



The Cytoplasm

It is composed of matrix or cytosol, in which are embedded several membrane – bound components called **organelles**, **cytoplasmic inclusions** and **cytoskeleton**.

The cytosol is a soluble ground substance consist of:

- 1- Fluid protein which is solution with dissolved ions and molecules.
- 2- Colloid with suspended molecules, especially proteins, many of these proteins are enzymes that break down small molecules to liberate energy or for synthesis of larger molecules as sugars, fatty acids, nucleotides, amino acids and other molecules.

The general functions of cytoplasm:

- 1- Regulates exchange of material outside the cell
- 2- Biosynthesis of macromolecules
- 3- Generation of energy
- 4- Cell movement



Cytoskeleton

The cytosol contain complex network of protein fibers called cytoskeleton that includes : **microtubules** , **microfilaments** and **intermediate filaments** (Figure.1) . These protein fibers are support the shape of the cells and hold the nucleus and organelles in its place. Also play an important role in movement of cells.

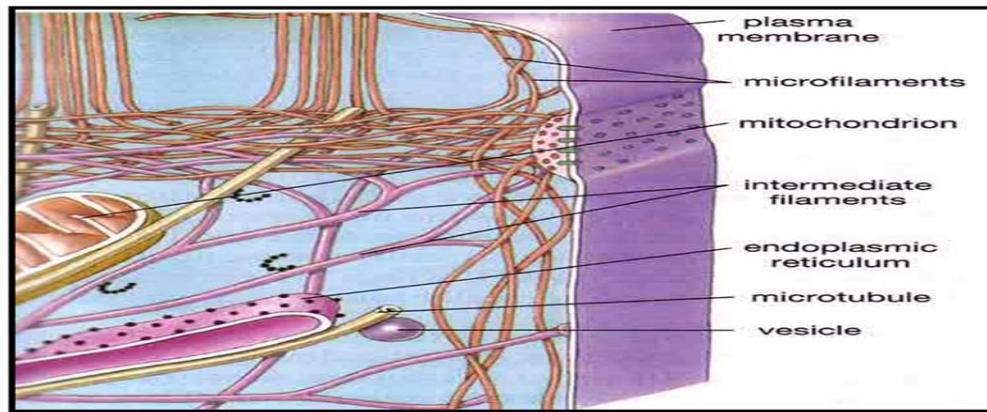


Figure (1): The distribution of cytoskeleton

1- Microtubules

Within the cytoplasmic matrix are long tubular structures known as microtubules with (24 nm) in diameter, consisting of dense wall 5 nm thick and hollow core 14 nm wide. The microtubules composed of protein subunits called **tubulin**. These subunits are heterodimer composed of α -tubulin and β -tubulin molecules. These tubulin subunits polymerize to form a linear polymer called **protofilament**. Thirteen protofilaments run parallel side by side (as a ring) around the hollow center to comprise the wall of microtubule (Figure.2).

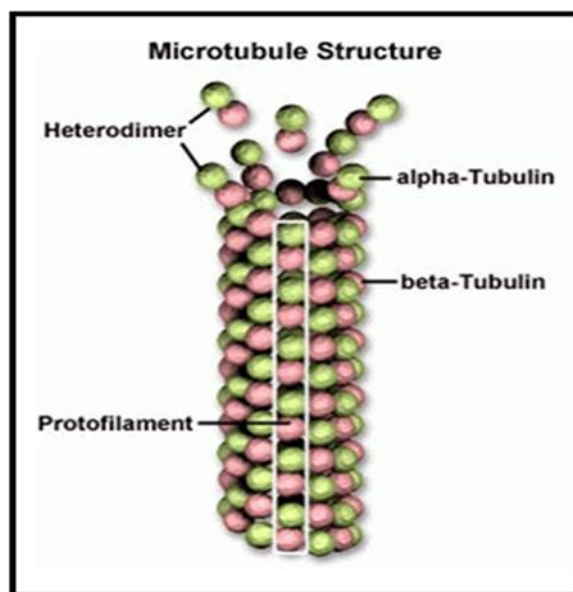


Figure (2): The structure of microtubule

Microtubule structure have important feature of polarity. The microtubule, have one end, the (+) end, with β -subunits exposed while the other end, the (-) end, where have α -subunits (Figure.3).

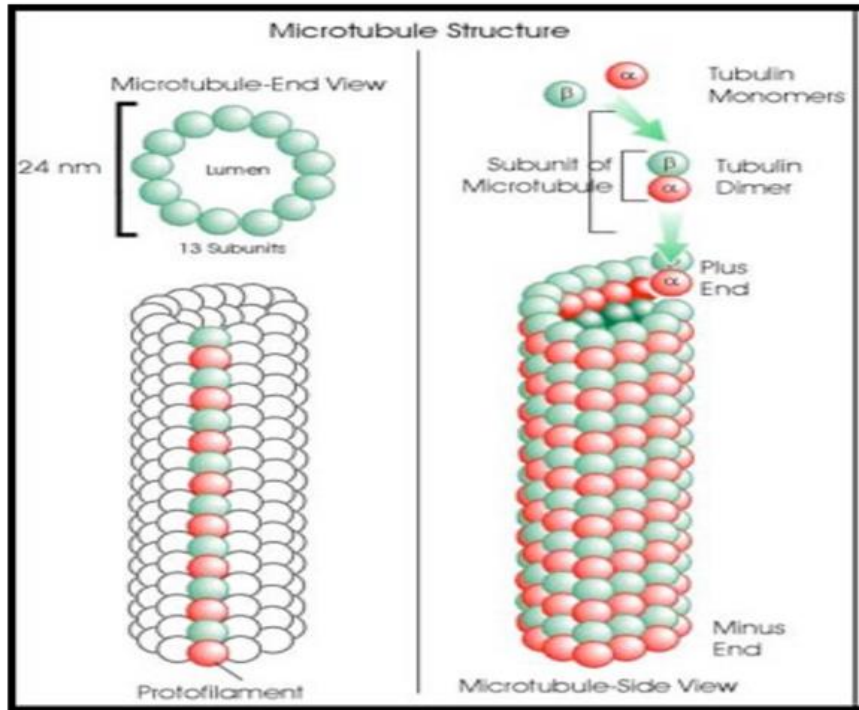


Figure (3): The organization of microtubules subunits

Microtubules present as a single elements scattered through the cytoplasm (Figure. 4). They are play various roles within the cell:

- 1- Play an important role in the development and maintenance of the cell form.
- 2- They form essential components of certain cell organelles such as centrioles, spindle fibers and cilia and flagella.
- 3- In the intracellular transport of organelles and vesicles, such as secretory vesicles. It is play role in axoplasmic transport in neurons, melanin transport in pigment cells, chromosome movements along the mitotic spindle, and vesicle movements between the endoplasmic

reticulum and Golgi complex and between the Golgi complex and the plasma membrane.

In each of these examples, movement occur by the presence of complex microtubules network and under the control of special proteins called motor proteins, where they are use energy to move these structures inside the cell.

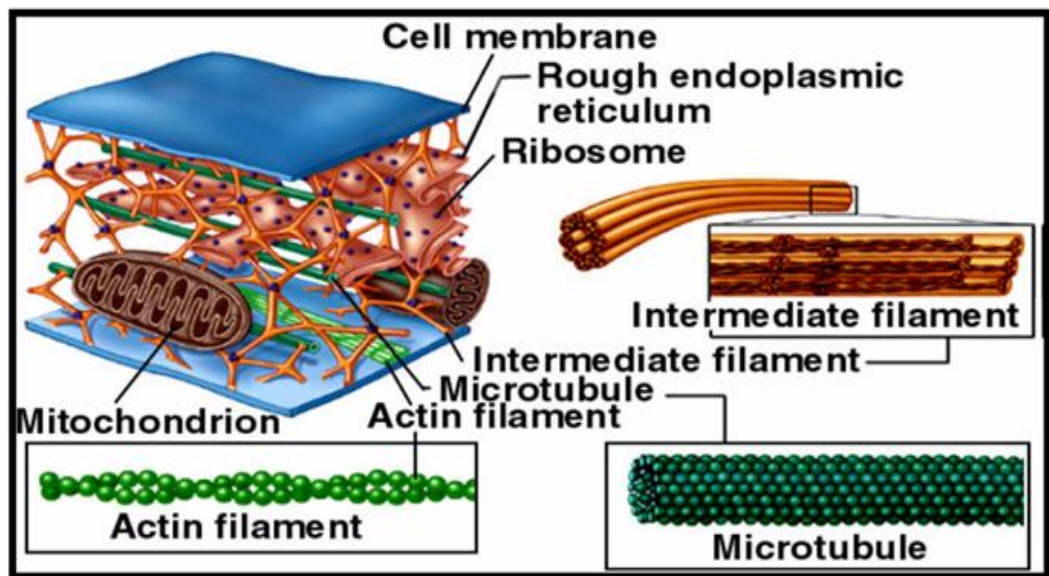


Figure (4): The distribution of microtubules within the cell.

2- Microfilaments (Actin filaments)

It is a thin filaments or small fibrils with (5 -7 nm) in diameter. It composed of two chains of protein called actin that twined around one another. These chains consist of globular subunits organized into double -stranded helix (Figure.5).

Microfilaments found organized as: linear bundles or network in the cytoplasm of the cell. They are mostly concentrated in the cortex of the cell at the periphery of the cell just beneath the cell membrane (Figure.4).

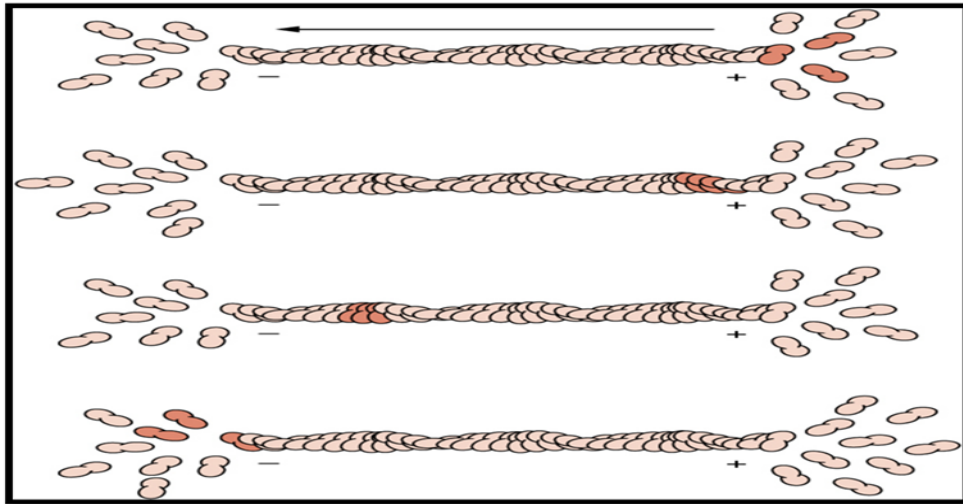


Figure (5): The structure of microfilament

The microfilaments can be organized into many forms :

- 1- In skeletal muscle, they assume para crystalline array integrated with myosin filaments (16nm) in diameter, this interaction lead to contractile activity in muscle cells .
- 2- In most cells, it forms thin sheath beneath the plasma membrane which called **cell cortex** or **terminal web**.
- 3- Microfilaments are associated with the movement of several cytoplasmic organelles, vesicles and granules.
- 4- In most cells, Microfilaments are found scattered within the cytoplasm, this network provides structural framework within the cell.

3- Intermediate filaments

It is a class of intermediate - sized filaments with (10 -12 nm) in diameter. They are protein fibers that composed of protein molecules twined together to form overlapping tetramers. The protein molecules arranged as double helix structure to form dimers. These dimmers join with another

dimer to form a tetramer. This tetramer is considered the basic subunit to form the intermediate filament (Figure.6)

The intermediate filaments arranged as network in the cytoplasm of most cells (Figure.4). Intermediate filaments integrate with the components of the cytoskeleton and organizes the internal structure of the cell. The intermediate filaments are not directly involved in cell movements. The intermediate filaments have a supporting or structural role where provide mechanical strength to cells.

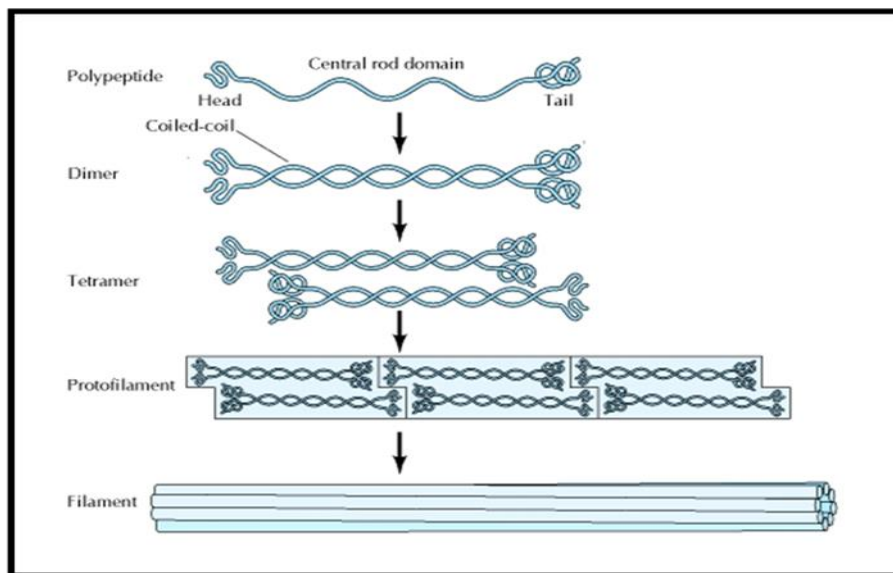


Figure (6): The structure of intermediate filaments

Intermediate filaments are composed of different groups of intermediate filament proteins include:

- 1- **Keratins** are found in epithelial cells of epidermis of the skin.
- 2- **Vimentin filaments:** are found in mesenchymal cells, fibroblasts and macrophages.
- 3- **Desmin (skeleton):** found in muscle cells of skeletal and cardiac muscles.
- 4- **Glial filaments:** found in astrocytes (glial cells).

5- Neurofilaments: found in neurons (nerve cells).

6- Lamins: present in the nuclear envelope.

Cytoplasmic inclusions

They are nonliving accumulations of metabolites, cell products resulting from synthesis or materials taken into the cell from outside. cytoplasmic inclusion forms:

- 1- **Lipids:** These are stored as droplets in the cytoplasm of adipose cells.
- 2- **Carbohydrates:** These are stored in the form of glycogen deposits in the cytoplasm. These deposits are stored chiefly in liver cells.
- 3- **Proteins:** These are stored in glandular cells as secretory granules or secretory vesicles.

4- **Pigments:** These are naturally colored substances present in the Cytoplasm of the cells that include:

- 1- **Melanin:** It brown or black pigment, it is found in the epidermis of the skin and hair.
- 2- **Lipofuscin (Lipochrom):** It is yellow-brown substances that increase in amount in the cells with age. It is present mainly in permanent cells (as neuron and cardiac muscle).
- 3- **Lutein:** It is yellow soluble coloring matter of luteal cells and fat tissue.