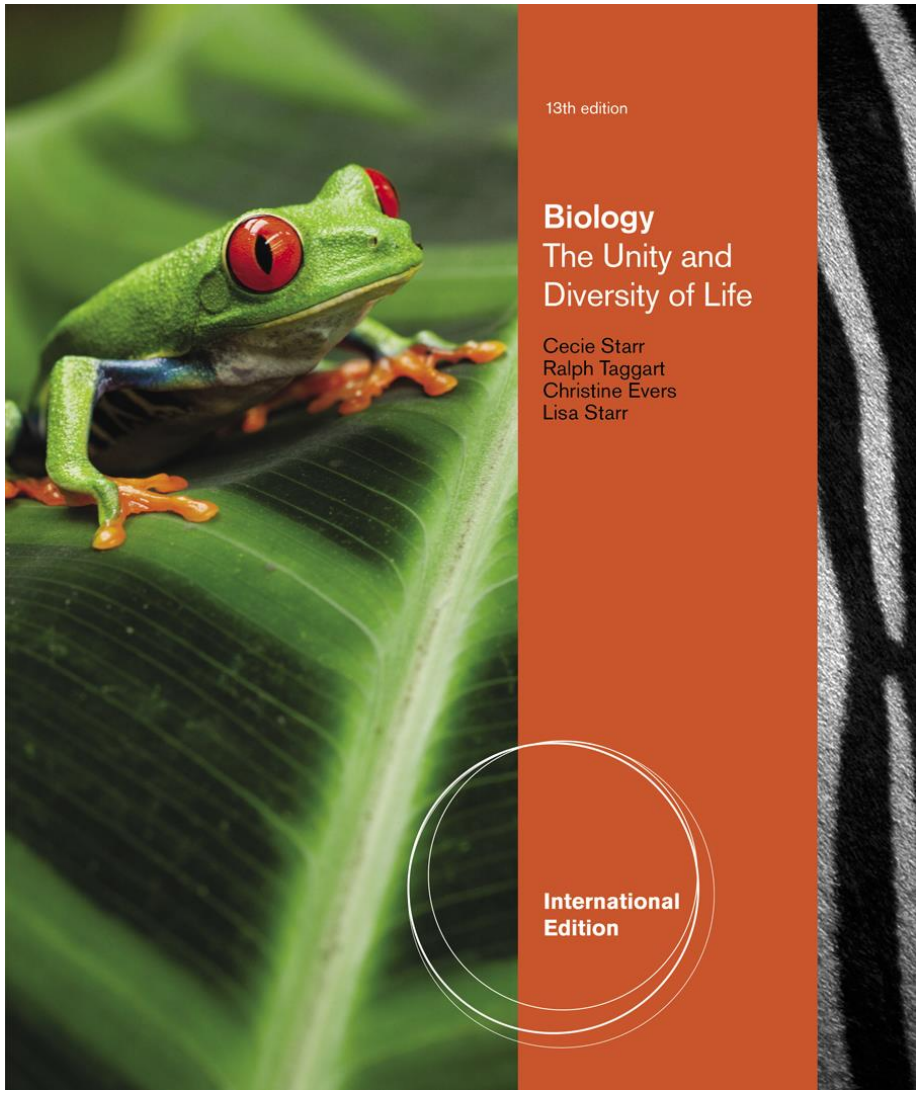
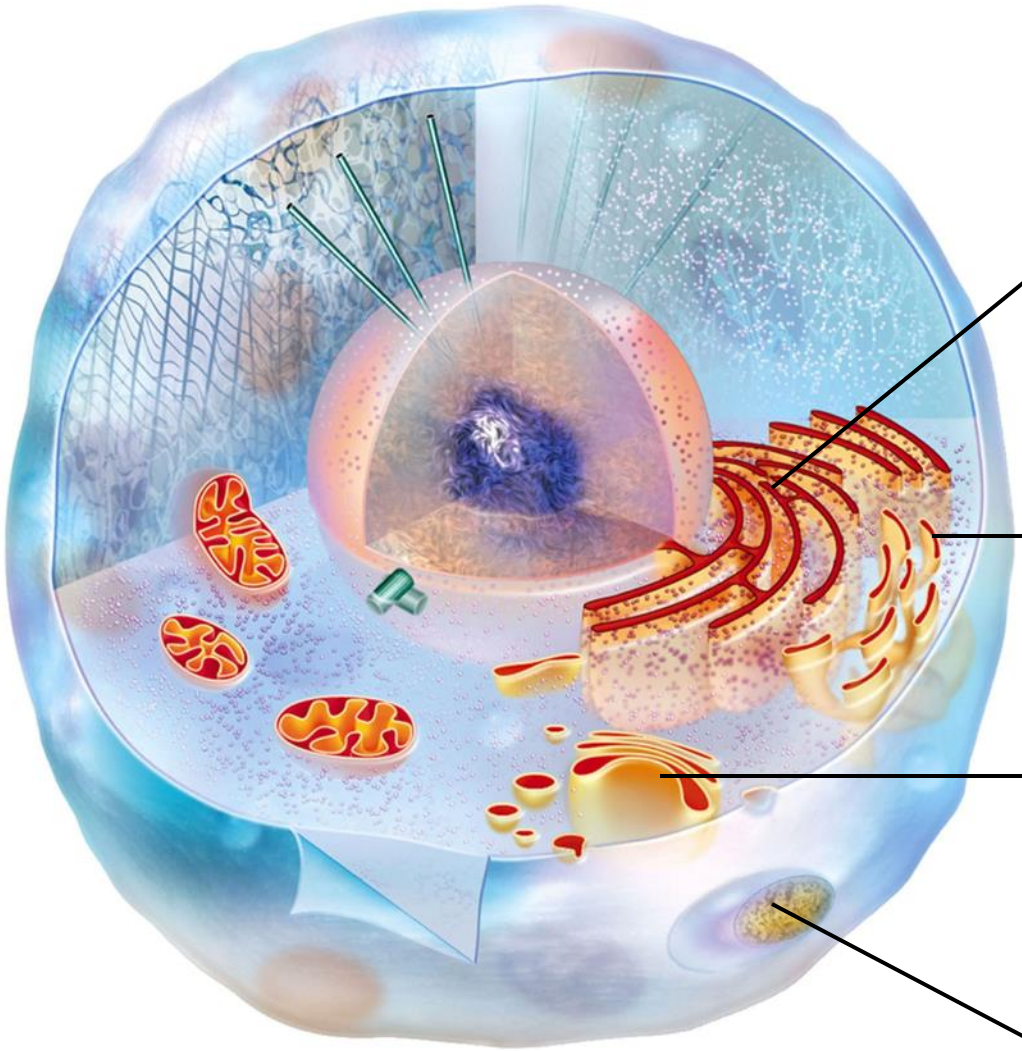


Chapter 4
Cell Structure and Function
Sections 7-12

4.7 The Endomembrane System

- **Endomembrane system**
  - A series of interacting organelles between the nucleus and the plasma membrane
  - Makes, modifies, and transports proteins and lipids for secretion or insertion into cell membranes
  - It also destroys toxins, recycles wastes, and has other specialized functions



Rough ER
Modifies proteins made by ribosomes attached to it

Smooth ER
Makes lipids, breaks down carbohydrates and fats, inactivates toxins

Golgi Body
Finishes, sorts, ships lipids, enzymes, and proteins

Lysosome
Digests, recycles materials

The Endoplasmic Reticulum

- **Endoplasmic reticulum (ER)**
  - An extension of the nuclear envelope that forms a continuous, folded compartment

- Two kinds of endoplasmic reticulum
  - Rough ER (with ribosomes) folds polypeptides into their tertiary form
  - Smooth ER (no ribosomes) makes lipids, breaks down carbohydrates and lipids, detoxifies poisons

Vesicles

- **Vesicles**
  - Small, membrane-enclosed saclike organelles that store or transport substances
- **Peroxisomes**
  - Vesicles containing enzymes that break down hydrogen peroxide, alcohol, and other toxins
- **Lysosomes**
  - Vesicles containing enzymes that fuse with vacuoles and digest waste materials

Vacuoles

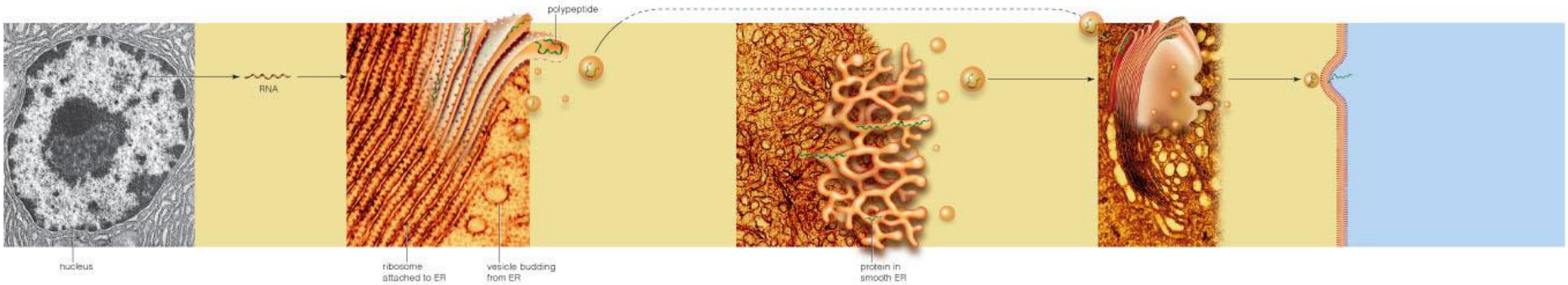
- **Vacuoles**
  - Vesicles with various functions depending on cell type
  - Many isolate or dispose of waste, debris, and toxins

- **Central vacuole**
  - Occupies 50 to 90 percent of a cell's interior
  - Stores amino acids, sugars, ions, wastes, toxins
  - Fluid pressure keeps plant cells firm

Golgi Bodies

- **Golgi body**
  - A folded membrane containing enzymes that finish polypeptides and lipids delivered by the ER
  - Packages finished products in vesicles that carry them to the plasma membrane or to lysosomes

The Endomembrane System



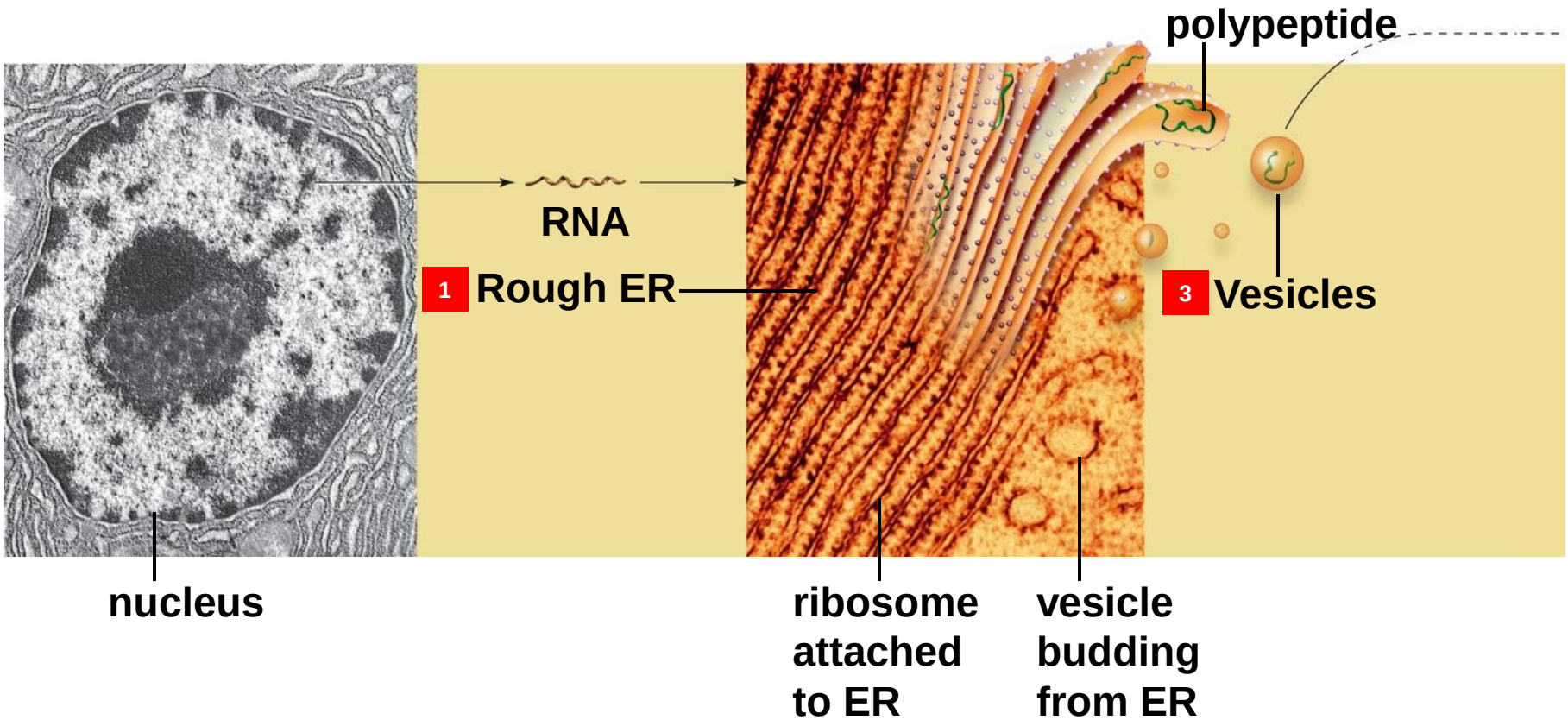


Figure 4-15 p64

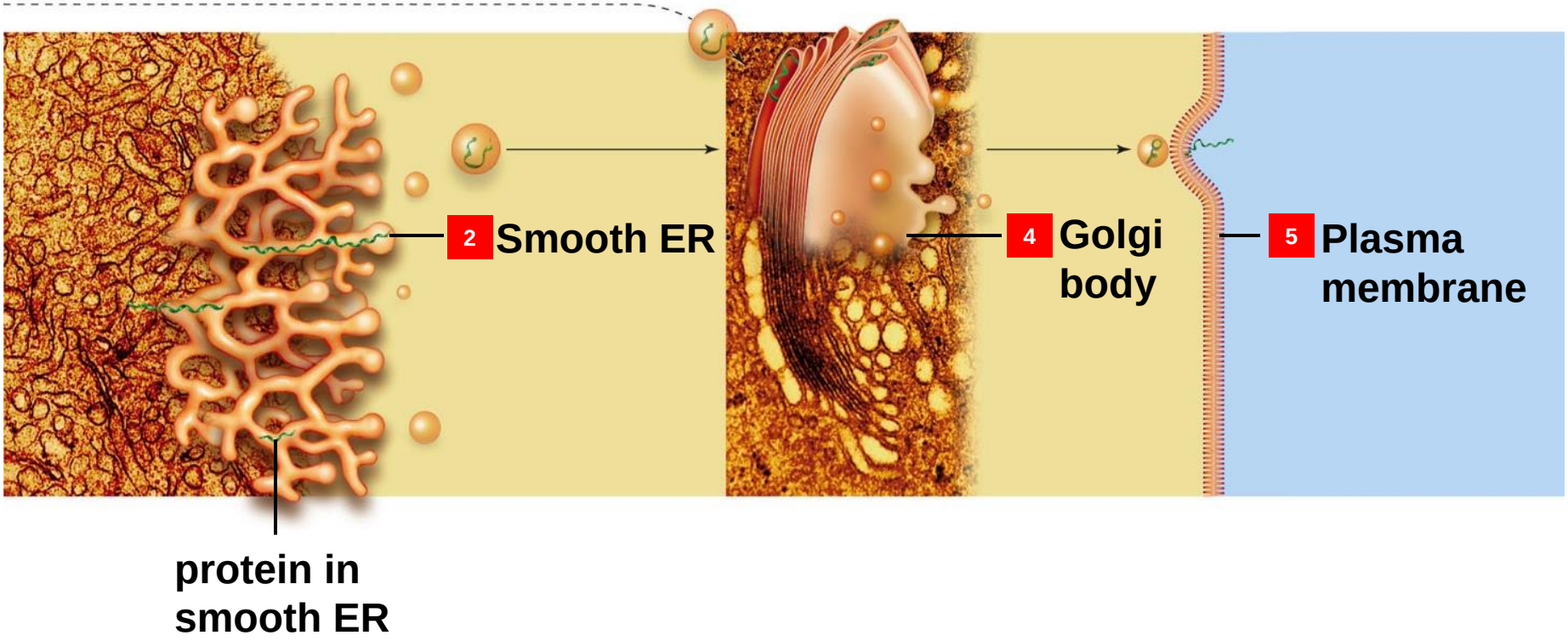


Figure 4-15 p65

ANIMATED FIGURE: The endomembrane system

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Take-Home Message:

What is the endomembrane system?

- *The endomembrane system includes rough and smooth endoplasmic reticulum, vesicles, and Golgi bodies*
- *This series of organelles works together mainly to synthesize and modify cell membrane proteins and lipids*

4.10 Lysosome Malfunction

- When lysosomes do not work properly, some cellular materials are not properly recycled, which can have devastating results
- Different kinds of molecules are broken down by different lysosomal enzymes
- One lysosomal enzyme breaks down gangliosides, a kind of lipid

Tay Sachs Disease

- A genetic mutation alters the lysosomal enzyme that breaks down gangliosides, which accumulate in nerve cells – affected children usually die by age five

Take-Home Message: Are all organelle types necessary for life?

- *Defects in the function of an organelle can have devastating consequences to health*

4.11 Other Organelles

- Eukaryotic cells make most of their ATP in mitochondria
- Plastids function in storage and photosynthesis in plants and some types of algae

Mitochondria

- **Mitochondrion**
  - Eukaryotic organelle that makes the energy molecule ATP through aerobic respiration
  - Contains two membranes, forming inner and outer compartments; buildup of hydrogen ions in the outer compartment drives ATP synthesis
  - Has its own DNA and ribosomes
  - Resembles bacteria; may have evolved through endosymbiosis

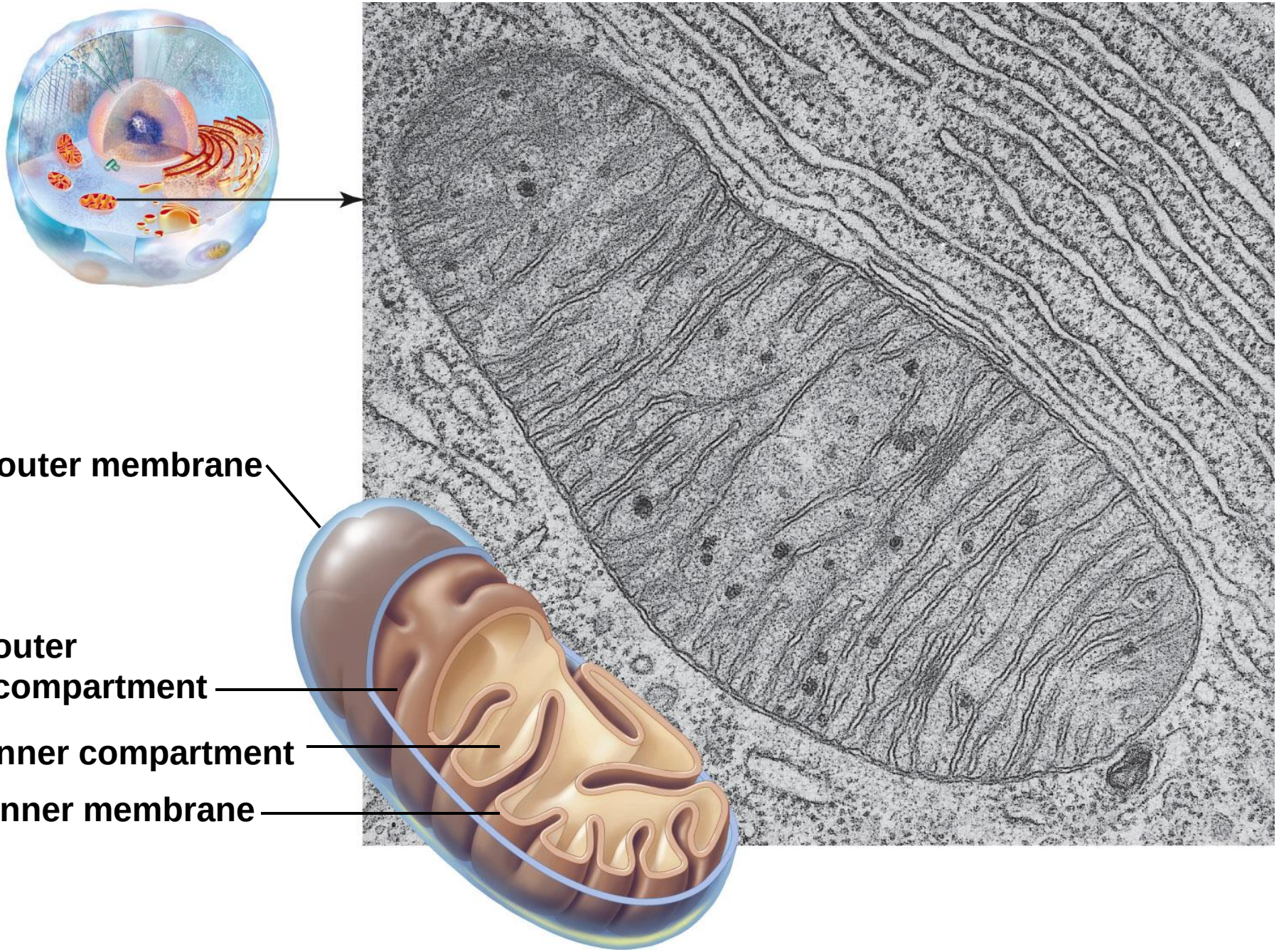
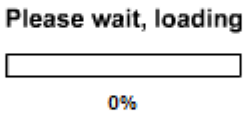


Figure 4-17 p67

ANIMATED FIGURE: Structure of a mitochondrion



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Plastids

- **Plastids**
  - Organelles that function in photosynthesis or storage in plants and algae; includes chromoplasts, amyloplasts, and chloroplasts

- **Chloroplasts**
  - Plastids specialized for photosynthesis
  - Resemble photosynthetic bacteria; may have evolved by endosymbiosis

A Photosynthetic cells in a leaf of *Plagiomnium ellipticum*, a moss.

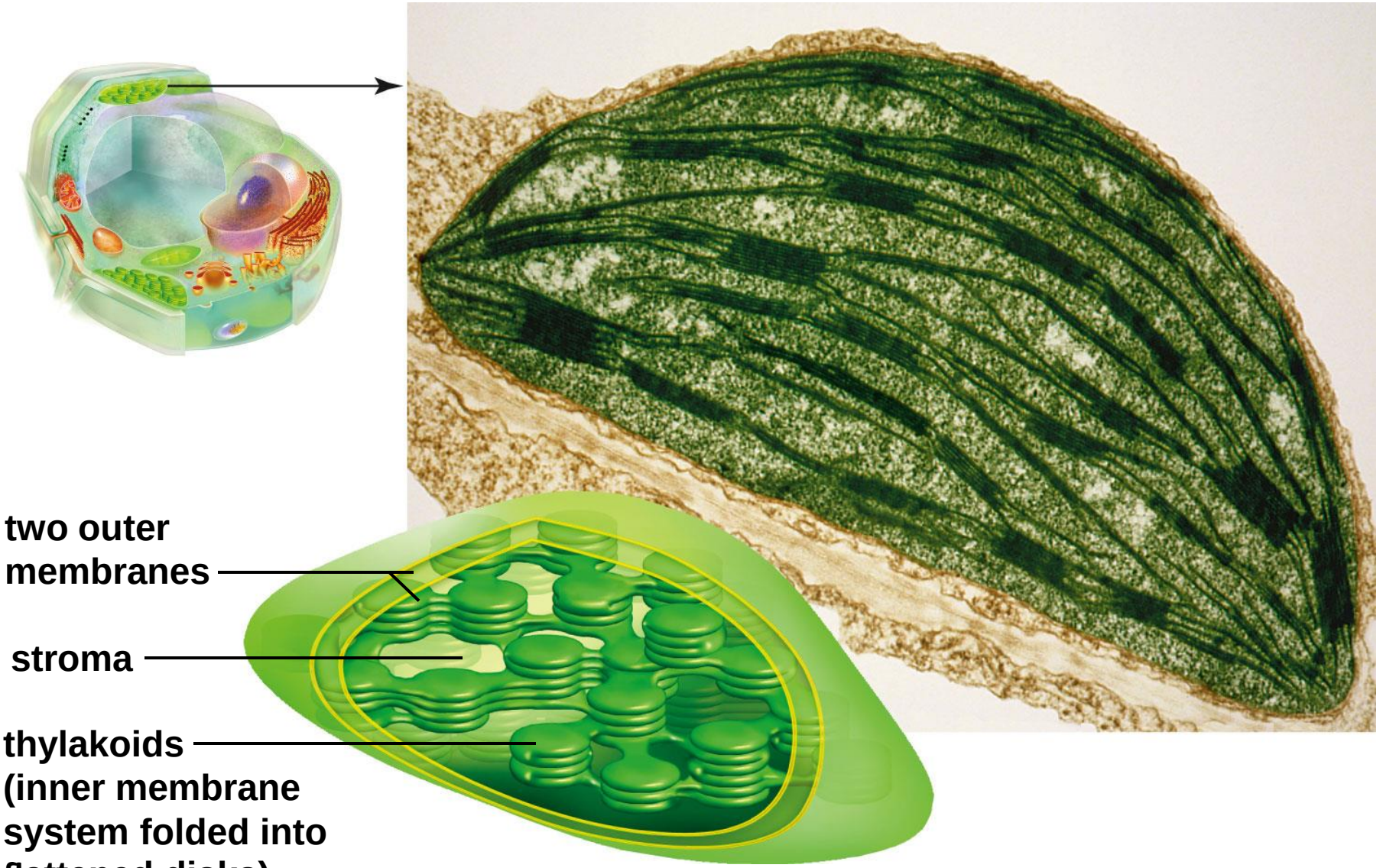

Figure 4-18b p67

ANIMATED FIGURE: Sites of photosynthesis

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Take-Home Message:

What organelles produce ATP?

- *Mitochondria are eukaryotic organelles that produce ATP from organic compounds in reactions that require oxygen*
- *Chloroplasts are plastids that carry out photosynthesis in cells of plants and many protists*

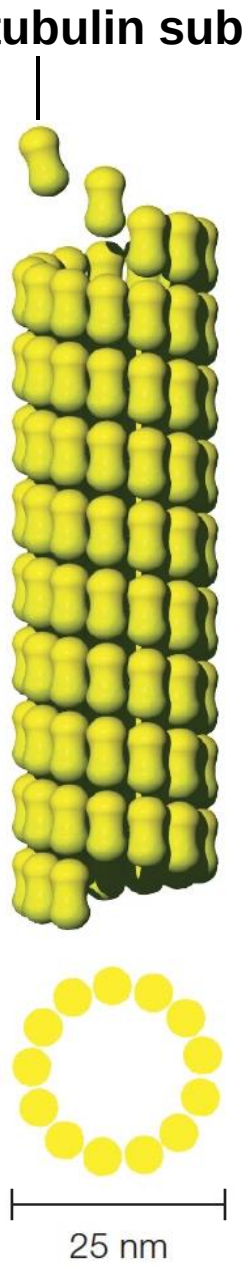
4.10 The Dynamic Cytoskeleton

- Eukaryotic cells have an extensive and dynamic internal framework called a cytoskeleton

- **Cytoskeleton**
  - An interconnected system of many protein filaments – some permanent, some temporary
  - Parts of the cytoskeleton reinforce, organize, and move cell structures, or even a whole cell

Components of the Cytoskeleton

- **Microtubules**
  - Long, hollow cylinders made of tubulin
  - Form dynamic scaffolding for cell processes
- **Microfilaments**
  - Consist mainly of the globular protein actin
  - Make up the **cell cortex**
- **Intermediate filaments**
  - Maintain cell and tissue structures

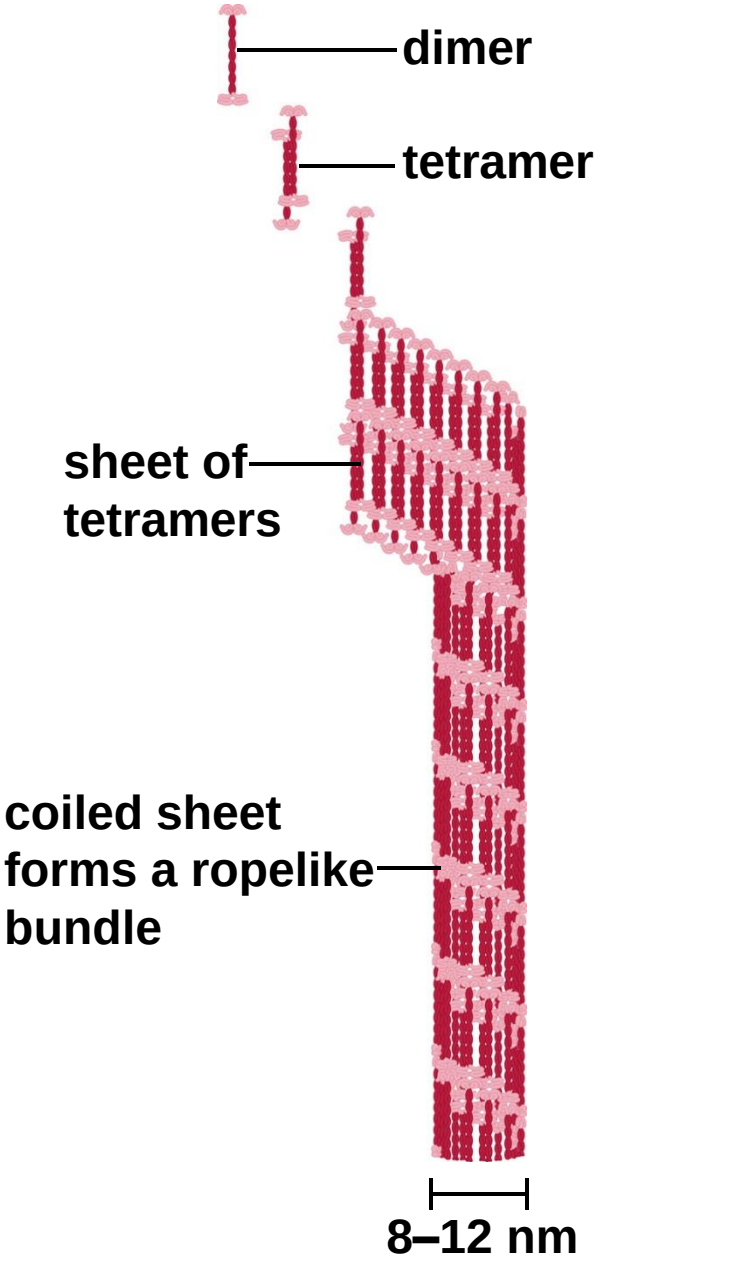


A Microtubule

Figure 4-19a p68

B Microfilament

Figure 4-19b p68



C Intermediate filament

Figure 4-19c p68

ANIMATED FIGURE: Cytoskeletal components

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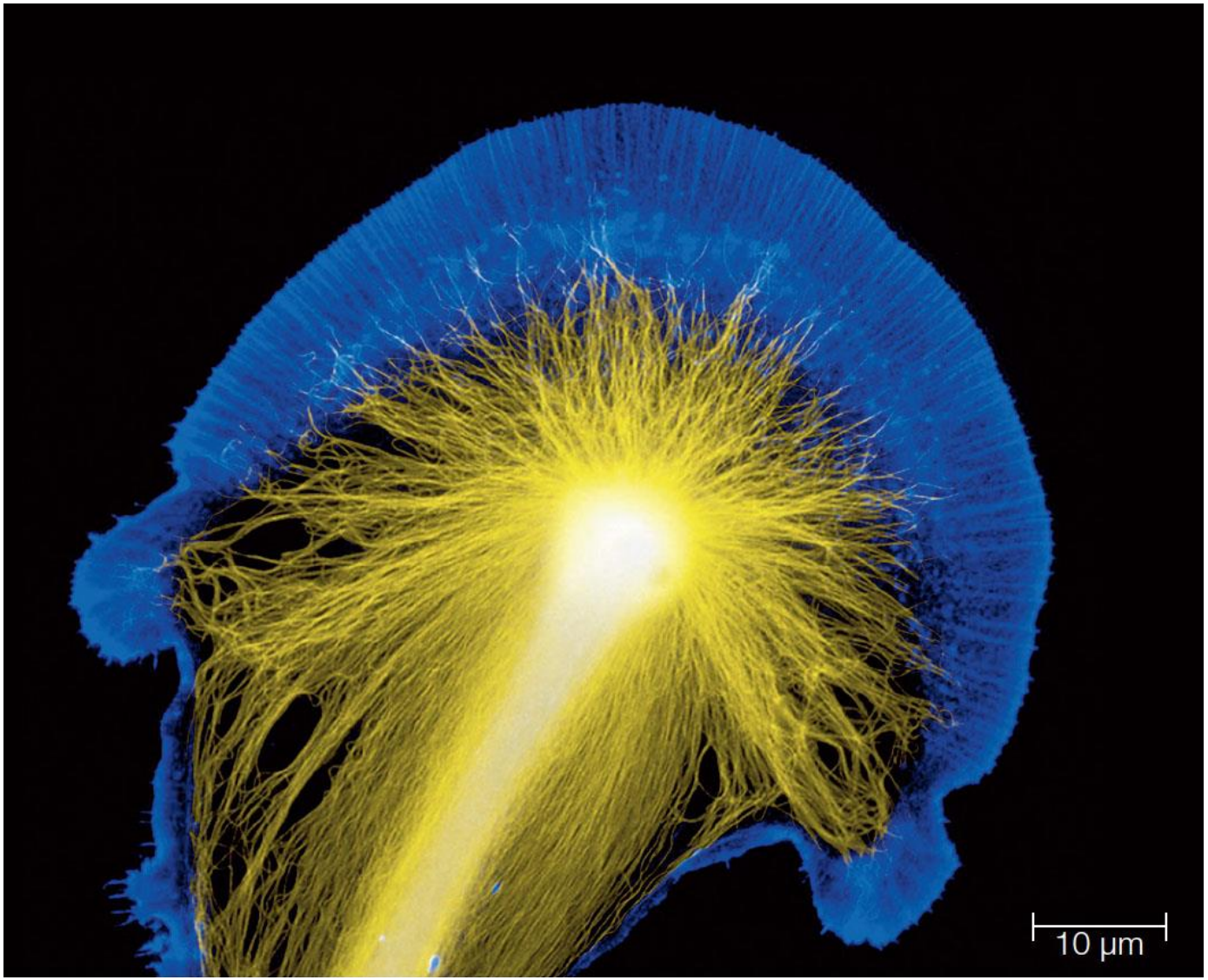
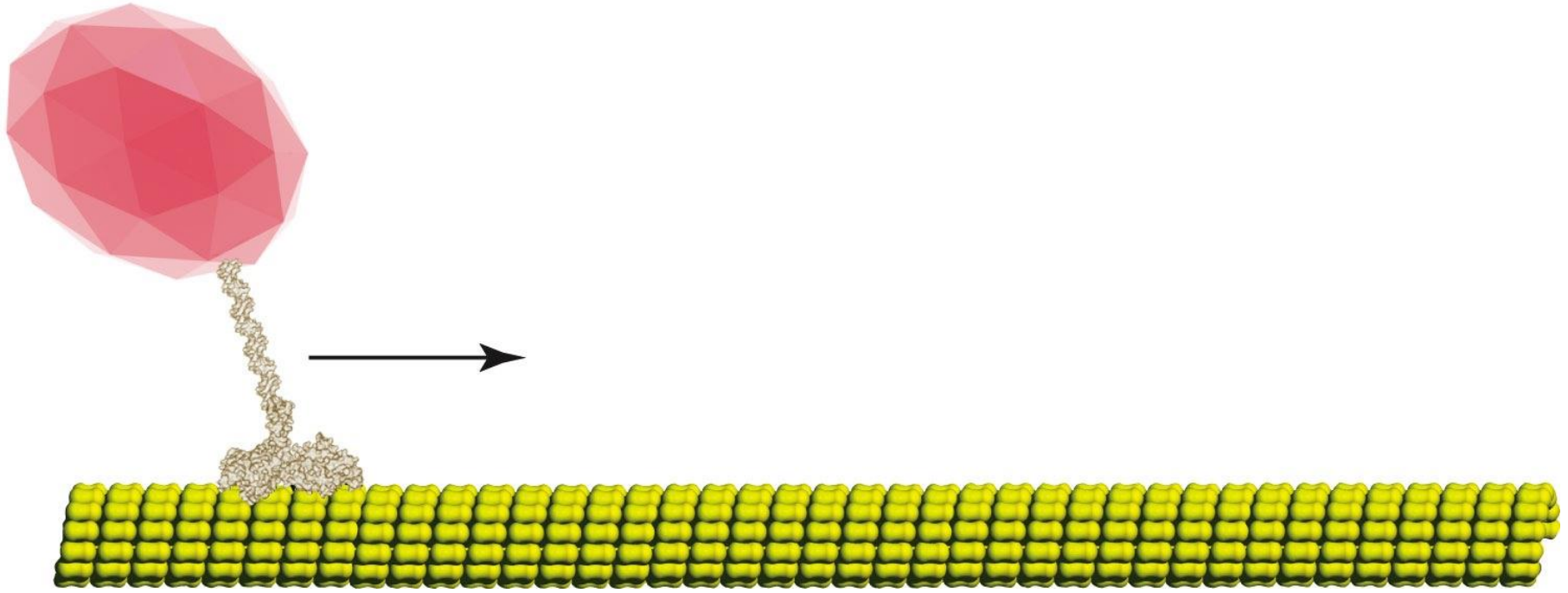
Microtubules and Microfilaments in a Nerve Cell



Motor Proteins

- **Motor proteins**
  - Accessory proteins that move molecules through cells on tracks of microtubules and microfilaments
  - Energized by ATP
  - *Example:* kinesins

Motor Protein: Kinesin



ANIMATED FIGURE: Motor proteins

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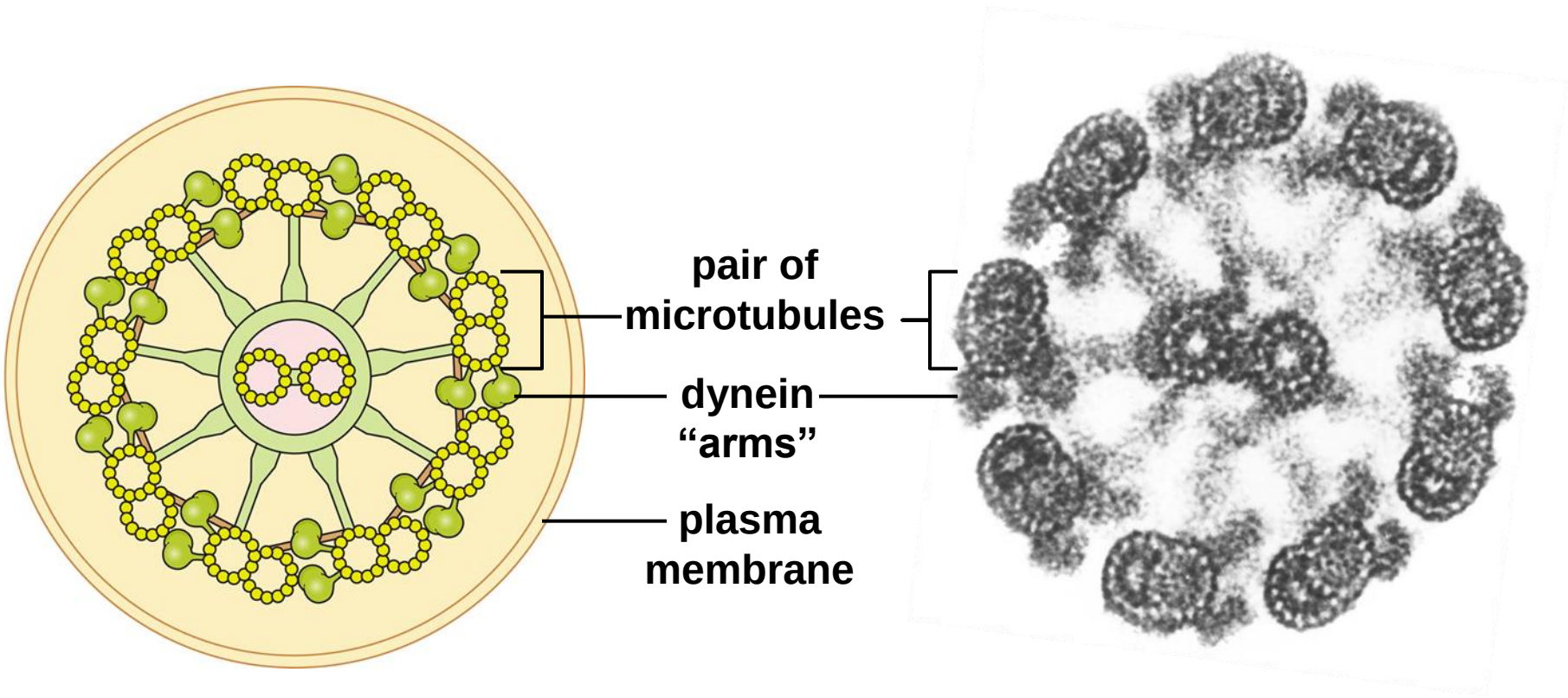
Cilia and Flagella

- Eukaryotic **flagella** and **cilia**
  - Whiplike structures formed from microtubules organized into 9 + 2 arrays

- Microtubules grow from a barrel-shaped **centriole**, which remains in the cytoplasm below as a **basal body**

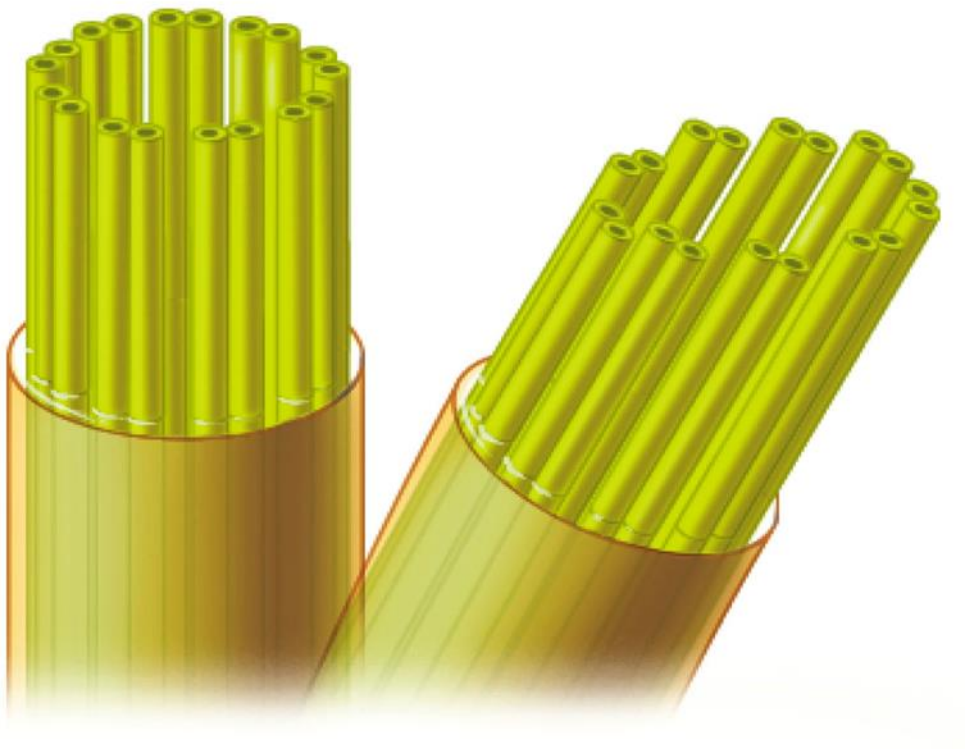


A Sketch and micrograph of a eukaryotic flagellum, cross-section. Like a cilium, it contains a 9 + 2 array: a ring of nine pairs of microtubules plus one pair at its core. Stabilizing spokes and linking elements that connect to the microtubules keep them aligned in a radial pattern. (Plasma membrane not visible in the micrograph.)

B Projecting from each pair of microtubules in the outer ring are "arms" of dynein, a motor protein. Phosphate-group transfers from ATP cause the dynein arms to repeatedly bind the adjacent pair of microtubules, bend, and then disengage. The dynein arms "walk" along the microtubules. Their motion causes adjacent microtubule pairs to slide past one another.

basal body (microtubule organizing center that gives rise to the 9 + 2 array and then remains beneath it, inside cytoplasm)

Figure 4-21b p69



C Short, sliding strokes occur in a coordinated sequence around the ring, down the length of each micro- tubule pair. The flagellum bends as the array inside bends.

Figure 4-21c p69

ANIMATED FIGURE: Flagella structure

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False Feet

- **Pseudopods** or “false feet”
  - Temporary, irregular lobes formed by amoebas and some other eukaryotic cells
  - Bulge outward to move the cell or engulf prey
  - Elongating microfilaments force the lobe to advance in a steady direction
  - Motor proteins attached to microfilaments drag the plasma membrane along with them

Take-Home Message:

What is a cytoskeleton?

- *A cytoskeleton of protein filaments is the basis of eukaryotic cell shape, internal structure, and movement*
- *Microtubules organize eukaryotic cells and help move their parts; networks of microfilaments reinforce their surfaces; intermediate filaments strengthen and maintain the shape of animal cells and tissues*
- *When energized by ATP, motor proteins move along tracks of microtubules and microfilaments; as part of cilia, flagella, and pseudopods, they can move whole cells*

4.11 Cell Surface Specializations

- Many cells secrete materials that form a covering or matrix outside their plasma membrane

- **Extracellular matrix (ECM)**
  - A nonliving, complex mixture of fibrous proteins and polysaccharides secreted by and surrounding cells
  - Structure and function varies with the type of tissue

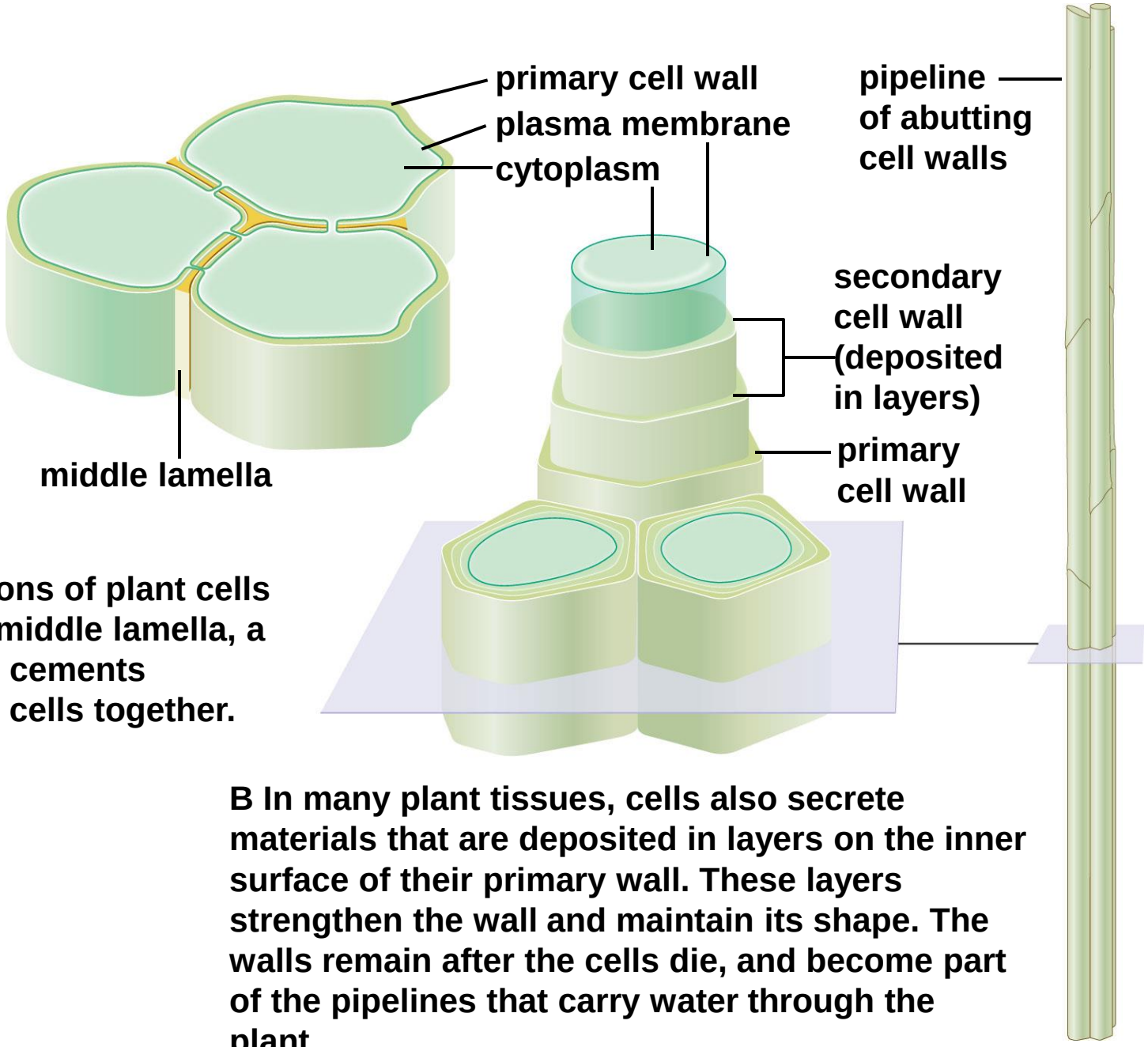
- *Example:* Bone is ECM composed mostly of the fibrous protein collagen, hardened by calcium and phosphorus

Eukaryotic Cell Walls

- Animal cells do not have walls, but plant cells and many protist and fungal cells do

- **Primary cell wall**
  - A thin, pliable wall formed by secretion of cellulose into the coating around young plant cells

- **Secondary cell wall**
  - A strong wall composed of **lignin**, formed in some plant stems and roots after maturity



A Secretions of plant cells form the middle lamella, a layer that cements adjoining cells together.

B In many plant tissues, cells also secrete materials that are deposited in layers on the inner surface of their primary wall. These layers strengthen the wall and maintain its shape. The walls remain after the cells die, and become part of the pipelines that carry water through the plant.

Figure 4-22ab p70

ANIMATED FIGURE: Plant cell walls

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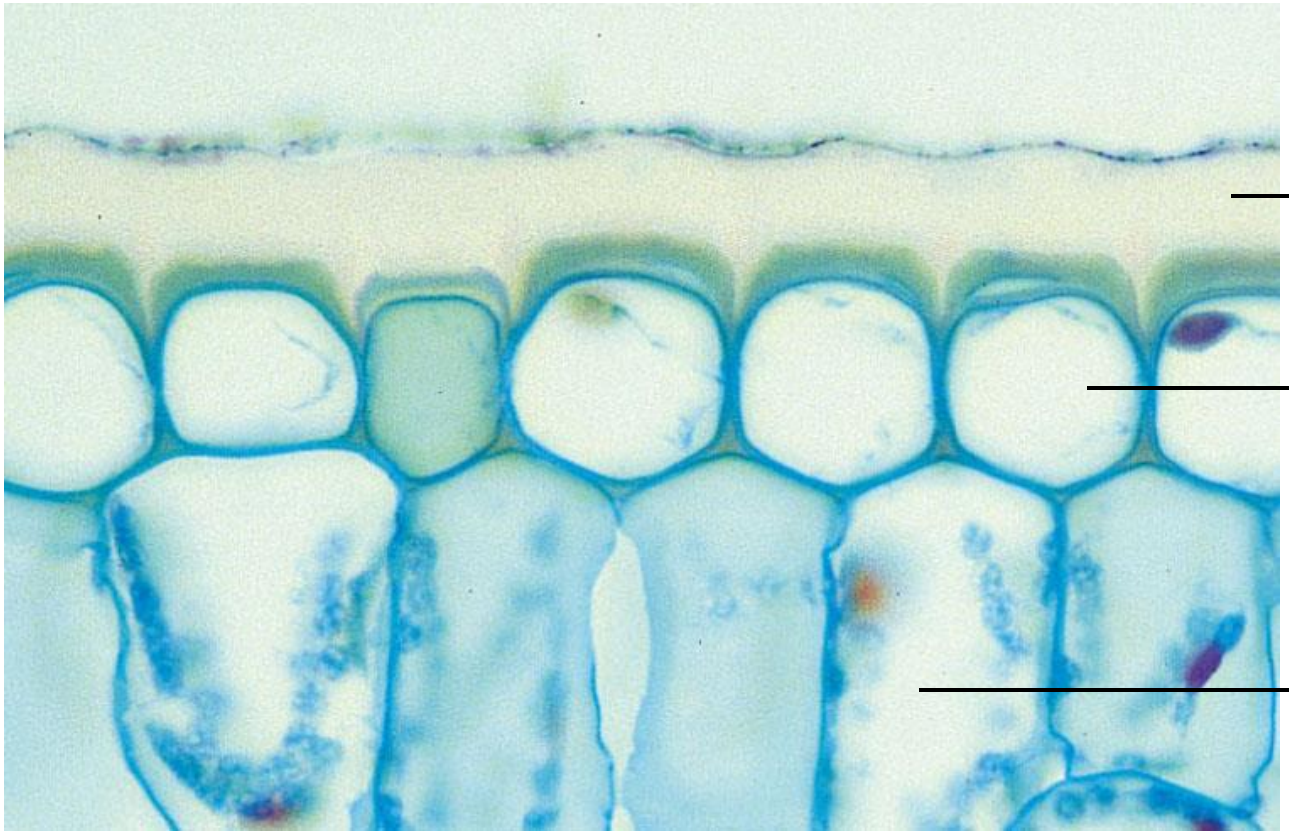
Cuticle

- **Cuticle**
  - A type of ECM secreted by cells at a body surface
  - Plant cuticles consist of waxes and proteins, and help plants retain water and fend off insects
  - Cuticles of crabs, spiders, and other arthropods is mainly chitin, a polysaccharide

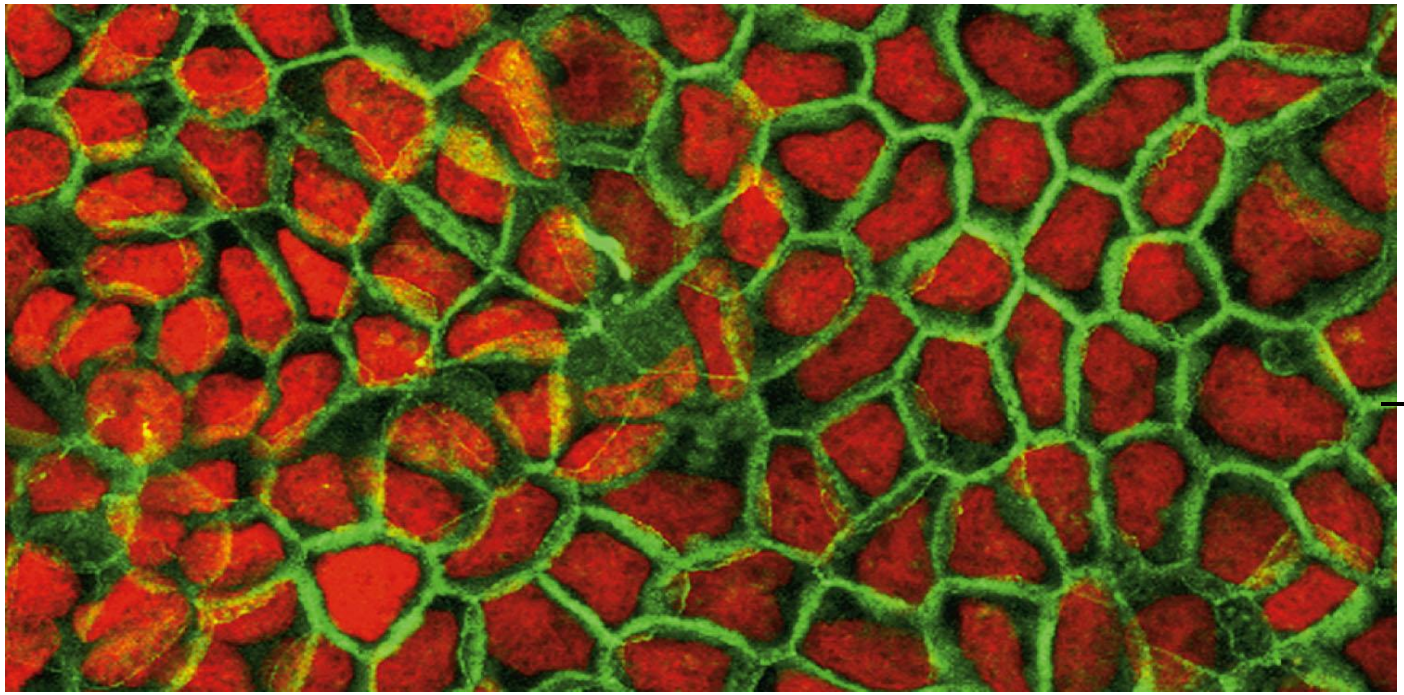
Plant Cuticle



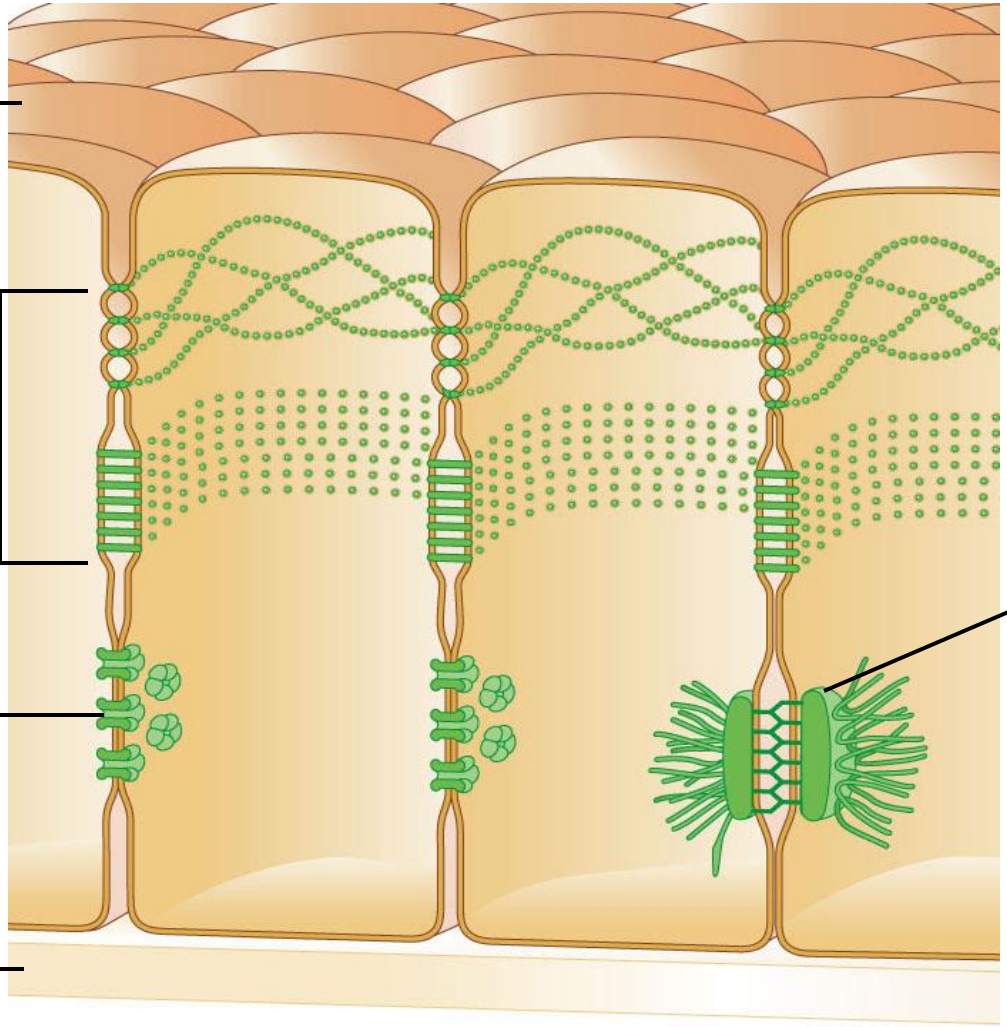
Cell Junctions

- **Cell junctions** allow cells to interact with each other and the environment
- In plants, **plasmodesmata** extend through cell walls to connect the cytoplasm of two cells
- Animals have three types of cell junctions: **tight junctions**, **adhering junctions**, **gap junctions**

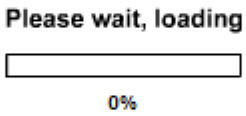
Cell Junctions in Animal Tissues



Cell Junctions in Animal Tissues



ANIMATED FIGURE: Animal cell junctions



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Take-Home Message:

What structures form outside cells?

- *Cells of many protists, nearly all fungi, and all plants have a porous wall around the plasma membrane; animal cells do not have walls*
- *Plant cell secretions form a waxy cuticle that helps protect the exposed surfaces of soft plant parts*
- *Cell secretions form extracellular matrixes between cells in many tissues*
- *Cells make structural and functional connections with one another and with extracellular matrix in tissues*

4.12 The Nature of Life

- We define life by describing the set of properties that is unique to living things
- Life is a property that emerges from cellular components, but a collection of those components in the right amounts and proportions is not necessarily alive
- Life continues only as long as a continuous flow of energy sustains its organization

Properties of Living Things

1. They make and use the organic molecules of life
2. They consist of one or more cells
3. They engage in self-sustaining biological processes such as metabolism and homeostasis
4. They change over their lifetime, for example by growing, maturing, and aging
5. They use DNA as their hereditary material
6. They have the collective capacity to change over successive generations… by adapting to environmental pressures

Life

Take-Home Message:

What is life?

- *We describe the characteristic of "life" in terms of a set of properties that are unique to living things*
- *In living things, the molecules of life are organized as one or more cells that engage in self-sustaining processes*
- *Organisms use DNA as their hereditary material*
- *Living things change over lifetimes, and over generations*

Table 4.4 Summary of Typical Components of Prokaryotic and Eukaryotic Cells

Cell Component	Main Functions	Bacteria, Archaea	Eukaryotes			
			Protists	Fungi	Plants	Animals
Cell wall	Protection, structural support	✔*	✔*	✔	✔	–
Plasma membrane	Control of substances moving into and out of cell	✔	✔	✔	✔	✔
Nucleus	Physical separation of DNA from cytoplasm	–**	✔	✔	✔	✔
DNA	Encoding of hereditary information	✔	✔	✔	✔	✔
Nucleolus	Assembly of ribosome subunits	–	✔	✔	✔	✔
Ribosome	Protein synthesis	✔	✔	✔	✔	✔
Endoplasmic reticulum (ER)	Initial modification of polypeptide chains; lipid synthesis	–	✔	✔	✔	✔
Golgi body	Final modification of proteins, lipid assembly, and packaging of both for use inside cell or export	–	✔	✔	✔	✔
Lysosome	Intracellular digestion	–	✔	✔*	✔*	✔
Mitochondrion	Aerobic production of ATP	–	✔	✔	✔	✔
Hydrogenosome	Anaerobic production of ATP	–	✔*	✔*	–	✔*
Photosynthetic pigments	Light-to-energy conversion	✔*	✔*	–	✔	–
Chloroplast	Photosynthesis; some starch storage	–	✔*	–	✔	–
Central vacuole	Increasing cell surface area; storage	–	–	✔*	✔	–
Bacterial flagellum	Locomotion through fluid surroundings	✔*	–	–	–	–
Eukaryotic flagellum or cilium	Locomotion through or motion within fluid surroundings	–	✔*	✔*	✔*	✔
Cytoskeleton	Cell shape; internal organization; basis of cell movement and, in many cells, locomotion	✔	✔*	✔*	✔*	✔

*Known to be present in some species.
** One or two lipid bilayers surround the DNA of some species