Cytoskeleton

Definition

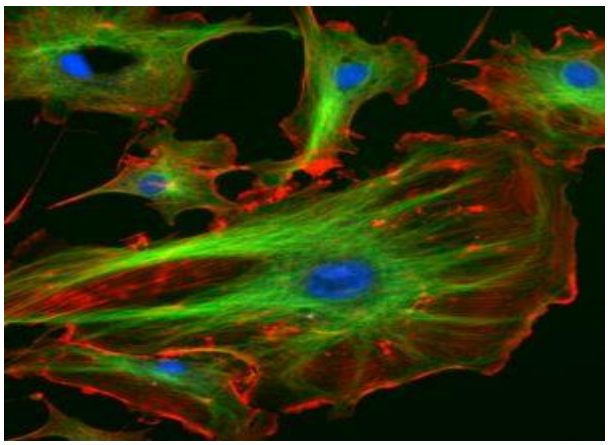
The cytoskeleton is a network of filaments and tubules that extends throughout a cell, through the cytoplasm, which is all of the material within a cell except for the nucleus. It is found in all cells, though the proteins that it is made of vary between organisms. The cytoskeleton supports the cell, gives it shape, organizes and tethers the organelles, and has roles in molecule transport, cell division and cell signaling.

Structure of the Cytoskeleton

The cytoskeleton is composed of at least three different types of fibers:

microtubules, **microfilaments,** and **intermediate** filaments. These fibers are distinguished by their size with microtubules being the thickest and microfilaments being the thinnest.

The microfilaments of this cell are shown in red, while microtubules are shown in green. The blue dots are nuclei.



Protein Fibers

- **Microtubules** are hollow rods functioning primarily to help support and shape the cell and as "routes" along which organelles can move. Microtubules are typically found in all eukaryotic cells. They vary in length and measure about 25 nm (nanometers) in diameter.
- **Microfilaments** or actin filaments are thin, solid rods that are active in muscle contraction. Microfilaments are particularly prevalent in muscle cells. Similar to microtubules, they are typically found in all eukaryotic cells. Microfilaments are composed primarily of the contractile protein actin and measure up to 8 nm in diameter. They also participate in organelle movement.

- **Intermediate filaments** can be abundant in many cells and provide support for microfilaments and microtubules by holding them in place. These filaments form keratins found in epithelial cells and neurofilaments in neurons. They measure 10 nm in diameter.

Cytoskeleton type[30]	Diameter (nm)[31]	Structure	Subunit examples[30]
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[32]	α- and β-tubulin

Motor Proteins

A number of motor proteins are found in the cytoskeleton. As their name suggests, these proteins actively move cytoskeleton fibers. As a result, molecules and organelles are transported around the cell. Motor proteins are powered by ATP, which is generated through cellular respiration. There are three types of motor proteins involved in cell movement.

- **Kinesins** move along microtubules carrying cellular components along the way. They are typically used to pull organelles toward the cell membrane.
- **Dyneins** are similar to kinesins and are used to pull cellular components inward toward the nucleus. Dyneins also work to slide microtubules relative to one another as observed in the movement of cilia and flagella.
- **Myosins** interact with actin in order to perform muscle contractions. They are also involved in cytokinesis, endocytosis (endo-cyt-osis), and exocytosis (exo-cyt-osis).

Cytoskeleton Function

The cytoskeleton extends throughout the cell's cytoplasm and directs a number of important functions.

- It helps the cell to maintain its shape and gives support to the cell.
- A variety of cellular organelles are held in place by the cytoskeleton.
- It assists in the formation of vacuoles.
- The cytoskeleton is not a static structure but is able to disassemble and reassemble its parts in order to enable internal and overall cell mobility. Types of intracellular movement supported by the cytoskeleton include transportation of vesicles into and out of a cell, chromosome manipulation during mitosis and meiosis, and organelle migration.
- The cytoskeleton makes cell migration possible as cell motility is needed for tissue construction and repair, cytokinesis (the division of the cytoplasm) in the formation of daughter cells, and in immune cell responses to germs.

- The cytoskeleton assists in the transportation of communication signals between cells.
- It forms cellular appendage-like protrusions, such as cilia and flagella, in some cells.

Cytoplasmic Streaming

- The cytoskeleton helps to make cytoplasmic streaming possible. Also known as **cyclosis**, this process involves the movement of the cytoplasm to circulate nutrients, organelles, and other substances within a cell. Cyclosis also aids in endocytosis and exocytosis, or the transport of substance into and out of a cell.
- As cytoskeletal microfilaments contract, they help to direct the flow of cytoplasmic particles. When microfilaments attached to organelles contract, the organelles are pulled along and the cytoplasm flows in the same direction.
- Cytoplasmic streaming occurs in both prokaryotic and eukaryotic cells. In protists, like amoebae, this process produces extensions of the cytoplasm known as **pseudopodia**. These structures are used for capturing food and for locomotion.