The cytoskeleton is a network of fibers that organizes structures and activities in the cell

- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm
- It organizes the cell's structures and activities, anchoring many organelles
- It is composed of three types of molecular structures:
  - Microtubules
  - Microfilaments
  - Intermediate filaments

- There is a multitude of functions that the cytoskeleton can perform. Primarily,

- it gives the cell shape

- mechanical resistance to deformation, so that through association with extracellular connective tissue and other cells it stabilizes entire tissues.

- The cytoskeleton can also actively contract, thereby deforming the cell and the cell's environment and allowing cells to migrate.

- Involved in many cell signaling pathways, in the uptake of extracellular material (endocytosis),

- segregates chromosomes during cellular division, is involved in cytokinesis (the division of a mother cell into two daughter cells),
- provides a scaffold to organize the contents of the cell in space and for intracellular transport (for example, the movement of vesicles and organelles within the cell);
- can be a template for the construction of a cell wall.
- It forms specialized structures, such as flagella, cilia, lamellipodia and podosomes

- In eukaryotes, the cytoskeletal matrix is a dynamic structure composed of three main proteins, which are capable of rapid growth or disassembly dependent on the cell's requirements at a certain period of time. However, the structure, function and dynamic behavior of the cytoskeleton can be very different, depending on organism and cell type.

- Similarly, within the same cell type the structure, dynamic behavior, and function of the cytoskeleton can change through association with other proteins and the previous history of the network

A large-scale example of an action performed by the cytoskeleton is muscle contraction. During contraction of a muscle, within each muscle cell, myosin molecular motors collectively exert forces on parallel actin filaments. This action contracts the muscle cell, and through the synchronous process in many muscle cells, the entire muscle.

Eukaryotic cytoskeleton

Eukaryotic cells contain three main kinds of cytoskeletal filaments: microfilaments, microtubules, and intermediate filaments

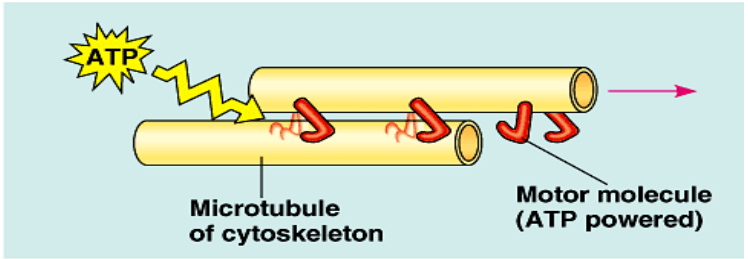
Each cytoskeletal filament has a shape and intracellular distribution. Additionally, the filaments are formed by polymerization of different types of sub-units. The microfilament consist of the polymers of the protein actin which has a diameter of 7 nm. The microtubules are made up of the protein called tublin which has a diameter of 25 nm.

- Intermediate filaments are made up of various proteins which varies depending on the cell type. These type of filament normally have diameters ranging from 8-12 nm.

- 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.

- A number of small molecule cytoskeletal drugs have been discovered that interact with actin and microtubules. These compounds have proven useful in studying the cytoskeleton and several have clinical applications

- The cytoskeleton also plays a major role in cell motility.
  - This involves both changes in cell location and limited movements of parts of the cell.
- The cytoskeleton interacts with motor proteins.
  - In cilia and flagella motor proteins pull components of the cytoskeleton past each other.
  - This is also true in muscle cells.



(a)

Roles of the Cytoskeleton: Support, Motility, and Regulation

- The cytoskeleton helps to support the cell and maintain its shape
- It interacts with **motor proteins** to produce motility
- Inside the cell, vesicles can travel along "monorails" provided by the cytoskeleton
- Recent evidence suggests that the cytoskeleton may help regulate biochemical activities

Components of the Cytoskeleton

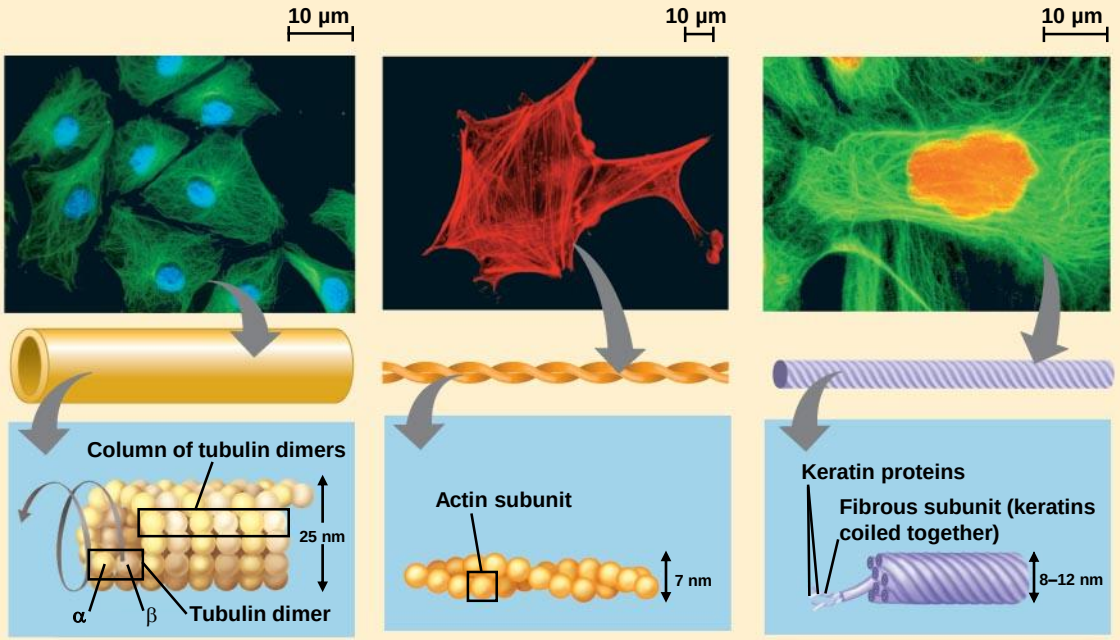
- Three main types of fibers make up the cytoskeleton:
  - *Microtubules* are the thickest of the three components of the cytoskeleton
  - *Microfilaments*, also called actin filaments, are the thinnest components
  - *Intermediate filaments* are fibers with diameters in a middle range

Table 6-1

Table 6.1 The Structure and Function of the Cytoskeleton

Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules	Two intertwined strands of actin, each a polymer of actin subunits	Fibrous proteins supercoiled into thicker cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins of the keratin family, depending on cell type
Main functions	Maintenance of cell shape (compression-resisting "girders") Cell motility (as in cilia or flagella) Chromosome movements in cell division Organelle movements	Maintenance of cell shape (tension-bearing elements) Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility (as in pseudopodia) Cell division (cleavage furrow formation)	Maintenance of cell shape (tension-bearing elements) Anchorage of nucleus and certain other organelles Formation of nuclear lamina

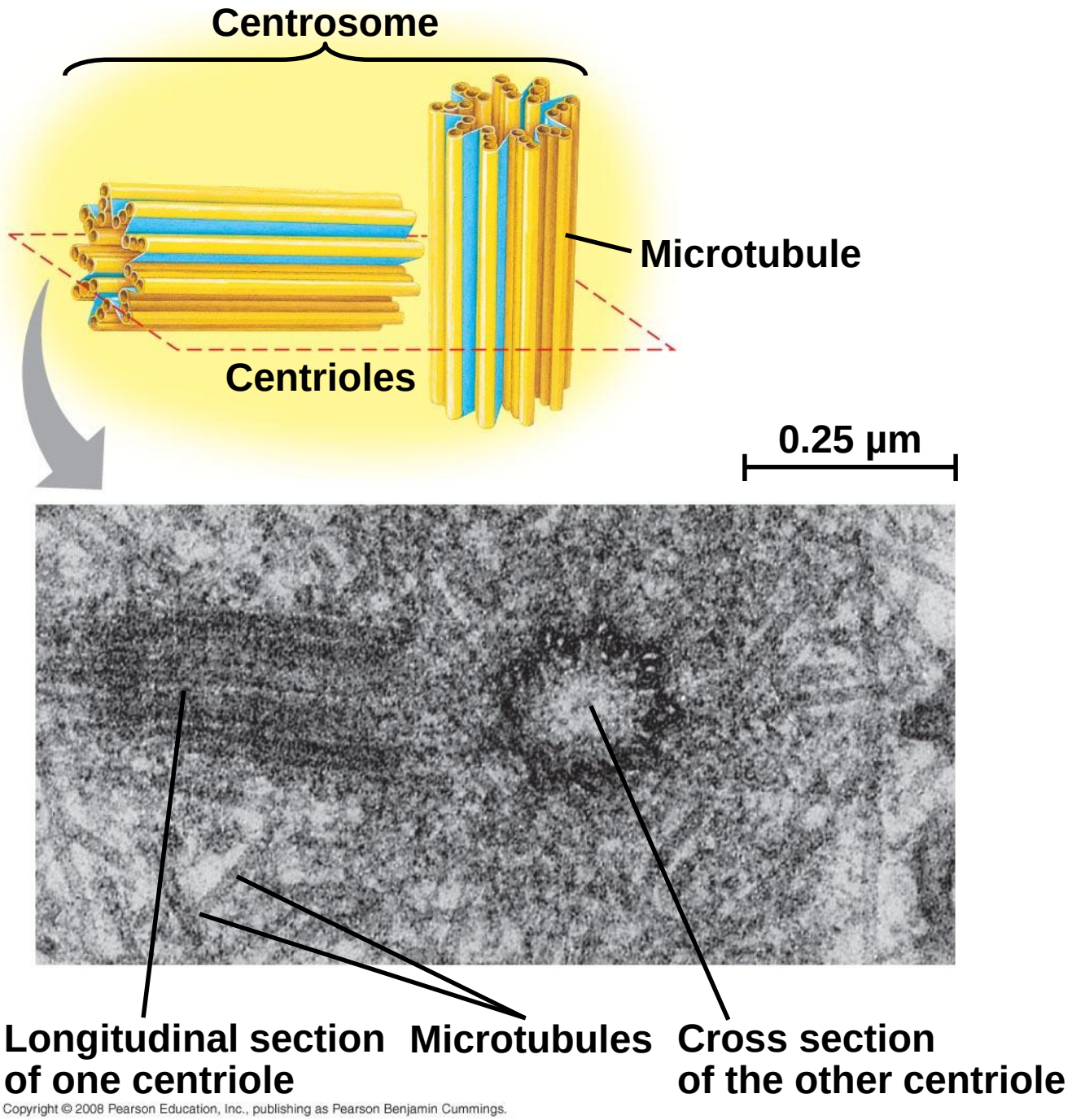
Micrographs of fibroblasts, a favorite cell type for cell biology studies. Each has been experimentally treated to fluorescently tag the structure of interest.



Centrosomes and Centrioles

- In many cells, microtubules grow out from a **centrosome** near the nucleus
- The centrosome is a "microtubule-organizing center"
- In animal cells, the centrosome has a pair of **centrioles**, each with nine triplets of microtubules arranged in a ring

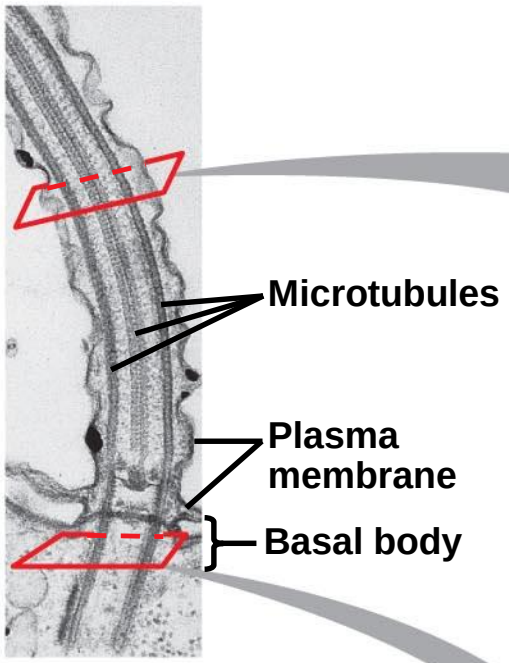
Fig. 6-22



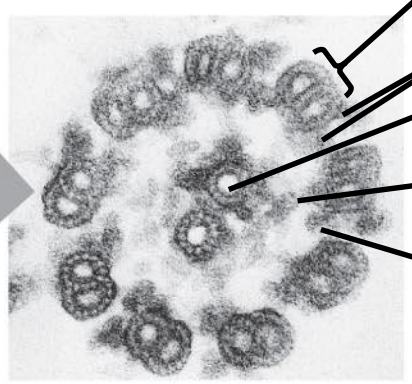
Cilia and Flagella

- Microtubules control the beating of **cilia** and **flagella**, locomotor appendages of some cells
- Cilia and flagella differ in their beating patterns

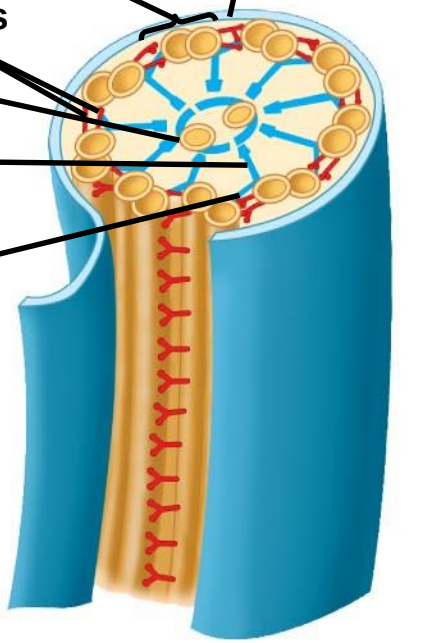
Fig. 6-24

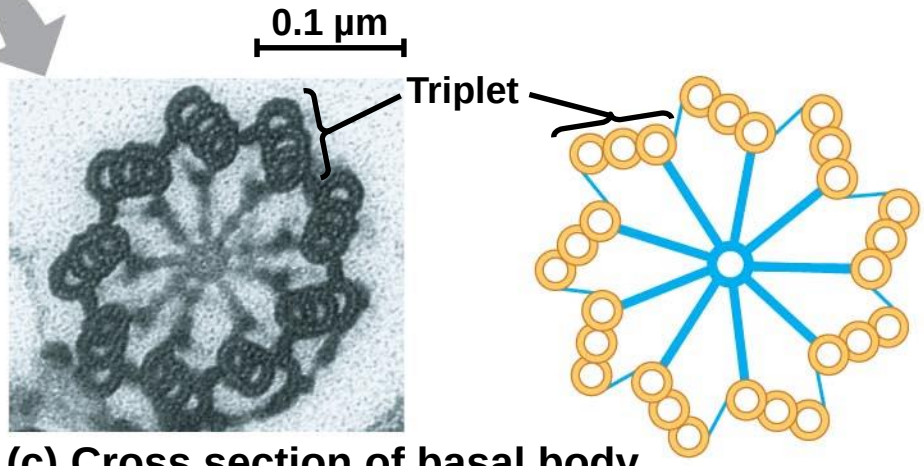


(a) Longitudinal section of cilium



(b) Cross section of cilium





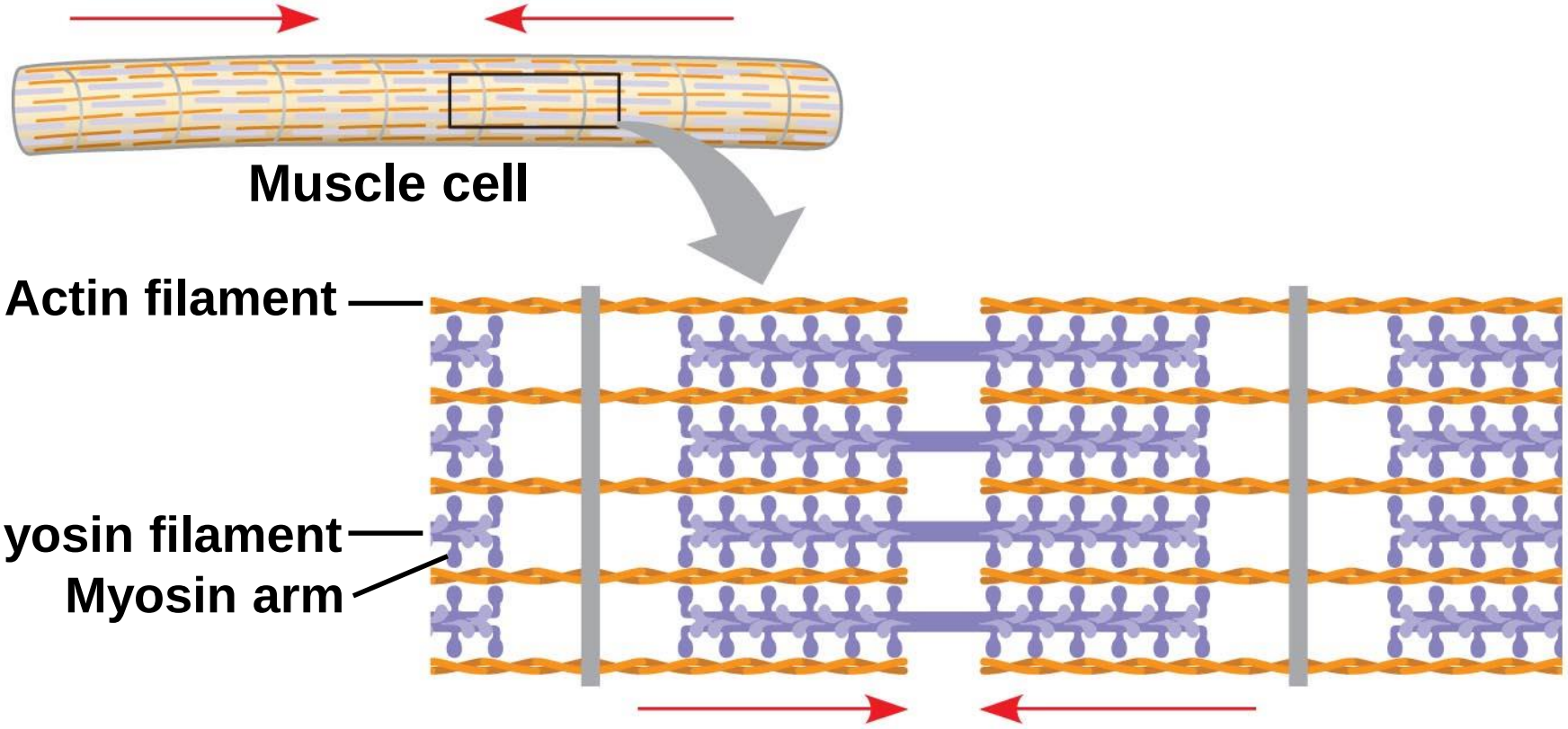
(c) Cross section of basal body

Microfilaments (Actin Filaments)

- **Microfilaments** are solid rods about 7 nm in diameter, built as a twisted double chain of **actin** subunits
- The structural role of microfilaments is to bear tension, resisting pulling forces within the cell
- They form a 3-D network called the **cortex** just inside the plasma membrane to help support the cell's shape
- Bundles of microfilaments make up the core of microvilli of intestinal cells

- Microfilaments that function in cellular motility contain the protein **myosin** in addition to actin
- In muscle cells, thousands of actin filaments are arranged parallel to one another
- Thicker filaments composed of myosin interdigitate with the thinner actin fibers

Fig, 6-27a



(a) Myosin motors in muscle cell contraction

Intermediate Filaments

- **Intermediate filaments** range in diameter from 8–12 nanometers, larger than microfilaments but smaller than microtubules
- They support cell shape and fix organelles in place
- Intermediate filaments are more permanent cytoskeleton fixtures than the other two classes