Structure of eukaryotic cell

- BIOLOGY 1st/ L5

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The nucleus, cell membrane, and cytoplasm are considered the basic components of any eukaryotic cell since these are present in all .eukaryotic cells

The cytoplasm

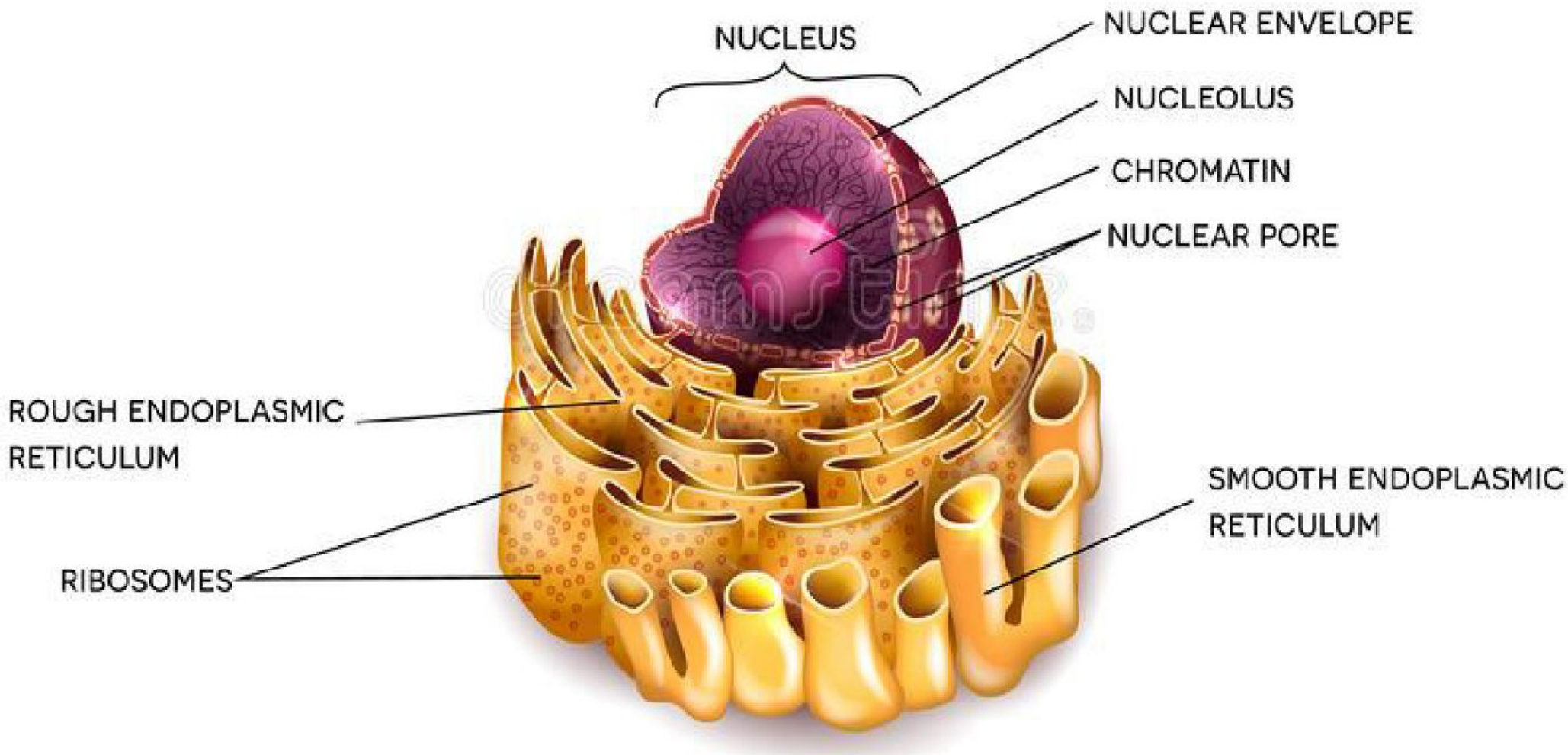
The cytoplasm is a jelly-like substance of the cell. In a eukaryotic cell, the cytoplasm is made up of the cytosol, the vesicles, the cytoskeleton, the inclusions, and the organelles except for the nucleus. The cytoplasm of a eukaryotic cell is that part of the cell between the cell membrane and the nuclear envelope. In fact, the cytoplasm and the nucleus make up the protoplasm. The cytoplasm is where the functions for cell expansion, growth, and metabolism are carried out.

Other Cellular Organelles

►The endoplasmic reticulum

- The endoplasmic reticulum (ER) is a series of interconnected membranous sacs and tubules that collectively modifies proteins and synthesizes lipids. The double membranes of smooth and rough ER form sacs called **cisternae**. Protein molecules are synthesized and collected in the cisternal space (**lumen)**.
- The RER performs many essential cellular function, including **protein synthesis**, **fragmentation** of nucleus, **calcium (Ca+) storage** and **release**, and **signaling to other organelles**.

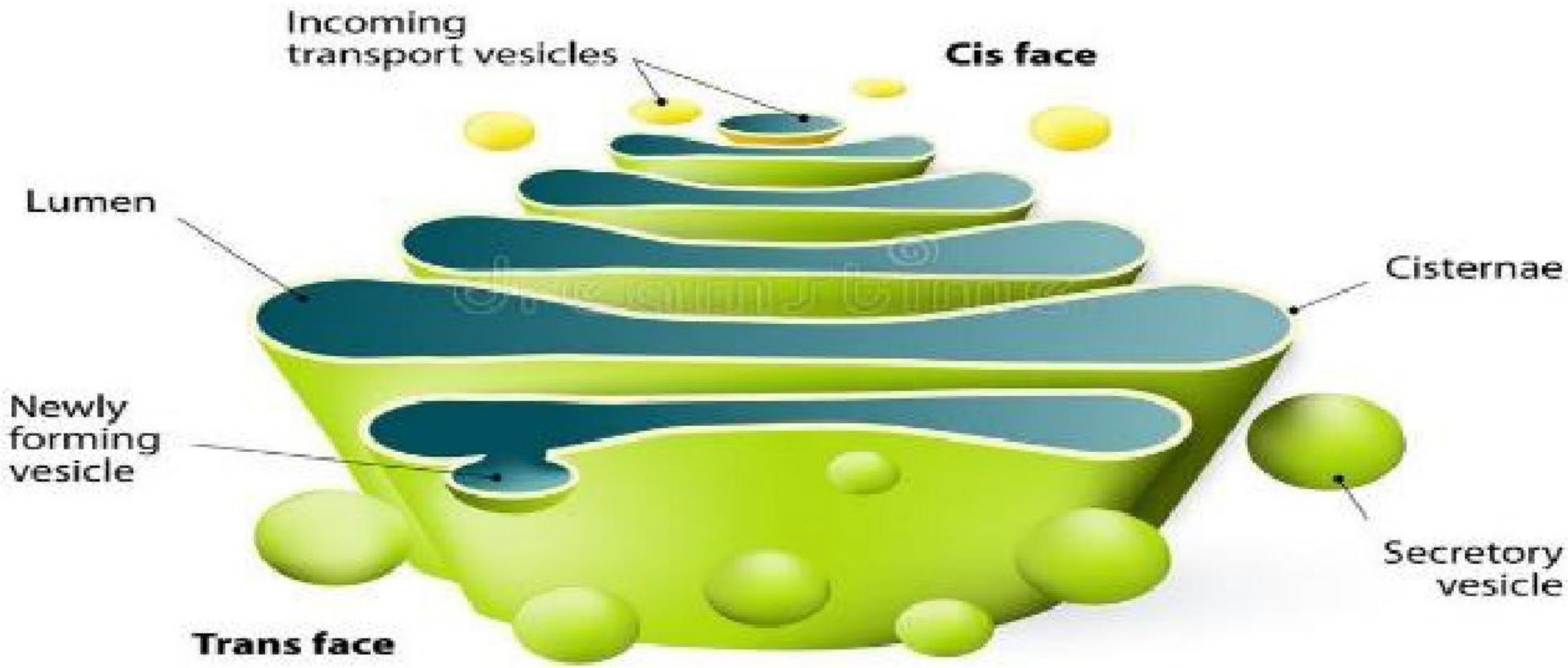
- SER is more tubular than RER and forms an interconnecting network sub-compartment of ER. It is found fairly evenly distributed throughout the cytoplasm. SER is devoted almost exclusively to the **manufacture of lipids** and in some cases to the **metabolism of them** and associated products.
- SER is also involved in the **production of steroid hormones** in the **adrenal cortex and endocrine glands**. SER also plays a large part in **detoxifying a number of organic chemicals** converting them to safer water-soluble products.


NUCLEUS
NUCLEAR ENVELOPE
NUCLEOLUS
CHROMATIN
NUCLEAR PORE
ROUGH ENDOPLASMIC RETICULUM
RIBOSOMES
SMOOTH ENDOPLASMIC RETICULUM

►Golgi body:

- Golgi body is a cellular organelle that packages and sorts proteins and other molecules before they are sent to their final destination. The Golgi apparatus consists of a stack of three to twenty slightly curved saccules (cisternae) whose appearance can be compared to a stack of pancakes.

Golgi Apparatus

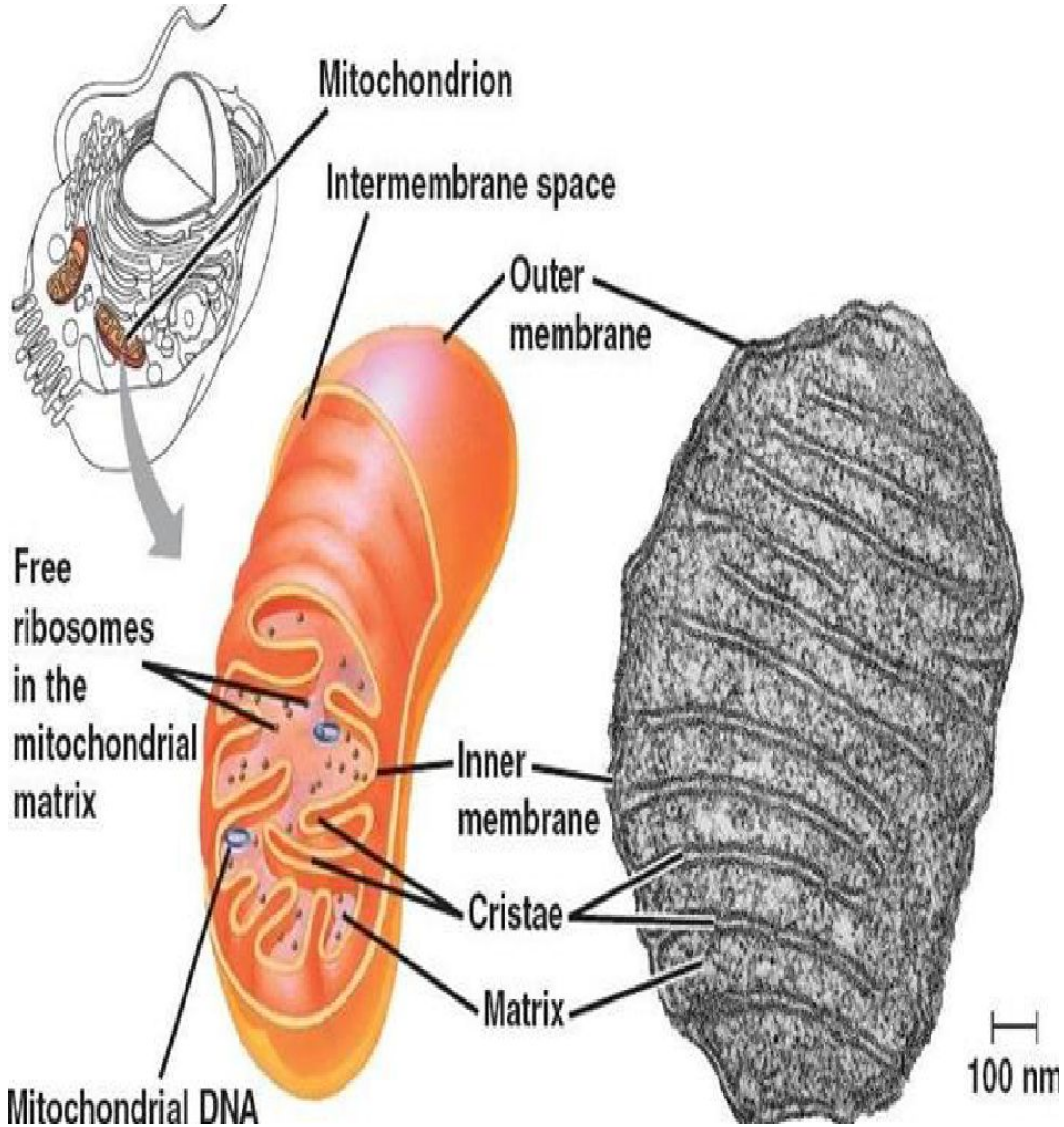


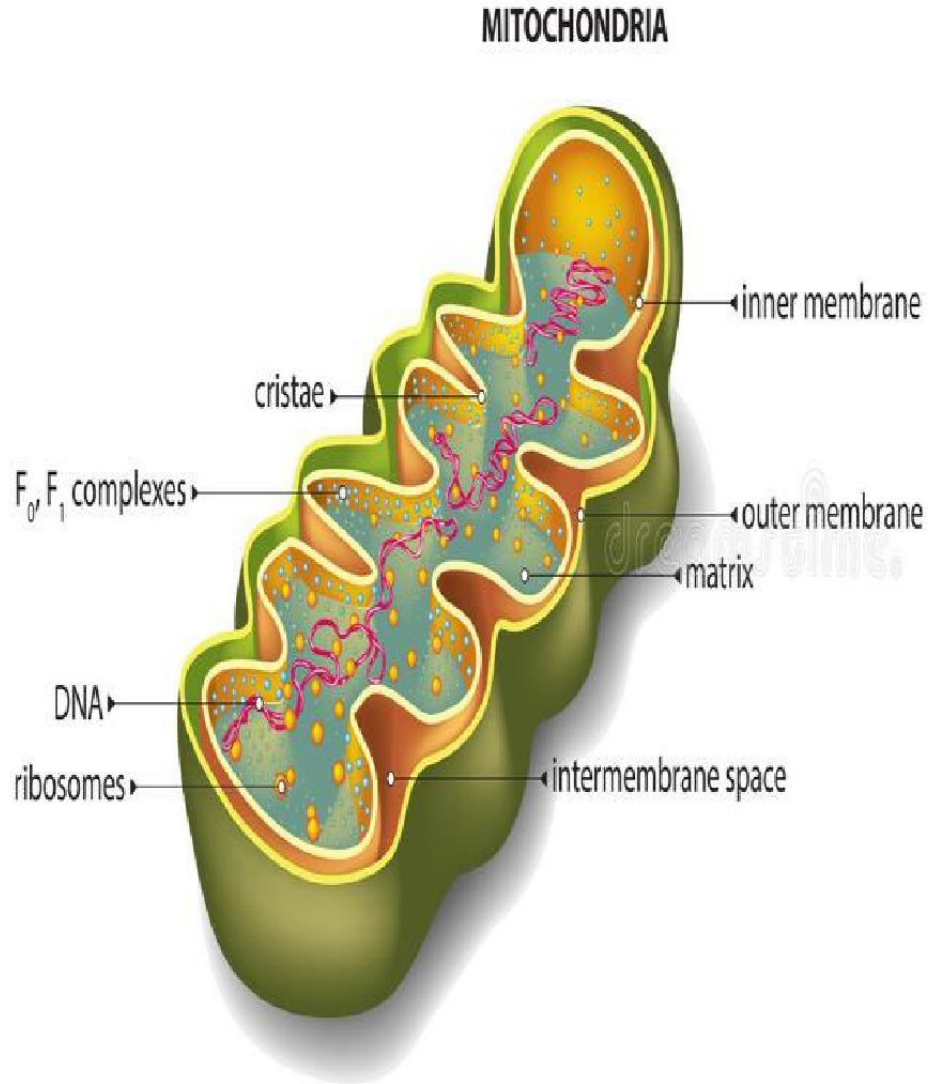
- **Function:**

- 1) Golgi apparatus modifies proteins that it receives from the RER.
- 2) Transport lipids to vital parts of the cell and creates lysosomes.
- 3) Some of modifications made inside the Golgi complex include; attaching polysaccharides to proteins, cutting proteins into smaller active fragments, incorporating phosphates on to protein molecules and addition of a sulfate group to molecules.
- 4) Production of glucosaminoglycans which go on to form parts of connective tissues.

►Mitochondria

- The mitochondrion (plural mitochondria) is a double membrane-bound organelle found in all eukaryotic organisms, although some cells in some organisms may lack them (e.g. red blood cells). Mitochondria have been described as "the powerhouse of the cell" because they generate most of the cell's supply of adenosine triphosphate (ATP), used as a source of chemical energy. Mitochondria are typically round to oval in shape and range in size from 0.5 -10 μm.
- The number of mitochondria per cell varies widely; for example, in human's liver and muscle cells may contain hundreds or even thousands.


Mitochondrion
Intermembrane space
Outer membrane
Free ribosomes in the mitochondrial matrix
Inner membrane
Cristae
Matrix
Mitochondrial DNA
100 nm


MITOCHONDRIA
inner membrane
cristae
F_0, F_1 complexes
outer membrane
matrix
DNA
ribosomes
intermembrane space

• Structure of Mitochondria

- **Outer membrane, inner membrane, inter-membrane space, and Matrix.**
- **The outer membrane** is a relatively simple phospholipid bilayer, containing protein structures called porins which render is permeable.
- **The inner membrane** is more complex in structure than the outer membrane as it contains the complexes of the electron transport chain and the ATP synthetase complex. The inner membrane has infoldings called the **cristae** that increase the surface area for the complexes and proteins that aid in the production of ATP.
- **The inter membrane space:** It has an important role in the primary function of mitochondria, which is oxidative phosphorylation happen.
- **The matrix** is a complex mixture of enzymes that are important for the synthesis of ATP molecules. It also contains mitochondrial DNA and ribosome.

- **Mitochondrial DNA**

- Mitochondria are independent organelles they have their own DNA and ribosomes. They have circular DNA similar to bacteria and replicate by fission. Mutations in the mitochondrial DNA leads to a number of diseases such as:

- Young-adult blindness.
- Progressive muscular disorders.
- Some cases of Alzheimer's disease.
- Type -two diabetes mellitus.

Function of Mitochondria

- 1- The most important function of the mitochondria is to **produce energy**.
- 2- Help the cells to **maintain** proper concentration of **calcium ions** within the cell .
- 3- Help in **building** certain parts of blood and **hormones like testosterone and estrogen** .
- 4- Have **enzymes** that **detoxify ammonia** .
- 5-Play important role in the process of **programmed cell death**.

►Ribosomes

- The ribosome is a complex molecular machine, found within all living cells, that serves as the site of biological protein synthesis (translation). Ribosomes link amino acids together in the order specified by messenger RNA (mRNA) molecules. Ribosomes consist of two major components: the small ribosomal subunit, which reads the mRNA, and the large subunit, which joins amino acids to form a polypeptide chain. Each subunit is composed of one or more ribosomal RNA (rRNA) molecules and a variety of ribosomal proteins.
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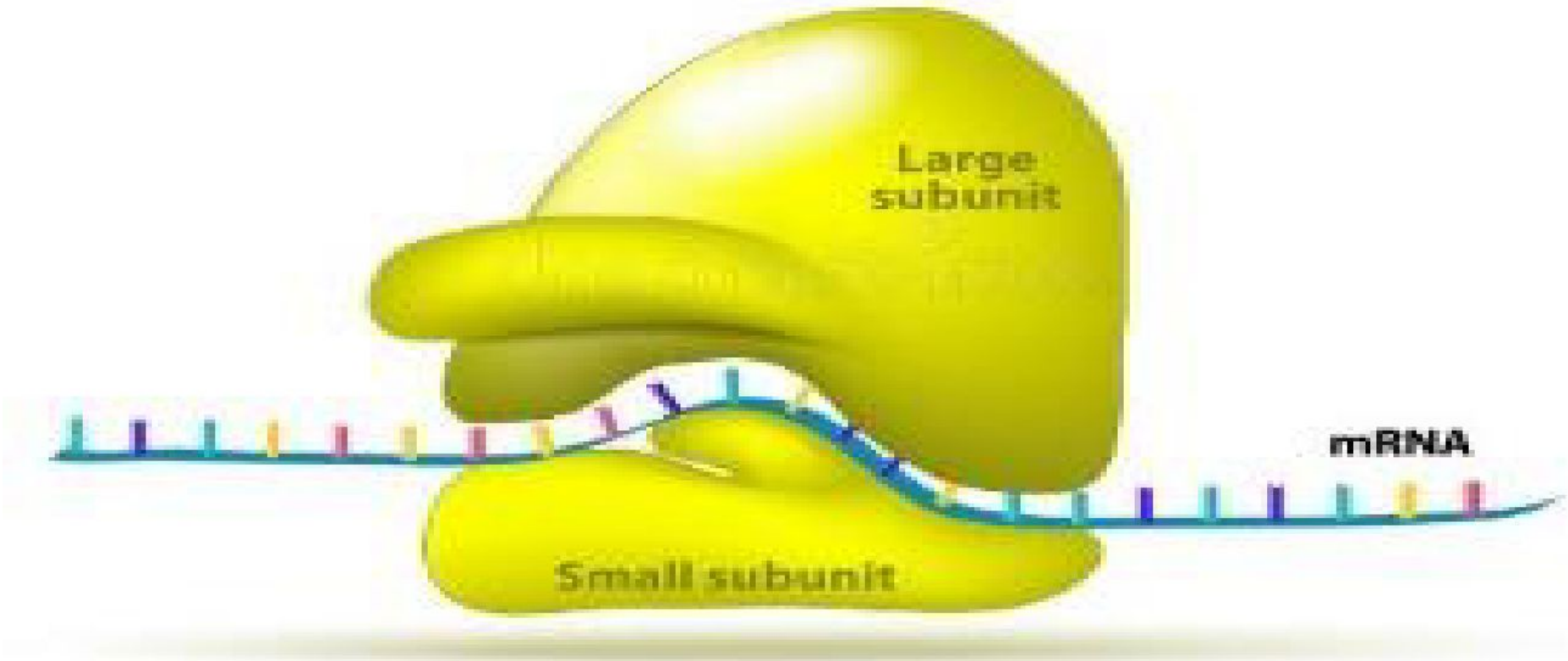
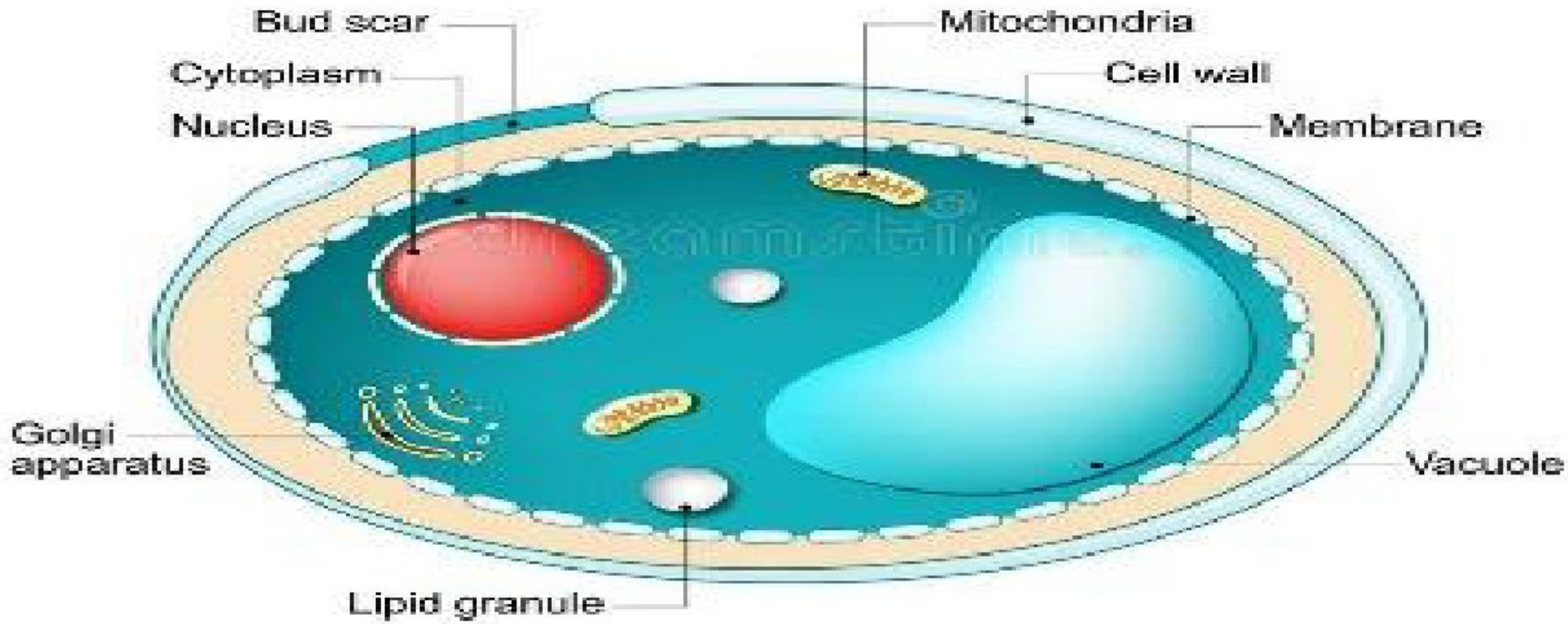
RIBOSOME



►Vacuole

- Vacuole is a membrane-bound organelle. The main function of vacuoles is:
- ·**Remove** and store **waste produced** during autophagy (when part of the cell is broken down due to age or damage)
- ·Remove and store harmful foreign products.
- ·Store water.
- ·Store nutrients such as lipids, proteins, and carbohydrates

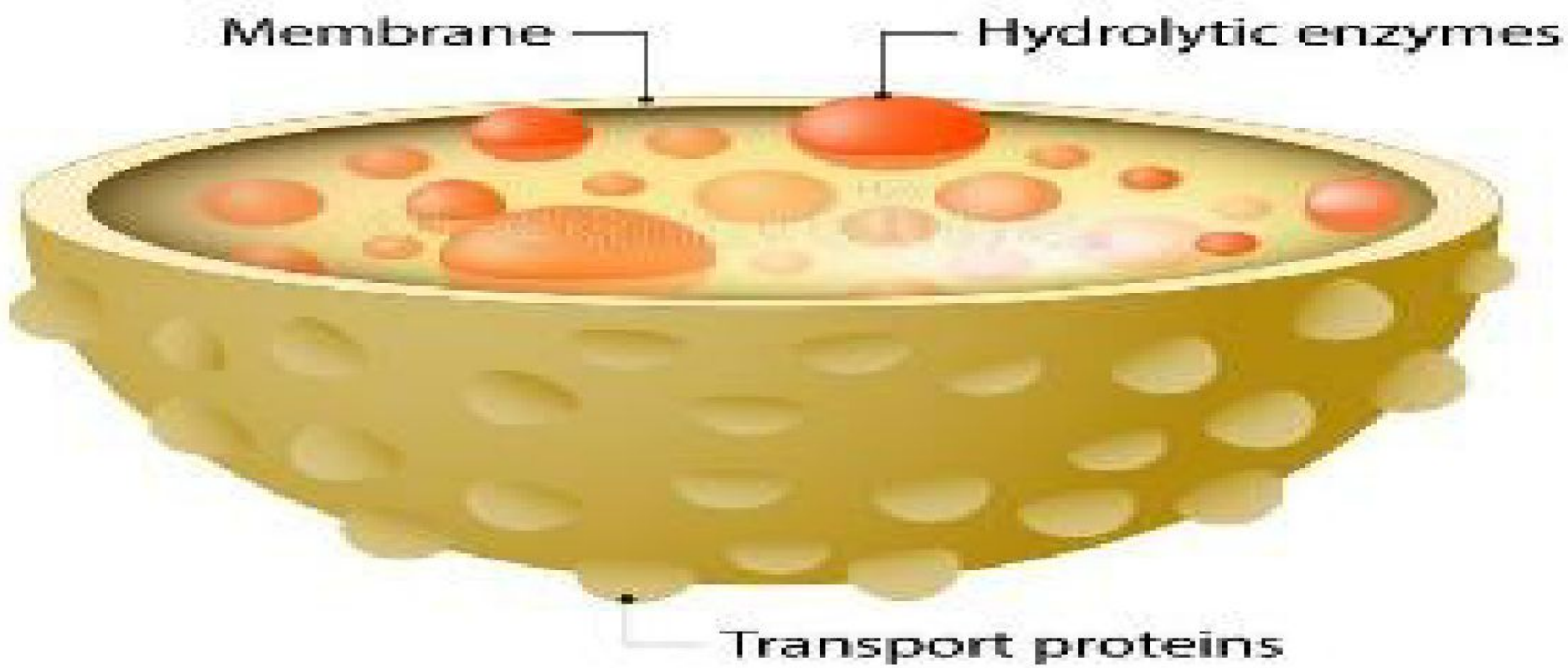
YEAST CELL


Bud scar
Cytoplasm
Nucleus
Mitochondria
Cell wall
Membrane
Golgi apparatus
Vacuole
Lipid granule

►Lysosome

- Lysosomes are actually membranous sacs filled with enzymes. Lysosomes digest many complex molecules such as carbohydrates, lipids, proteins, and nucleic acids, within the cell then recycles for other uses. The pH of lysosomes is acidic (around pH 5) because their hydrolytic enzymes function best at this pH instead of at the neutral pH of the rest of the cell.
- The main two types of lysosome are:
- 1-**Autophagic** vacuoles (Auto-phagosomes, Auto-lysosomes): is a spherical structure with double layer membranes. It is an intracellular degradation system for cytoplasmic contents (e.g. abnormal intracellular proteins, excess or damaged organelles) and also for invading microorganisms.
- 2-**Heterophagosomes** or digestive vacuoles: A secondary lysosome is formed by phagocytosis or pinocytosis, which becomes fused with a lysosome, subjecting its contents to enzymatic digestion.

LYSOSOME



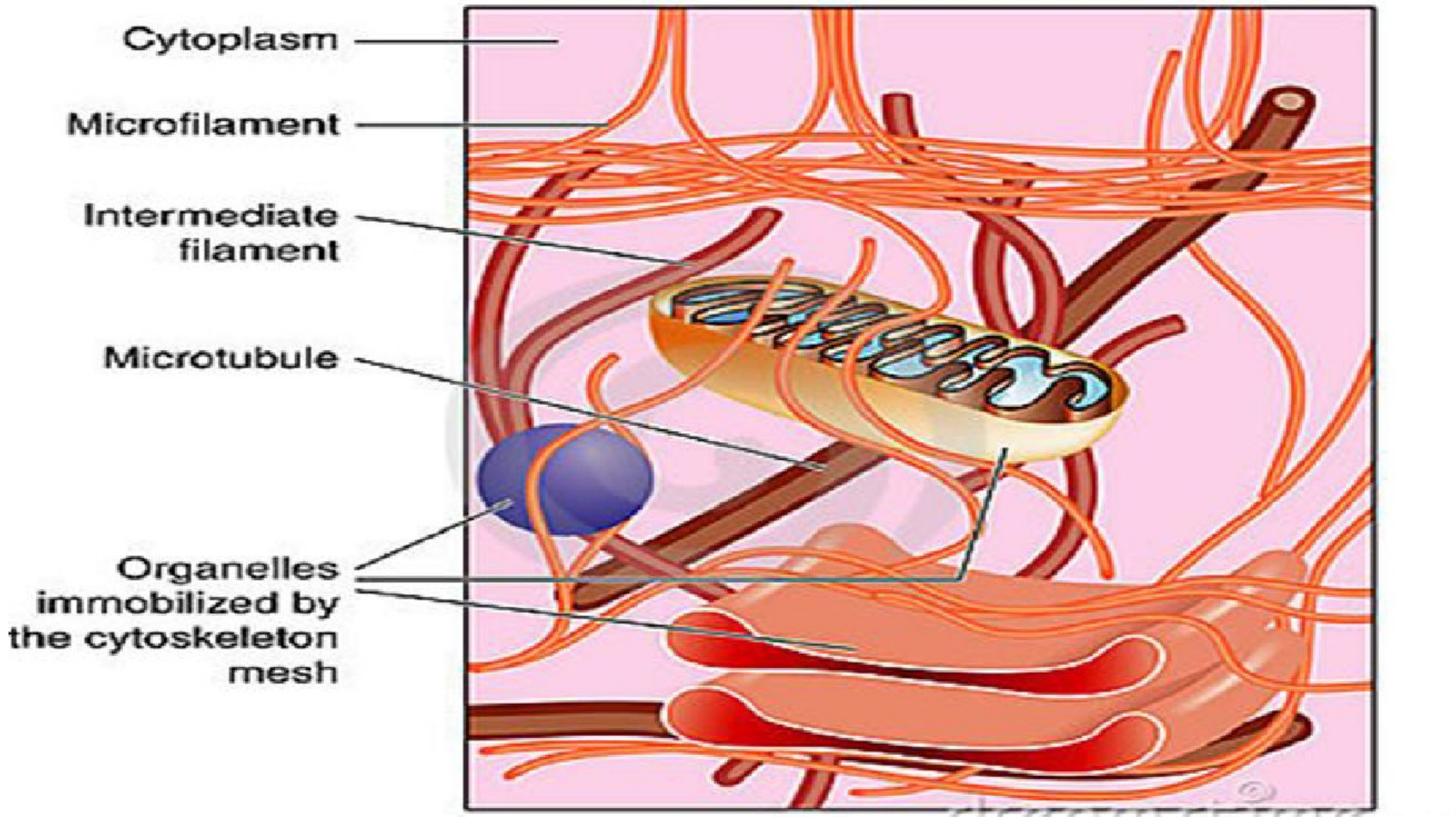
Peroxisome

- Peroxisome is a type of organelles known as a microbody. The main function of peroxisomes is to **break down long fatty acid chains through beta-oxidation** and **synthesize necessary phospholipids** (such as **plasmalogen)** that are critical for proper brain and lung function.

►Eukaryotic Cytoskeleton

- The cytoskeleton is a network of fibers throughout the cell's cytoplasm. The structure, function and dynamic behavior of the cytoskeleton can be very different, depending on the organism and cell type. Even within one cell the cytoskeleton can change through association with other proteins.
- It is typically divided into three categories based on the diameter and composition of the filaments.

1. Microfilaments (Actin filaments).
2. 2- Intermediate filaments
3. 3- Microtubules.


Cytoplasm
Microfilament
Intermediate filament
Microtubule
Organelles immobilized by the cytoskeleton mesh

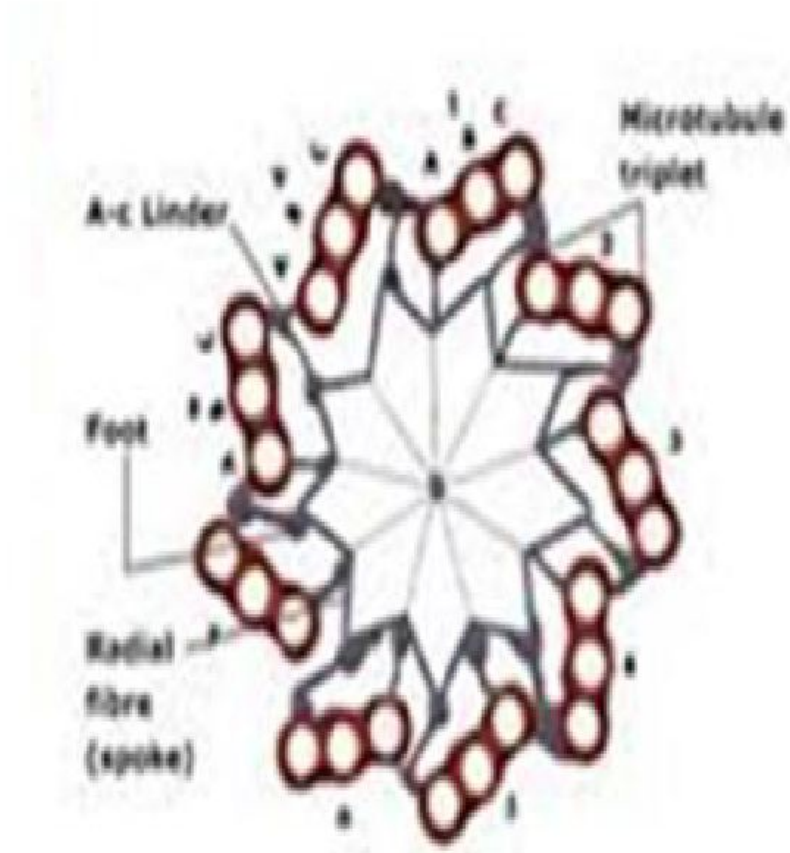
• ►Microfilaments (Actin filaments AF):

- Microfilaments are solid rods made of a protein known as **actin**. It is about 3-6 nm.

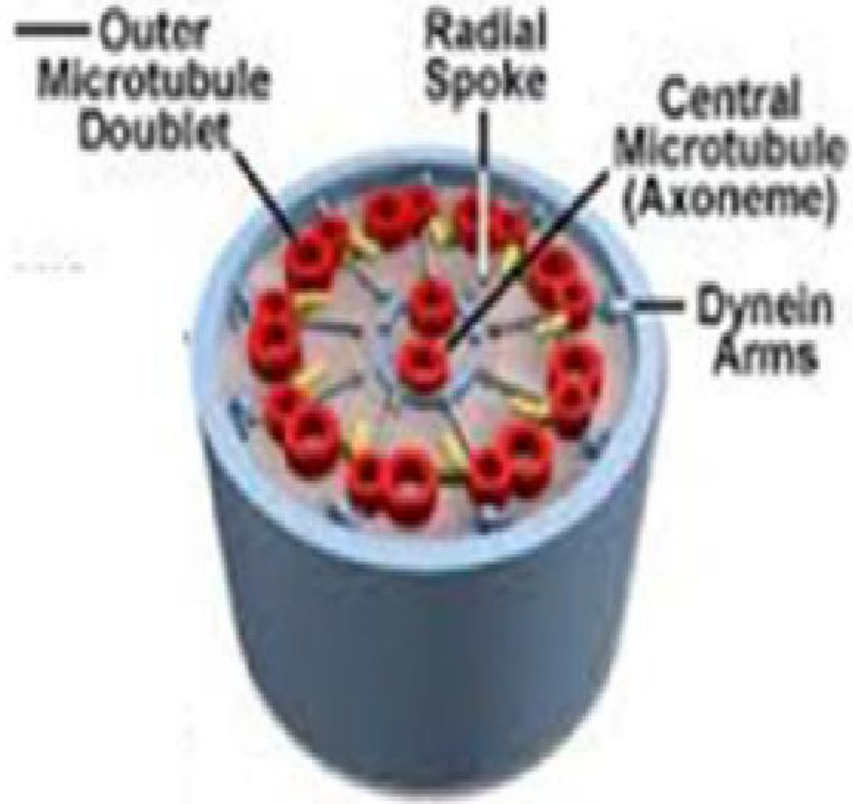
• <u>Functions of microfilaments:</u>

- 1- Provides **mechanical strength** to the cell
- 2- **Link transmembrane proteins** (e.g. cell surface receptor) to cytoplasmic proteins.
- 3-**Anchors the centrosomes** at opposite poles of the cell during mitosis.
- 4-**Pinches the dividing animal cells** during cytokinesis.
- 5-**Supports the plasma membrane**.
- 6- **Associate with the protein myosin** which is responsible for muscle contraction.
- 7- **Maintenance of cell-shape**.
- 8- These filaments are associated with membrane activities such as ***endocytosis*** and ***exocytosis.***

- **Microtubules (MT):**
- Microtubules are hollow cylindrical tubes, 20-25 nm in diameter. It is composed of polymers of **alpha** and **beta tubulin**.
- In nine triplet sets (star-shaped), they form the centriole, and in nine doublets oriented about two additional microtubules (wheel-shaped) they form **cilia** and **flagella.**
- The latter formation is commonly referred to as **“9+2”** arrangement, where in each doublet is connected to another by protein dynein.



Cross section of: Centriole



Cilia and Flagella

- **MT plays key roles in:**

- 1. Responsible for various kinds of **movements** in all eukaryotic cells.
- 2. Microtubules are involved in nucleic and **cell division**.
- 3. **Organization of intracellular structur**e, and intracellular **transport.**
- Intracellular transport (associated with dyneins and kinesis). They transport organelles like mitochondria or vesicles) and chromosomes during mitosis.
- 4. **The axoneme** of cilia and flagella.
- 5. **Form the mitotic spindle.**

- **Intermediate Filaments (Keratin filaments) (IF)**

- Intermediate filaments have a diameter of about 10 nm, which is intermediate between the diameters of two other principles elements of the cytoskeleton, actin filaments and microtubules. The intermediate filaments are not directly involved in cell movements. Instead, they appear to **play basically a structural role by providing mechanical strength** to cells and tissues.

- **Originally**:
- Filaments are serving as structural components of the nuclear lamina and sarcomeres (functional unit of striated muscle).
- The dysfunction of the cytoskeleton, a constituent element of the cell, is often associated with pathologies such as the onset of metastases. For this reason, it is a target of interest in numerous therapies.
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