Cytoskeleton

- The **cytoskeleton** is a complex, dynamic network of interlinking protein filaments present in the cytoplasm of all cells including bacteria and archaea.
- It extends from the cell nucleus to the cell membrane and is composed of similar proteins in the various organisms. In eukaryotes, it is composed of three main components, microfilaments, intermediate filaments and microtubules, and these are all capable of rapid growth or disassembly dependent on the cell's requirements.
- A multitude of functions can be performed by the cytoskeleton. Its primary function is to give the cell its shape and mechanical resistance to deformation, and through association with extracellular connective tissue and other cells it stabilizes entire tissues.
- The cytoskeleton can also contract, thereby deforming the cell and the cell's environment and allowing cells to migrate Moreover, it is involved in many cell signaling pathways and in the uptake of extracellular material endocytosis the segregation of chromosomes during cellular division, the cytokinesis stage of cell division, as scaffolding to organize the contents of the cell in space and in intracellular transport (for example, the movement of vesicles and organelles within the cell and can be a template for the construction of a cell wall.
- Furthermore, it can form specialized structures, such as flagella, cilia, lamellipodia and podosomes.
- The structure, function and dynamic behavior of the cytoskeleton can be very different, depending on organism and cell type.
- Even within one cell, the cytoskeleton can change through association with other proteins and the previous history of the network.

History

In 1903, Nikolai K. Koltsov proposed that the shape of cells was determined by a network of tubules that he termed the cytoskeleton. The concept of a protein mosaic that dynamically coordinated cytoplasmic biochemistry was proposed by Rudolph Peters in 1929 while the term (*cytosquelette*, in French) was first introduced by French embryologist Paul Wintrebert in 1931.

Types Of Cytoskeleton

Prokaryotic and eukaryotic cytoskeletons are its different types-

Prokaryotic cytoskeleton : It is of mainly three types , actin and tubulin. tubulin molecules are three types alpha ,beta and gama. Besides these prokaryotes have FtsZ, MreB, ParM types of cytoskeleton .

FtsZ was the first protein of the prokaryotic cytoskeleton to be identified. Like tubulin, FtsZ forms filaments in the presence of guanosine triphosphate (GTP), but these filaments do not group into tubules. During cell division, FtsZ is the first protein to move to the division site, and is essential for recruiting other proteins that synthesize the new cell wall between the dividing cells.

MreB and ParM

Prokaryotic actin-like proteins, such as MreB, are involved in the maintenance of cell shape.

All non-spherical bacteria have genes encoding actin-like proteins, and these proteins form a helical network beneath the cell membrane that guides the proteins involved in cell wall biosynthesis

Some plasmids encode a separate system that involves an actin-like protein .

Filaments of ParM exhibit dynamic instability, and may partition plasmid DNA into the dividing daughter cells by a mechanism analogous to that used by microtubules during eukaryotic mitosis

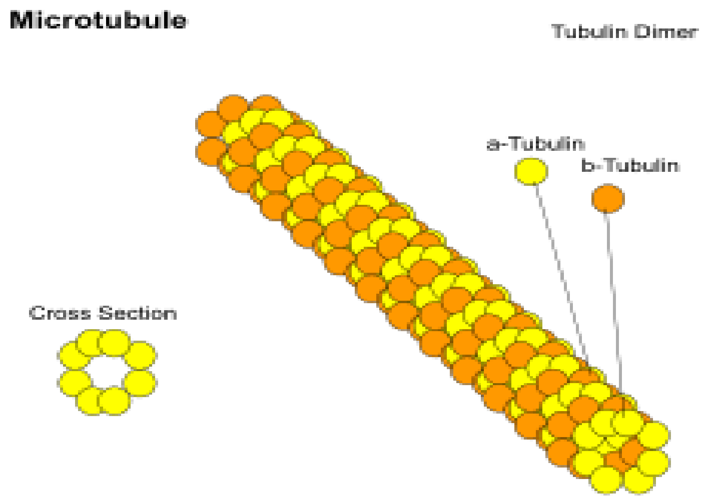
Crescentin: The bacterium *Caulobacter crescentus* contains a third protein, crescentin that is related to the intermediate filaments of eukaryotic cells. Crescentin is also involved in maintaining cell shape, such as helical and vibrioid forms of bacteria, but the mechanism by which it does this is currently unclear.[] Additionally, curvature could be described by the displacement of crescentic filaments, after the disruption of peptidoglycan synthesis.

Eukaryotic cytoskeleton

- Eukaryotic cells contain three main kinds of cytoskeletal filaments: microfilaments, microtubules, and intermediate filaments. Each type is formed by the polymerization of a distinct type of protein subunit and has its own characteristic shape and intracellular distribution.
- Microfilaments are polymers of the protein actin and are 7 nm in diameter.
- Microtubules are composed of tubulin and are 25 nm in diameter. Intermediate filaments are composed of various proteins, depending on the type of cell in which they are found; they are normally 8-12 nm in diameter.
- The cytoskeleton provides the cell with structure and shape, and by excluding macromolecules from some of the cytosol, it adds to the level of macromolecular crowding in this compartment.
- Cytoskeletal elements interact extensively and intimately with cellular membranes.

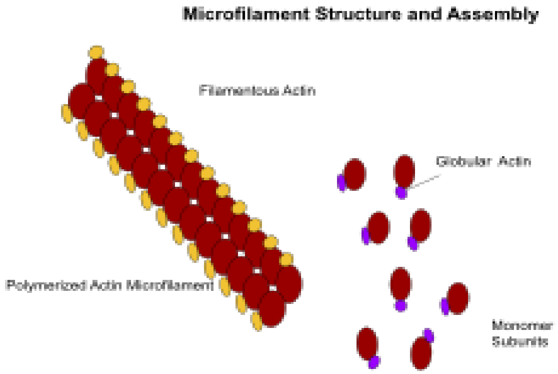
Structure and functions of microtubule, microfilaments and intermediate filaments

- **Structure and** functions **of microtubule**



- Microtubules are hollow cylinders about 23 nm in diameter (lumen diameter of approximately 15 nm), most commonly comprising 13 protofilaments that, in turn, are polymers of alpha and beta tubulin.
- FUNCTION: They have a very dynamic behaviour, binding GTP for polymerization. They are commonly organized by the centrosome.
- In nine triplet sets (star-shaped), they form the centrioles, and in nine doublets oriented about two additional microtubules (wheel-shaped), they form cilia and flagella. The latter formation is commonly referred to as a "9+2" arrangement, wherein each doublet is connected to another by the protein dynein. As both flagella and cilia are structural components of the cell, and are maintained by microtubules, they can be considered part of the cytoskeleton. There are two types of cilia: motile and non-motile cilia. Cilia are short and more numerous than flagella. The motile cilia have a rhythmic waving or beating motion compared to the non-motile cilia which receive sensory information for the cell; processing signals from the other cells or the fluids surrounding it. The microtubules control the beating (movement) of the cilia and flagella. Also, the dynein arms attached to the microtubules function as the molecular motors.
- The motion of the cilia and flagella is created by the microtubules sliding past one another, which requires ATP.
- They play key roles intracellular transport (associated with dyneins and kinesins, they transport organelles like mitochondria or vesicles). the axoneme of cilia and flagella.
- The mitotic spindle.
- Synthesis of the cell wall in plants.

STRUCTURE AND FUNCTION OF MICROFILAMENTS



Microfilaments, also known as actin filaments, are composed of linear polymers of G-actin proteins, and generate force when the growing (plus) end of the filament pushes against a barrier, such as the cell membrane. They also act as tracks for the movement of myosin molecules that affix to the microfilament and "walk" along them. In general, the major component or protein of microfilaments are actin. The G-actin monomer combines to form a polymer which continues to form the microfilament (actin filament). These subunits then assemble into two chains that intertwine into what are called F-actin chains. Myosin motoring along F-actin filaments generates contractile forces in so-called actomyosin fibers, both in muscle as well as most non-muscle cell types. Actin structures are controlled by the Rho family of small GTP-binding proteins such as Rho itself for contractile acto-myosin filaments ("stress fibers"), Rac for lamellipodia and Cdc42 for filopodia.

Functions include:

Muscle contraction

Cell movement

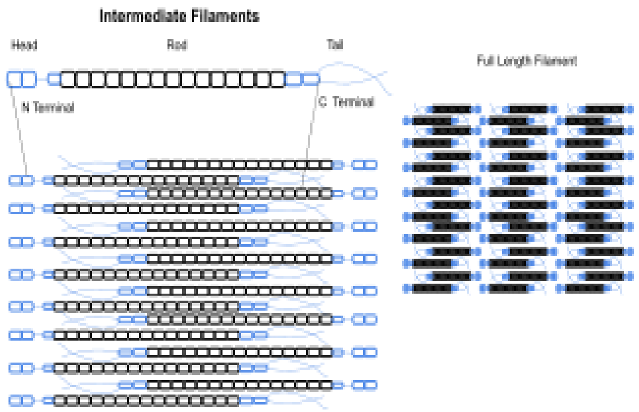
Intracellular transport/trafficking

Maintenance of eukaryotic cell shape

Cytokinesis

Cytoplasmic streaming

Structure and function of intermediate filaments



Intermediate filaments are a part of the cytoskeleton of many eukaryotic cells. These filaments, averaging 10 nanometers in diameter, are more stable (strongly bound) than microfilaments, and heterogeneous constituents of the cytoskeleton. Like actin filaments, they function in the maintenance of cell-shape by bearing tension (microtubules, by contrast, resist compression but can also bear tension during mitosis and during the positioning of the centrosome).

FUNCTIONS

Intermediate filaments organize the internal tridimensional structure of the cell, anchoring organelles and serving as structural components of the nuclear lamina. They also participate in some cell-cell and cell-matrix junctions. Nuclear lamina exist in all animals and all tissues. Some animals like the fruit fly do not have any cytoplasmic intermediate filaments. In those animals that express cytoplasmic intermediate filaments, these are tissue specific. Keratin intermediate filaments in epithelial cells provide protection for different mechanical stresses the skin may endure. They also provide protection for organs against metabolic, oxidative, and chemical stresses. Strengthening of epithelial cells with these intermediate filaments may prevent onset of apoptosis, or cell death, by reducing the probability of stress.

Intermediate filaments are most commonly known as the support system or “scaffolding” for the cell and nucleus while also playing a role in some cell functions. In combination with proteins and desmosomes, the intermediate filaments form cell-cell connections and anchor the cell-matrix junctions that are used in messaging between cells as well as vital functions of the cell. These connections allow the cell to communicate through the desmosome of multiple cells to adjust structures of the tissue based on signals from the cells environment. Mutations in the IF proteins have been shown to cause serious medical issues such as premature aging, desmin mutations compromising organs, Alexander Disease, and muscular dystrophy.

Different intermediate filaments are:

made of vimentins. Vimentin intermediate filaments are in general present in mesenchymal cells.

made of keratin. Keratin is present in general in epithelial cells.

neurofilaments of neural cells.

made of lamin, giving structural support to the nuclear envelope.

made of desmin, play an important role in structural and mechanical support

COMPARISION BETWEEN MICROTUBULE .MICROFILAMENTS AND INTERMEDIATE FILAMENTS

Cytoskeleton type	Diameter (nm)	Structure	Subunit examples
Microfilaments	6	Double helix	Actin
Intermediate filaments	10	Two anti-parallel helices/dimers, forming tetramers	• Vimentin (mesenchyme) • Glial fibrillary acidic protein (glial cells) • Neurofilament proteins (neuronal processes) • Keratins (epithelial cells) • Nuclear lamins
Microtubules	23	Protofilaments, in turn consisting of tubulin subunits in complex with stathmin	α- and β-Tubulin