Faculty of Medicine
Histology Department

NON-MEMBRANOUS ORGANELLES

Lecture 10
In
Block 102PMS

Dr/ Maha Mahmoud Abd El Rouf
Lecturer of Histology

Histology and cell biology Department/ Faculty of Medicine/Assiut University

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Learning objectives

After the lecture, students should be able to:

- Define cytoskeleton and enumerate its components.
- Discriminate the structure and function of microtubules and centrosomes.
- Illustrate the structure and function of microfilaments.
- Recognize structure and types of intermediate filaments.
- Describe the structure and types of ribosomes.

Non- Membranous organelles

They include:

1- Cytoskeleton which includes (Microfilaments, Intermediate filaments and Microtubules)

2- Proteosomes

3- Centrosomes

4- ***Ribosomes***

The Cytoskeleton

The term cytoskeleton collectively refers to three separate classes of proteins seen as fine cytoplasmic filaments.

Microfilaments (also called actin filaments); have the smallest diameter ; about 6 nm.

Intermediate filaments; they are about 8 to 10 nm in diameter.

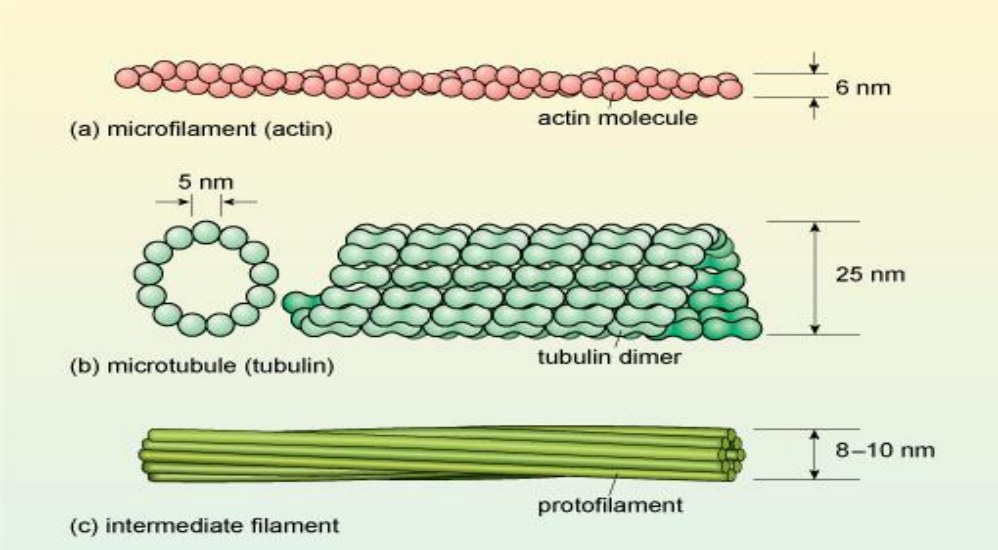
Microtubules, which are about 25 nm in diameter.

Function:

1-Determine the shapes of cells.

2- Play an important role in the movements of organelles and cytoplasmic vesicles.

3- Allow the movement of entire cells.



Cytoskeleton

1-Microtubules

Microtubules are fine tubular structures within the cytoplasm of all eukaryotic cells.

Structure:

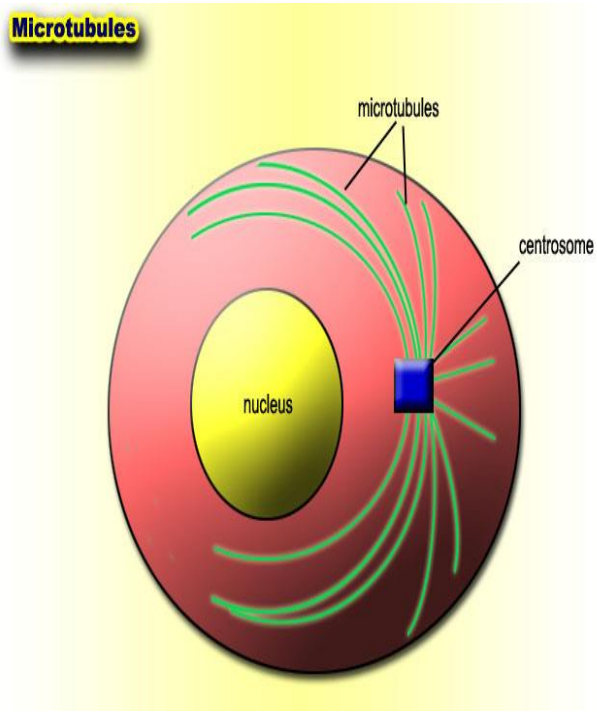
- Each microtubule is hollow, a rigid structure with an outer diameter of 25 nm, that help to maintain cell shape.
- The protein subunit of a microtubule is a heterodimer of ***α*** and ***β tubulin.***
- The tubulin subunits align as ***protofilaments***.
- The circumference of each microtubule wall is formed of 13 protofilaments.
- Microtubule are highly dynamic in length by a process of polymeraization or depolymerization of tubulin subunits.

Functions:

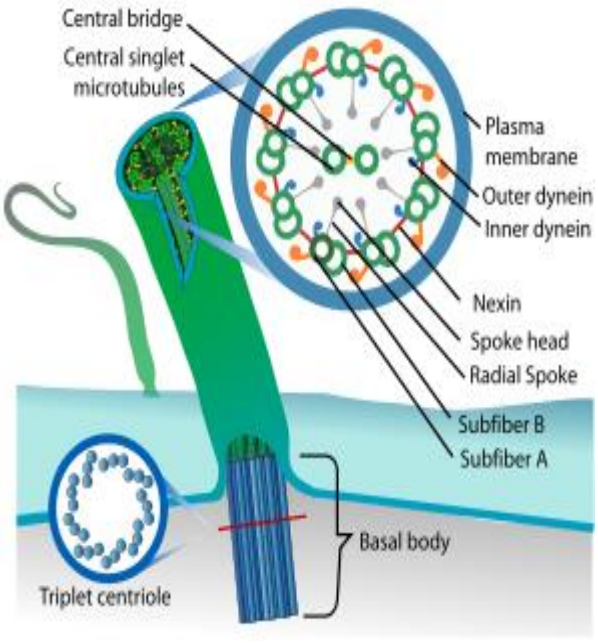
1-Microtubules maintain the cell shape.

2- Help in intracellular transport of membranous vesicles, macromolecules and organelles.

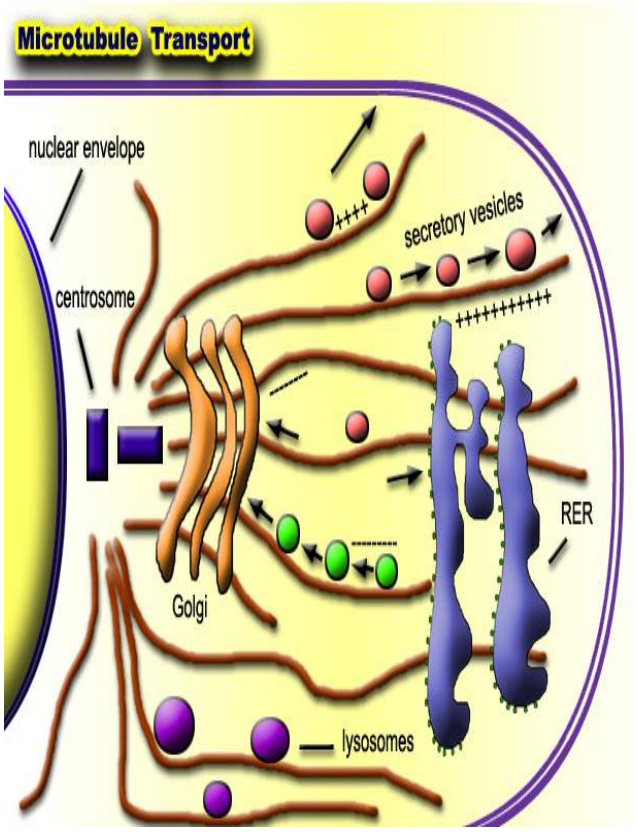
3- Microtubules are organized to form dynamic structures such as mitotic spindle of cell division, centrioles, basal bodies and axoneme of cilia and flagella.

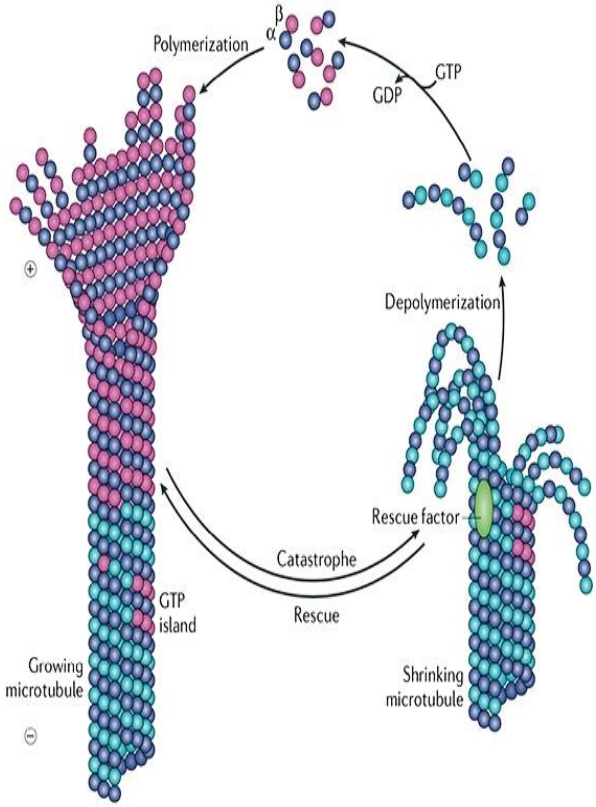


Mitotic spindle



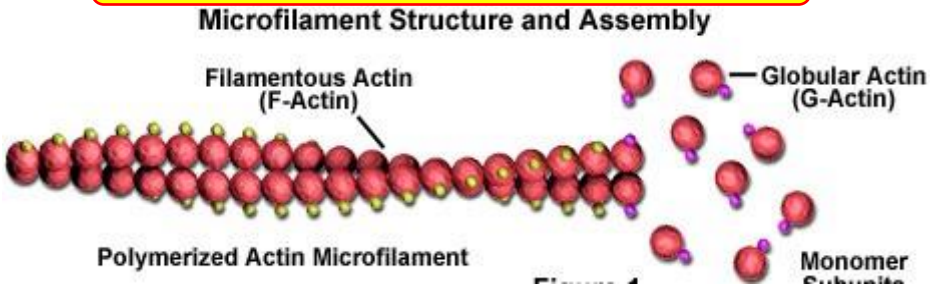
cilia and basal body





Microtubular transport **Change of microtubule length**

2-Microfilaments (Actin Filaments)



- Actin filaments are thin (6 nm diameter), shorter and more flexible than microtubules.
- The cytoplasmic actin filament is a thin 6-nm wide, very long polymer of a globular actin monomer; it is a homopolymer in that all its protein subunits are the same.
- The actin filaments in a cell are highly dynamic (they are in a constant state of assembly and disassembly).

Functions:

1- Actin filaments are found in great abundance in muscle cells (they make up about 60% of the protein in these cells); actin filaments integrated with myosin (a motor protein) permit very forceful contractions.

2- They are found as a major protein (10% to 15%) in essentially all non muscle cells as well, where they play a central role in "cell locomotion", "maintenance of cell shape", "translocation of cell organelles", "formation of the contractile ring in mitosis", and numerous other activities.

3-Intermediate Filaments

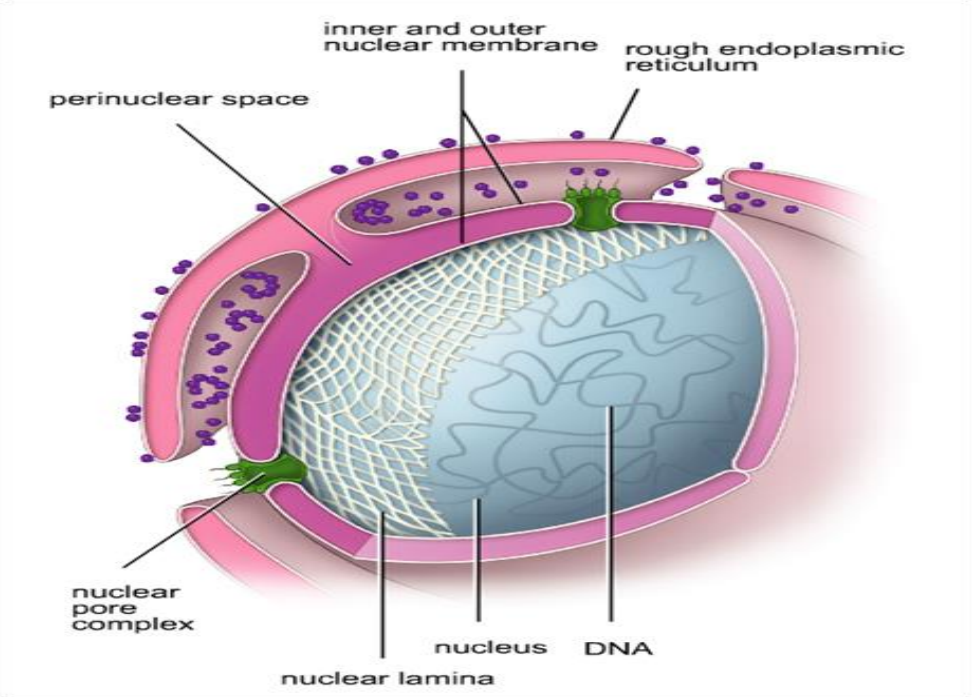
- They are intermediate in size between the other two components, with a diameter averaging 10 nm.
- Unlike microtubules and actin filaments, these intermediate filaments are stable.
- Intermediate filament proteins have particular biological, histological, or pathological importance.
- They are made up of different protein subunits in different cell types.
- Intermediate filaments can be localized in various cells by immunohistochemistry.

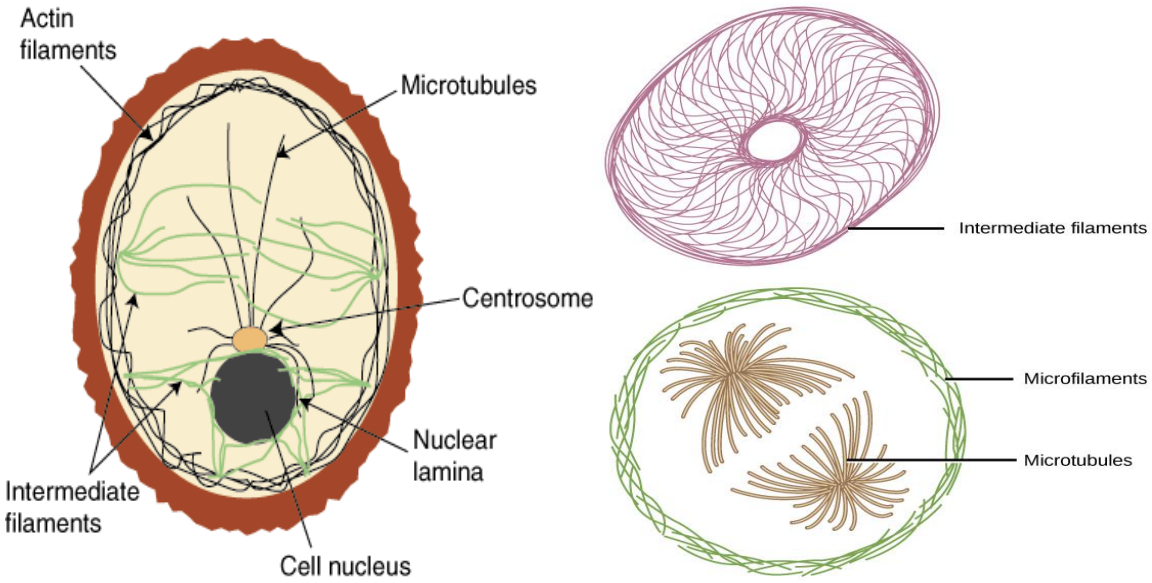
There are 6 major classes of intermediate filaments

Intermediate filament protein	***Cell distribution***
Acidic cytokeratin	Epithelial cells
Basic cytokeratin	Epithelial cells
Vimentin	Mesenchymal cells
desmin	Muscle cells
GFAP	Astrocytes
Neurofilaments (NF)	Neurons
Lamins	Nuclei of all cells
Nestin	Neural stem cells

- ***Keratins or cytokeratins***: in all epithelial cells .

  Intermediate filaments of keratins form large bundles (*tonofibrils*) that attach to certain junctions between epithelial cells. In skin epidermal cells, cytokeratins accumulate during differentiation in the process of *keratinization* producing an outer layer of non-living cells.
- ***Vimentin*:** is found in most cells derived from embryonic mesenchyme.
- **Important vimentin-like proteins** include ***desmin*** found in almost all muscle cells and ***glial fibrillary acidic protein (GFAP)*** found especially in astrocytes (supporting cells of central nervous system tissue).
- ***Neurofilament proteins*** are the major intermediate filaments of neurons.
- ***Lamins*** are the intermediate filaments form the nuclear lamina associated with the inner membrane of the nuclear envelope. Lamins help maintain nuclear shape, participate in anchoring chromatin to the nuclear envelope and participate in nuclear assembly-disassembly during cell division.

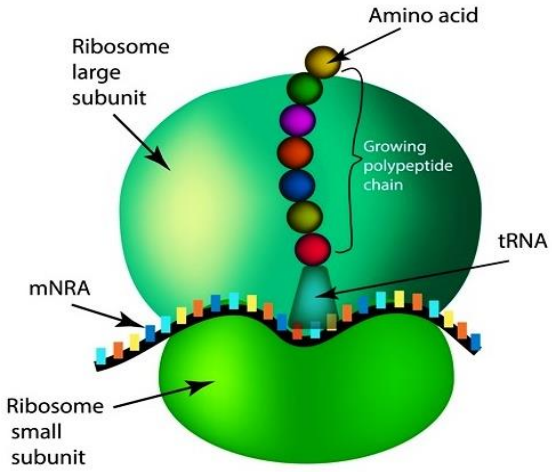




CYTOSKELETON

Ribosomes

Ribosomes: are small, non- membranous organelles about 20 × 30 nm in size, present in all animal cells in varying amounts **depending on their activity in protein synthesis**.



Structure: A functional ribosome has two subunits (small subunit& large subunit) bound to a strand of mRNA. *Chemically*; ribosomes are composed of ribosomal RNA (rRNA) and proteins.

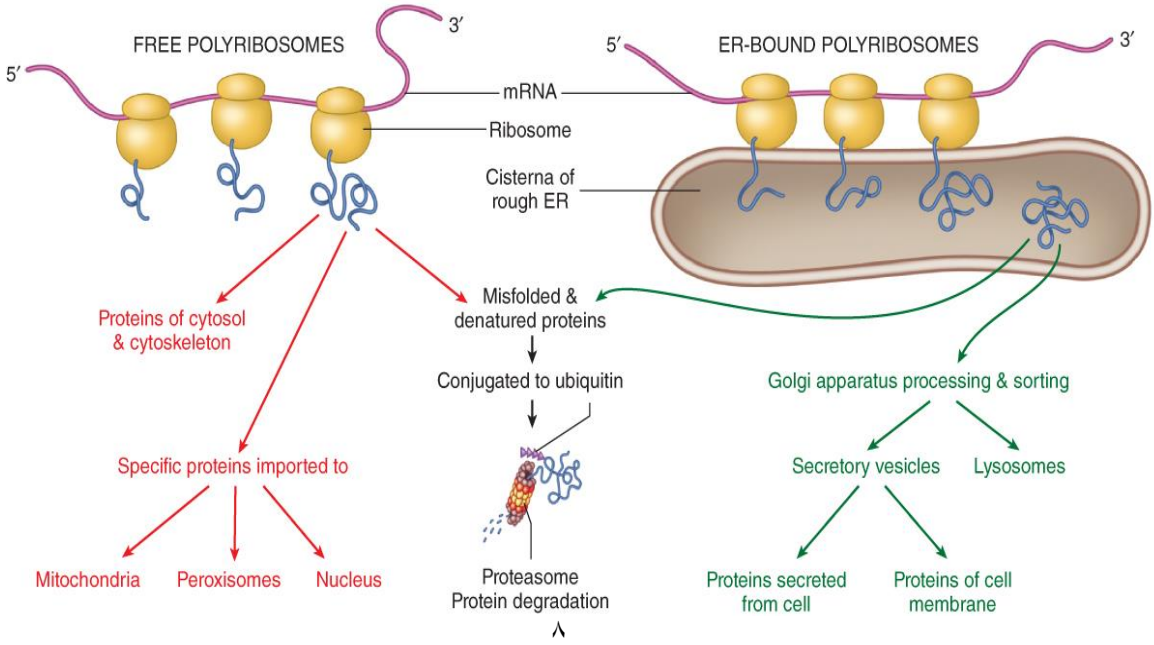
- These ribosomal proteins are themselves synthesized in cytoplasmic ribosomes, but are then imported to the nucleus where they associate with newly synthesized rRNA. The ribosomal subunits thus formed then move from the nucleus to the cytoplasm where they are reused many times, for translation of any mRNA strand.
- During protein synthesis many ribosomes typically bind the same strand of mRNA to form larger complexes called **polyribosomes**, or **polysomes**.
- *In stained preparations* of cells polyribosomes are intensely basophilic because of the numerous phosphate groups of the constituent RNA molecules.

Types of polyribosomes:

1- Free polyribosomes: They exist as isolated cytoplasmic clusters and synthesize cytoplasmic proteins needed for cellular growth and differentiation.

2- Bound polyribosomes:

- ***Endoplasmic reticulum (ER) Bound polyribosomes***: Polyribosomes attached to membranes of the endoplasmic reticulum (RER). They are involved in the formation of membrane proteins of the ER, the Golgi apparatus, or the cell membrane; enzymes to be stored in lysosomes; and secretory proteins.
- ***Polyribosomes associated with the outer membrane of the nuclear envelope.*** The outer membrane itself is continuous with the (RER).



Proteasomes

- Proteasomes are very small abundant protein complexes not associated with membrane, each approximately the size of the small ribosomal subunit.
- Whereas lysosomes digest organelles or membranes by autophagy; *proteasomes deal primarily with free proteins molecules including denatured and short-lived proteins.*
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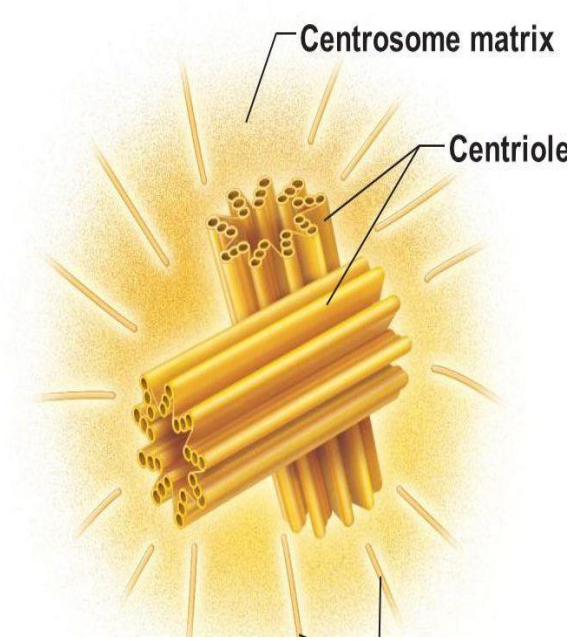
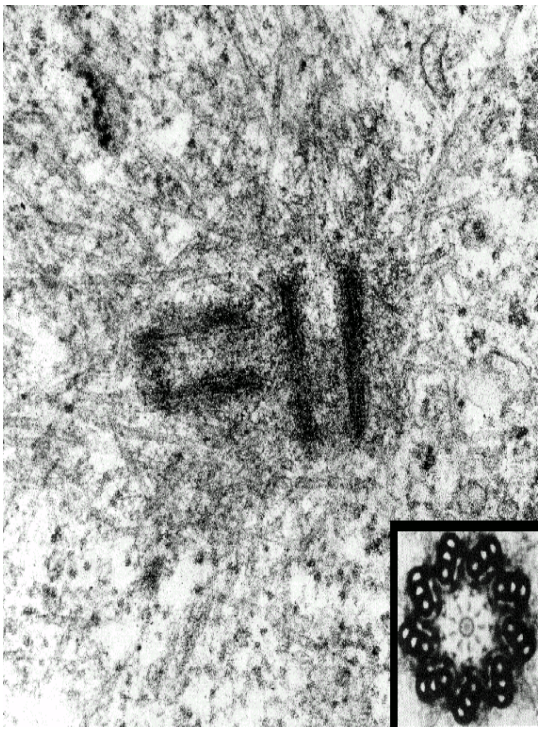
Centrosomes

Structure:

- It is composed of two cylindrical centrioles surrounded by a pericentriolar matrix (PCM) that found close to the nucleus of dividing cells.
- The two cylindrical centrioles have their long axes at right angles.
- Each centriole is composed of *nine highly organized microtubule triplets* and there are no central microtubules.

Before cell division, more specifically during the period of DNA replication, the centrosome duplicates itself so that now each centrosome has two pairs of centrioles.



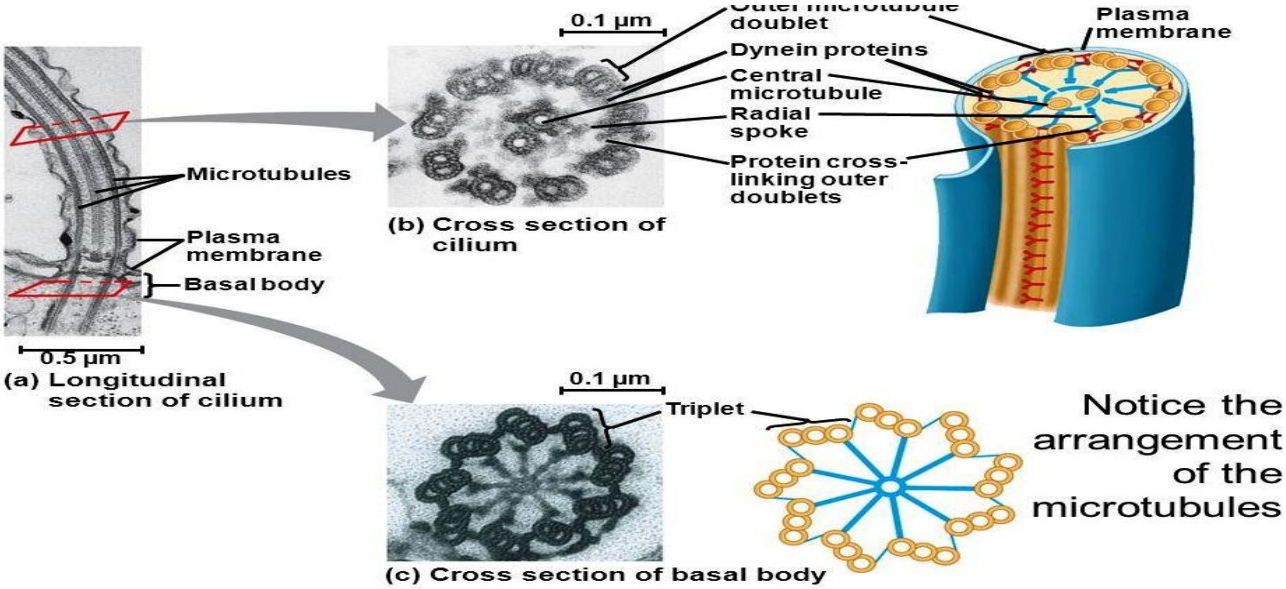


Functions:

1-During mitosis, the centrosome divides into halves, which move to opposite poles of the cell, and become organizing centers for the microtubules of the mitotic spindle. ***Cells lack centrosomes cannot divide***.

2- It serves as the basal body for cilia. Ciliated cells contain hundreds or even thousands of basal bodies or centrioles.

3- It serves as the basal body from which the microtubules of the tail of the sperm grow.



References

- **Lippincott Illustrated Reviews: Integrated systems. 2016; 2: 41–42.**
- **Elsevier's Integrated Histology. 2007; 1: 24- 30.**
- **Junqueira's Basic Histology Text & Atlas. 2018; 1: 37 and 42- 47.**

Self Assessment

1- Which structure is directly responsible for the formation of proteins within the cell?

a) Lysosomes
b) Vacuoles
c) Centrioles
d) Ribosomes
e) SER

2- Regarding centrioles all of the following are correct EXCEPT:

a) Occur in pairs.
b) Duplicate prior to mitosis.
c) Located near the nucleus.
d) Comprised of microfilaments.
e) Function in the formation of mitotic spindle.

3- All of the following structures are made from microtubules except:

a) Cilia
b) Flagella
c) centrosome
d) Mitotic spindle
e) Microvilli

4- Regarding microfilaments, which is <u>incorrect</u> ?

a) They are one of the components of the cytoskeleton.
b) Their wall is composed of a protein called desmin.
c) Their wall is composed of a protein called actin.
d) They are very thin structures about 5 nm in diameter
e) They form of the contractile ring in mitosis

5- The intermediate filament …….. is found in all nuclei, but …… is the intermediate filament characteristic for astrocytes.

6- The …… is composed of nine highly organized microtubule triplets and there are no central microtubules.

7- Enumerate 2 important intermediate filaments.