Microtubules, microfilaments & intermediate filaments

The Cytoskeleton

The cytoskeleton is unique to eukaryotic cells. It is a dynamic three-dimensional structure that fills the cytoplasm. This structure acts as both muscle and skeleton, for movement and stability. The long fibers of the cytoskeleton are polymers of subunits. The primary types of fibers comprising the cytoskeleton are microfilaments, microtubules, and intermediate filaments.

Microfilaments

Microfilaments are fine, thread-like protein fibers, 3-6 nm in diameter. They are composed predominantly of a contractile protein called actin, which is the most abundant cellular protein. Microfilaments' association with the protein myosin is responsible for muscle contraction. Microfilaments can also carry out cellular movements including gliding, contraction, and cytokinesis.

Microtubules

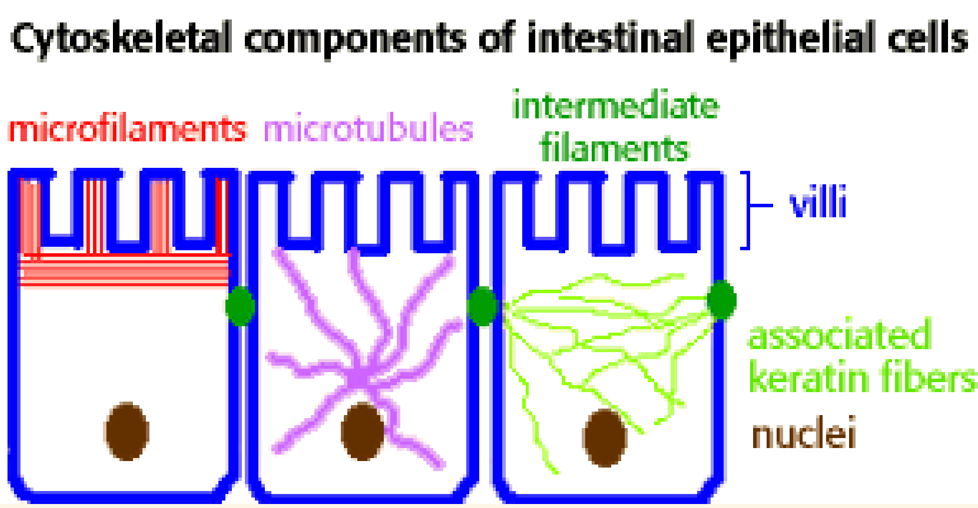
Microtubules are cylindrical tubes, 20-25 nm in diameter. They are composed of subunits of the protein tubulin--these subunits are termed alpha and beta. Microtubules act as a scaffold to determine cell shape, and provide a set of "tracks" for cell organelles and vesicles to move on. Microtubules also form the spindle fibers for separating chromosomes during mitosis. When arranged in geometric patterns inside flagella and cilia, they are used for locomotion.

Intermediate Filaments

Intermediate filaments are about 10 nm diameter and provide tensile strength for the cell.

Examples of the cytoskeleton in epithelial cells

In the epithelial (skin) cells of the intestine, all three types of fibers are present. Microfilaments project into the villi, giving shape to the cell surface. Microtubules grow out of the centrosome to the cell periphery. Intermediate filaments connect adjacent cells through desmosomes.



External cell movement

Cellular movement

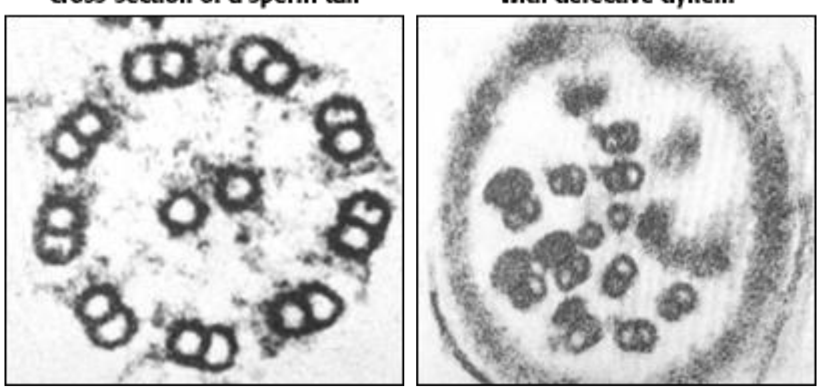
Cellular movement is accomplished by cilia and flagella.

Cilia are hair-like structures that can beat in synchrony causing the movement of unicellular paramecium. Cilia are also found in specialize linings in eukaryotes. For example, cilia sweep fluids past stationary cells in the lining of trachea and tubes of female oviduct.

Flagella are whip-like appendages that undulate to move cells. They are longer than cilia, but have similar internal structures made of microtubules. Prokaryotic and eukaryotic flagella differ greatly.

Both flagella and cilia have a 9 + 2 arrangement of microtubules. This arrangement refers to the 9 fused pairs of microtubules on the outside of a cylinder, and the 2 unfused microtubules in the center. Dynein "arms" attached to the microtubules serve as the molecular motors. Defective dynein arms cause male infertility and also lead to respiratory tract and sinus problems. Below are two cross-sections of sperm tails (flagella).

Electron Micrograph of the cross-section of a sperm tail | **Cross-section of sperm tail with defective dynein**



Internal cell movement

Examples

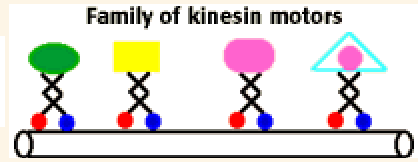
The cytoskeleton acts as a "track" on which cells can move organelles, chromosomes and other things. Some examples are:

1. Vesicle movement between organelles and the cell surface, frequently studied in the squid axon.
2. Cytoplasmic streaming
3. Movement of pigment vesicles for protective coloration
4. Discharge of vesicle content for water regulation in protozoa
5. Cell division--cytokinesis
6. Movement of chromosomes during mitosis and meiosis

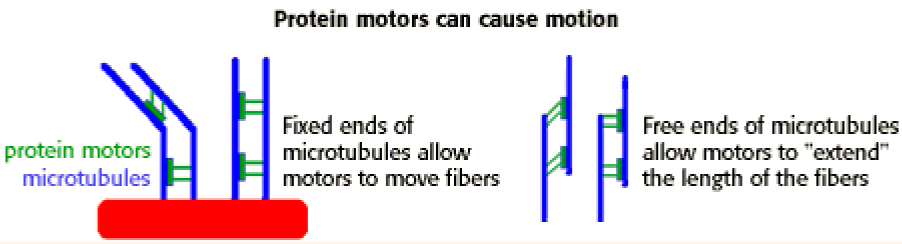
Cellular motors

Cells have protein motors that bind two molecules, and using ATP as energy, cause one molecule to shift in relationship to the other. Two types of these protein motors are myosin and actin, and dynein or kinesin and microtubules. These families of proteins all have a motor end, but may have several kinds of different molecular structures on the binding end. When these proteins bind, they can cause many different molecules, organelles, etc. to move.

To the right is an example of the different binding ends found in the kinesin family of motors.



When linked to other microtubules, protein motors can cause motion if the ends are fixed or extend the lengths of the fiber bundles if the ends are free.



Broken motors

In healthy individuals, the protein dystrophin is part of the linkage between the cellular cytoskeleton and the adhesive proteins on the outside of the cell. In Duchenne Muscular Dystrophy, however, the gene that codes for dystrophin is defective, resulting in muscle degeneration and finally death. This disease is X-linked recessive and occurs in 1 out of every 3,500 males.

Fetures	**Microtubules**	**Microfilaments**	**Intermediate filaments**
Structure	Hollow, cylindrical, consists of 13 protofilaments	Two intertwined chains of F-actin	Hollow with wallsmade up of 4-5 protofilaments.
Diameter	Outer: 25 nm; inner: 15 nm.	7 nm.	10 nm.
Monomer units	α – tubulin and β-tubulin	G-actin	Five different proteins
Nucleotide bound	GTP	ATP	-
ATPase activity	None	Present in dynein arms.	None
Polarity	Plus and minus ends	Plus and minus ends	Apolar
Function	• Motility of eukaryotes.	• Muscle contraction.	• Anchorage. • Cytoskeletal

	• Chromosome movement. • Movement of intracellular materials. • Maintain cell shape.	• Cell shape change. • Protoplasmic streaming. • Cytokinesis.	structural function in cytosol.