# Microtubules

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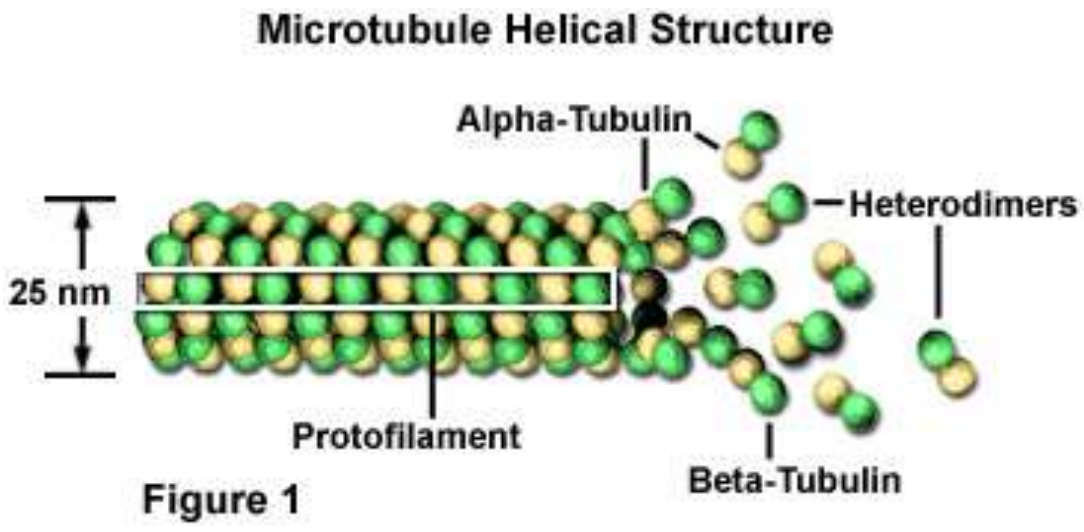
## Introduction

Microtubules are microscopic hollow tubes made of the polymer of tubulin protein, that are part of a cell's cytoskeleton, a network of protein filaments that extends throughout the cell. They provide the cell shape, and keeps its organelles in place. Microtubules are the largest structures in the cytoskeleton at about 25 nanometers thick. They have roles in cellular processes like cell movement, cell division, and transport of materials within cells. They are also involved in maintaining the structure of the cell and along with microfilaments and intermediate filaments, forms cytoskeleton

Microtubules were first discovered in 1964 by American and Canadian-American biologists Myron Ledbetter and Keith Porter.

## Microtubule Structure

Microtubules are hollow cylinders made up of repeating protein structures, specifically dimers of alpha and beta tubulin (also referred to in writing as α-tubulin and β-tubulin). Dimers are complexes of two proteins. α-tubulin and β-tubulin bind to each other to form a dimer, and then multiple units of these dimers bind together, always alternating alpha and beta, to form a chain called a protofilament. Then, thirteen protofilaments arrange into a cylindrical pattern to form a microtubule. Microtubules are constantly assembling and disassembling via the addition and removal of dimers.

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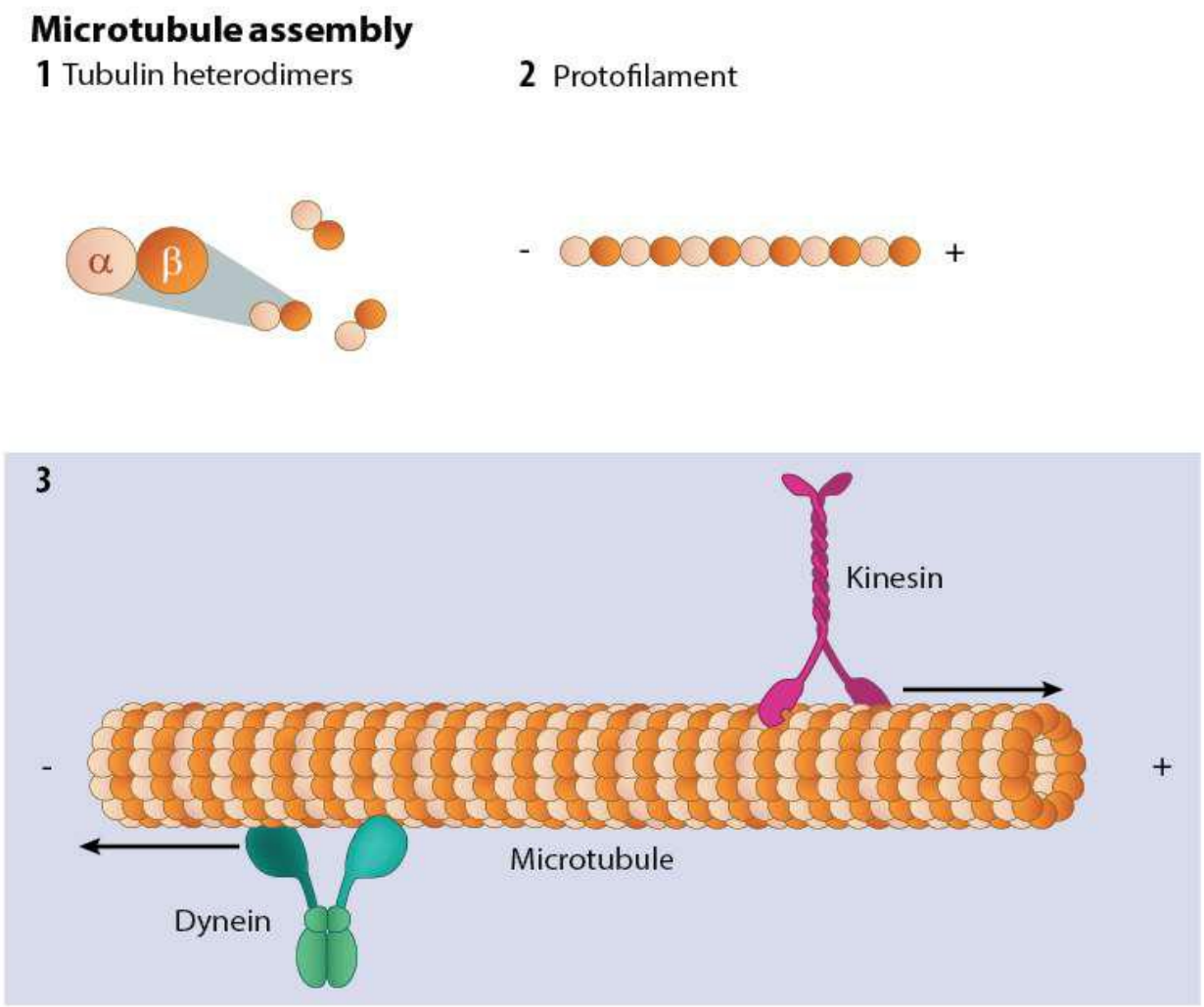
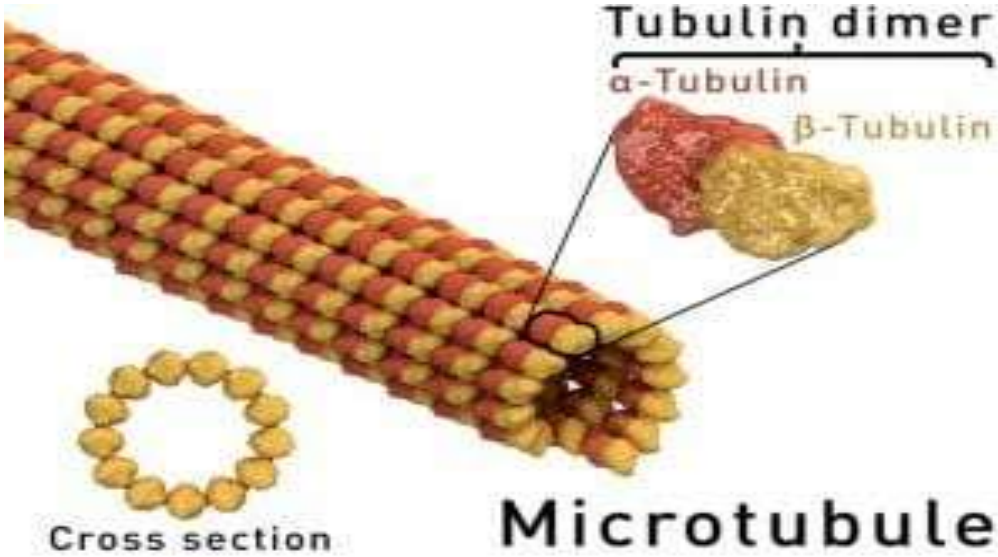



Microtubules are polar molecules, with a positively charged end that grows relatively fast and a negatively charged end that grows relatively slow. Protofilaments arrange themselves parallel to each other in a

microtubule, so the positive end of the microtubule always has beta subunits exposed, while the negative end has alpha subunits exposed. Having polarity allows the microtubule to assemble in a specific way and function correctly.

In animal cell, microtubules radiate outwards from an organelle in the center of the cell called a centrosome, which is a microtubule organizing center (MTOC). The cells of plants and fungi do not have centrosomes, and instead the nuclear envelope—the membrane surrounding the cell's nucleus—is an MTOC.




# Function of Microtubules

## Architectural framework

Microtubules helps in forming architectural framework that establishes the overall polarity of the cell by influencing the organization of the nucleus, organelles and other cytoskeleton components.

## Cell Movement

Microtubules give structures like cilia and flagella their structure. Cilia are small protuberances of a cell. In humans, they are found on cells lining the trachea, where they prevent materials like mucus and dirt from

entering the lungs. They are also found in the fallopian tubes of the female reproductive system, where they help move the egg that is released from the ovary to the uterus. Flagella are tail-like appendages that allow cells to move. They are found in some bacteria, and human sperm also move via flagella. Microtubules also allow whole cells to “crawl” or migrate from one place to another by contracting at one end of the cell and expanding at another.

## Cell Division

Microtubules play a key role in forming the mitotic spindle, also called the spindle apparatus. This is a structure that is formed during mitosis (cell division) in eukaryotic cells. The mitotic spindle organizes and separates chromosomes during cell division so that the chromosomes can be partitioned into two separate daughter cells. Its components include microtubules, the MTOC, and microtubule-associated proteins (MAPs).

Three subgroups of microtubules aid in the process of mitosis: astral, polar, and kinetochore microtubules. Astral microtubules radiate from the MTOCs of a cell to the cell membrane, keeping the mitotic spindle in place. Polar microtubules intertwine between two MTOCs and help separate chromosomes. (All microtubules are polar; these ones are just specifically called polar microtubules.) Kinetochore microtubules attach to chromosomes to help pull them apart; the chromosomes are attached to the microtubules by a complex of proteins called a kinetochore.

## Cell Transport

As part of the cytoskeleton, microtubules help move organelles inside a cell’s cytoplasm, which is all of the cell’s contents except for its nucleus. They also help various areas of the cell communicate with each other. However, even though microtubules help components of the cell to move, they also provide the cell with shape and structure.

To form an internal transport network for the movement of vesicles containing essential materials to the rest of the cells, microtubule associated proteins with motor protein activity such as kinesin and dynein perform the activity.