus and its contents from the cytoplasm.
- **Nuclear pores:** tiny holes called nuclear pores are found in the nuclear envelope and help to regulate the exchange of materials (such as RNA and proteins) between the nucleus and the cytoplasm.
- **Chromatin:** thin long strands of DNA and protein.
- **Nucleolus:** the nucleolus makes RNA another type of nucleic acid.

Nucleus



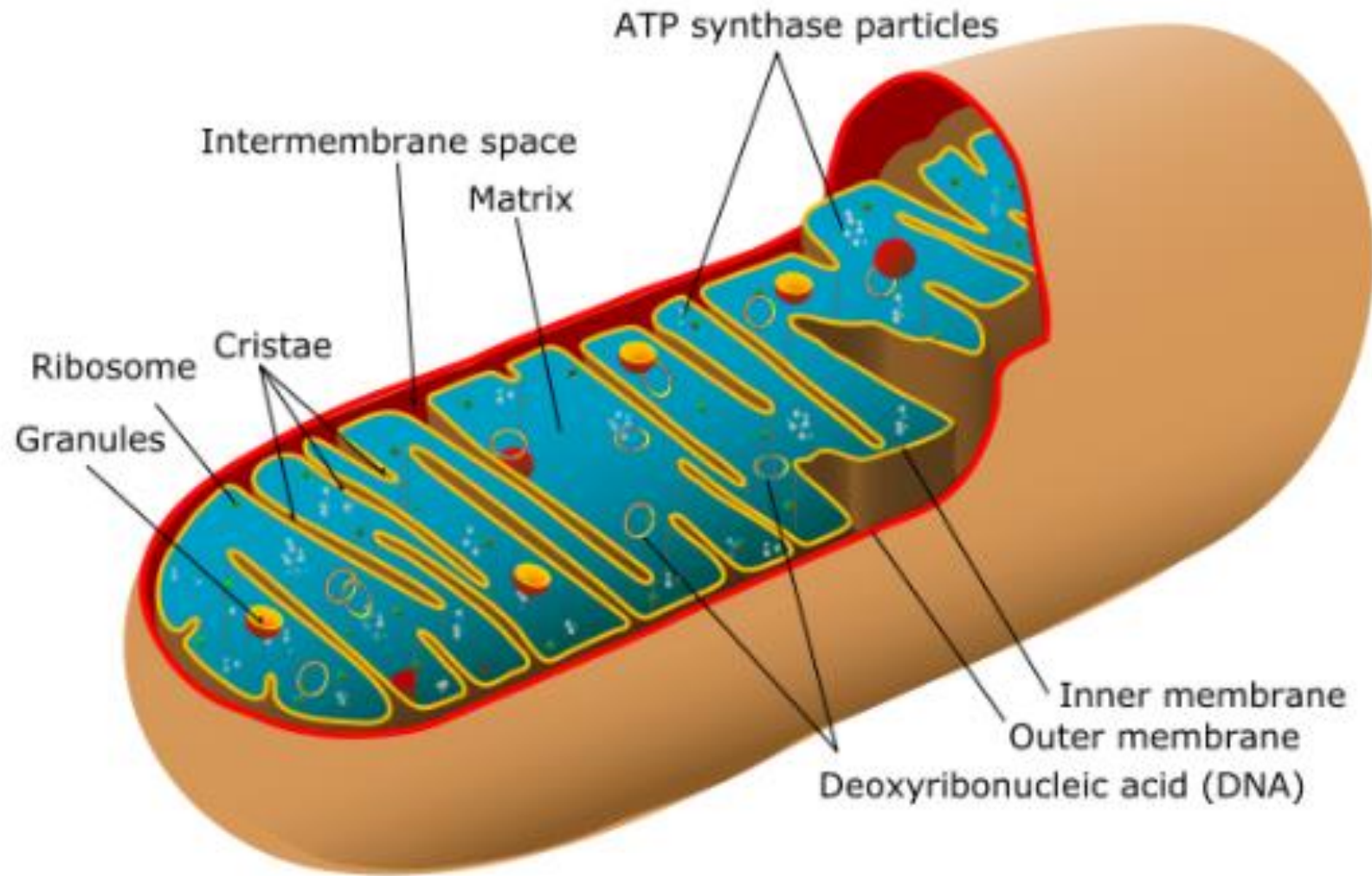
Functions of the nucleus

- The main function of the cell nucleus is to control gene expression and facilitate the replication of DNA during the cell cycle (which you will learn about in the next chapter).
- The nucleus controls the *metabolic* functions of the cell by producing mRNA which encodes for enzymes e.g. insulin.
- The nucleus controls the *structure* of the cell by transcribing DNA which encodes for structural proteins such as actin and keratin.
- The nucleus is the site of ribosomal RNA (rRNA) synthesis, which is important for the construction of ribosomes. Ribosomes are the site of protein translation (synthesis of proteins from amino acids).
- Characteristics are transmitted from parent to offspring through genetic material contained in the nucleus.

Mitochondria

- A mitochondrion is a membrane bound organelle found in eukaryotic cells. This organelle generates the cell's supply of chemical energy by releasing energy stored in molecules from food and using it to produce ATP (adenosine triphosphate). ATP is a special type of "energy carrying" molecule.
- **Structure and function of the mitochondrion**
- Mitochondria contain two phospholipid bilayers: there is an outer membrane, and an inner membrane. The inner membrane contains many folds called cristae which contain specialised membrane proteins that enable the mitochondria to synthesise ATP. Inside the inner membrane is a jelly-like matrix. Listed from the outermost layer to the innermost compartment, the compartments of the mitochondrion, are:
 - Outer mitochondrial membrane
 - Intermembrane space
 - Inner mitochondrial membrane
 - Cristae (folds of the inner membrane)
 - matrix (jelly-like substance within the inner membrane)

Structure of Mitochondria



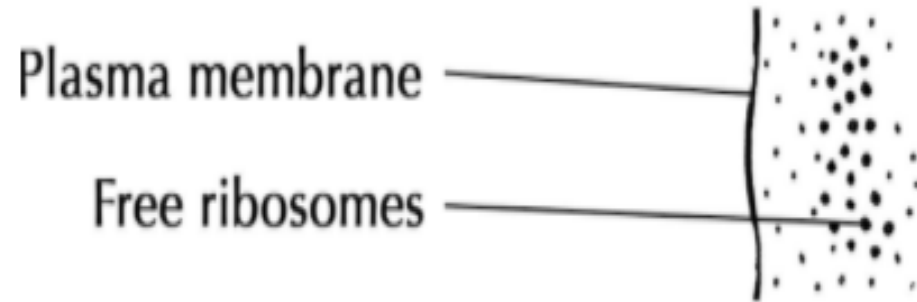
Endoplasmic reticulum

- The endoplasmic reticulum (ER) is an organelle found in eukaryotic cells only. The ER has a double membrane consisting of a network of hollow tubes, flattened sheets, and round sacs. These flattened, hollow folds and sacs are called cisternae. The ER is located in the cytoplasm and is connected to the nuclear envelope. There are two types of endoplasmic reticulum: smooth and rough ER.
- **Smooth ER:** does not have any ribosomes attached. It is involved in the synthesis of lipids, including oils, phospholipids and steroids. It is also responsible for metabolism of carbohydrates, regulation of calcium concentration and detoxification of drugs.
- **Rough ER:** is covered with ribosomes giving the endoplasmic reticulum its rough appearance. It is responsible for protein synthesis and plays a role in membrane production. The folds present in the membrane increase the surface area allowing more ribosomes to be present on the ER, thereby allowing greater protein production.

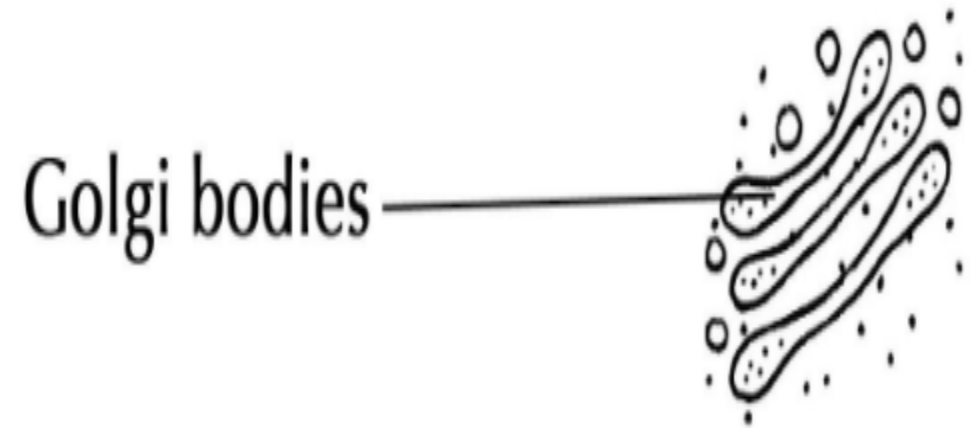
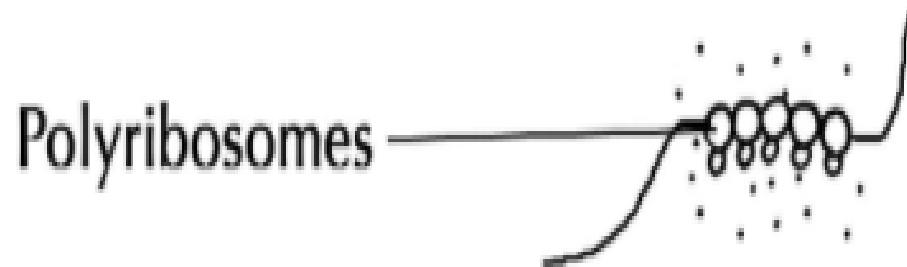
Ribosomes

- Ribosomes are composed of RNA and protein.
- They occur in the cytoplasm and are the sites where protein synthesis occurs.
- Ribosomes may occur singly in the cytoplasm or in groups or may be attached to the endoplasmic reticulum thus forming the rough endoplasmic reticulum.
- Ribosomes are important for protein production. Together with a structure known as messenger RNA (a type of nucleic acid) ribosomes form a structure known as a polyribosome which is important in protein synthesis.

Free Ribosome



Polyribosome



Golgi body

- The Golgi body is found near the nucleus and endoplasmic reticulum. The Golgi body consists of a stack of flat membrane-bound sacs called cisternae. The cisternae within the Golgi body consist of enzymes which modify the packaged products of the Golgi body (proteins).
- **Functions of the Golgi body**
- It is important for proteins to be transported from where they are synthesised to where they are required in the cell. The organelle responsible for this is the Golgi Body. The Golgi body is the sorting organelle of the cell.
- Proteins are transported from the rough endoplasmic reticulum (RER) to the Golgi. In the Golgi, proteins are modified and packaged into vesicle. The Golgi body therefore receives proteins made in one location in the cell and transfers these to another location within the cell where they are required. For this reason the Golgi body can be considered to be the 'post office' of the cell.

Vesicles and Lysosomes

- **Vesicles** are small, membrane-bound spherical sacs which facilitate the metabolism, transport and storage of molecules.
- Many vesicles are made in the Golgi body and the endoplasmic reticulum, or are made from parts of the cell membrane.
- Vesicles can be classified according to their contents and function. Transport vesicles transport molecules within the cell.
- **Lysosomes** are formed by the Golgi body and contain powerful digestive enzymes that can potentially digest the cell.
- Lysosomes are formed by the Golgi body or the endoplasmic reticulum. These powerful enzymes can digest cell structures and food molecules such as carbohydrates and proteins.
- Lysosomes are abundant in animal cells that ingest food through food vacuoles. When a cell dies, the lysosome releases its enzymes and digests the cell.

Centrioles

- Animal cells contain a special organelle called a centriole.
- The centriole is a cylindrical tube-like structure that is composed of 9 microtubules arranged in a very particular pattern.
- Two centrioles arranged perpendicular to each other are referred to as a **centrosome**.
- The centrosome plays a very important role in cell division.
- The centrioles are responsible for organising the microtubules that position the chromosomes in the correct location during cell division.