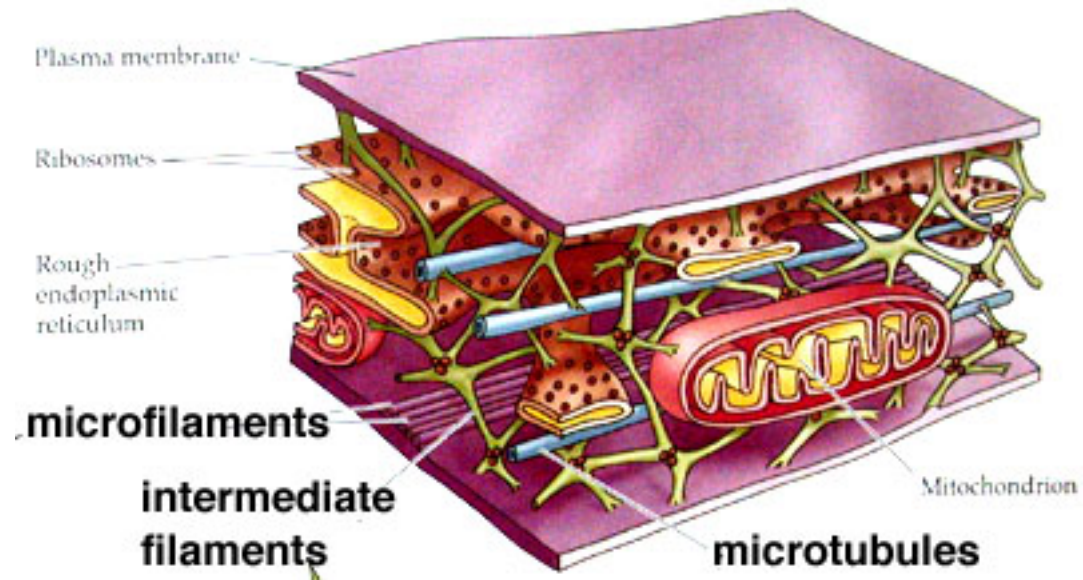

Lecture 15

Cytoskeleton



Cytoskeleton

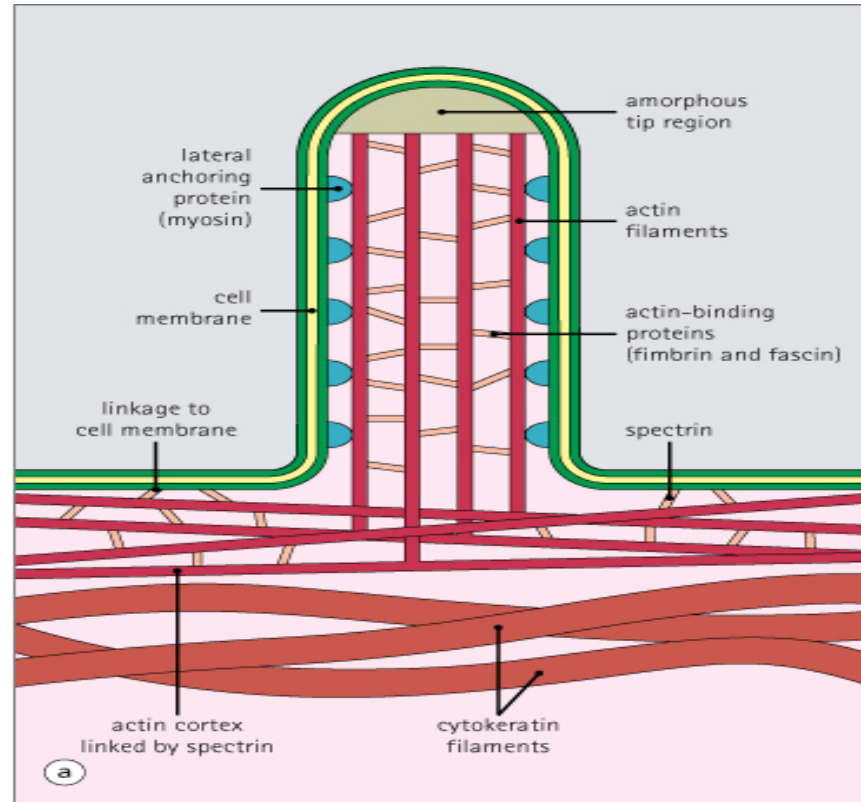
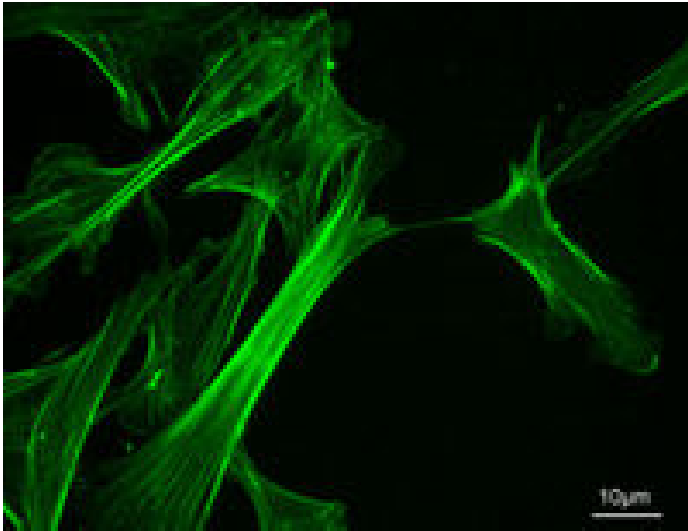
- The cytoskeleton extends through out the cytoplasm. Composed of protein fibers called intermediate filaments, microtubules and microfilaments, the cytoskeleton maintains cell shape, allows the cell to move, and moves structures within the cell.
- For example, when a cell ingests a food particle by phagocytosis, it extends its plasma membrane around the food particle. The cytoskeleton is what moves the plasma membrane.
- Proteins and lipids made on the RER and SER are packaged into vesicles and transported to the golgi for modification. The cytoskeleton is what transports the vesicle.

The eukaryotic cytoskeleton

- Eukaryotic cells contain three main kinds of cytoskeletal filaments, which are microfilaments, intermediate filaments, and microtubules.
- 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.

Actin filaments / Microfilaments

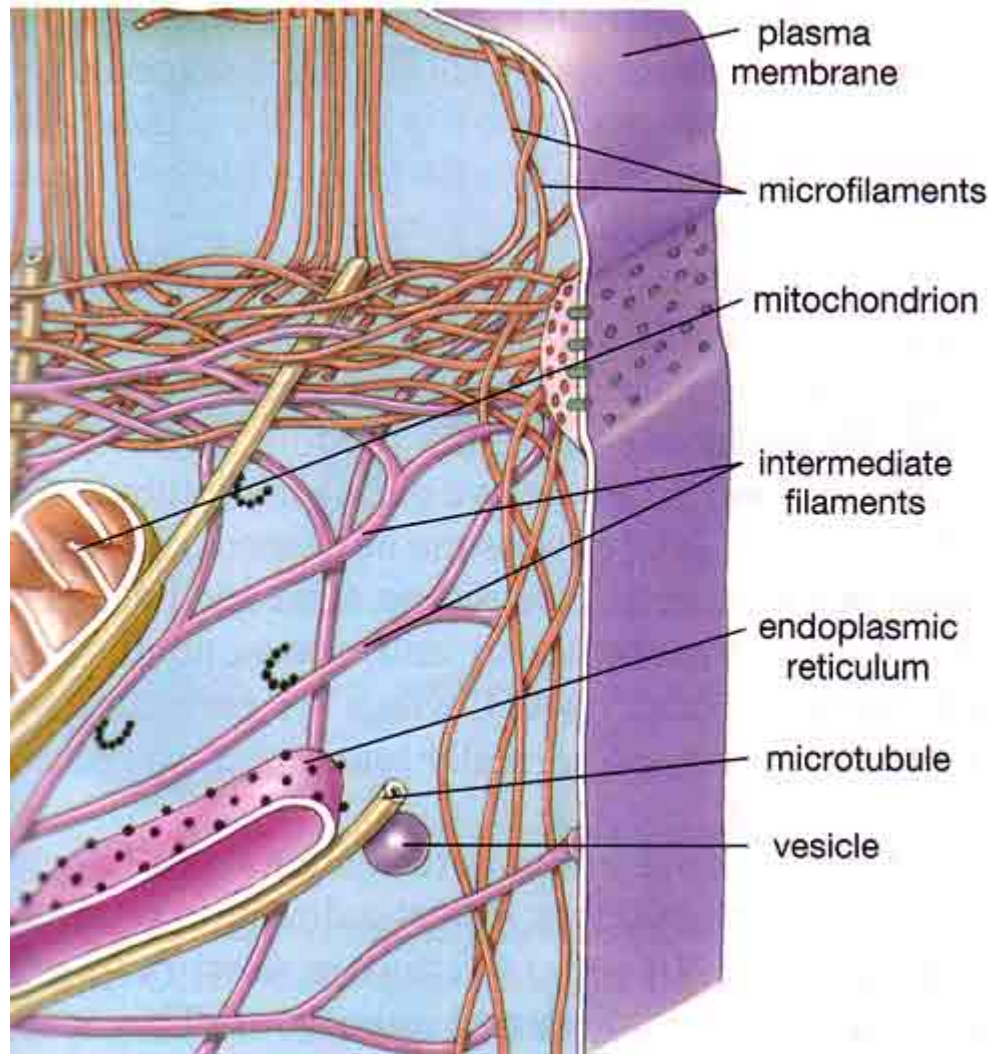
- Globular protein (G-actin). polymerize to form filaments (F-actin). Have several molecular variants isoforms. Solid rods arranged in a twisted double chain.
- Around 7 nm in diameter, this filament type is composed of two intertwined chains. Microfilaments are most concentrated just beneath the cell membrane, and are responsible for resisting tension and maintaining cellular shape, forming cytoplasmic protuberances (like pseudopodia and microvilli), and participation in some cell-to-cell or cell-to-matrix junctions.
- Microfilaments are essential to transduction. They are also important for cytokinesis (specifically, formation of the cleavage furrow) and, along with myosin, muscular contraction. Actin/Myosin interactions also help produce cytoplasmic streaming in most cells.



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Intermediate filaments

- These filaments, around 10 nanometers in diameter, are more stable (strongly bound) than actin filaments, and heterogeneous constituents of the cytoskeleton.
- Like actin filaments, they function in the maintenance of cell-shape by bearing tension microtubules resist compression
- Intermediate filaments organize the internal tridimensional structure of the cell, anchoring organelles and serving as structural components of the nuclear lamina and sarcomeres.
- They also participate in some cell-cell and cell-matrix junctions.
- Different intermediate filaments are:
 - made of vimentins, being the common structural support of many cells.
 - made of keratin, found in skin cells, hair and nails.
 - neurofilaments of neural cells.
 - made of lamin, giving structural support to the nuclear envelope

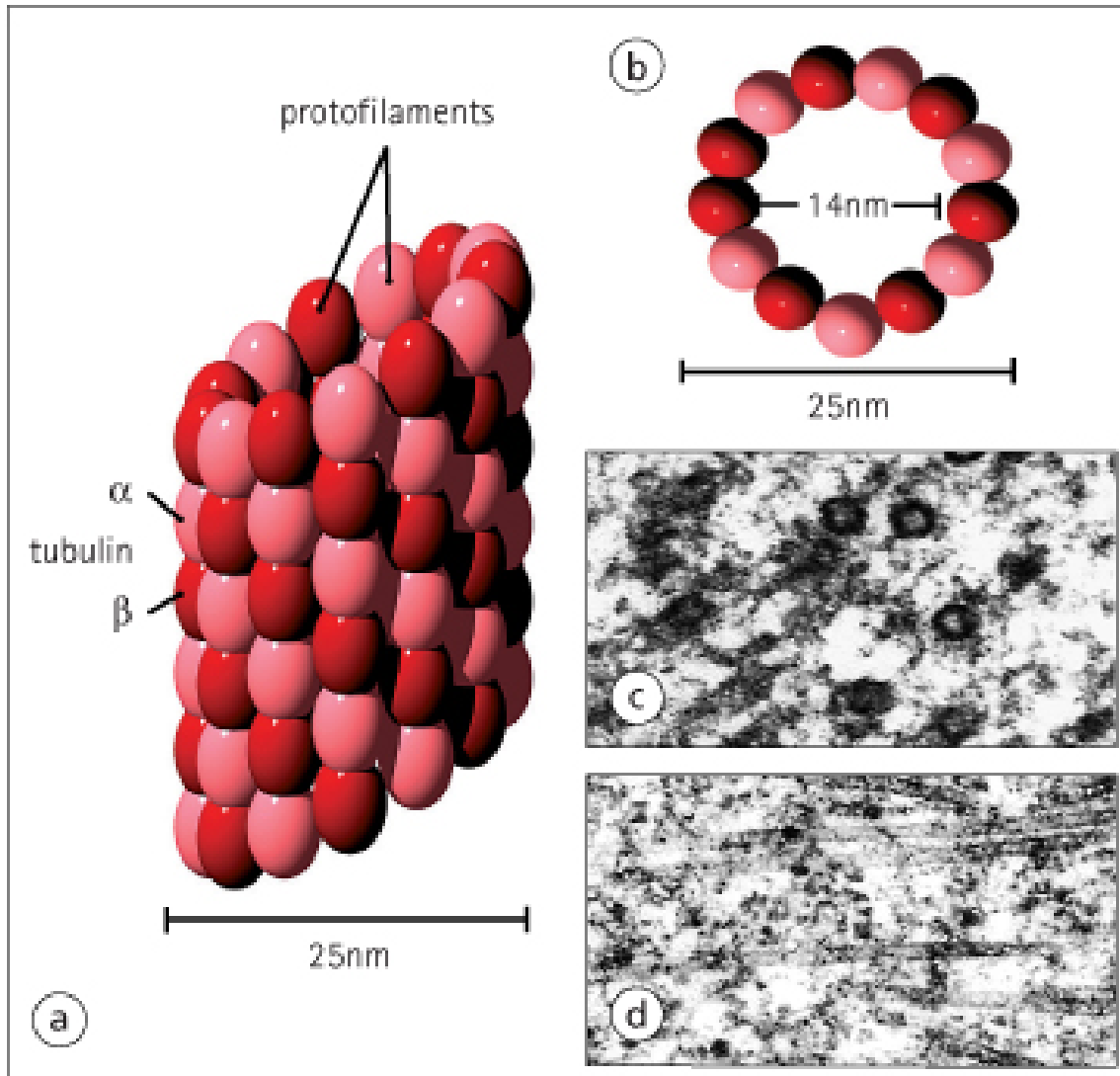


Myosin

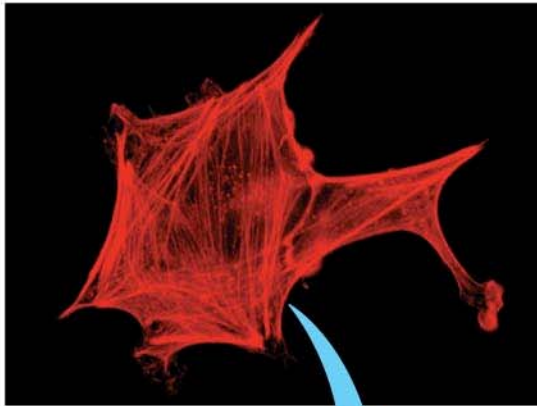
- **Myosins** are a large family of motor proteins found in eukaryotic tissues. They are responsible for actin-based motility.
- Most myosin molecules are composed of a head, neck, and tail domain.
- The head domain binds the filamentous actin, and uses ATP hydrolysis to generate force and to "walk" along the filament towards the barbed (+) end.
- The neck domain acts as a linker and as a lever arm for transducing force generated by the catalytic motor domain. The neck domain can also serve as a binding site for myosin light chains which are distinct proteins that form part of a macromolecular complex and generally have regulatory functions.
- The tail domain generally mediates interaction with cargo molecules and/or other myosin subunits. In some cases, the tail domain may play a role in regulating motor activity.

Microtubules

- Microtubules are hollow cylinders about 23 nm in diameter (lumen = approximately 15nm in diameter), most commonly comprised of 13 protofilaments which, in turn, are polymers of alpha and beta tubulin. 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



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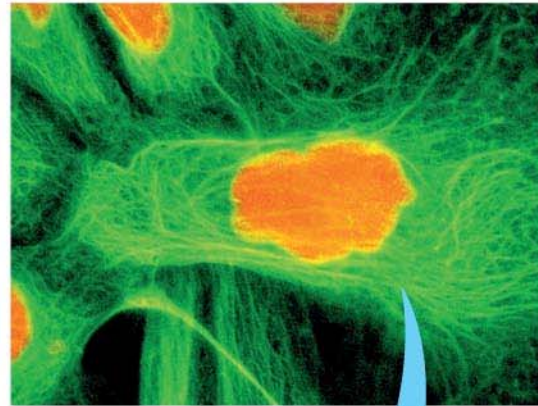


Actin subunit



Microfilament

7 nm

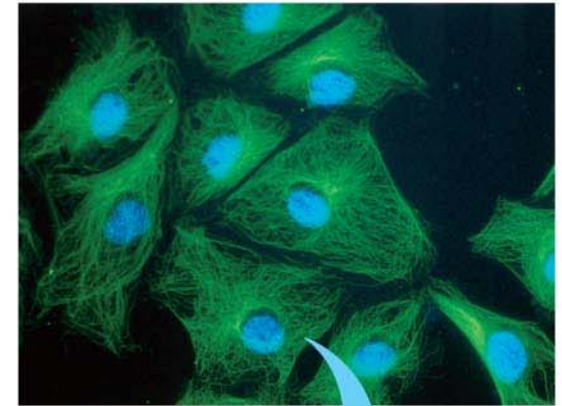


Fibrous subunits

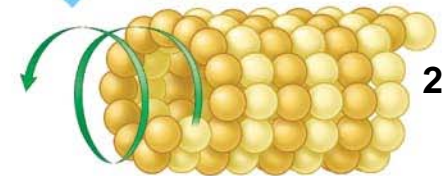


Intermediate filament

10 nm



Tubulin subunit



Microtubule

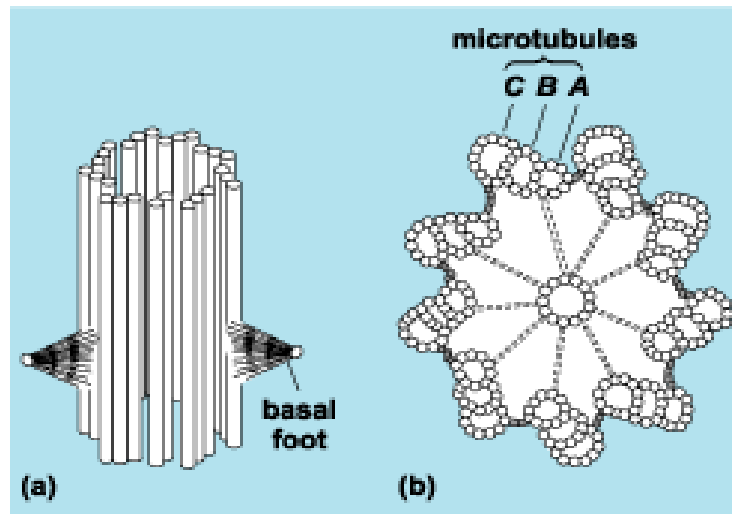
25 nm

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Centrosome

- In cell biology, the **centrosome** is an organelle that serves as the main microtubule organizing center (MTOC) of the animal cell as well as a regulator of cell-cycle progression.
- Centrosomes are composed of two orthogonally arranged centrioles surrounded by an amorphous mass of protein termed the pericentriolar material (PCM). The PCM contains proteins responsible for microtubule nucleation.
- In general, each centriole of the centrosome is based on a nine triplet microtubule assembled in a cartwheel structure, and contains centrin,

Centrioles



Cytokinesis

- **Cytokinesis**, is the process in which the cytoplasm of a single eukaryotic cell is divided to form two daughter cells.
- It usually initiates during the late stages of mitosis, and sometimes meiosis, splitting a binucleate cell in two, to ensure that chromosome number is maintained from one generation to the next.
- A contractile ring, made of non-muscle myosin II and actin filaments, assembles (in the middle of the cell) at the cell cortex (adjacent to the cell membrane).
- Myosin II uses the free energy released when ATP is hydrolysed to move along these actin filaments, constricting the cell membrane to form a cleavage furrow. Continued hydrolysis causes this cleavage furrow to ingress (move inwards)
- The position at which the contractile ring assembles is dictated by the mitotic spindle

Pseudopod

- **Pseudopods** or **pseudopodia** (singular: **pseudopodium**) are temporary projections of eukaryotic cells.
- Cells having this faculty are generally referred to as amoeboids. Pseudopodia extend and contract by the reversible assembly of actin subunits into microfilaments. Filaments near the cell's end interact with myosin which causes contraction.
- The pseudopodium extends itself until the actin reassembles itself into a network. This is how amoebas move, as well as some cells found in animals, such as white blood cells.
- Pseudopodia (which translates to "false feet") are temporary cytoplasm-filled projections of the cell wall that certain eukaryotic cells use for motion or for ingesting nutrients.
- Pseudopodia are formed by microtubule and filament structures. The cell surface projects a membrane process called the lamellipodium, which is supported inside by filaments that form at the leading edge, turning into networks as they blend together. Cytoplasm flows into the lamelliopdium, forming the pseudopodia.

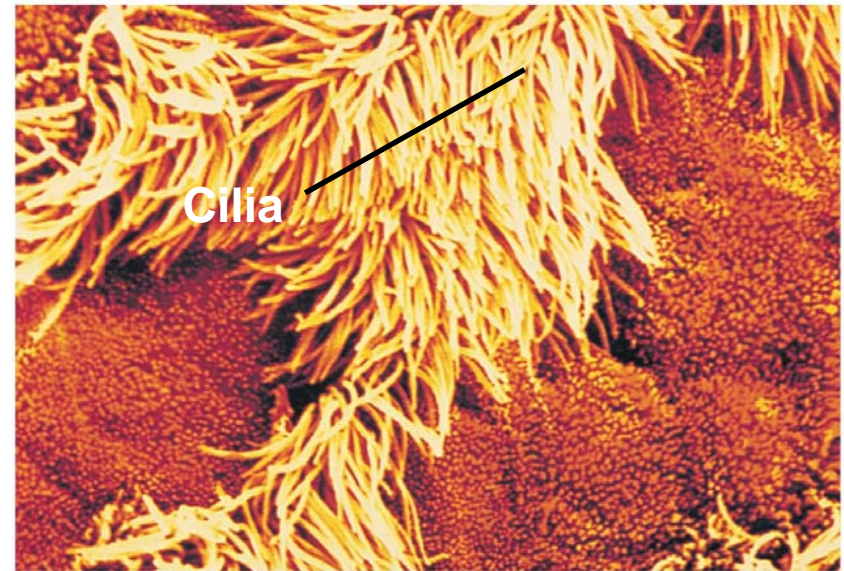
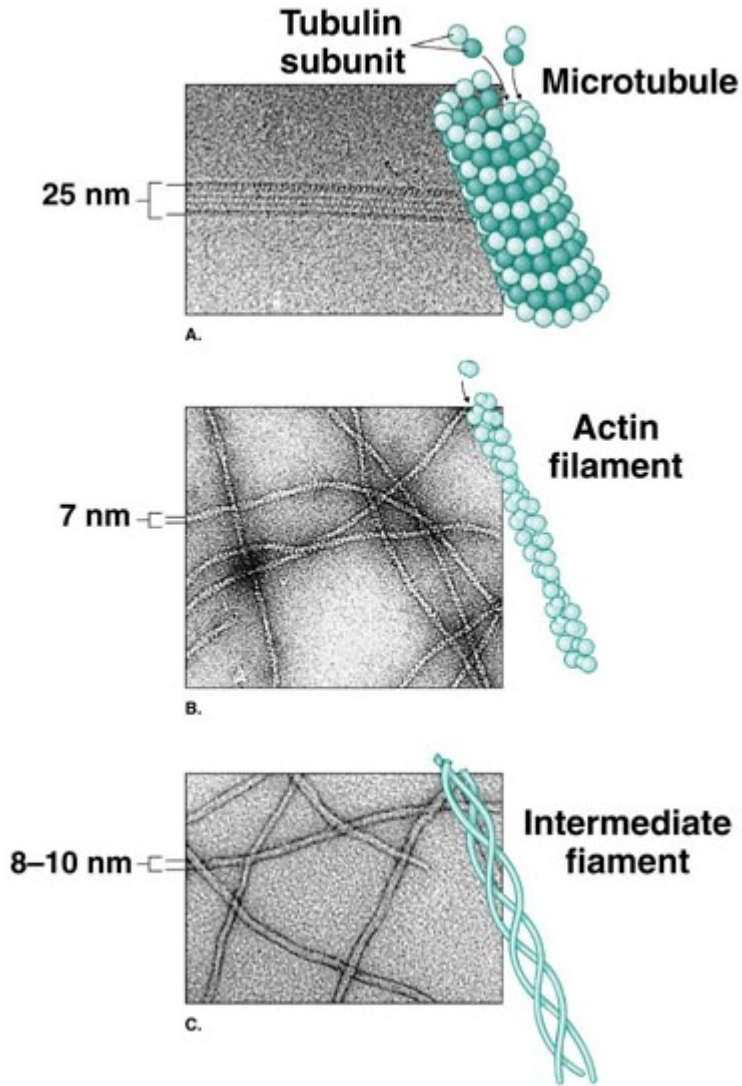
Microtubule functions

- Microtubules serve as structural components within cells and are involved in many cellular processes including mitosis, cytokinesis, and vesicular transport
- Another important feature of microtubule structure is polarity. Tubulin polymerizes end to end with the α subunit of one tubulin dimer contacting the β subunit of the next.
- Therefore, in a protofilament, one end will have the α subunit exposed while the other end will have the β subunit exposed.
- These ends are designated the (-) and (+) ends, respectively. The protofilaments bundle parallel to one another, so in a microtubule, there is one end, the (+) end, with only β subunits exposed while the other end, the (-) end, only has α subunits exposed.
- Microtubules are nucleated and organized by the microtubule organizing centers (MTOCs), such as centrioles and basal bodies
- They are capable of growing and shrinking in order to generate force
- Microtubules are also part of the cilia and flagella of eukaryotic cells

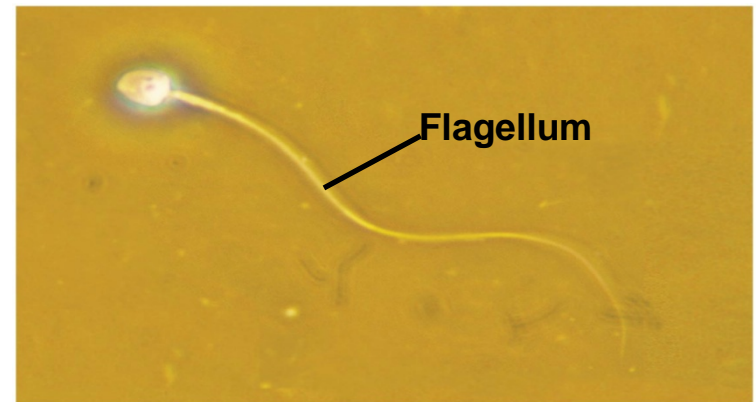
Cilia and flagella

Both are composed of microtubules wrapped in an extension of cell membrane.

- Composed of 9 bundles of microtubules each consist of 2 . **This characteristic arrangement is (9+2)** called doublet tubules
- In eukaryotic cilia and flagella, there are in addition 2 central microtubules.
- They are anchored in a structure called “basal body” similar to centrioles.(9 + 3) called triplet tubules.
- Cilia move like **coordinated oars** e.g in human respiratory system to sweep mucus containing trapped debris. Flagella move like an undulating **whipelike motion** e.g. flagellated sperm



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