Al-Mustaqbal University

College of Engineering and Technologies

Biomedical Engineering Department

Biology

Lecture: 3

The Cytoplasm and Cellular Organelles

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The Cytoplasm and Cellular Organelles

Cytoplasm:

The **cytosol** is a complex jelly-like material of cell interior not occupied by the nucleus, containing a number of distinct, highly organized membrane-enclosed structures called the **organelles** dispersed within the cytosol. All cells contain six main types of organelles- (1). the endoplasmic reticulum, (2) Golgi complex, (3) lysosomes, (4) peroxisomes, (5) mitochondria, and (6) vacuoles. They are similar in all cells, but with some variations depending on the cell specialization. Each organelle is a separate compartment, containing different chemically setting for fulfilling a partial or cellular function. These organelles occupy about **half** of the total cell volume.

1. Endoplasmic Reticulum (ER)

The Structure and Types:

The endoplasmic reticulum is a fluid-filled membrane system extensively present throughout the cytosol. The ER is one continuous organelle with many communicating channels. The two different types are **smooth endoplasmic reticulum (smooth ER)** and the **rough endoplasmic reticulum (rough ER)**. The smooth ER is a meshwork of interconnected tubules, whereas the rough ER projects outwards from the reticulum as stacks of flattened sacs. Though different in structure and function, they are continuous with each other.

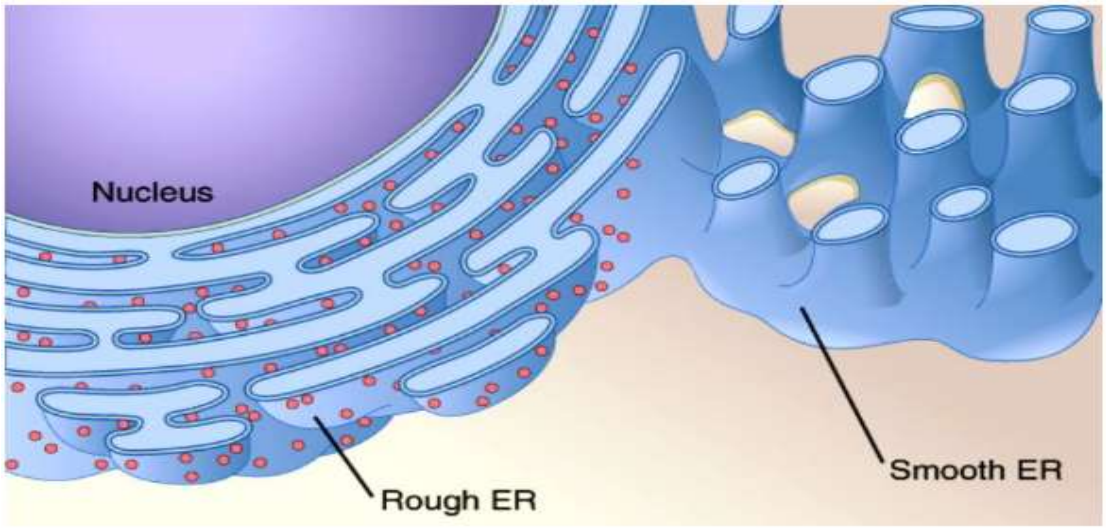

Figure1. The Endoplasmic Reticulum.

-Rough Endoplasmic Reticulum: The outer surface of the rough ER contains dark particles called **ribosomes**, which are **ribosomal RNA protein complexes** that produce **protein** under the direction of nuclear DNA.

Functions:

1.The rough ER in association with ribosomes produces and releases a variety of proteins.

- Some proteins for export as secretory products (hormones or enzymes).
- Other proteins are transported to sites within the cell for use in the construction of new plasma membrane or new organelle membrane.

2. ER membrane also contains enzymes required for the synthesis of almost all the lipids needed for the production of new membranes.

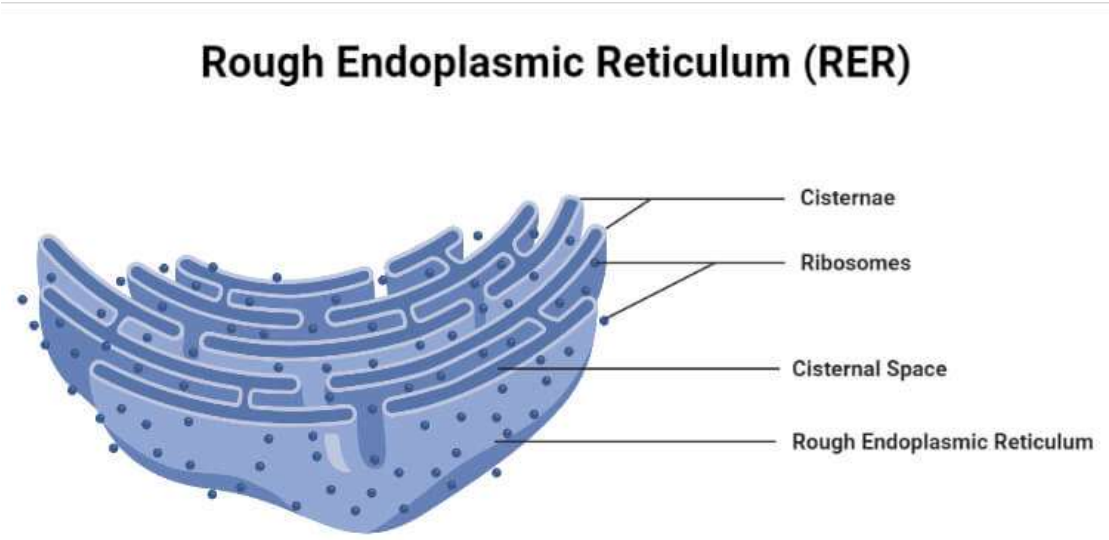

Figure 2. Rough Endoplasmic Reticulum.

-Smooth Endoplasmic Reticulum: Since it **does not** have **ribosomes**, it looks **''smooth''** and does not produce proteins.

Functions:

It serves a variety of other functions that differ in cell types.

1. In most cells, the smooth ER is sparse and serves in packaging and discharging site for protein molecules.

2. All new proteins and fats pass from ER gathered in the smooth ER.

3. Portions of the smooth ER then "bud off/pinch of", giving rise to **''transport vesicles''**, they contain the new molecule wrapped in a membrane derived from the smooth ER membrane.

4. Transport vesicles move to the Golgi complex for further processing of their cargo.

Some specialized cells have an extensive smooth ER, which has additional functions as follows:

- ✓ The smooth ER is well developed in cells specialized in lipid metabolism- cells that synthesize steroid hormones. The membrane wall of the smooth ER contains enzymes for synthesis of lipids. This is an additional site for synthesis in addition for ER to keep pace with demands for hormone secretion.
- ✓ The smooth ER of the liver and kidney cells are responsible for the detoxification and inactivation of drugs. Enzymes within the smooth ER can inactivate or destroy a variety of chemicals including alcohol, pesticides, and carcinogens.
- ✓ In skeletal muscle cells, a modified form of smooth ER stores Ca2+ to be released for muscle contraction.

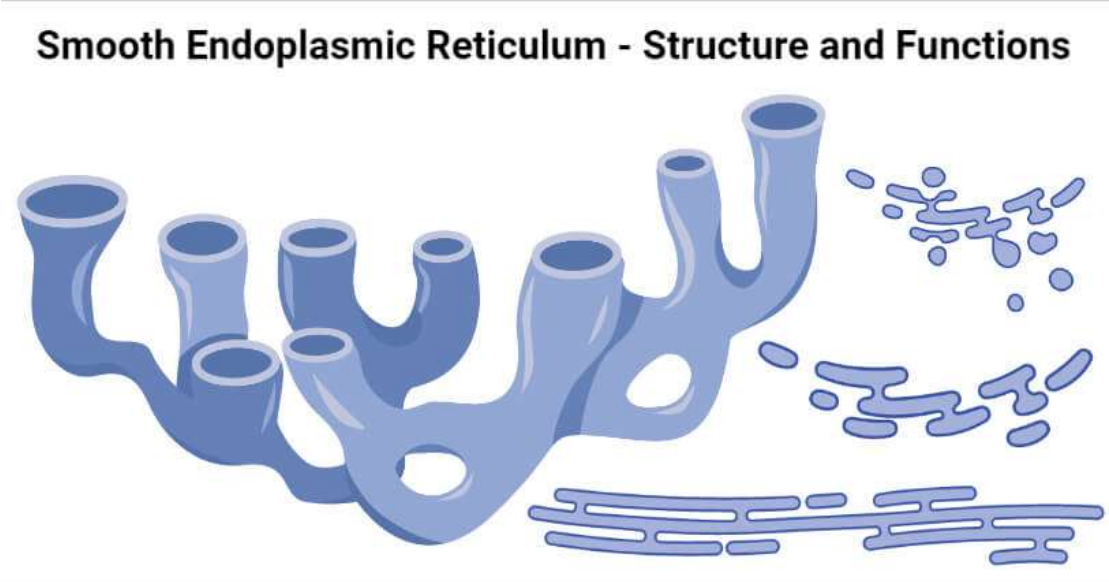

Figure 3. Smooth Endoplasmic Reticulum.

2. Golgi Complex

Structure:

The Golgi complex is elaborately associated with the ER and contains sets of flattened, curved, membrane- enclosed sacs, or cisternae, stacked

in layers. Number of stacks vary in cells; cells specialized for protein secretion have hundreds of stacks, whereas some have only one.

The majority of newly formed molecules budding off from the smooth ER enter a Golgi complex stacks. It performs the following important functions.

1. Processing the raw material into finished products. In the Golgi complex, the "raw" protein from the ER are modified into their final state.
2. Sorting and directing finished product to their final destination.

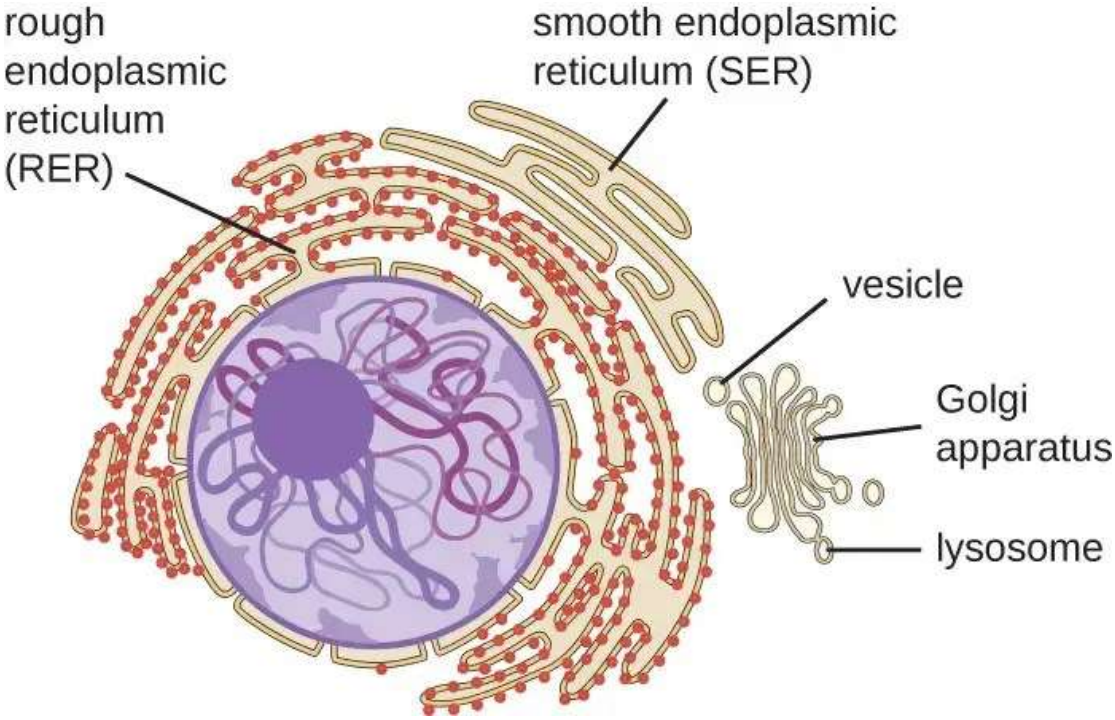

Figure 4. Structure of endoplasmic reticulum and their relation to Golgi complex and nucleus.

3. Lysosomes:

Structure:

Lysosomes are membrane-enclosed sacs containing powerful hydrolytic enzymes capable of digesting and removing unwanted cellular debris and

foreign materials such as bacteria. Lysosomes vary in size and shape, and about 300μm in a cell.

Function:

Lysosomes serve as the intracellular **''digestive system''**.

Extrinsic material to be attacked by lysosomal enzymes is brought into the interior of the cell through the process of **endocytosis**, which include: **Pinocytosis** and **Phagocytosis**.

In pinocytosis, extracellular fluid (ECF) and a large molecule such as protein is engulfed.

In phagocytosis, large multimolecular particles is engulfed; this is achieved by only a few specialized cells- white blood cells that play an important role in the body's defense mechanism. When a leukocyte encounters large multimolecular particle, such as bacteria or tissue debris, it extends projection (**pseudopodia**) that completely surround or engulf the particle, forming an internalized vesicle that traps the large multimolecular particle within it.

A lysosome fuses with the membrane of the internalized vesicle and releases its contents of hydrolytic enzymes into the vesicle. These enzymes safely attack the microbes or other trapped material within the enclosed confines of the vesicle without damaging the remainder of the cell.

Lysosomes can take up old organelles such as mitochondria and break down into their component molecules. Those molecules that can be released are reabsorbed into the cytosol, and the rest are dumped out of the cell. The process by which worn-out organelles are digested is called

autophagy, example: a human liver cell recycles about half its content every week.

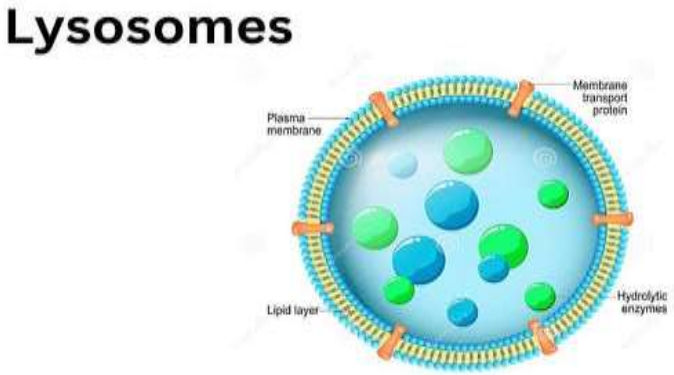

Figure 5. The structure of Lysosomes.

4. **Peroxisome**

Structure:

Peroxisome is membrane-enclosed sacs containing **oxidative enzymes** and **catalase** that detoxify various wastes. It is shorter and smoother than lysosome and several hundred may present in one cell.

Functions:

Oxidative enzymes need oxygen to remove hydrogen from specific substance/molecule; such reactions are important in detoxifying various waste products within the cell or foreign compounds that have entered in, such as ethanol consumed in alcoholic drinks (in liver and kidneys). The major product generated is **hydrogen peroxide (H_2O_2)**; hydrogen peroxide itself is a powerful oxidant. It also contains catalase, and antioxidant enzyme decomposing hydrogen peroxide into harmless water and oxygen. This reaction is an important safety reaction that destroys

deadly hydrogen peroxide, at the site of production, thereby preventing possible devastating escape into the cytosol.

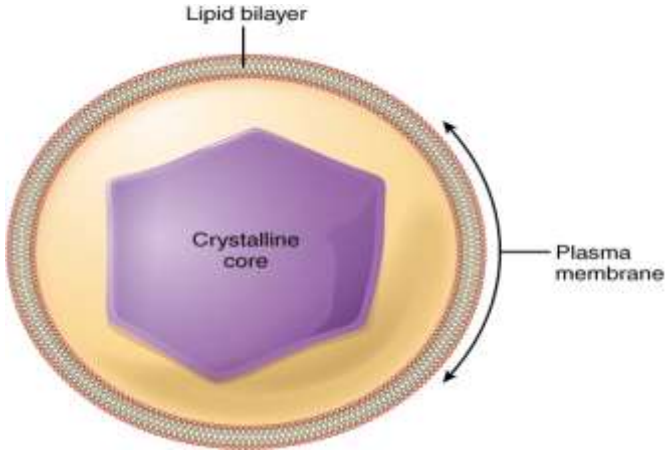

Figure 6. The Structure of Peroxisome.

5. Mitochondria

Structure:

Mitochondria are rod or oval shaped about the size of a bacterium. Each is enclosed by a double membrane - a **smooth outer** that surrounds the mitochondria, and an **inner membrane** that forms a series of enfolding or shelves called **cristae**, which project into an inner cavity filled with a **jelly-like matrix** .

Functions:

-Mitochondria are the "power houses" of a cell; they extract energy from nutrients in food and transform it into usable form (ATP). Their number varies depending on the energy needs of each particular cell types. A single cell may have few hundreds or thousands.

-**The cristae** contain **proteins** that convert much of the energy in food into a usable form (the electron transport protein). The enfolding increase the surface area available for keeping these important proteins.

2-**The matrix** contains a mixture of hundreds of different dissolved **enzymes** (Citric acid cycle enzymes) that are important in preparing nutrient molecules for the final extraction of usable energy by the cristae proteins.

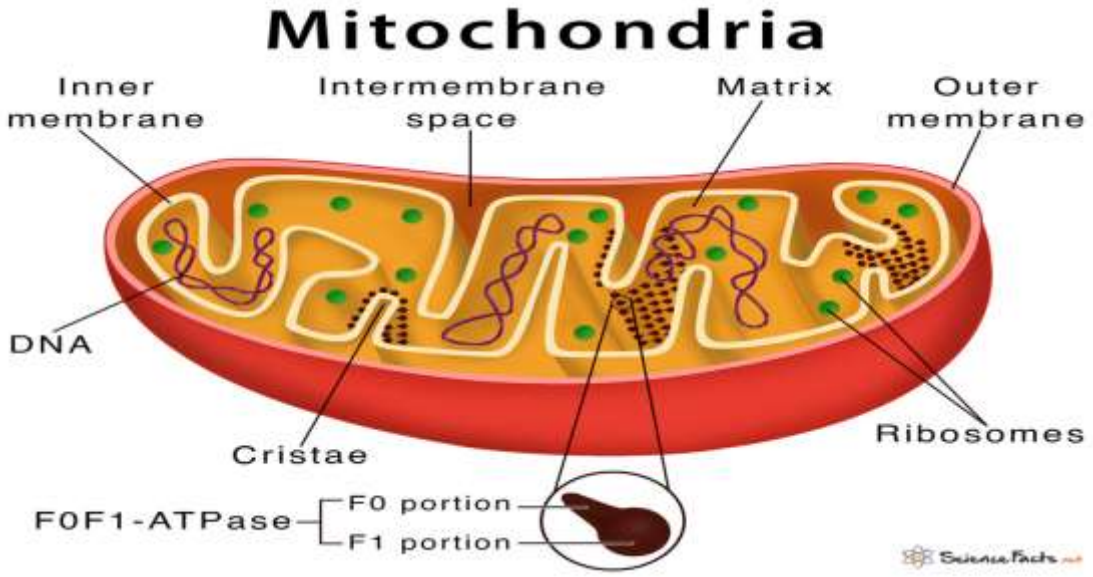

Figure 7. Structure of Mitochondria.

Mitochondria are unusual organelles in two ways:

- In the matrix they have their own unique DNA called mitochondrial DNA.
- Mitochondria have the ability to replicate themselves even when the cell to which they belong is not undergoing cell division.

6. Chloroplasts

Chloroplasts are useful organelles among plastids as they highly participate in the process of photosynthesis which is a process by which plants synthesize their own food. They are located in outer surface of the cell to receive enough light. Chloroplasts are green colored due to the chlorophyll pigments found in its internal parts. Some of important

characteristics of plant is its ability to carry out photosynthesis as the way they use in making their own food and pass through converting light energy in chemical energy.

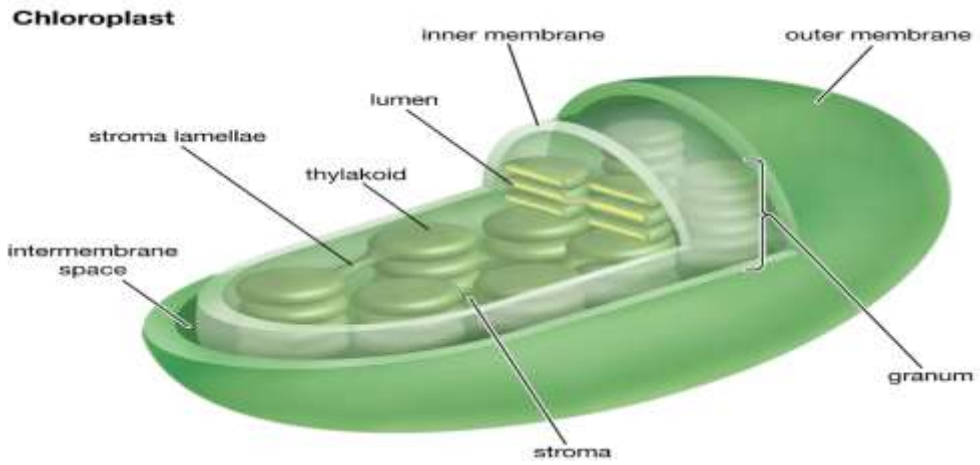

Figure 8. Structure of Chloroplast.

7. Vacuoles

Structure:

Vacuoles are essentially large vesicles, and they are formed by the joining together of many Vesicles. They are membrane bound organelles that have no specific shape and contain water with a number of different compounds within it.

Functions:

Their function varies greatly depending on the type of cell they are part of. In plant cells they are important in maintaining Turgor Pressure.

8. Cytoskeleton

Structure:

This network has at least four distinct elements: **Microtubules**, **Microfilaments**, **Intermediate filaments** and **Microtubular lattice**.

Functions:

The cytoskeleton is a complex protein network that act as the **''bone and muscle''** of the cell. This necessary intracellular structures supports and organizes cellular components arrangements and to control their movements; this provides distinct shape, size to the cell. Generally, cytoskeletons determine/ provide the:

- ✓ shape of a cell
- ✓ structural support
- ✓ organizing its contents
- ✓ substances movement through cell (cilia, flagella and intracytoplasmic vesicles), and
- ✓ contribute to movements of the cell as a whole.

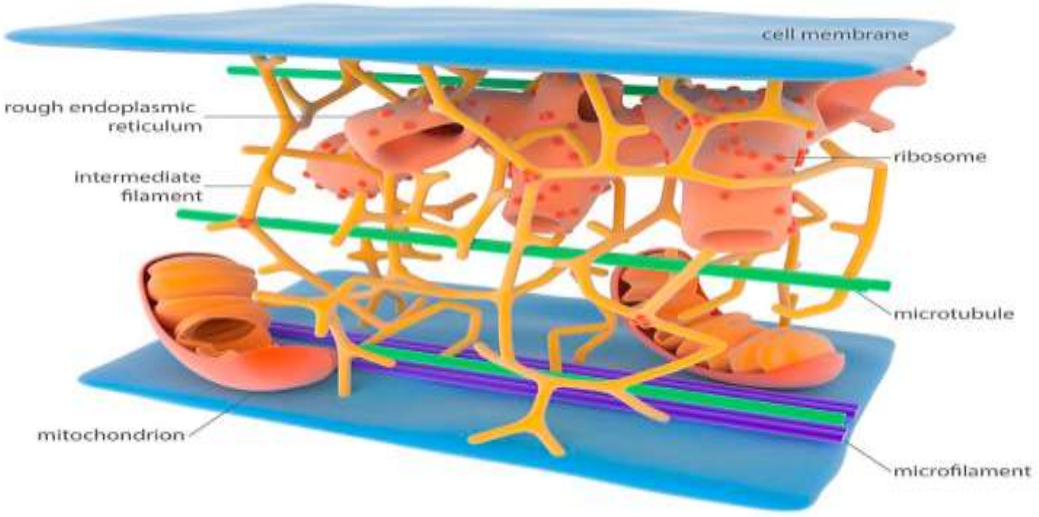

Figure 9. The Cytoskeleton.

9. Centrioles

Structure:

Centrioles are paired barrel-shaped organelles located in the cytoplasm of **animal cells** near the nuclear envelope.

Functions:

Centrioles play a role in organizing microtubules that serve as the cell's skeletal system. They help determine the locations of the nucleus and other organelles within the cell, which also have a vital role in cell mitotic division.

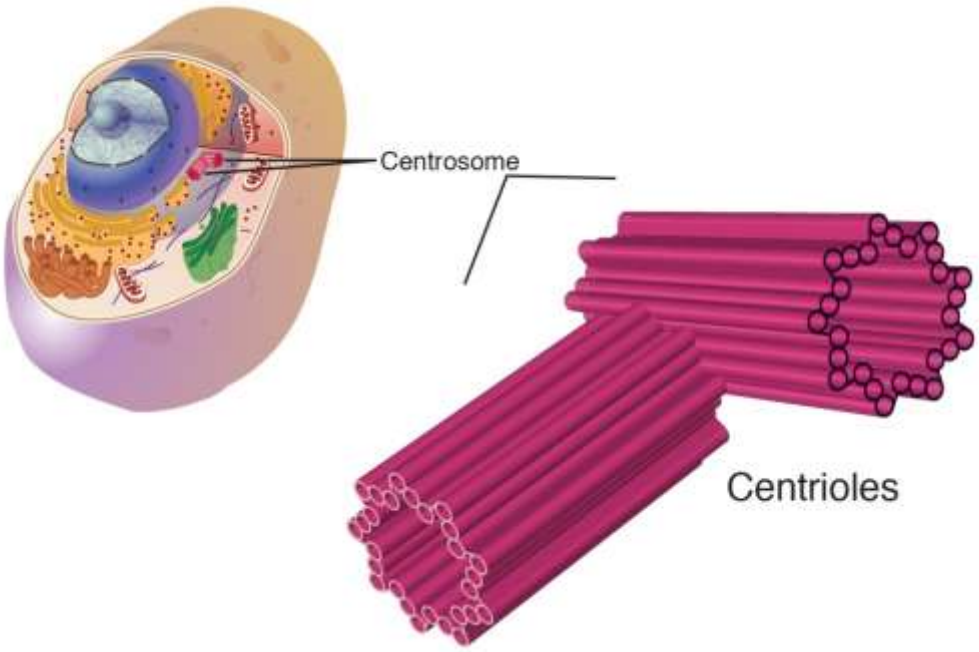

Figure 10. The structure and location of centrioles.

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