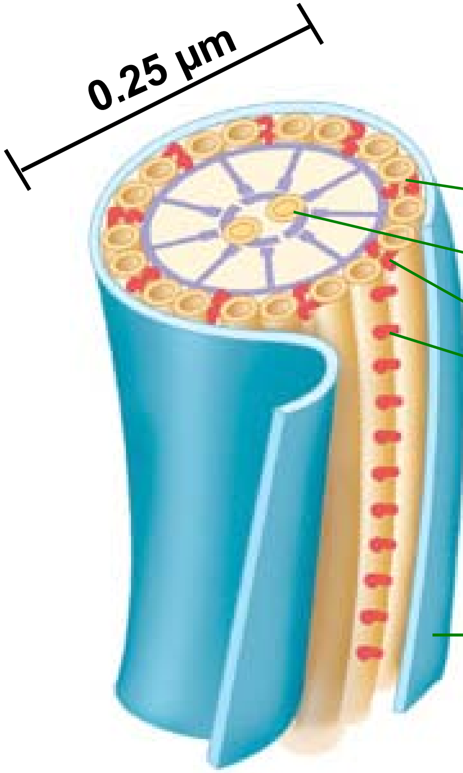
BIO 311C
Spring 2010

Prokaryotic cells contain structures that are very similar to structures of the eukaryotic cytoskeleton. Prokaryotic cytoskeletal elements are required for cell division, maintaining non-spherical cell shapes and separating plasmids from each other.

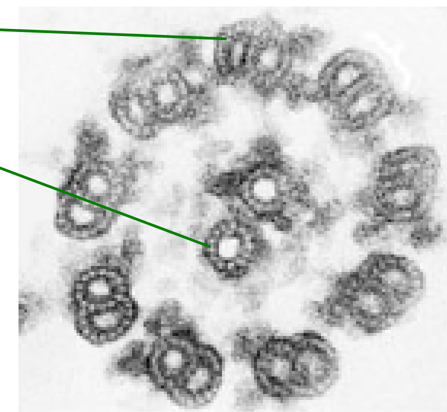
Lecture 7 – Wednesday 3 Feb. 2010

Cross-sectional View of a Flagellum or Cilium

From textbook Fig. 6.24, p. 115



digramatic representation



electron microscope picture

cilia and flagella appear identical in cross-sectional view

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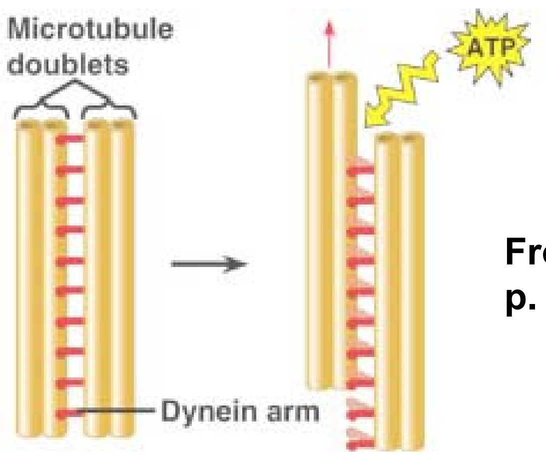
Mechanism of movement of Flagella and Cilia

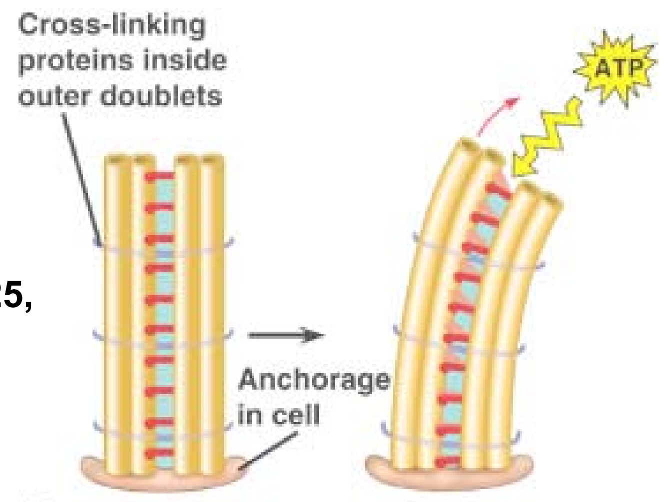
a. Energy in the form of ATP is directed to a motor molecule called dynein.

b. Energized dynein causes one doublet of microtubules to slide past another doublet.

c. Since all microtubule doublets are anchored together at their base, dynein movement causes the entire structure to bend.



From textbook Fig. 6.25, p. 116



This illustration shows that movement would occur without bending if the doublets were not all anchored at their bases.

This illustration shows the bending that occurs since the doublets are all anchored at their bases.

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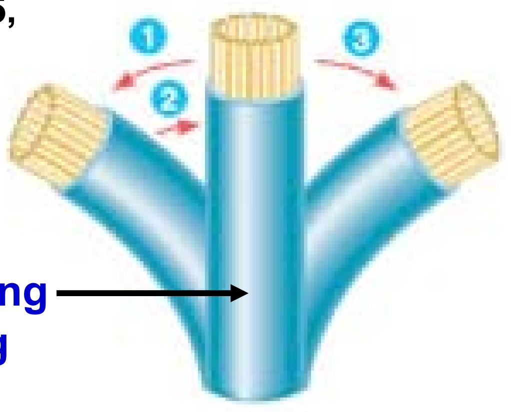
Bending of a microtubule doublet causes the entire flagellum (or cilium) to bend since all of the doublets and other components of the flagellum are anchored together.

Sequential energization of dynein on different microtubule doublets causes the flagellum to bend in different directions at different periods of time.

From textbook Fig. 6.25, p. 116



flagellum (or cilium), showing plasma membrane covering

Numbered arrows show different directions of flagellar bending at different periods of time.

An elaborate cellular control mechanism regulates exactly which dynein molecules are energized at each interval of time, thereby controlling the direction of bending of the microtubule doublets at each interval of time.

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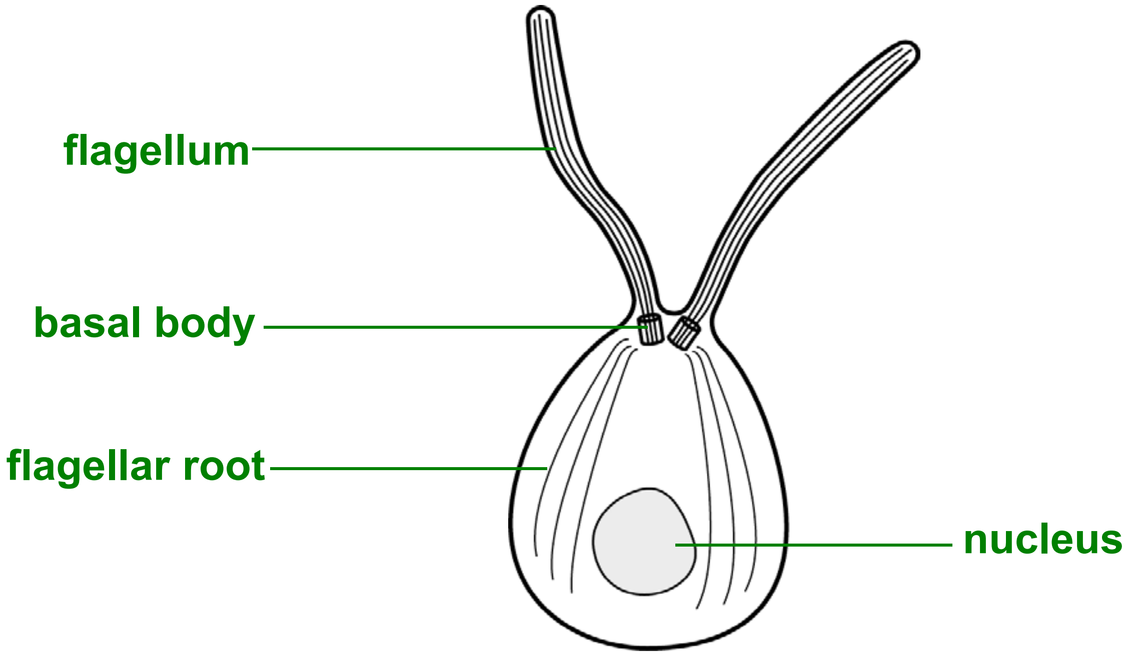
The microtubule doublets of each flagellum (or cilium) extend into the cell for a short distance, where they become microtubule triplets, in a structure called a basal body.

In cells that contain flagella, separate microtubules or bundles of several microtubules often start at the region of the basal bodies and extend into various regions of the cell. They are called flagellar roots.



flagellated
unicellular eukaryote

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Basal bodies differ from flagella or cilia in that that they:

- are composed of 9 triplets (instead of doublets) of microtubules
- do not contain a central pair of microtubules,
- do not contain dynein, and
- are not surrounded by plasma membrane.

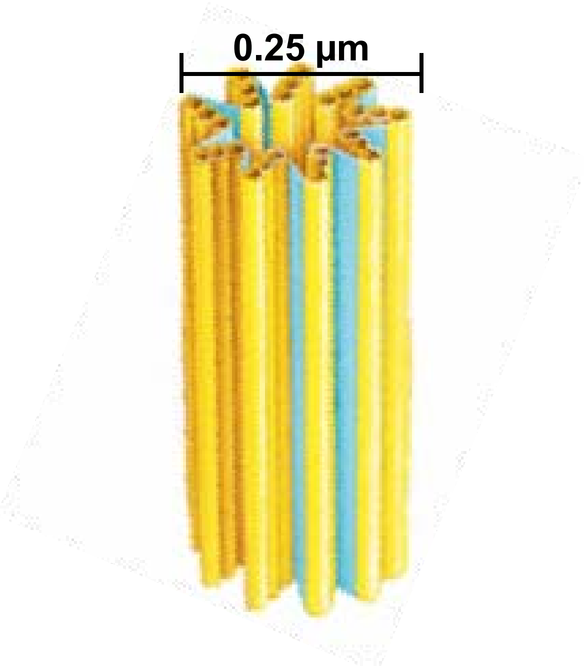


diagram of a side view
of a basal body
(blue represents associated
proteins that hold
the triplets together)

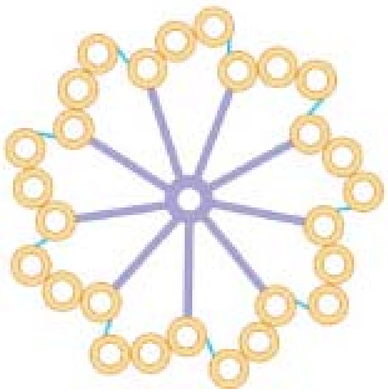
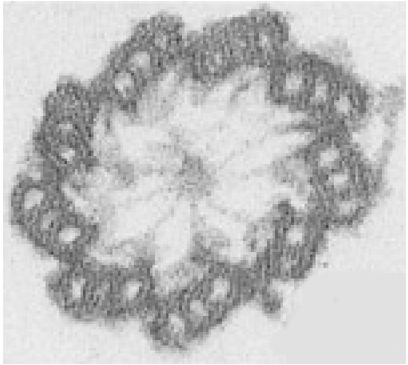


diagram of a cross section
of a basal body

See textbook Fig 6.22, p. 114



electron microscope picture of
a cross section of a basal body

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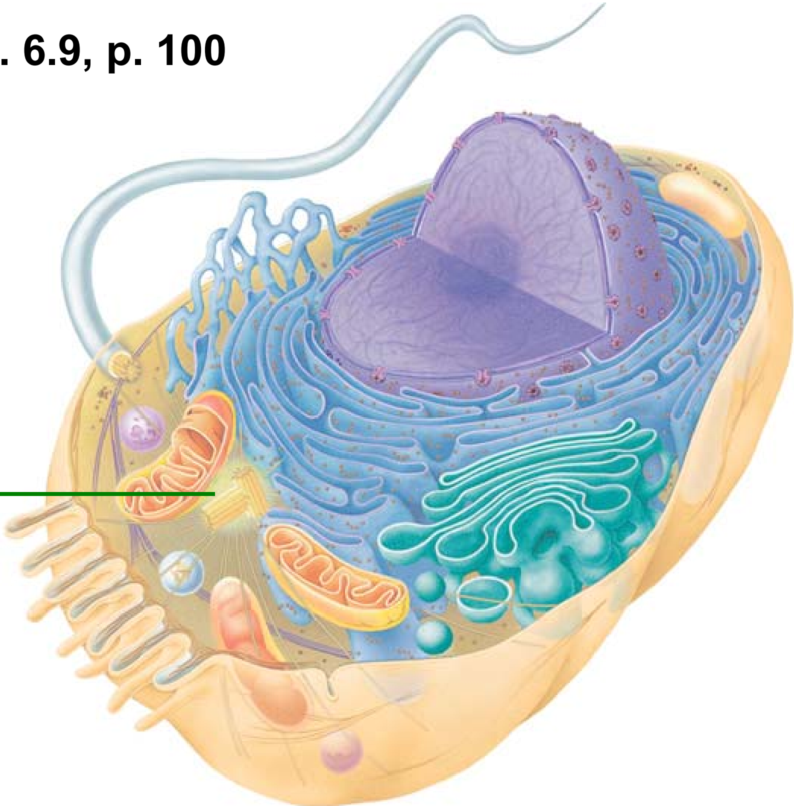
In the cytoplasmic matrix of eukaryotic cells there is a region called the centrosome or microtubule organizing center (MTOC). Microtubules radiate from this region. In animal cells there are two structures called centrioles in the centrosome.

From textbook Fig. 6.9, p. 100



animal cell

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The MTOC provides a reference point for organizing the locations of various structures within the cell with respect to a framework of microtubules.

The two centrioles in a centrosome lie at right angles to each other.

Each centriole in the centrosome appears identical to a basal body.

See textbook Fig. 6.22, p. 114

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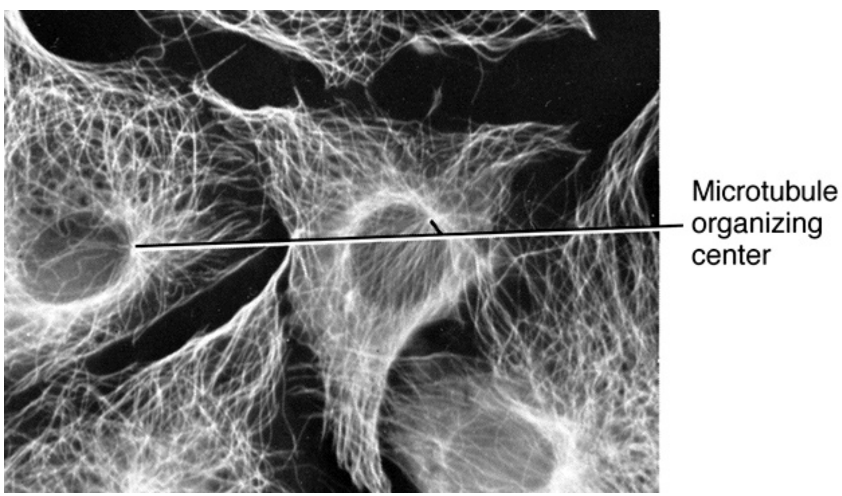
Although all eukaryotes contain a microtubule organizing center (MTOC), plant cells do not contain centrioles in this center.

Many individual microtubules radiate from the MTOC in various directions within the cytoplasmic matrix. The contents of the cell are organized with respect to this center and its radiating microtubules.

Because of their location near the center of the cell and their role in organizing the positions of other components of the cell, the MTOC is sometimes called the "cell center".



Electron microscope picture of microtubules radiating from the MTOC of a plant cell

See textbook Fig. 6,9, p. 101 for a diagrammatic illustration of a plant cell MTOC (centrosome).

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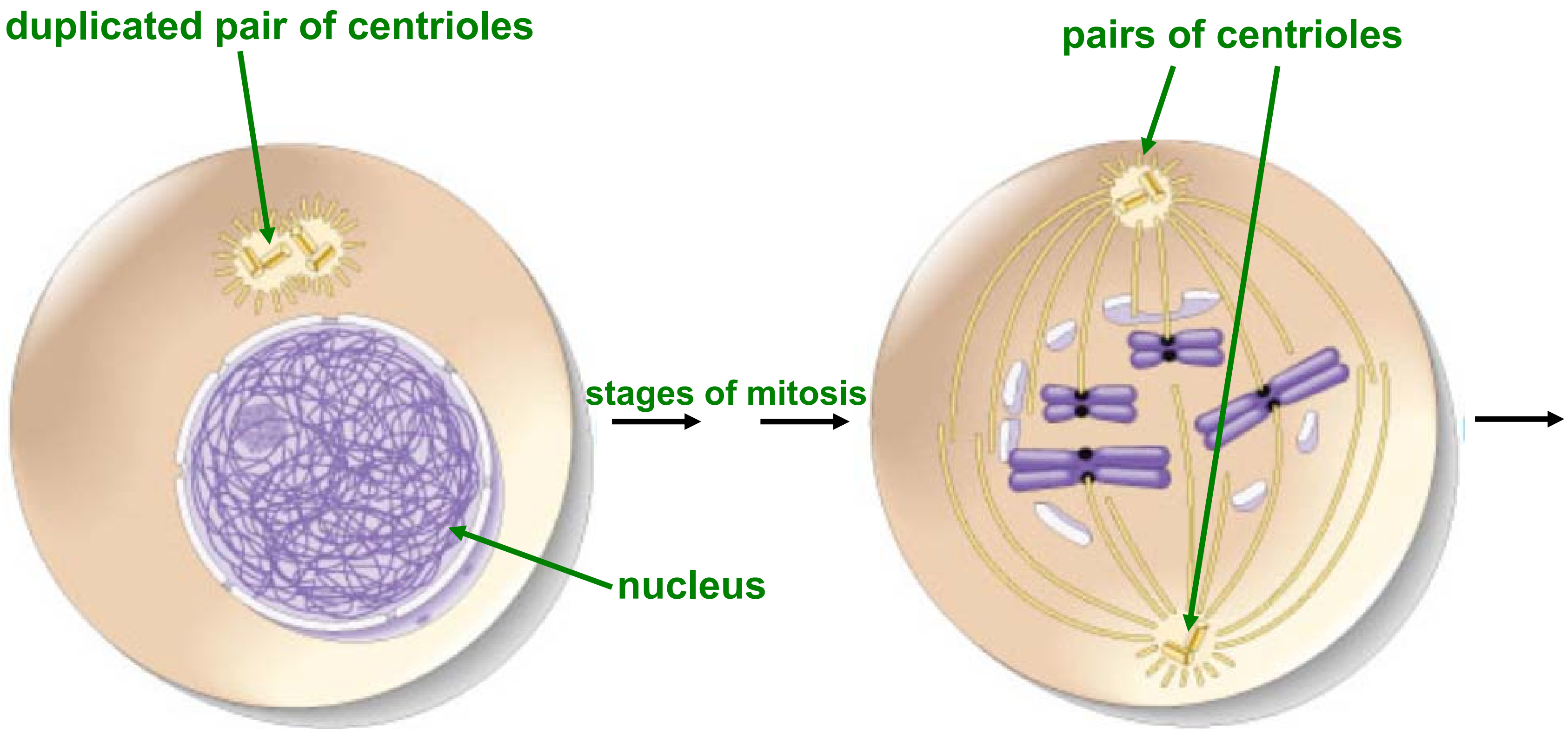
The centrosome (MTOC) plays a central role in mitosis and other events associated with eukaryotic cell division.



The animal cell illustrated here is just beginning the process of mitosis. The pair of centrioles has recently been duplicated and there are now two centrosomes in the MTOC.

The cell is now in a later stage of mitosis. One centrosome has migrated to the opposite side of the cell, forming a second MTOC.

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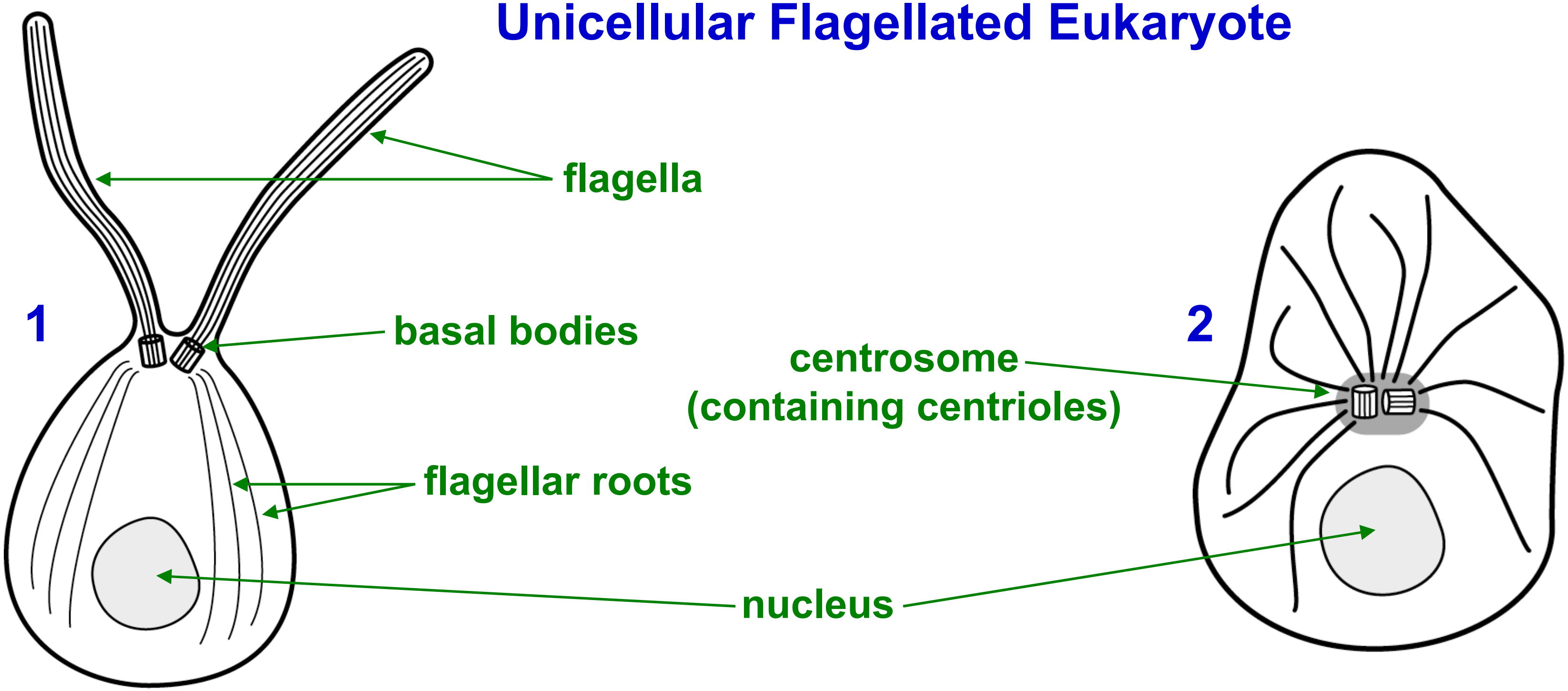
Relationship Between Basal Bodies and Centrioles in a Unicellular Flagellated Eukaryote



These illustrations represent two stages in the life cycle of the same cell. (1) During most of its lifetime, the cell has flagella with basal bodies as well as flagellar roots that radiate deep into the cell interior, helping to organize the cell contents. (2) The cell loses it's flagella when it prepares to undergo mitosis and divide. The basal bodies then move to a site near the center of the cell where they become centrioles as a centrosome forms. Microtubules are produced by the cell and radiate from the centrosome, where they provide a framework for re-organizing cellular components in preparation for mitosis and cell division. After the cell divides, the centrioles of each new cell will again migrate to the front part of the cell to become basal bodies and provide a framework for the formation of new flagella.

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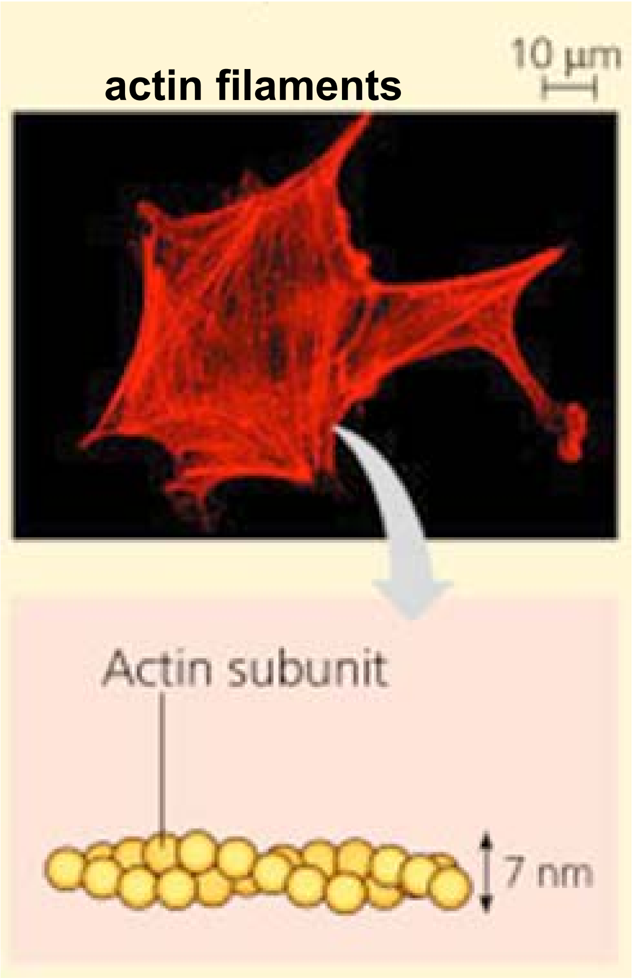
Microfilaments form a framework of thin filamentous structures within the cytoplasm of eukaryotic cells.

From textbook Table 6.1, p. 113



Microfilaments vary in length, and may be hundreds of nm long. They are always 7 nm in diameter.

Microfilaments are dynamic structures, dis-assembled into protein monomers (single proteins) called g-actin when no longer needed, then re-assembled into new microfilaments as needed elsewhere in the cell.

Microfilaments are also sometimes called "thin filaments" or "actin filaments".

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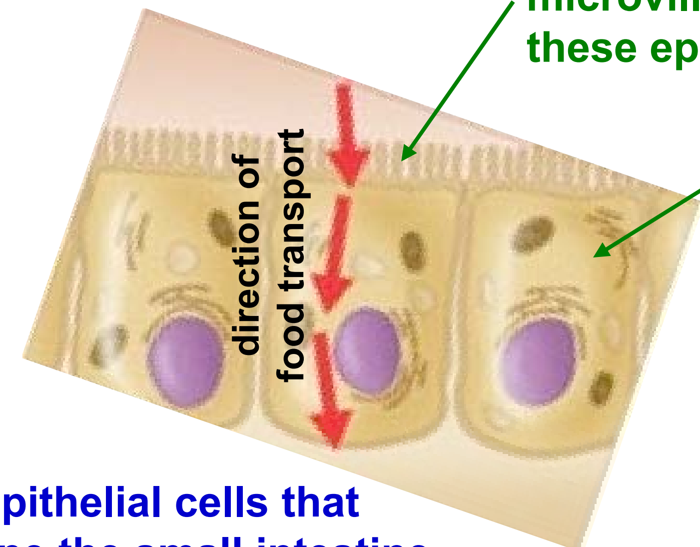
Microfilaments are important for maintaining the shapes of animal cells.



microvilli = small protrusions on the surface of these epithelial cells, used to increase surface area.

epithelial cell

Epithelial cells that line the small intestine

Specific shapes are often maintained in eukaryotic cells that don't contain external walls by microfilaments that are distributed within the cytoplasm to produce a gel-like consistency (the cytogel).

Some eukaryotic cells have highly irregular cell surfaces to increase their surface/volume ratio or to facilitate their movement along a surface. These irregular shapes are maintained in many kinds of cells without an external wall by microfilaments extending into the cell projections.

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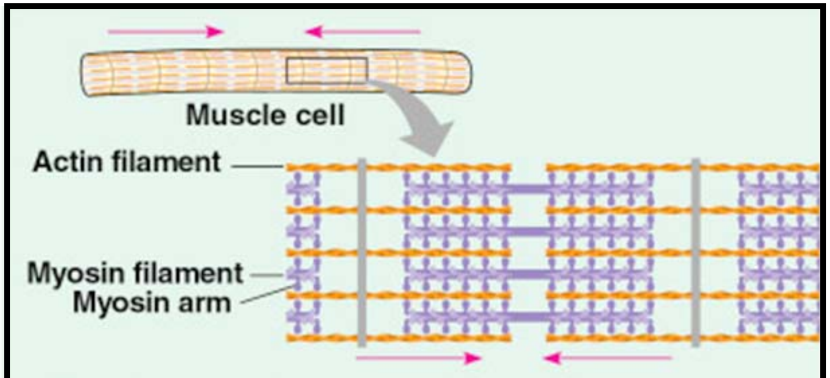
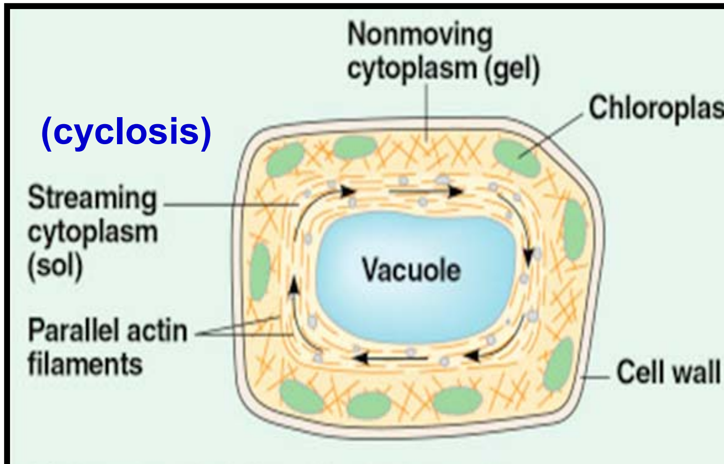
Examples of Microfilament Function

See textbook Fig. 6.27, p. 117



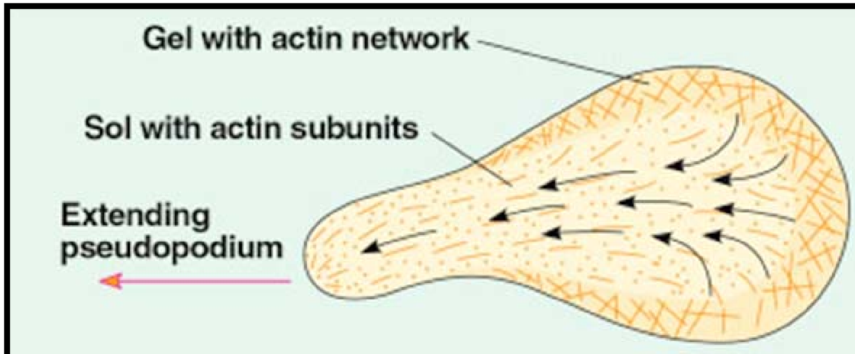
(a) Myosin motors in muscle cell contraction

Animal muscle cell



(c) Cytoplasmic streaming in plant cells

Plant cell



(b) Amoeboid movement

Protist cell

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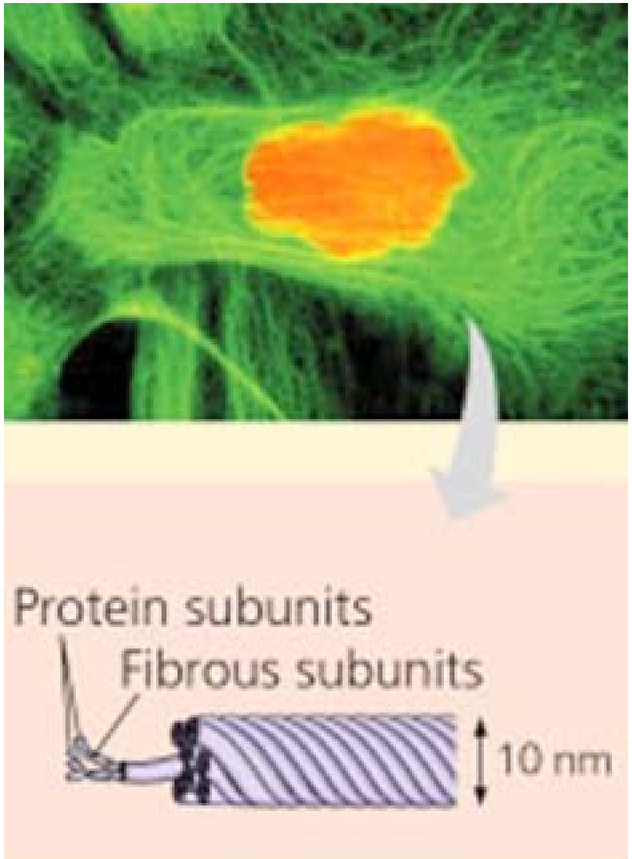
Intermediate filaments form a framework of thin filamentous structures within the cytoplasm of most eukaryotic cells.

green = microfilaments
orange = nucleus



From textbook Table 6.1, p. 113

Intermediate filaments vary in length, and may be several µm long.

Many different kinds of intermediate filaments occur in eukaryotic cells, depending on the organism and the type of tissue.

They vary in diameter, depending on the kind of intermediate filament, within the range of 8 to 12 nm.

Intermediate filaments are not dynamic structures. Most kinds remain intact for the life of the cell after they are assembled.

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A Few of the Many Types of Intermediate Filaments that Occur in Higher Animal Cells

Keratin: is the major component of skin cell cytoplasmic matrix;
is the major component of hair and nails;
is the main component of bird feathers.

Neurofilaments: occur in the cytoplasmic matrix of nerve cells.

Lamins: occur in nucleoplasm.

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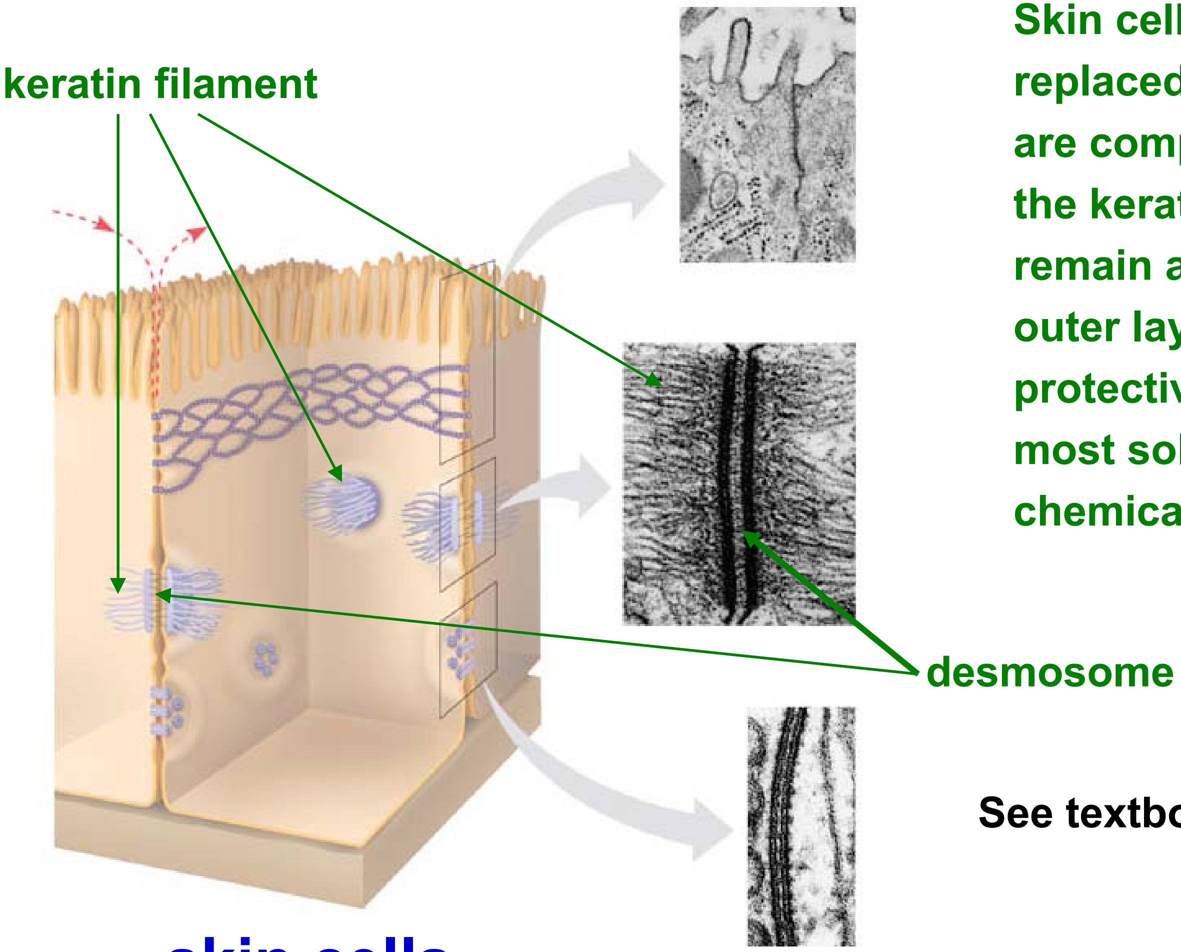
Keratin intermediate filaments align in parallel within the cytoplasmic matrix of skin cells. They are concentrated at points where the cell is connected tightly to adjacent cells through anchoring junctions called desmosomes.



skin cells

Skin cells continuously die and are replaced by new cells. The dead cells are completely destroyed, except for the keratin microfilaments, which remain as a surface coating on the outer layer of skin. Keratin is highly protective, since it is impenetrable to most solvents and inert to most chemical agents.

See textbook Fig. 6.32, p. 121

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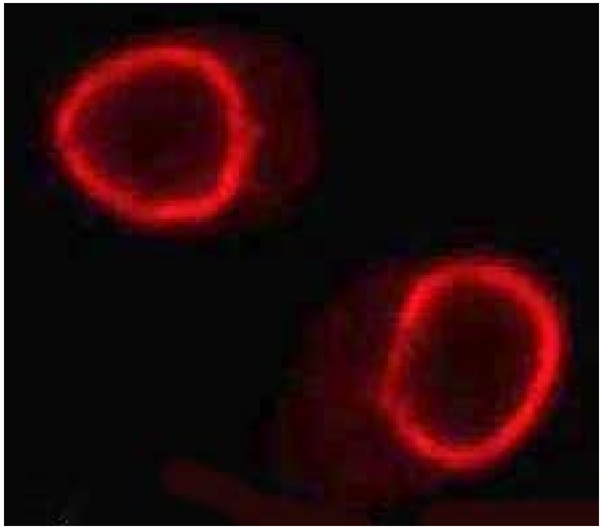
Fluorescent Stain of Lamin, Showing its Occurrence in the Nucleoplasm, Just Inside of the Nuclear Envelope



Most kinds of Intermediate filaments occur in the cytoplasmic matrix. Lamin is an exception.

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Some ways that intermediate filaments are different from microfilaments and microtubules

Microtubules and microfilaments are made of globular proteins while intermediate filaments are made of fibrous proteins.

Microtubules and microfilaments are dynamic structures that can be quickly dis-assembled and re-assembled from their subunits by the cell. Intermediate filaments are very stable and most of them are not dis-assembled after they are formed.

Microfilaments and microtubules perform a large variety of functions, many of which involve movement. Each kind of intermediate filament has a very narrow range of functions, and intermediate filaments generally do not facilitate movement.

Microtubules as well as microfilaments are virtually identical in all eukaryotic cells, while intermediate filaments are quite specialized, and each different type of cell has its own specific intermediate filaments with its own functions. Diameters of different kinds of microfilaments are also somewhat different from each other.

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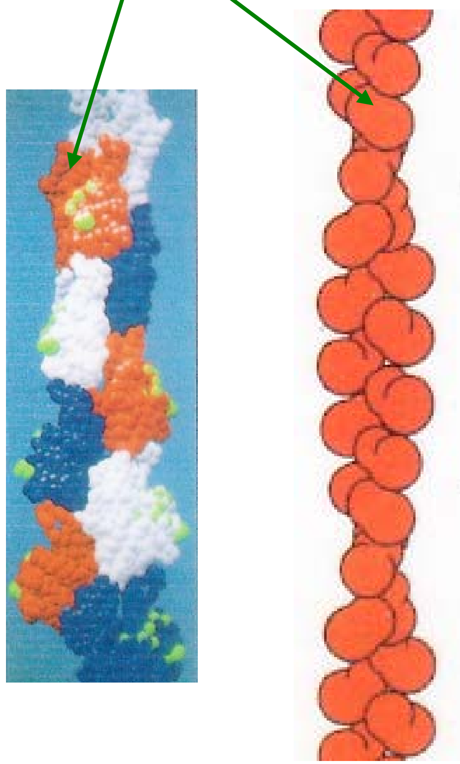
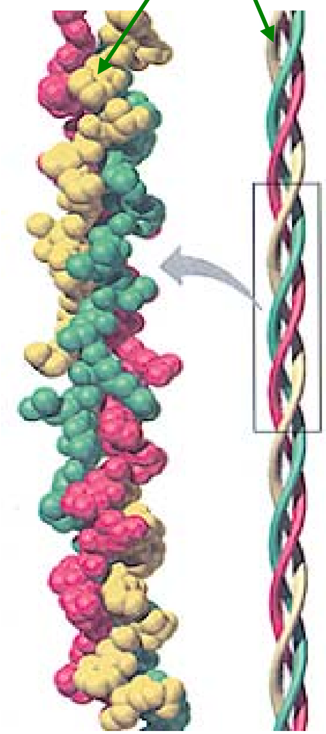
Globular vs Fibrous Polypeptide Chains

Globular polypeptide chains (proteins)



Molecular models of an actin filament (a microfilament)

Fibrous polypeptide chains (proteins)



Molecular models of a keratin intermediate filament

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