Figure 7.18aa

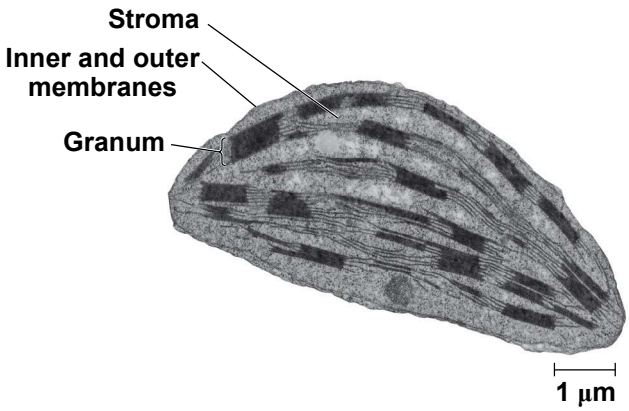
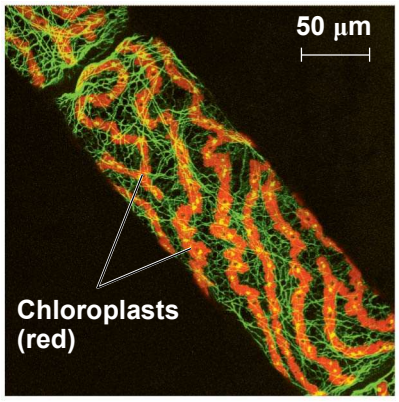


Figure 7.18b



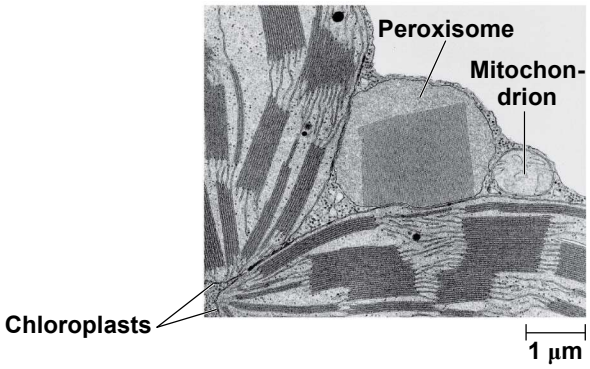
(b) Chloroplasts in an algal cell

- Chloroplast structure includes
  - **Thylakoids**, membranous sacs, stacked to form a **granum**
  - **Stroma**, the internal fluid
- The chloroplast is one of a group of plant organelles, called **plastids**

Peroxisomes: Oxidation

- **Peroxisomes** are specialized metabolic compartments bounded by a single membrane
- Peroxisomes produce hydrogen peroxide and convert it to water
- Peroxisomes perform reactions with many different functions
- How peroxisomes are related to other organelles is still unknown

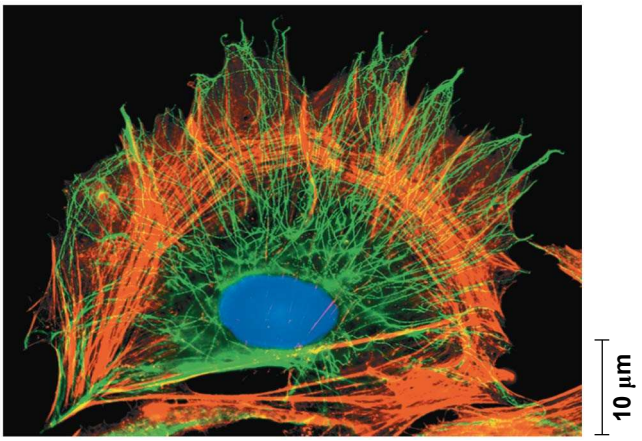
Figure 7.19



Concept 7.6: 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

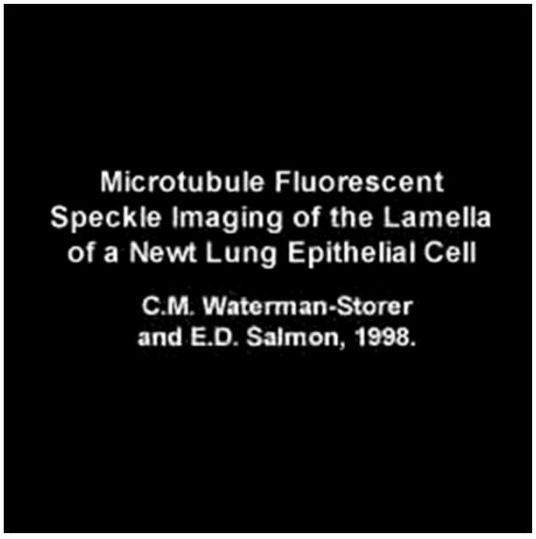
Figure 7.20



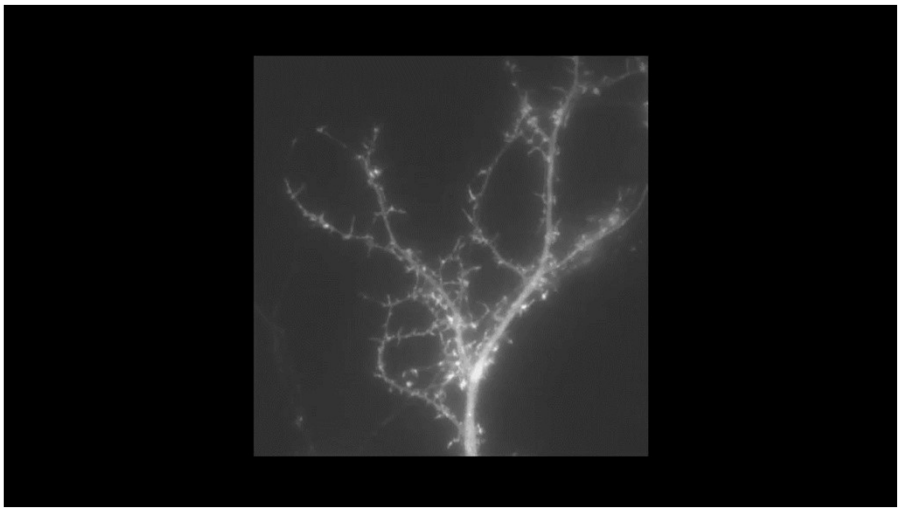
Video: The Cytoskeleton in Neuron Growth Cone

Video: Interphase Microtubule Dynamics

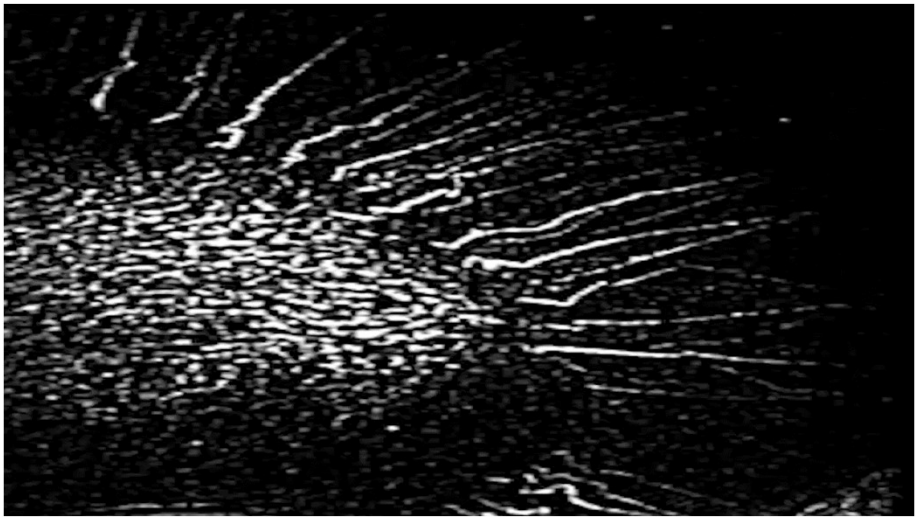
Video: Microtubule Dynamics



Video: Actin Visualization in Dendrites



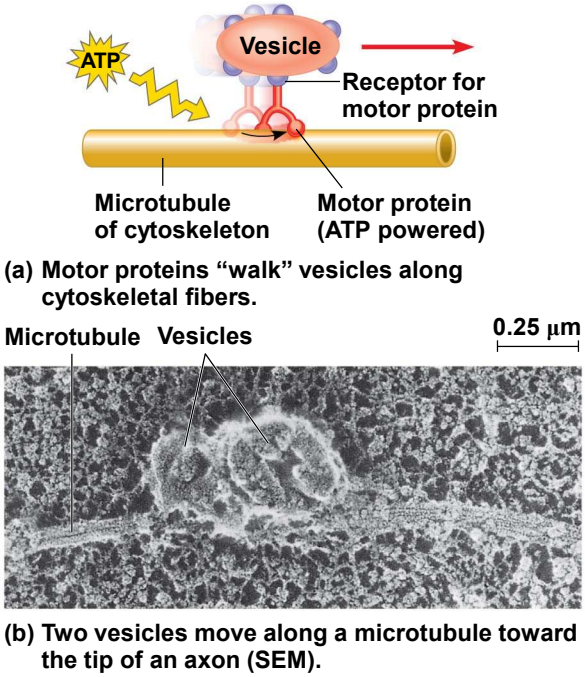
Video: Cytoskeletal Protein Dynamics



Roles of the Cytoskeleton: Support and Motility

- The cytoskeleton helps to support the cell and maintain its shape
- It interacts with **motor proteins** to produce cell motility
- Inside the cell, vesicles can travel along tracks provided by the cytoskeleton

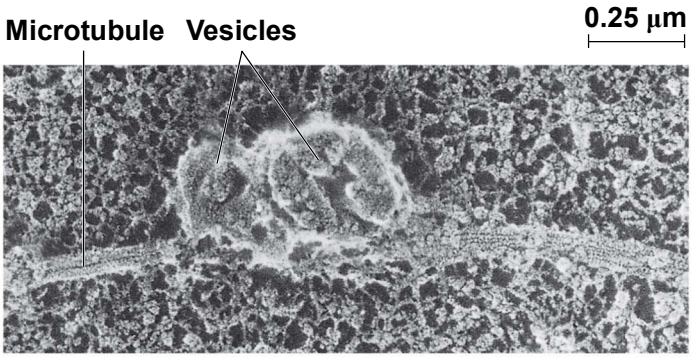
Figure 7.21



(a) Motor proteins "walk" vesicles along cytoskeletal fibers.

(b) Two vesicles move along a microtubule toward the tip of an axon (SEM).

Figure 7.21a



(b) Two vesicles move along a microtubule toward the tip of an axon (SEM).

Video: Movement of Organelles *In Vitro*

Video: Movement of Organelles *In Vivo*

Video: Transport Along Microtubules

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

Figure 7.T01

Table 7.1 The Structure and Function of the Cytoskeleton

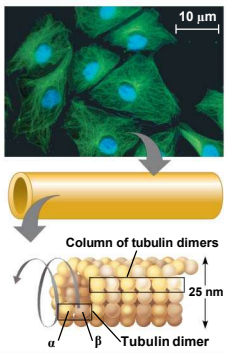
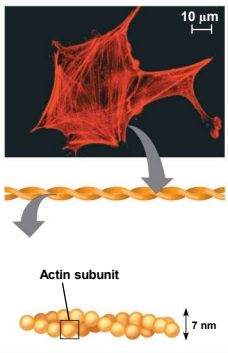
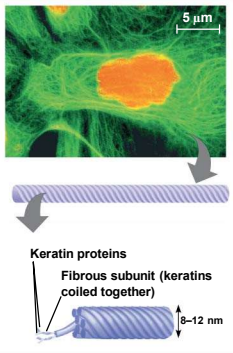
Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
Main functions	Maintenance of cell shape (compression-resisting "girder"); 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 in plant cells; cell motility (as in amoeboid movement); division of animal cells	Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina
Fluorescence micrographs of fibroblasts. Fibroblasts are a favorite cell type for cell biology studies because they spread out flat and their internal structures are easy to see. In each, the structure of interest has been tagged with fluorescent molecules. The DNA in the nucleus has also been tagged in the first micrograph (blue) and third micrograph (orange).			

Figure 7.T01a

Table 7.1 The Structure and Function of the Cytoskeleton

Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
25 nm with 15-nm lumen	7 nm	8–12 nm
Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
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 in plant cells; cell motility (as in amoeboid movement); division of animal cells	Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina

Figure 7.T01b

Microtubules (Tubulin Polymers)
Hollow tubes
25 nm with 15-nm lumen
Tubulin, a dimer consisting of α-tubulin and β-tubulin
Maintenance of cell shape (compression-resisting "girder"); cell motility (as in cilia or flagella); chromosome movements in cell division; organelle movements

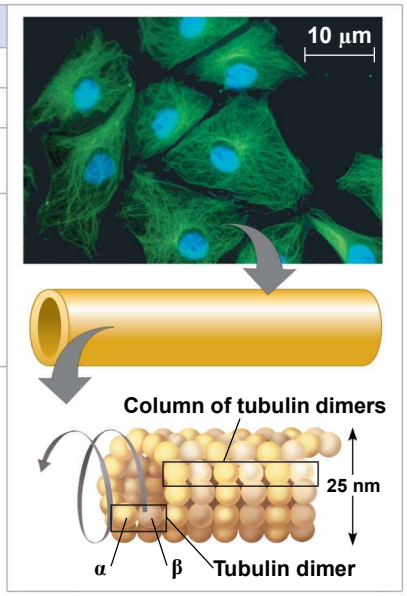


Figure 7.T01c

Microfilaments (Actin Filaments)
Two intertwined strands of actin
7 nm
Actin
Maintenance of cell shape (tension-bearing elements); changes in cell shape; muscle contraction; cytoplasmic streaming in plant cells; cell motility (as in amoeboid movement); division of animal cells

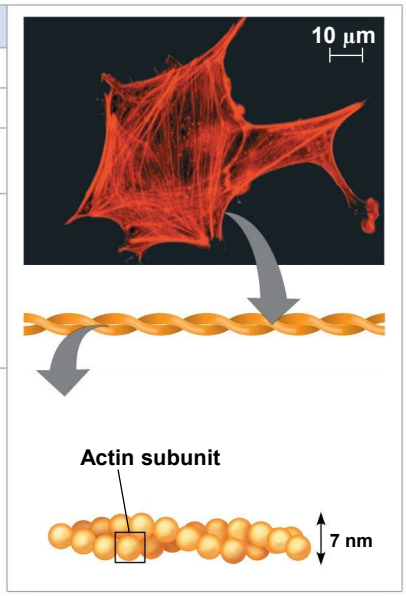
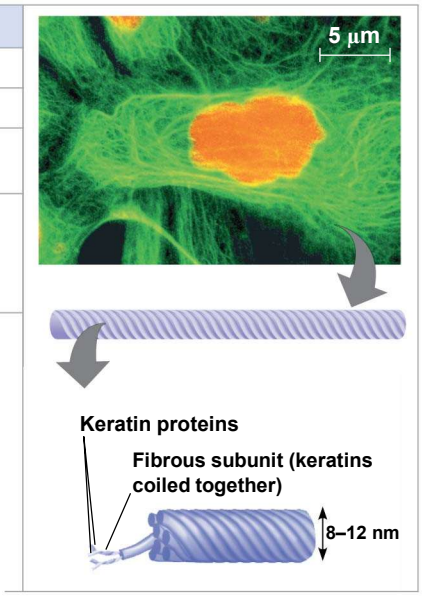


Figure 7.T01d

Intermediate Filaments
Fibrous proteins coiled into cables
8–12 nm
One of several different proteins (such as keratins)
Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina



Microtubules

- **Microtubules** are hollow rods about 25 nm in diameter and about 200 nm to 25 microns long
- Microtubules are constructed of dimers of tubulin
- Functions of microtubules:
  - Shaping the cell
  - Guiding movement of organelles
  - Separating chromosomes during cell division

Centrosomes and Centrioles

- In animal cells, microtubules grow out from a **centrosome** near the nucleus
- In animal cells, the centrosome has a pair of **centrioles**, each with nine triplets of microtubules arranged in a ring

Figure 7.22

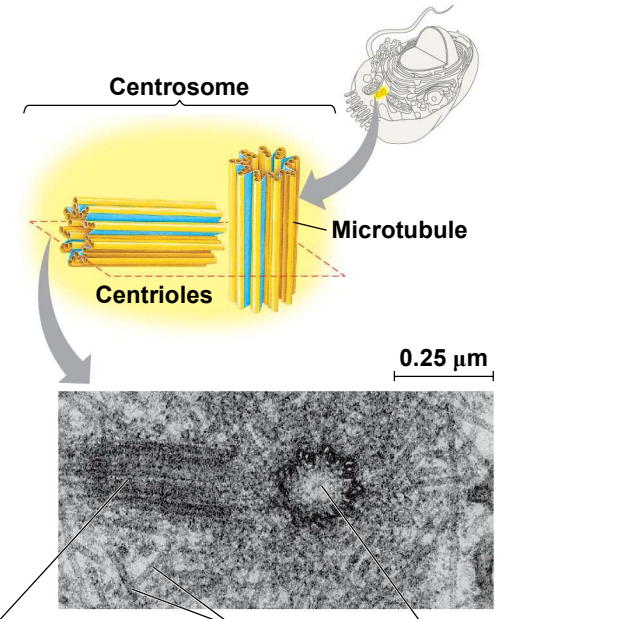
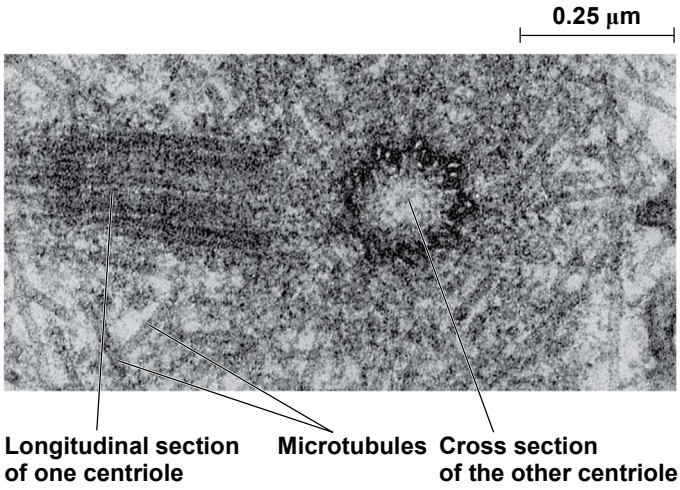


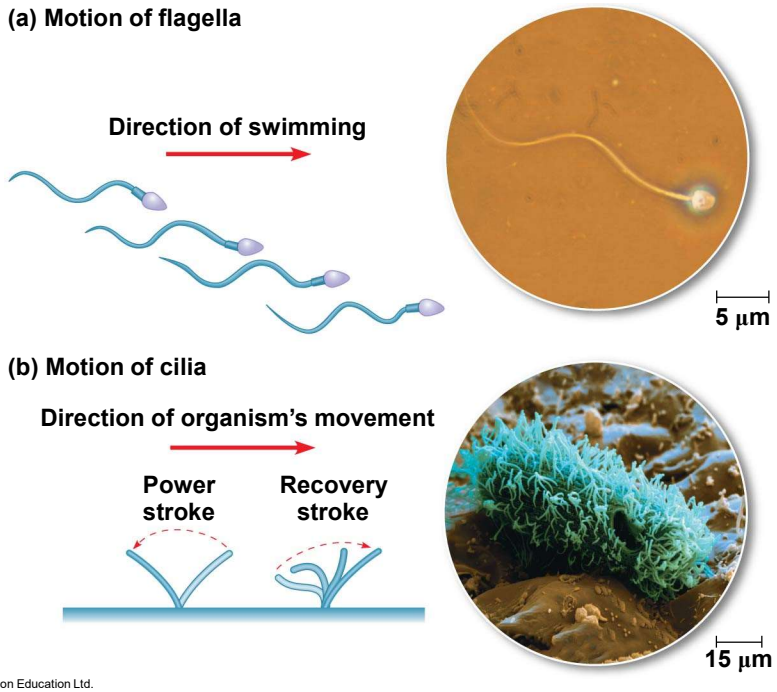
Figure 7.22a



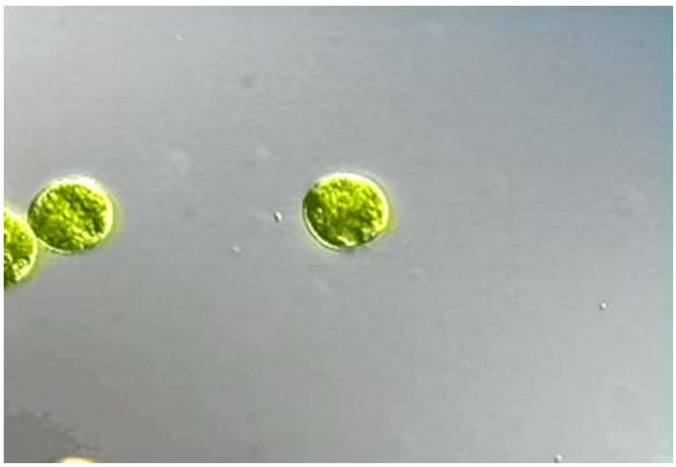
Cilia and Flagella

- Microtubules control the beating of **flagella** and **cilia**, microtubule-containing extensions that project from some cells
- Many unicellular eukaryotes are propelled through water by cilia or flagella
- Cilia and flagella differ in their beating patterns

Figure 7.23

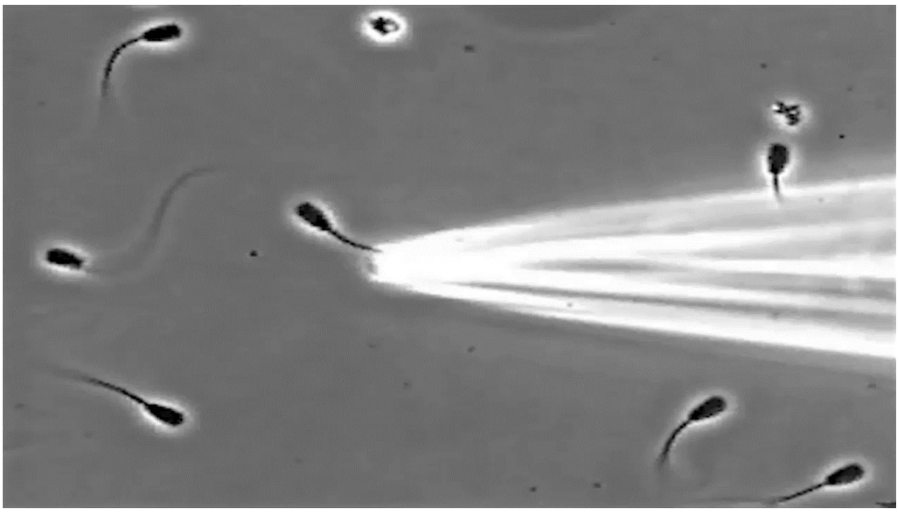


Video: *Chlamydomonas*



Video: Flagellum Movement in Swimming Sperm

Video: Motion of Isolated Flagellum



Video: *Paramecium* Cilia

Video: Ciliary Motion

- Cilia and flagella share a common structure
  - A group of microtubules sheathed by an extension of the plasma membrane
  - A **basal body** that anchors the cilium or flagellum
  - A motor protein called **dynein**, which drives the bending movements of a cilium or flagellum

Figure 7.24

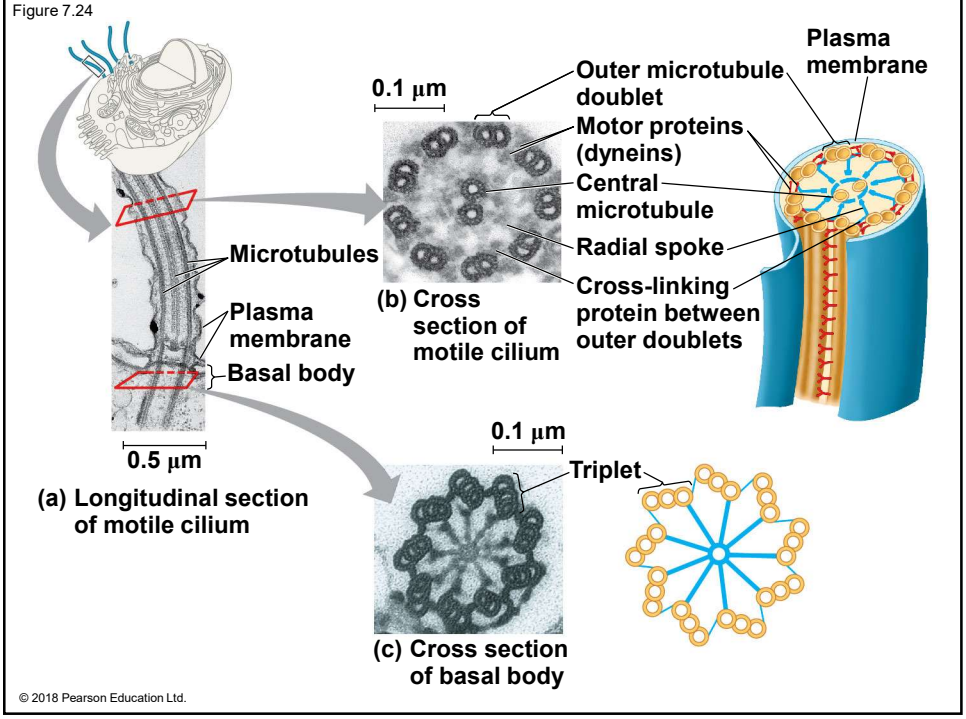


Figure 7.24a

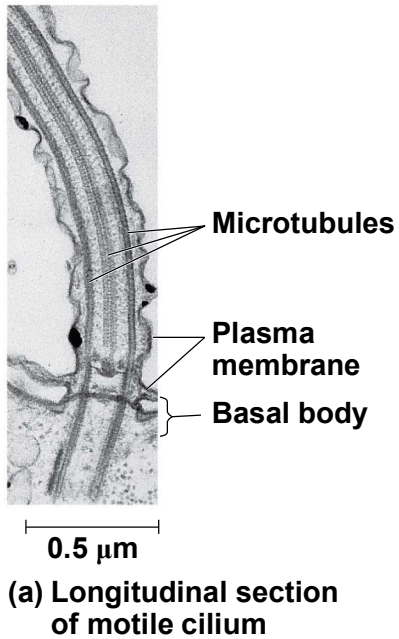


Figure 7.24b

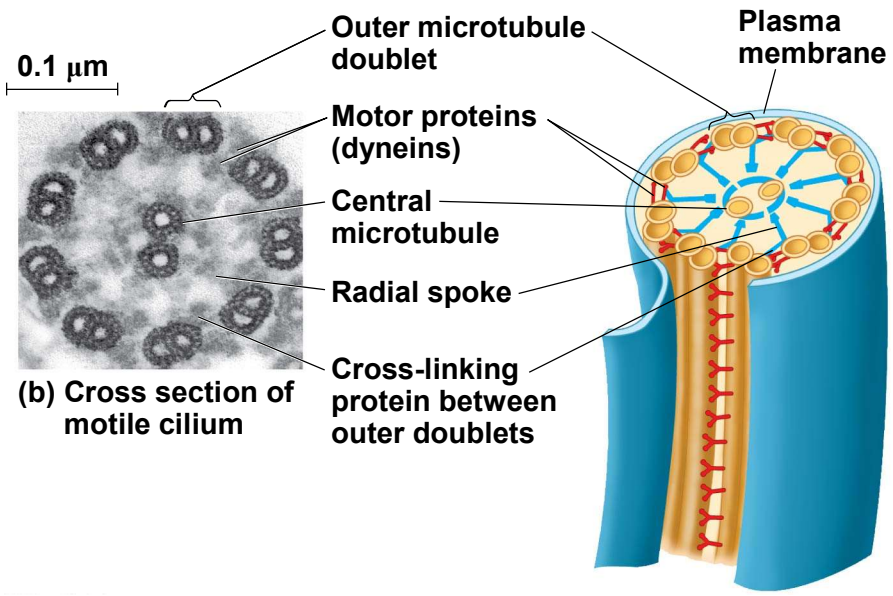


Figure 7.24ba

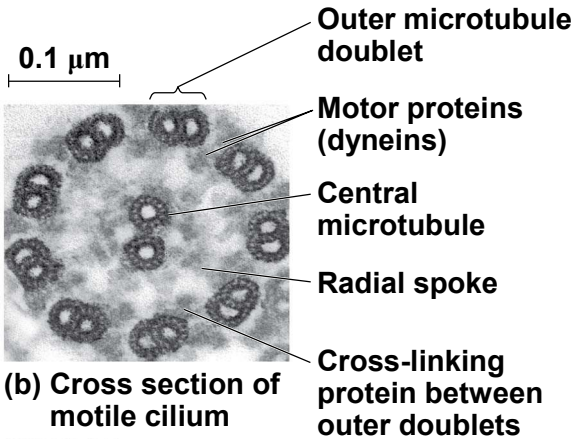


Figure 7.24c

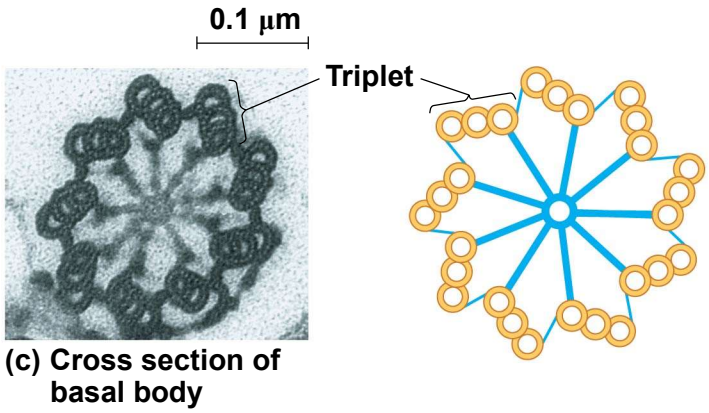
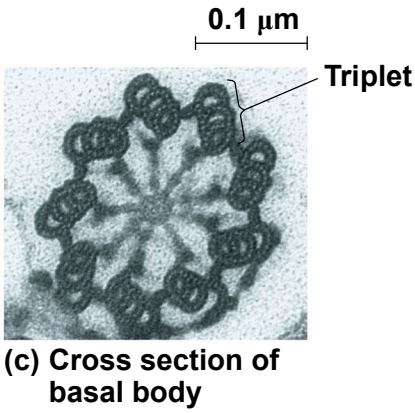
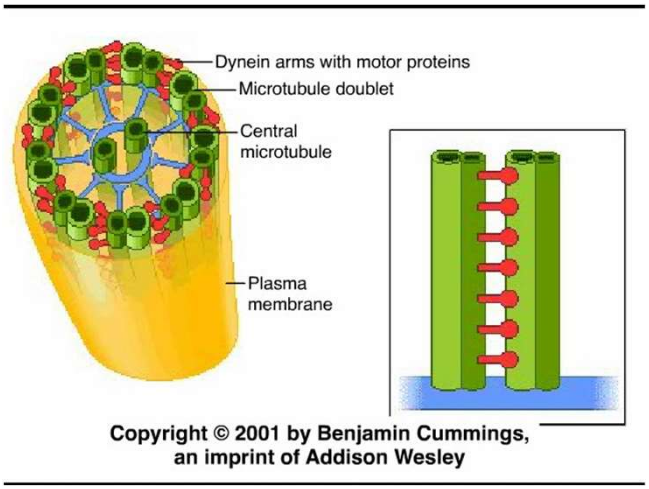


Figure 7.24ca



Animation: Cilia and Flagella



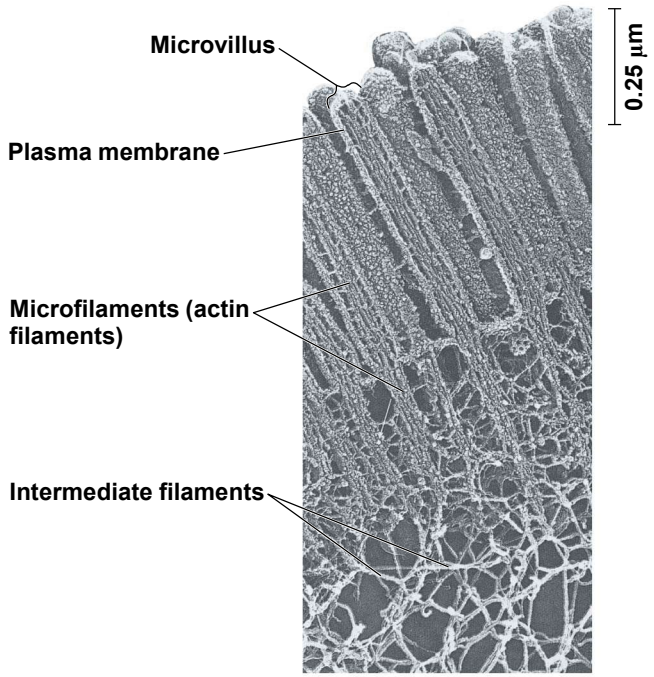
Video: Microtubule Sliding in Flagellum Movement

- Dynein has two “feet” that “walk” along microtubules
- One foot maintains contact, while the other releases and reattaches one step farther along
- Movements of the feet cause the microtubules to bend, rather than slide, because the microtubules are held in place

Microfilaments (Actin Filaments)

- **Microfilaments** are solid rods about 7 nm in diameter, built as a twisted double chain of **actin** subunits
- A network of microfilaments helps support the cell’s shape
- They form a **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

Figure 7.25



- Microfilaments that function in cellular motility contain the protein **myosin** in addition to actin
- Cells crawl along a surface by extending **pseudopodia** (cellular extensions) and moving toward them
- **Cytoplasmic streaming** is a circular flow of cytoplasm within cells, driven by actin-myosin interactions

Figure 7.26

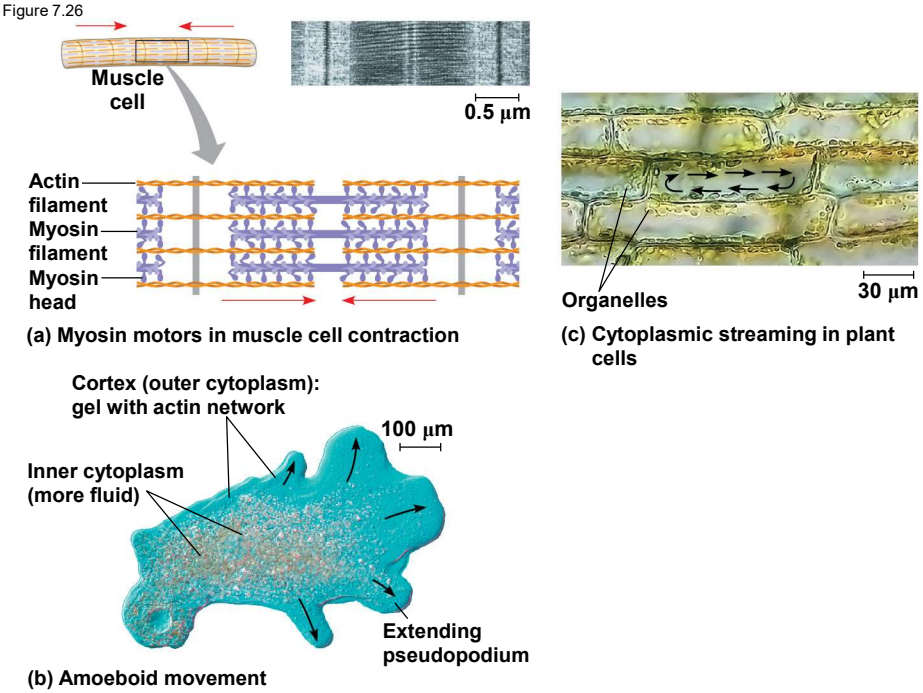


Figure 7.26a

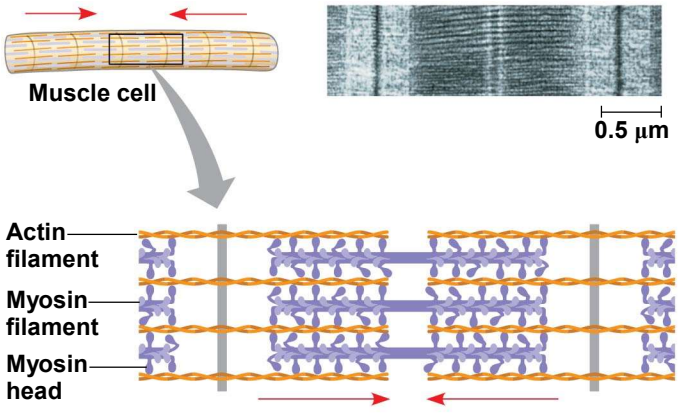


Figure 7.26aa

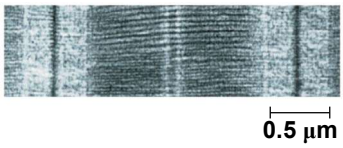
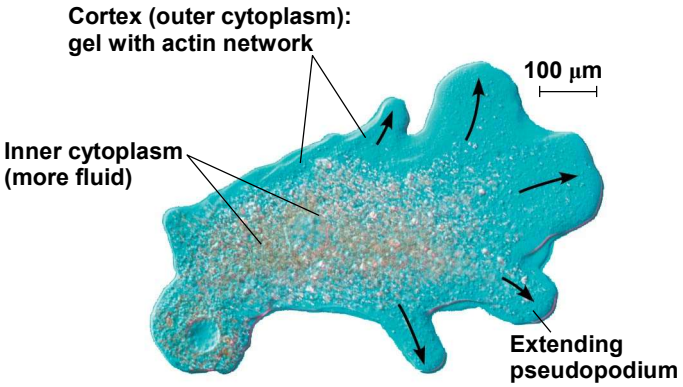
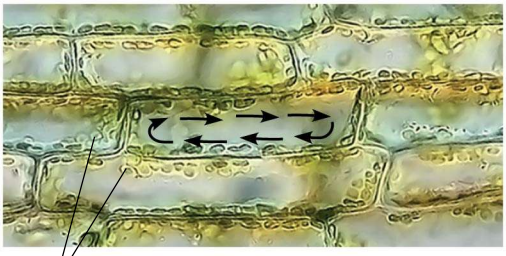


Figure 7.26b



(b) Amoeboid movement

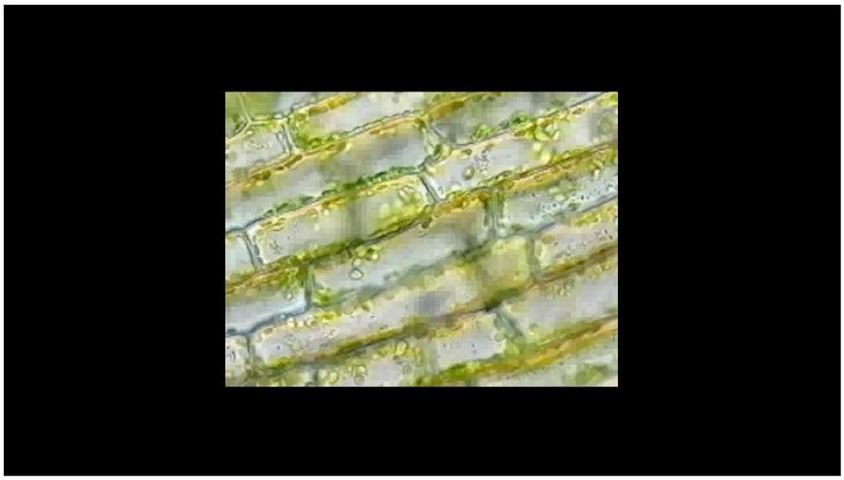
Figure 7.26c



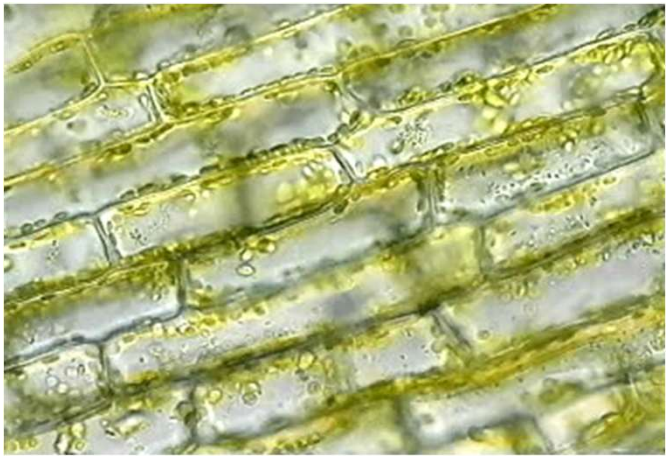
(c) Cytoplasmic streaming in plant cells

Video: Actin Network in Crawling Cells

Video: Chloroplast Movement



Video: Cytoplasmic Streaming



Intermediate Filaments

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

Concept 7.7: Extracellular components and connections between cells help coordinate cellular activities

- Most cells synthesize and secrete materials that are external to the plasma membrane
- These extracellular materials and structures are involved in a great many cellular functions

Cell Walls of Plants

- The **cell wall** is an extracellular structure that distinguishes plant cells from animal cells
- Prokaryotes, fungi, and some unicellular eukaryotes also have cell walls
- The cell wall protects the plant cell, maintains its shape, and prevents excessive uptake of water
- Plant cell walls are made of cellulose fibers embedded in other polysaccharides and protein

- Plant cell walls may have multiple layers:
  - **Primary cell wall**: Relatively thin and flexible
  - **Middle lamella**: Thin layer between primary walls of adjacent cells
  - **Secondary cell wall** (in some cells): Added between the plasma membrane and the primary cell wall

Figure 7.27

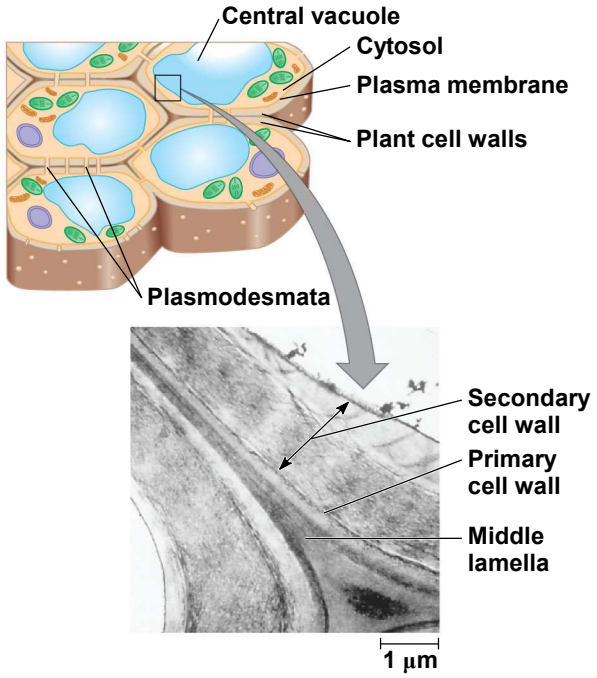
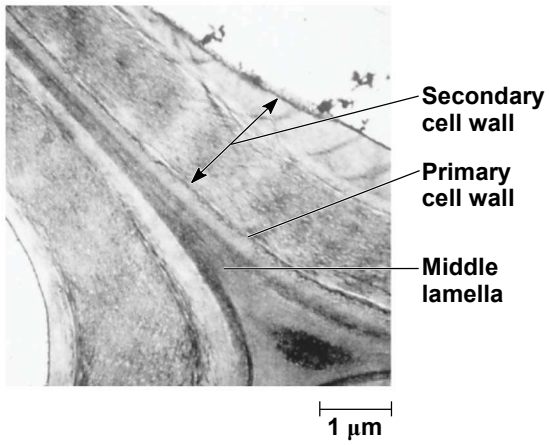


Figure 7.27a



The Extracellular Matrix (ECM) of Animal Cells

- Animal cells lack cell walls but are covered by an elaborate **extracellular matrix (ECM)**
- The ECM is made up of glycoproteins such as **collagen**, **proteoglycans**, and **fibronectin**
- ECM proteins bind to receptor proteins in the plasma membrane called **integrins**

Figure 7.28

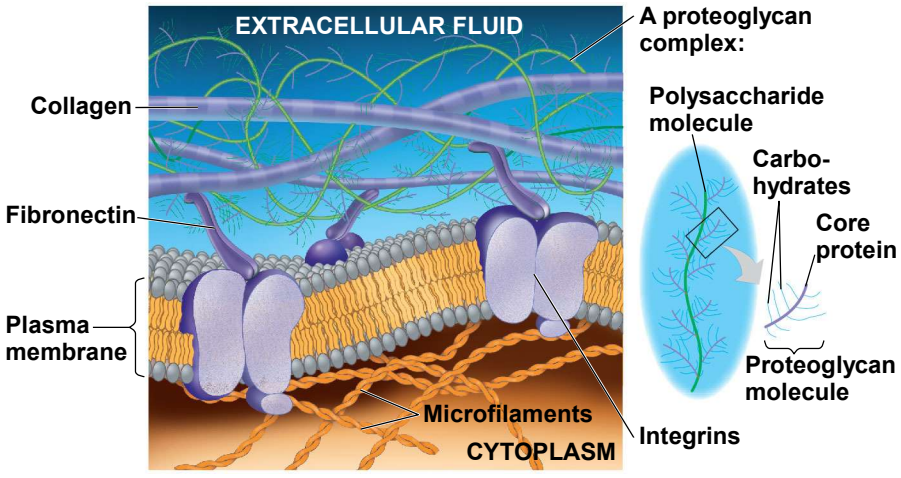
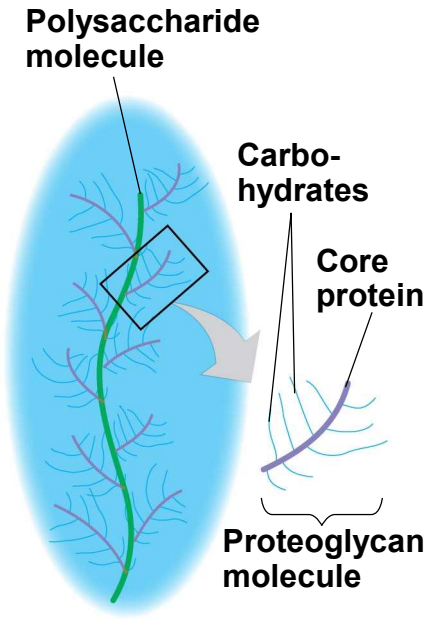
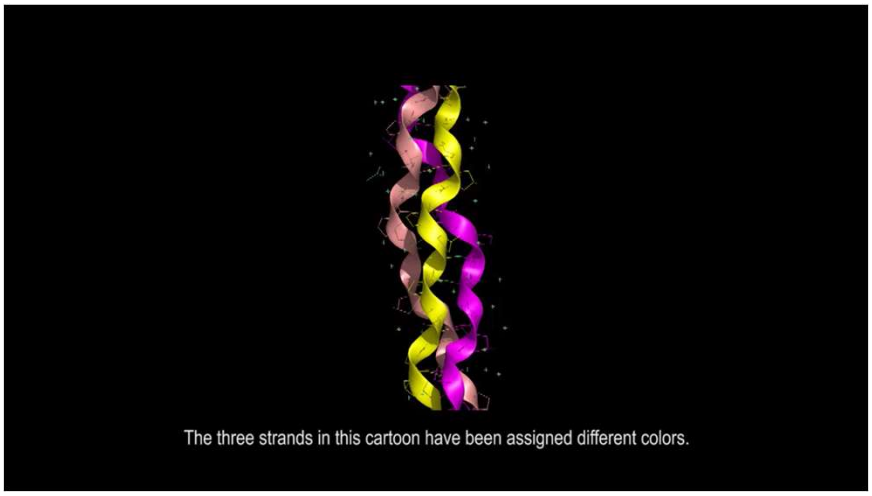


Figure 7.28a



Video: Cartoon Model of a Collagen Triple Helix



Video: Fibronectin Fibrils

- The ECM has an influential role in the lives of cells
- ECM can regulate a cell's behavior by communicating with a cell through integrins
- The ECM around a cell can influence the activity of gene in the nucleus
- Mechanical signaling may occur through cytoskeletal changes that trigger chemical signals in the cell

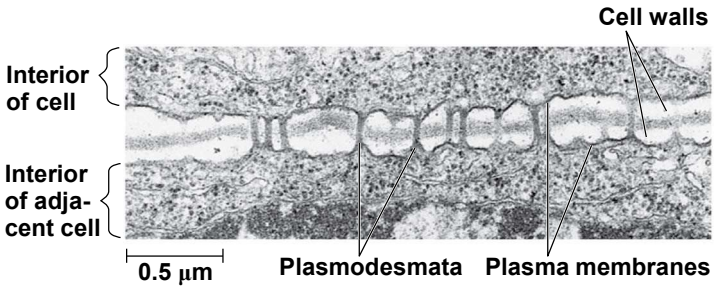
Cell Junctions

- Neighboring cells in tissues, organs, or organ systems often adhere, interact, and communicate through direct physical contact

Plasmodesmata in Plant Cells

- **Plasmodesmata** are channels that perforate plant cell walls
- Through plasmodesmata, water and small solutes (and sometimes proteins and RNA) can pass from cell to cell

Figure 7.29



Tight Junctions, Desmosomes, and Gap Junctions in Animal Cells

- Three types of cell junctions are common in epithelial tissues
  - At tight junctions, membranes of neighboring cells are pressed together, preventing leakage of extracellular fluid
  - Desmosomes (anchoring junctions) fasten cells together into strong sheets
  - Gap junctions (communicating junctions) provide cytoplasmic channels between adjacent cells

Figure 7.30

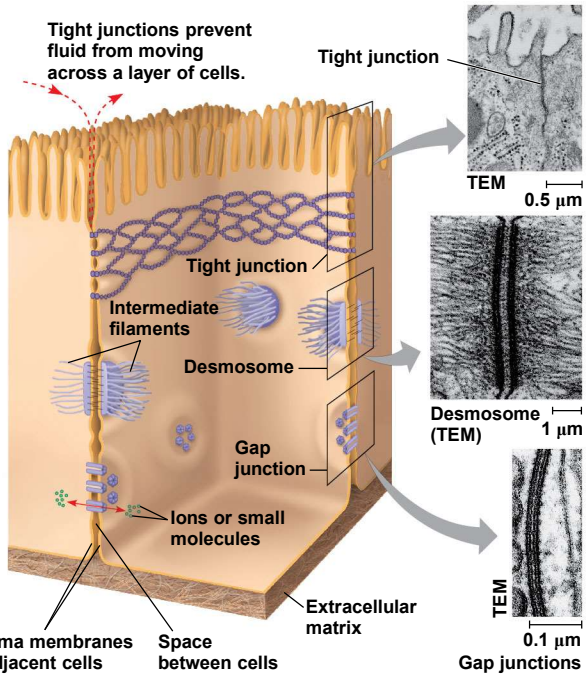


Figure 7.30a

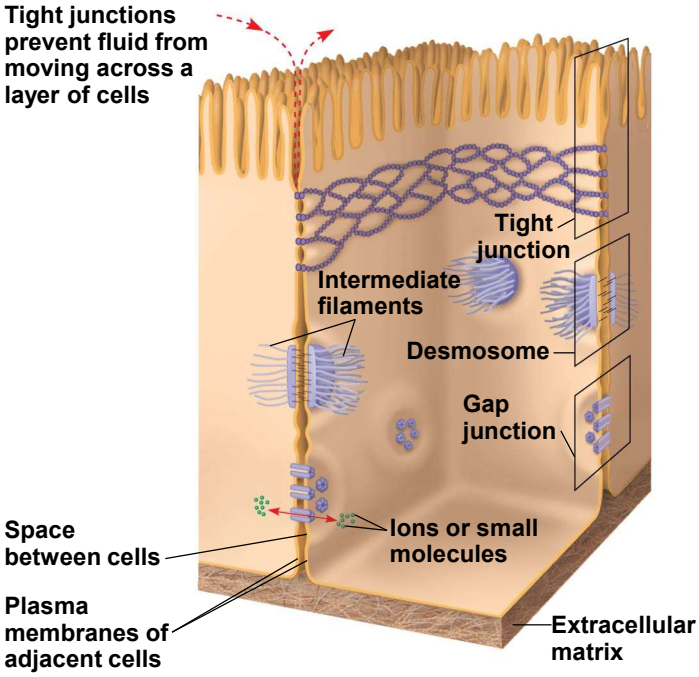


Figure 7.30b

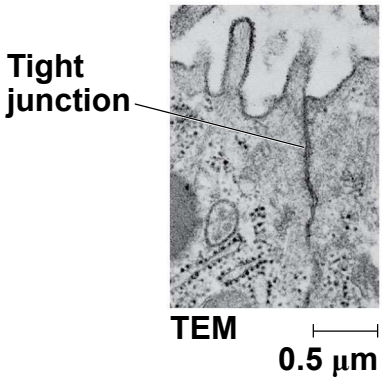


Figure 7.30c

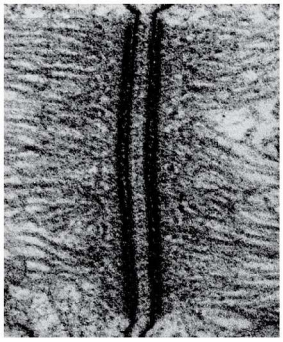
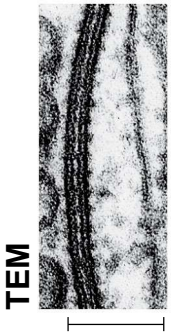
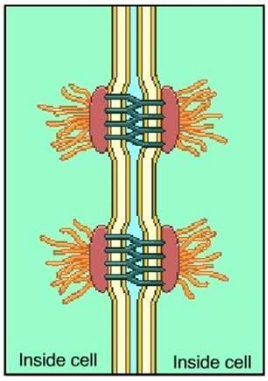


Figure 7.30d

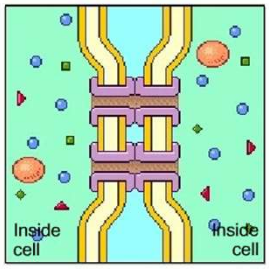


Gap junction

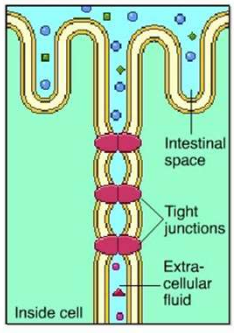
Animation: Desmosomes



Animation: Gap Junctions



Animation: Tight Junctions



Concept 7.8: A cell is greater than the sum of its parts

- Cells rely on the integration of structures and organelles in order to function
- For example, a macrophage's ability to destroy bacteria involves the whole cell, coordinating components such as the cytoskeleton, lysosomes, and plasma membrane

Figure 7.31

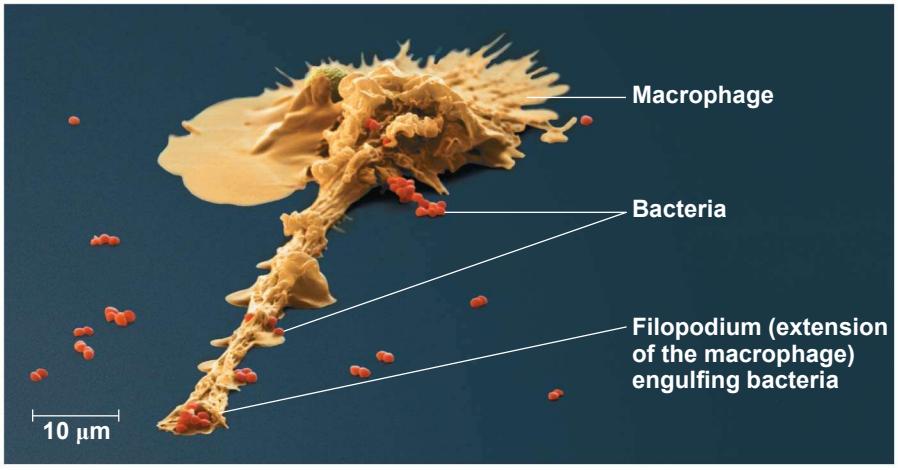


Figure 7.32a

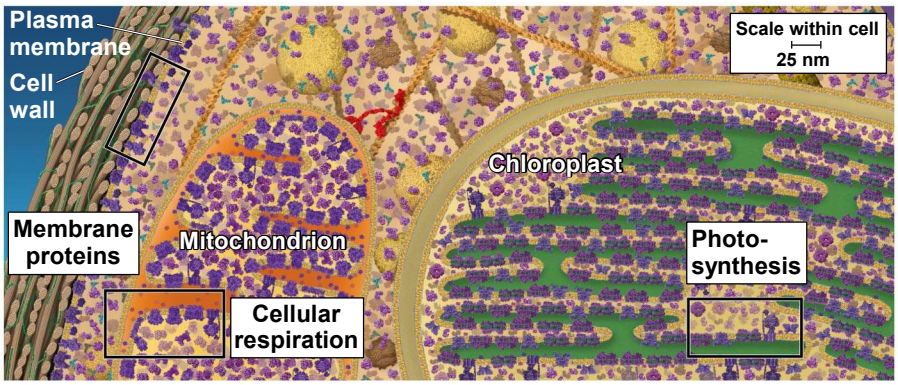


Figure 7.32b

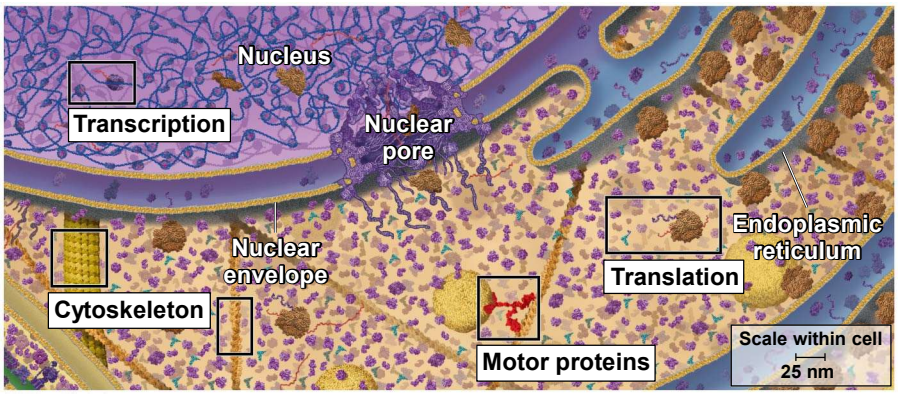


Figure 7.32j

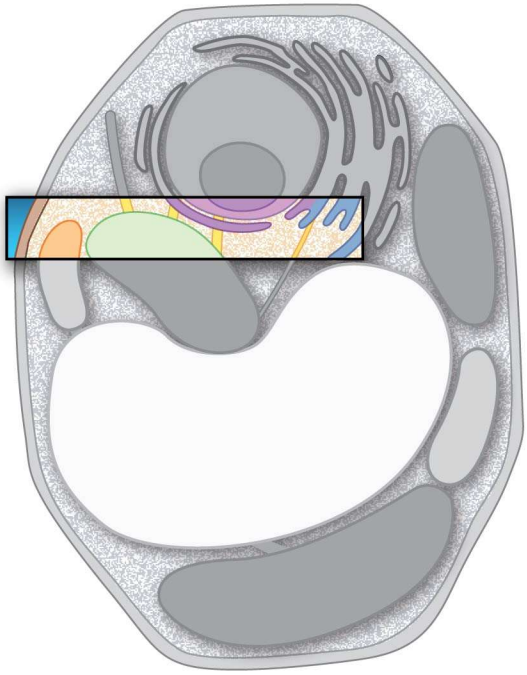


Figure 7.8c

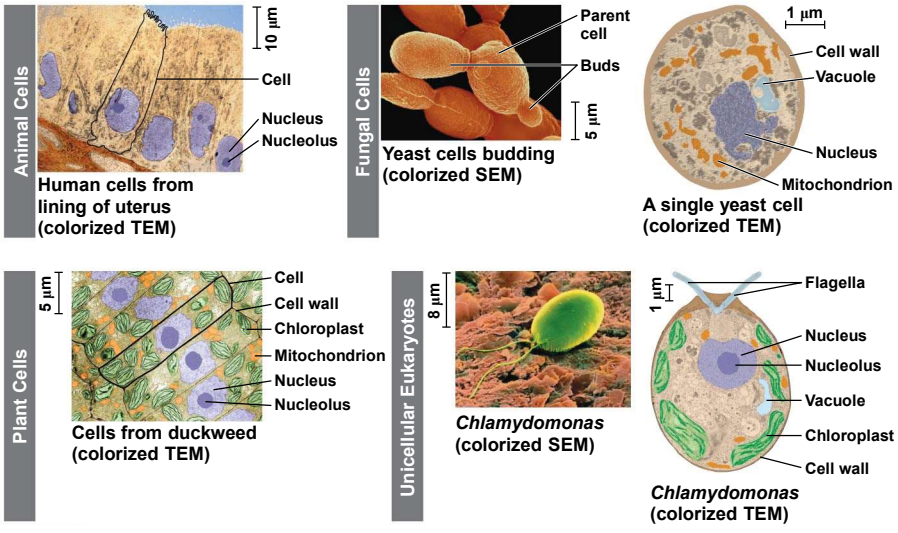
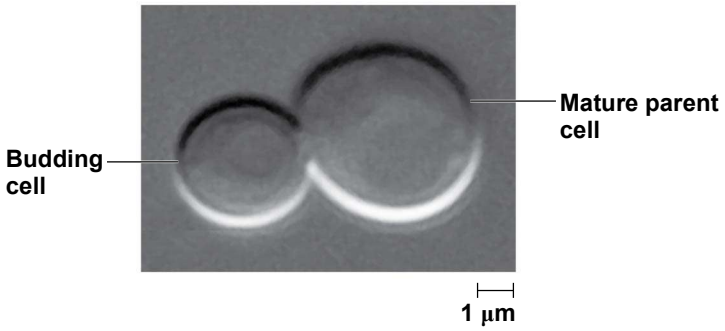


Figure 7.UN01a



Micrograph from Kelly Tatchell, using yeast cells grown for experiments described in L. Kozubowski et al., Role of the septin ring in the asymmetric localization of proteins at the mother-bud neck in *Saccharomyces cerevisiae, Molecular Biology of the Cell* 16:3455–3466 (2005).

Figure 7.UN01b

$$V = \frac{4}{3}\pi r^3$$

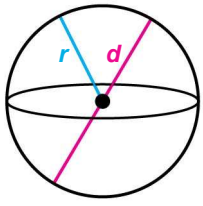


Figure 7.UN02

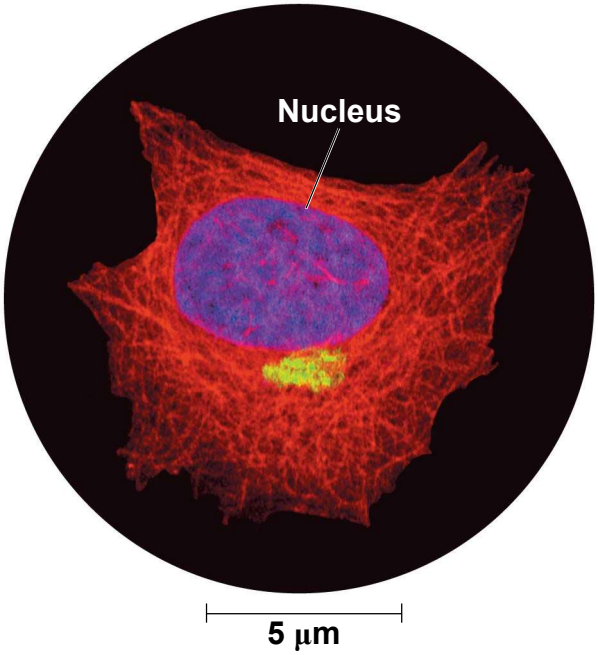


Figure 7.UN03

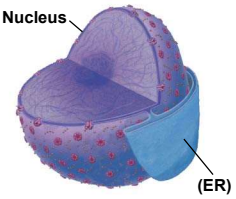
Cell Component	Structure	Function
Nucleus  (ER)	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores; nuclear envelope continuous with endoplasmic reticulum (ER)	Houses chromosomes, which are made of chromatin (DNA and proteins); contains nucleoli, where ribosomal subunits are made; pores regulate entry and exit of materials
Ribosome 	Two subunits made of ribosomal RNAs and proteins; can be free in cytosol or bound to ER	Protein synthesis

Figure 7.UN04

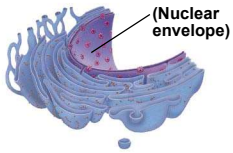
Cell Component	Structure	Function
Endoplasmic reticulum (ER) 	Extensive network of membrane-bounded tubules and sacs; membrane separates lumen from cytosol; continuous with nuclear envelope	Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons Rough ER: aids in synthesis of secretory and other proteins on bound ribosomes; adds carbohydrates to proteins to make glycoproteins; produces new membrane
Golgi apparatus 	Stacks of flattened membranous sacs; has polarity (*cis* and *trans* faces)	Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released in vesicles
Lysosome 	Membranous sac of hydrolytic enzymes (in animal cells)	Breakdown of ingested substances, cell macromolecules, and damaged organelles for recycling
Vacuole 	Large membrane-bounded vesicle	Digestion, storage, waste disposal, water balance, cell growth, and protection

Figure 7.UN05

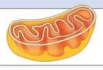
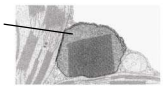
Cell Component	Structure	Function
Mitochondrion 	Bounded by double membrane; inner membrane has infoldings	Cellular respiration
Chloroplast 	Typically two membranes around fluid stroma, which contains thylakoids stacked into grana	Photosynthesis (chloroplasts are in cells of photosynthetic eukaryotes, including plants)
Peroxisome 	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer H atoms from substrates to oxygen, producing H_2O_2 (hydrogen peroxide), which is converted to H_2O.

Figure 7.UN06