Chapter 6

A Tour of the Cell

Inner Life of Cell

Edited by Shawn Lester

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Overview: The Fundamental Units of Life

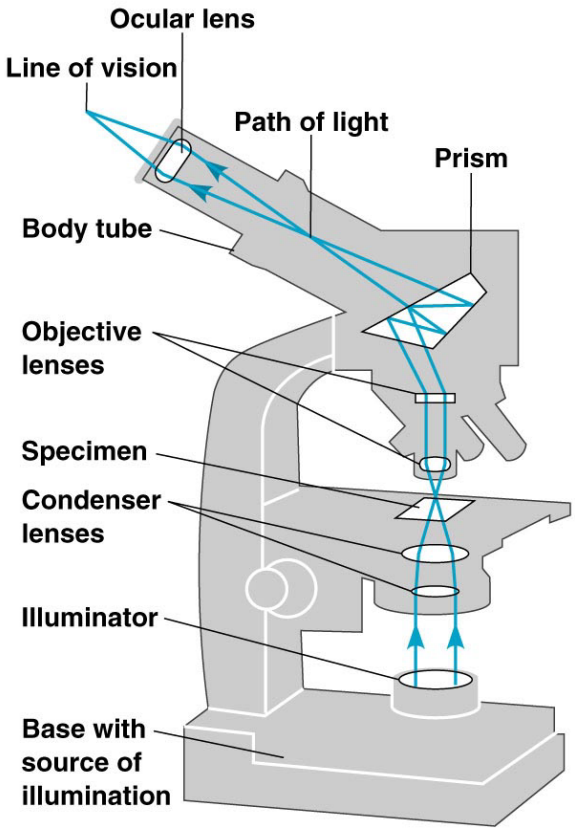
- Cell Theory:
- -All organisms are made of cells
- -The cell is the simplest collection of matter that can live (smallest unit of life)
- -All cells come from pre-existing cells

Concept 6.1: To study cells, biologists use microscopes and the tools of biochemistry

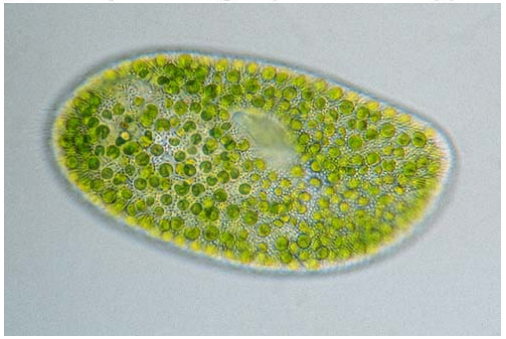
- Though usually too small to be seen by the unaided eye, cells can be complex

Microscopy

- Scientists use microscopes to visualize cells too small to see with the naked eye
- In a **light microscope (brightfield)**, visible light passes through a specimen and then through glass lenses, which magnify the image

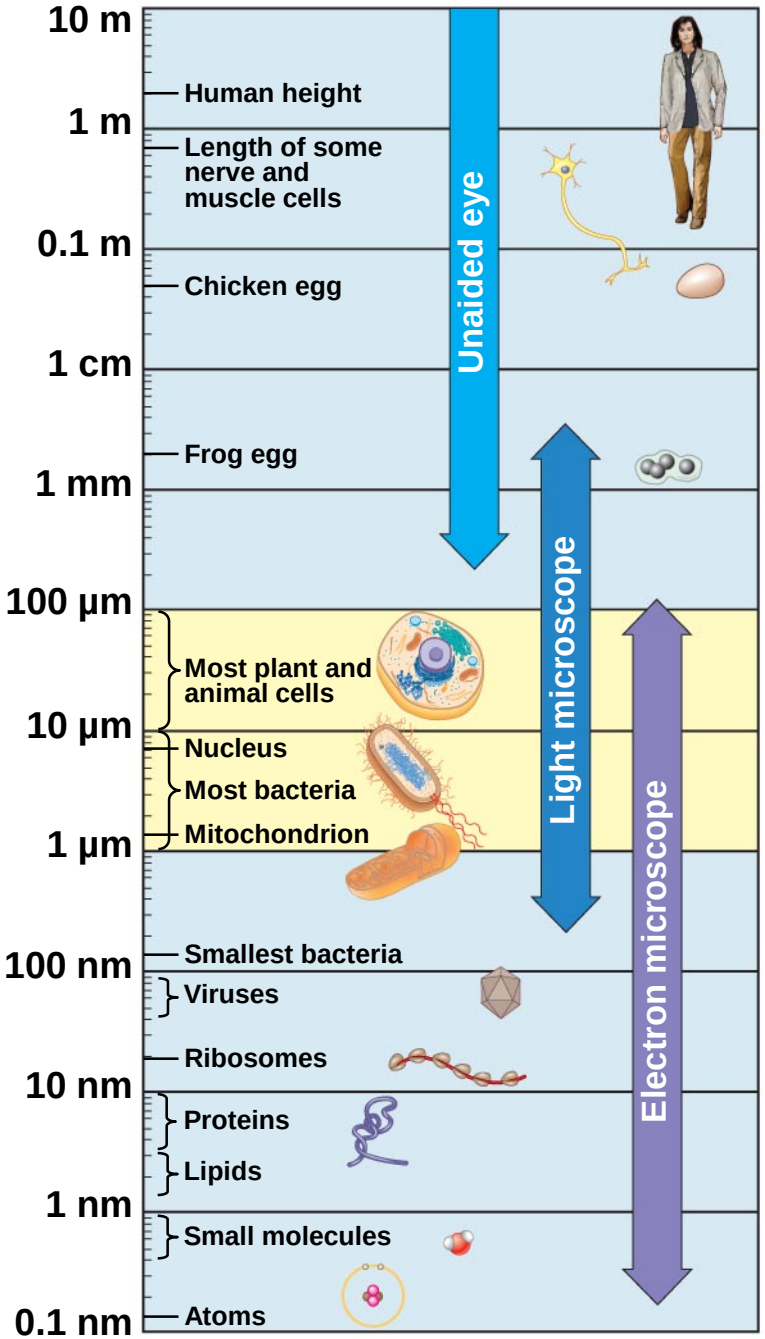


(b) The path of light (bottom to top)



- The quality of an image depends on
  - *Magnification*, the ratio of an object's image size to its real size
  - *Resolution*, the measure of the clarity of the image, the ability to distinguish two points as separate
  - *Contrast*, visible differences in parts of the sample

Fig. 6-2



http://learn.genetics.utah.edu/content/begin/cells/scale

- Light microscopes can magnify effectively to about 1,000 times the size of the actual specimen
- Various techniques enhance contrast and enable cell components to be stained or labeled
- Most subcellular structures, including **organelles** (membrane-enclosed compartments), are too small to be resolved by an light microscope

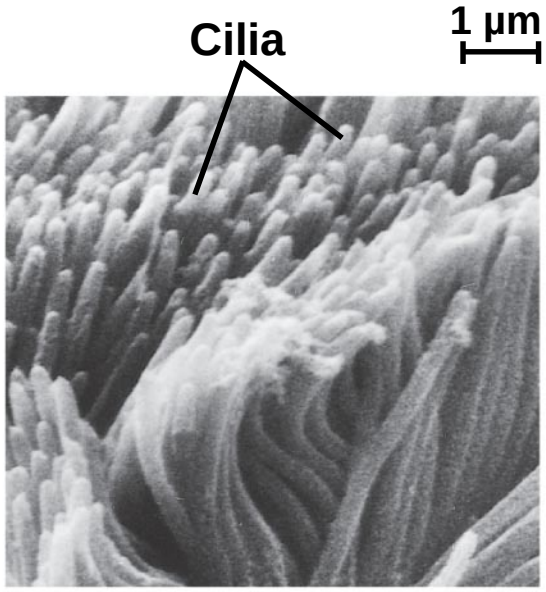
- Two basic types of **electron microscopes (EMs)** are used to study subcellular structures
- **Scanning electron microscopes (SEMs)** focus a beam of electrons onto the surface of a specimen, providing images that look 3-D
- **Transmission electron microscopes (TEMs)** focus a beam of electrons through a specimen
- TEMs are used mainly to study the internal structure of cells

Fig. 6-4

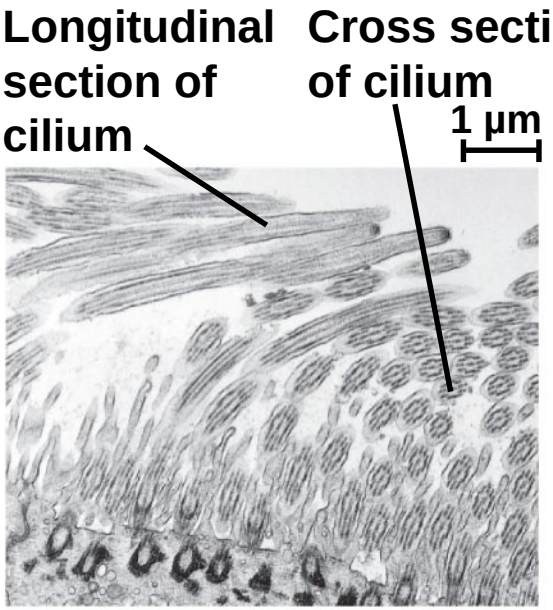
TECHNIQUE

RESULTS

(a) Scanning electron microscopy (SEM)



(b) Transmission electron microscopy (TEM)



Concept 6.2: Eukaryotic cells have internal membranes that compartmentalize their functions

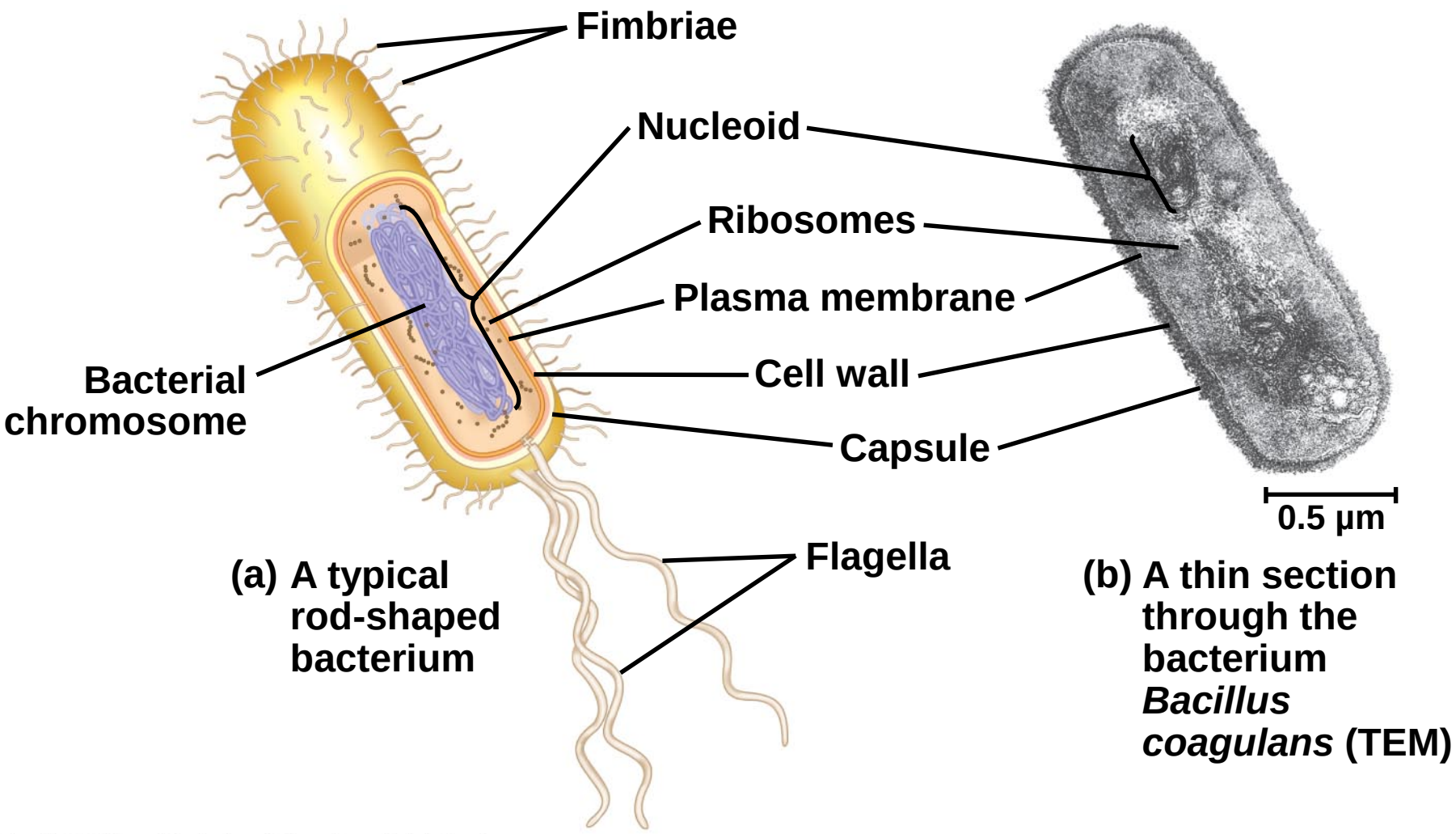
- The basic structural and functional unit of every organism is one of two types of cells: prokaryotic or eukaryotic
- Only organisms of the domains Bacteria and Archaea consist of prokaryotic cells
- Protists, fungi, animals, and plants all consist of eukaryotic cells

Comparing Prokaryotic and Eukaryotic Cells

- Basic features of all cells:
  - Plasma membrane
  - Semifluid substance called **cytosol** (watery part with dissolved substances, does not include organelles)
  - Chromosomes (carry genes)
  - Ribosomes (make proteins)

- **Prokaryotic cells** are characterized by having
  - No nucleus
  - DNA in an unbound region called the **nucleoid**
  - No membrane-bound organelles
  - **Cytoplasm** bound by the plasma membrane (everything within the plasma membrane including organelles)

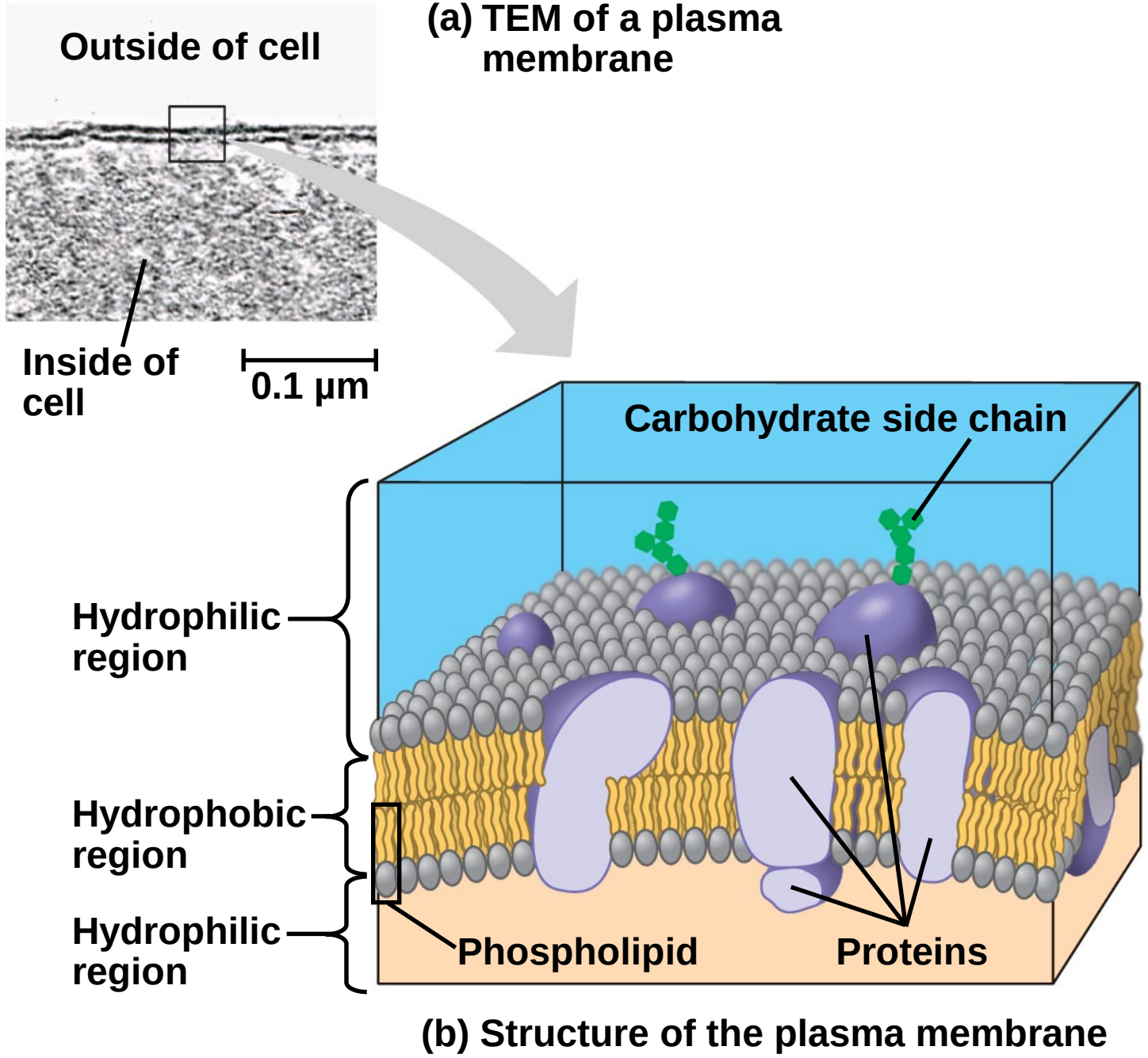
Fig. 6-6



- **Eukaryotic cells** are characterized by having
  - DNA in a nucleus that is bounded by a membranous nuclear envelope
  - Membrane-bound organelles
  - Cytoplasm in the region between the plasma membrane and nucleus
- Eukaryotic cells are generally much larger than prokaryotic cells

- The **plasma membrane** is a selective barrier that allows sufficient passage of oxygen, nutrients, and waste to service the volume of every cell
- The general structure of a biological membrane is a double layer of phospholipids

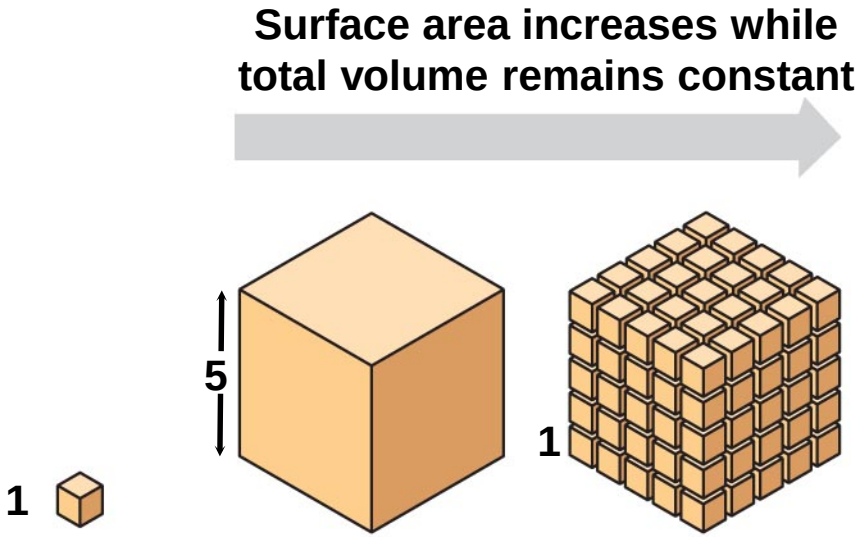
Fig. 6-7



- The logistics of carrying out cellular metabolism sets limits on the size of cells
- The surface area to volume ratio of a cell is critical
- As the surface area increases by a factor of n^2, the volume increases by a factor of n^3
- Small cells have a greater surface area relative to volume

Fig. 6-8

As cell size increases, surface-to-volume ratio decreases making it harder to transport substances across cell membrane.



Total surface area [Sum of the surface areas (height × width) of all boxes sides × number of boxes]	**6**	**150**	**750**
Total volume [height × width × length × number of boxes]	**1**	**125**	**125**
Surface-to-volume (S-to-V) ratio [surface area ÷ volume]	**6**	**1.2**	**6**

A Panoramic View of the Eukaryotic Cell

- A eukaryotic cell has internal membranes that partition the cell into organelles
- Plant and animal cells have most of the same organelles

Fig. 6-9a

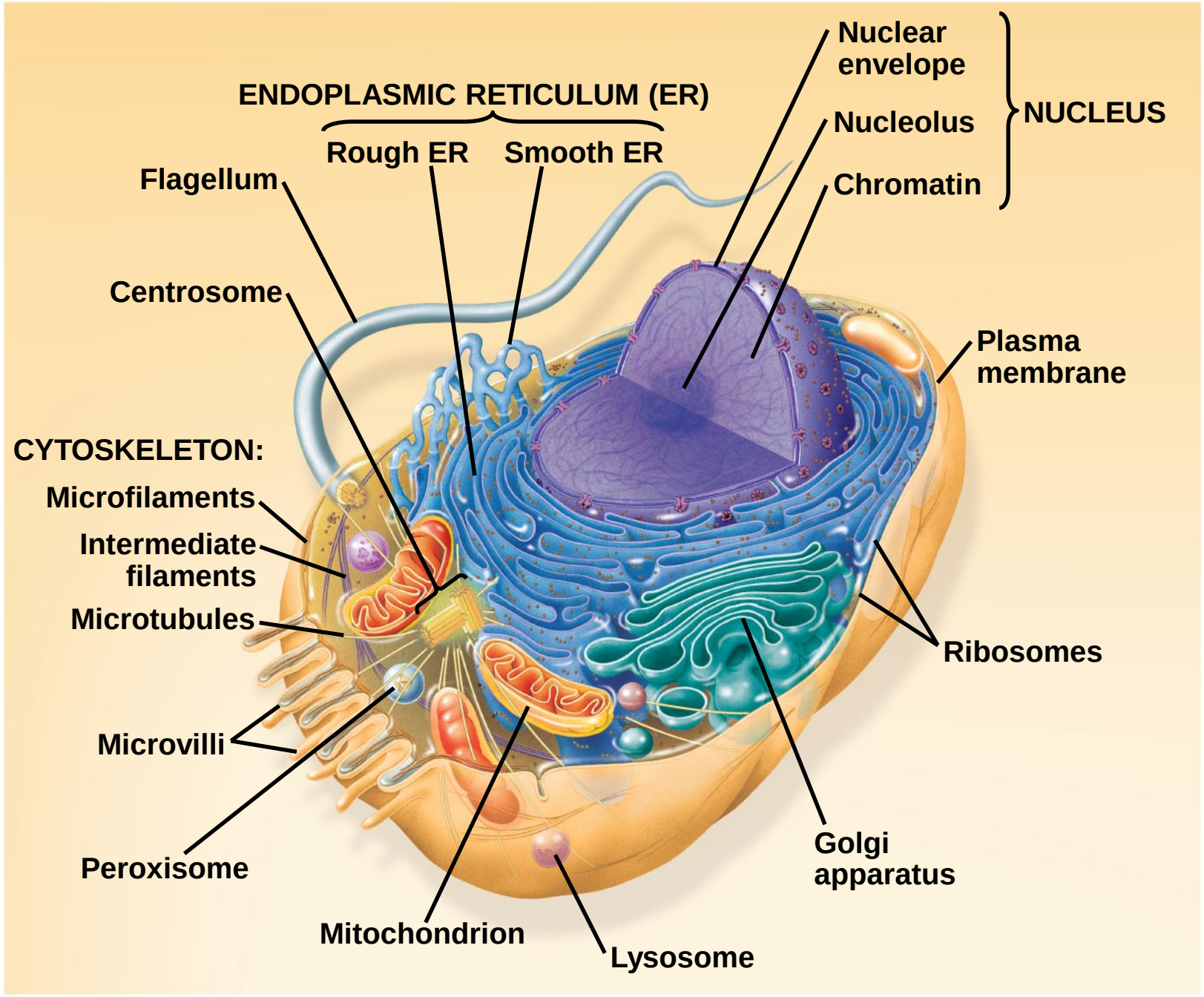
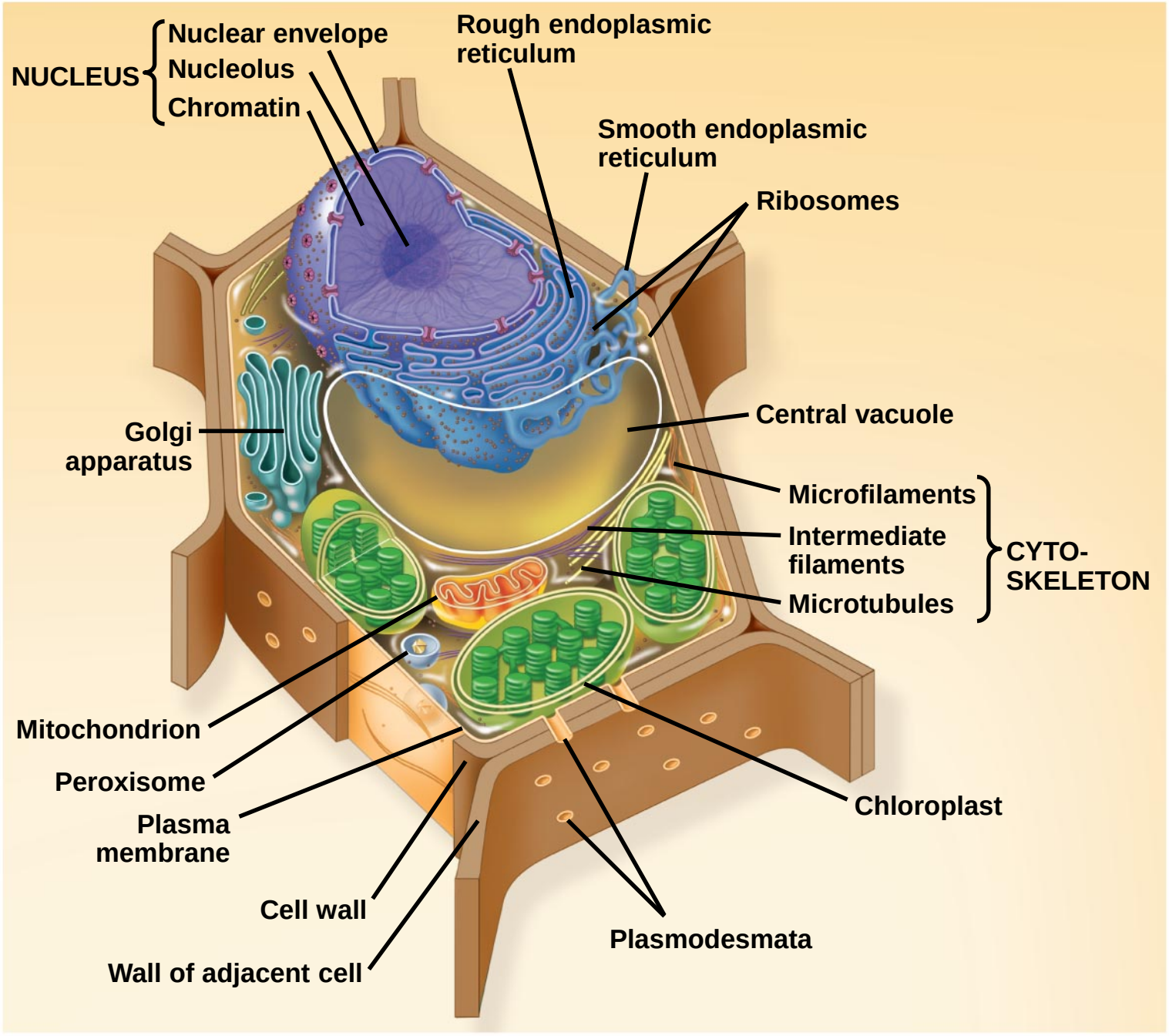


Fig. 6-9b



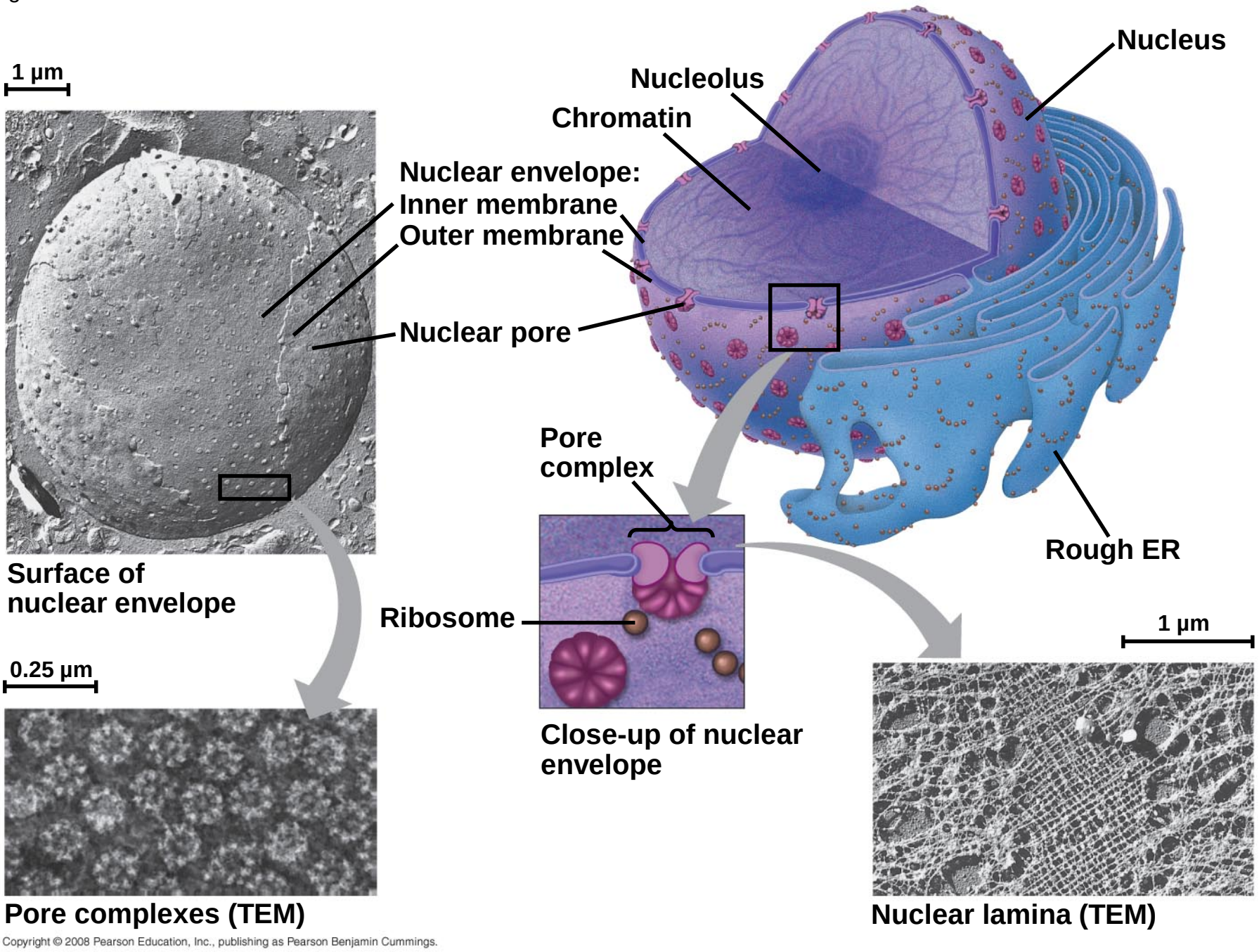
Concept 6.3: The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes

- The nucleus contains most of the DNA in a eukaryotic cell
- Ribosomes use the information from the DNA to make proteins

The Nucleus: Information Central

- The **nucleus** contains most of the cell's genes and is usually the most conspicuous organelle
- The **nuclear envelope** encloses the nucleus, separating it from the cytoplasm
- The nuclear membrane is a double membrane; each membrane consists of a lipid bilayer
- Pores regulate the entry and exit of molecules from the nucleus

Fig. 6-10

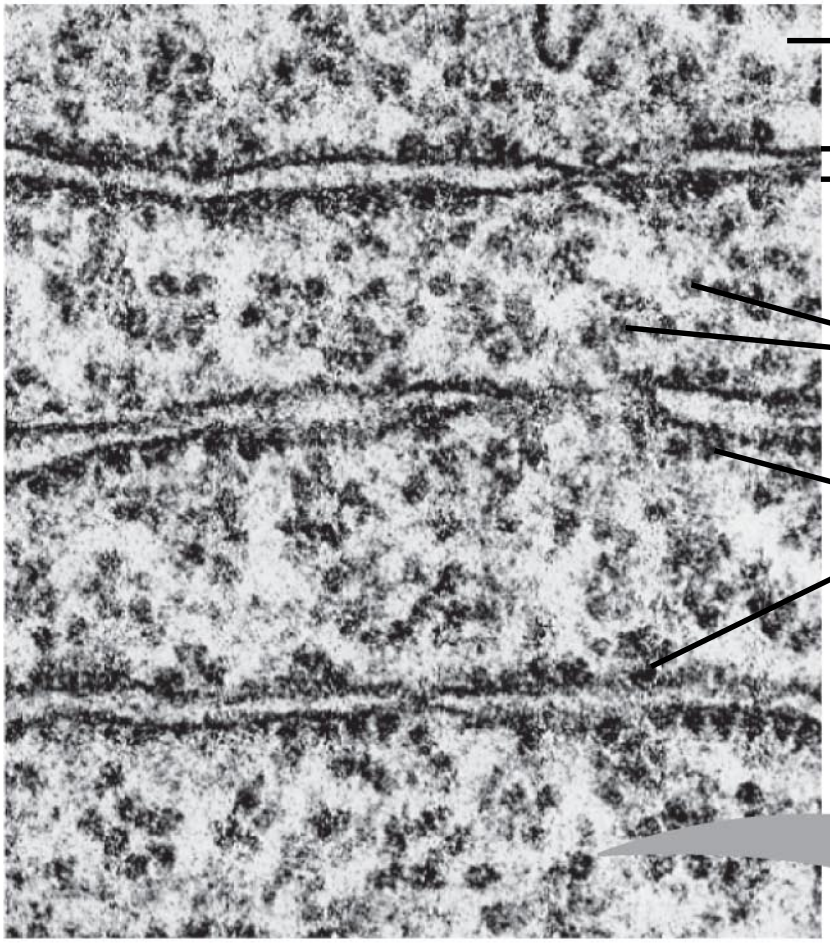


- In the nucleus, DNA and proteins form genetic material called **chromatin**
- Chromatin condenses to form discrete **chromosomes**
- The **nucleolus** is located within the nucleus and is the site of ribosomal RNA (rRNA) synthesis

Ribosomes: Protein Factories

- **Ribosomes** are particles made of ribosomal RNA and protein
- Ribosomes carry out protein synthesis in two locations:
  - In the cytosol (free ribosomes)
  - On the outside of the endoplasmic reticulum or the nuclear envelope (bound ribosomes)

Fig. 6-11



TEM showing ER and ribosomes

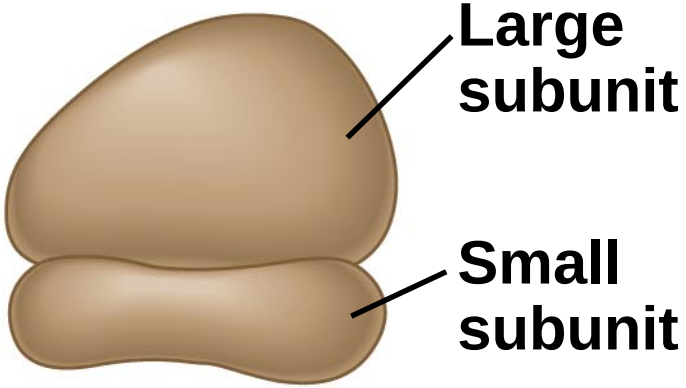
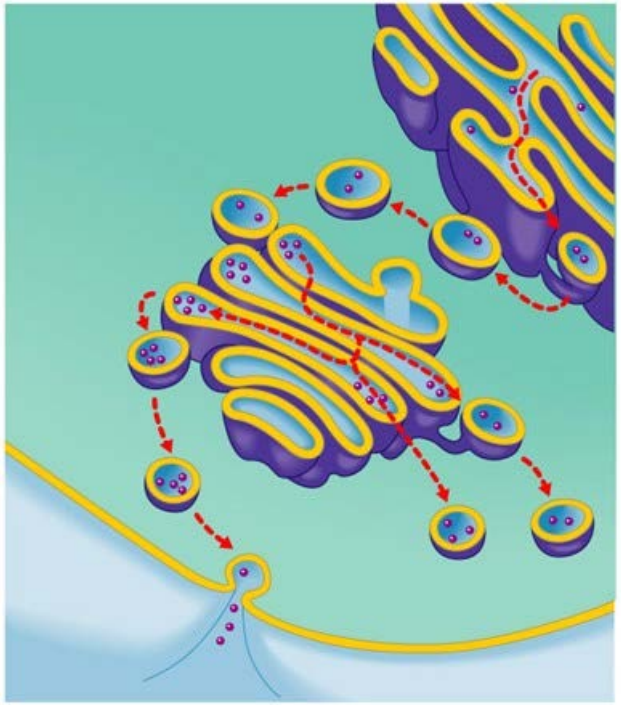


Diagram of a ribosome

Concept 6.4: The endomembrane system regulates protein traffic and performs metabolic functions in the cell

- Components of the **endomembrane system**:
  - Nuclear envelope
  - Endoplasmic reticulum
  - Golgi apparatus
  - Lysosomes
  - Vacuoles
  - Plasma membrane

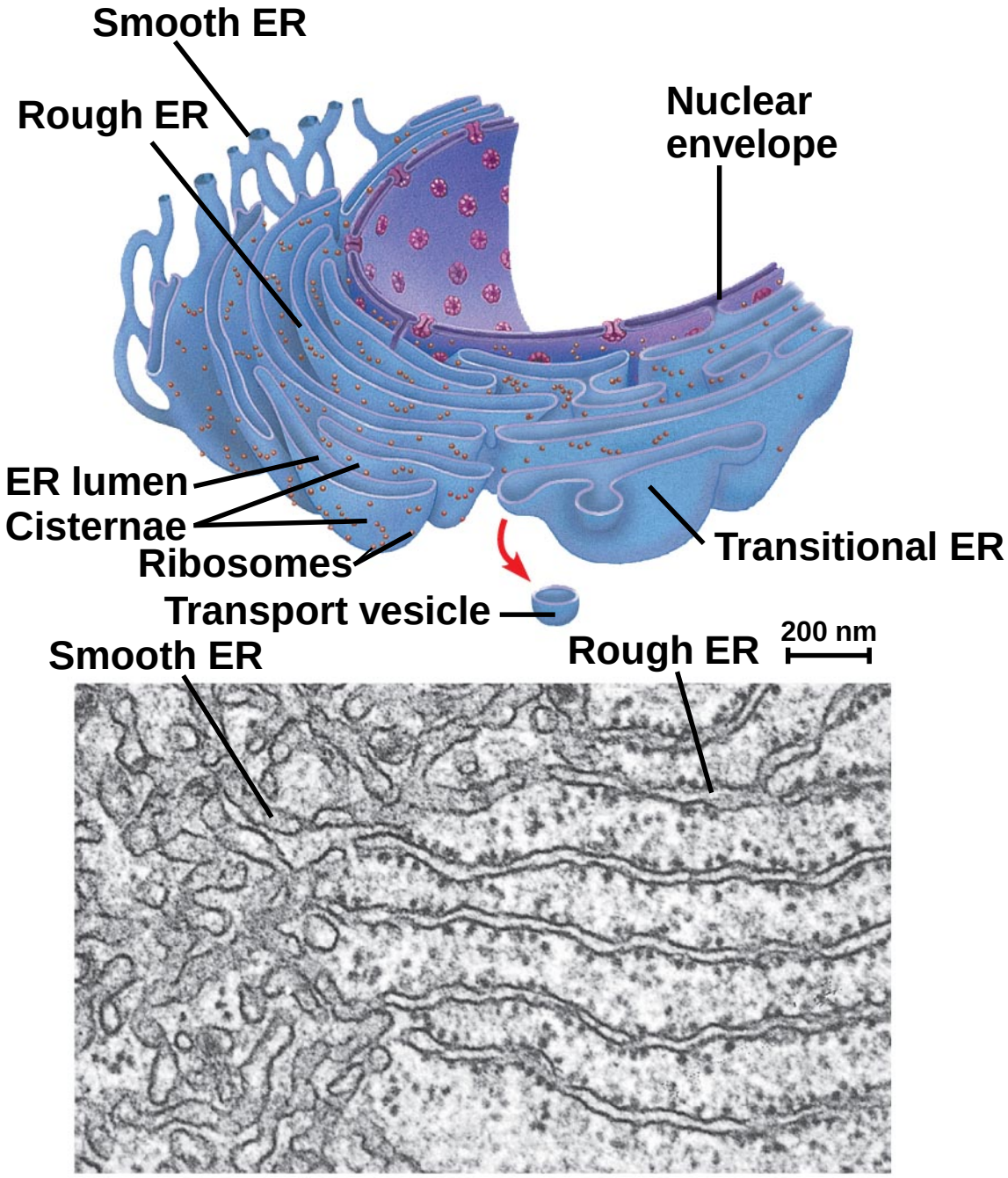


- These components are either continuous or connected via transfer by **vesicles**

The Endoplasmic Reticulum: Biosynthetic Factory

- The **endoplasmic reticulum (ER)** accounts for more than half of the total membrane in many eukaryotic cells
- The ER membrane is continuous with the nuclear envelope
- There are two distinct regions of ER:
  - **Smooth ER**, which lacks ribosomes
  - **Rough ER**, with ribosomes studding its surface

Fig. 6-12



Functions of Smooth ER

- The smooth ER
  - Synthesizes lipids
  - Metabolizes carbohydrates
  - Detoxifies poison
  - Stores calcium

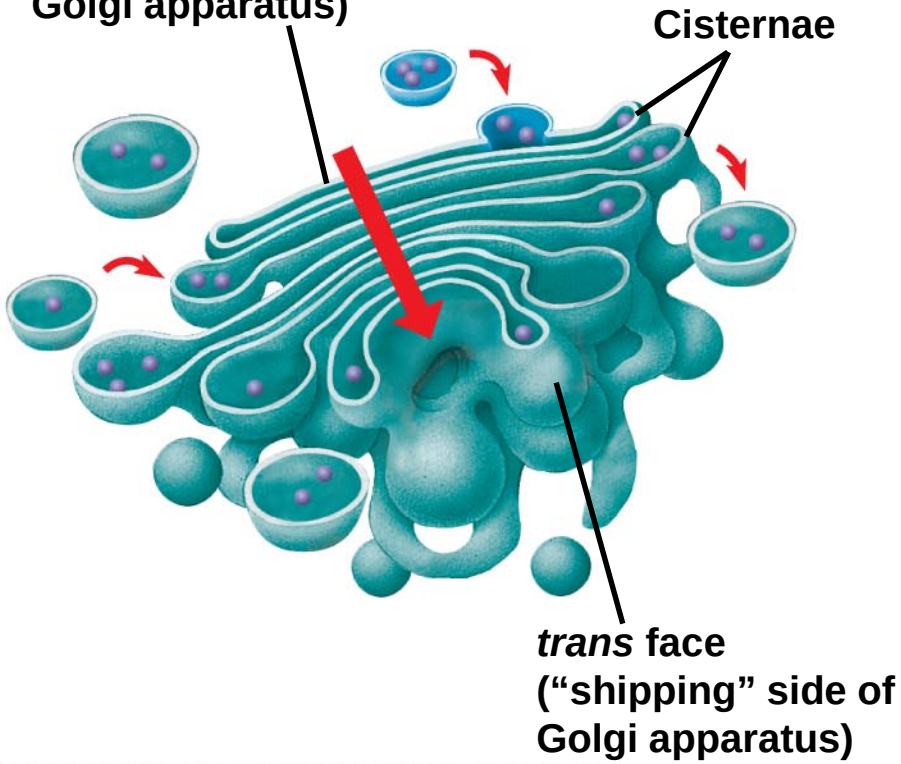
Functions of Rough ER

- The rough ER
  - Has bound ribosomes, which secrete **glycoproteins** (proteins covalently bonded to carbohydrates)
  - Distributes **transport vesicles,** proteins surrounded by membranes
  - Is a membrane factory for the cell

The Golgi Apparatus: Shipping and Receiving Center

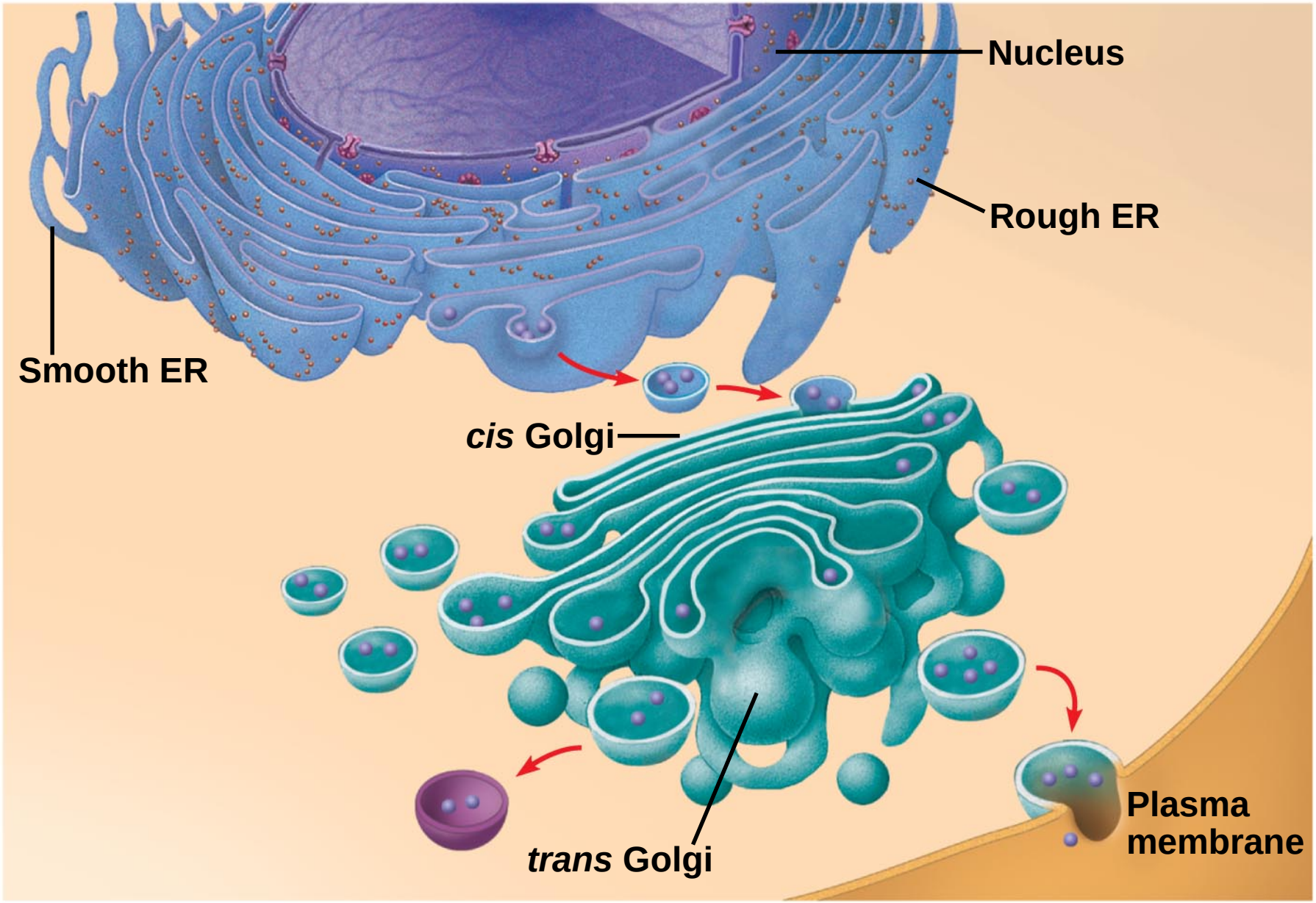
- The **Golgi apparatus** consists of flattened membranous sacs called cisternae
- Functions of the Golgi apparatus:
  - Modifies products of the ER
  - Sorts and packages materials into transport vesicles

Fig. 6-13



TEM of Golgi apparatus

Fig. 6-16-3

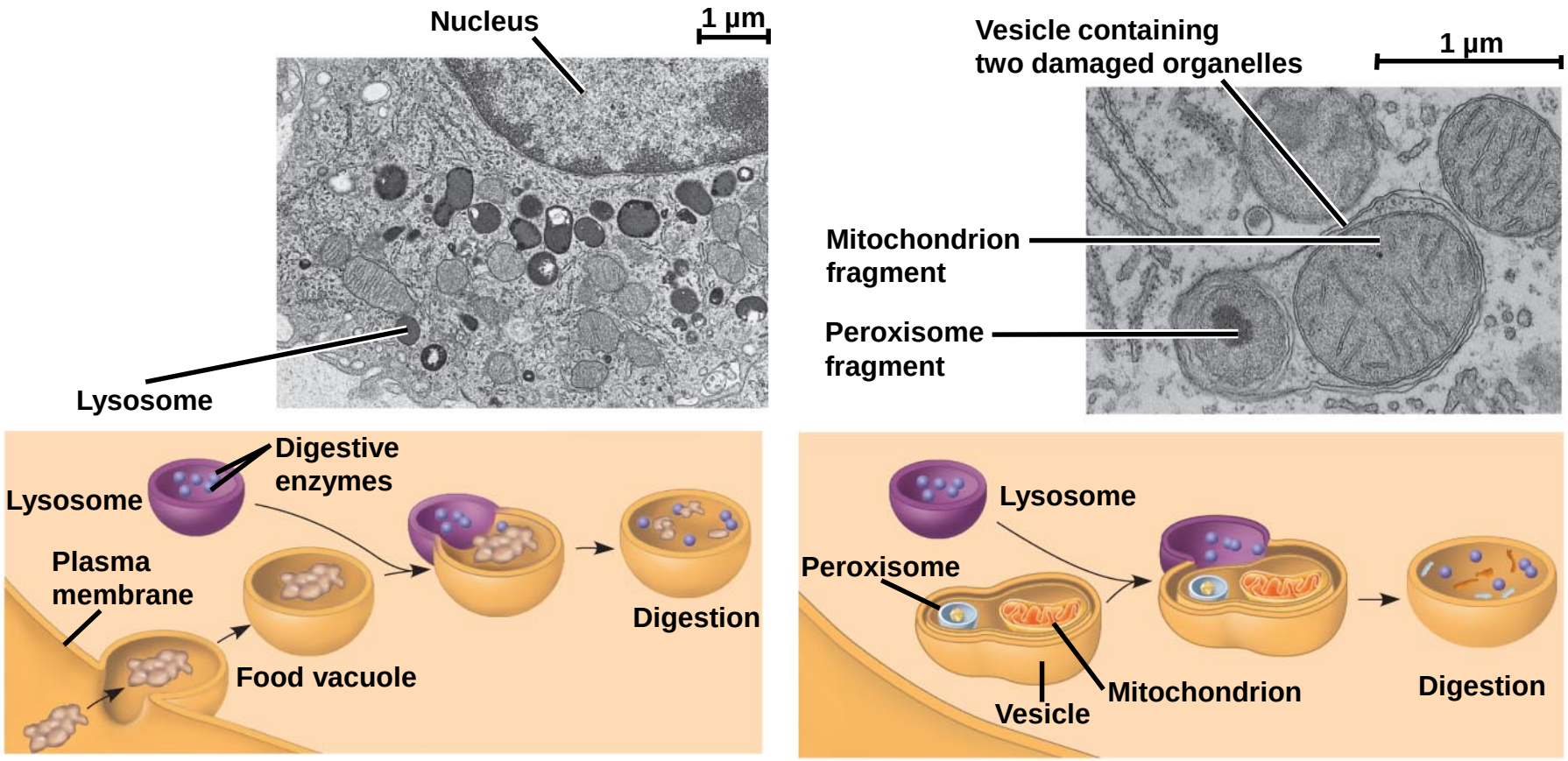

Nucleus
Rough ER
Smooth ER
cis Golgi
trans Golgi
Plasma membrane

Lysosomes: Digestive Compartments

- A **lysosome** is a membranous sac of hydrolytic enzymes that can digest macromolecules
- Lysosomal enzymes can hydrolyze proteins, fats, polysaccharides, and nucleic acids

- Some types of cell can engulf another cell by **phagocytosis**; this forms a food vacuole
- A lysosome fuses with the food vacuole and digests the molecules
- Lysosomes also use enzymes to recycle the cell's own organelles and macromolecules, a process called autophagy

Fig. 6-14

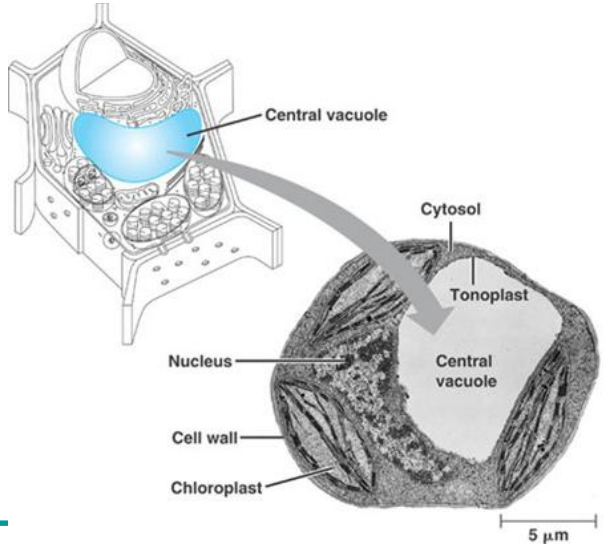


(a) Phagocytosis

(b) Autophagy

Vacuoles: Diverse Maintenance Compartments

- **Food vacuoles** are formed by phagocytosis
- **Contractile vacuoles**, found in many freshwater protists, pump excess water out of cells
- **Central vacuoles**, found in many mature plant cells, hold organic compounds and water



Concept 6.5: Mitochondria and chloroplasts change energy from one form to another

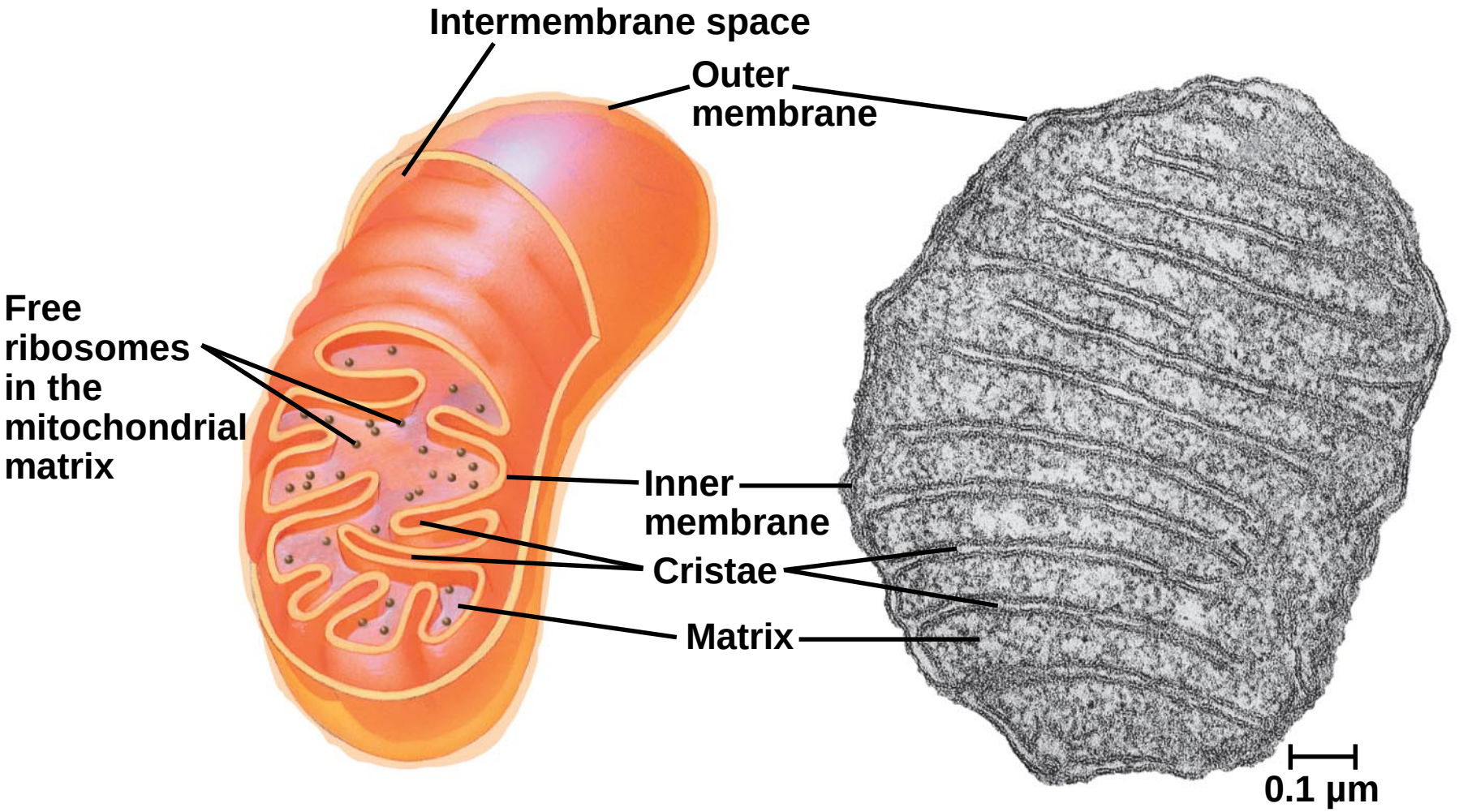
- **Mitochondria** are the sites of cellular respiration, a metabolic process that generates ATP
- **Chloroplasts**, found in plants and algae, are the sites of photosynthesis

- Mitochondria and chloroplasts
  - Are not part of the endomembrane system
  - Have a double membrane
  - Have proteins made by free ribosomes
  - Contain their own DNA

Mitochondria: Chemical Energy Conversion

- Mitochondria are in nearly all eukaryotic cells
- They have a smooth outer membrane and an inner membrane folded into **cristae**
- The inner membrane creates two compartments: intermembrane space and **mitochondrial matrix**
- Some metabolic steps of cellular respiration are catalyzed in the mitochondrial matrix
- Cristae present a large surface area for enzymes that synthesize ATP

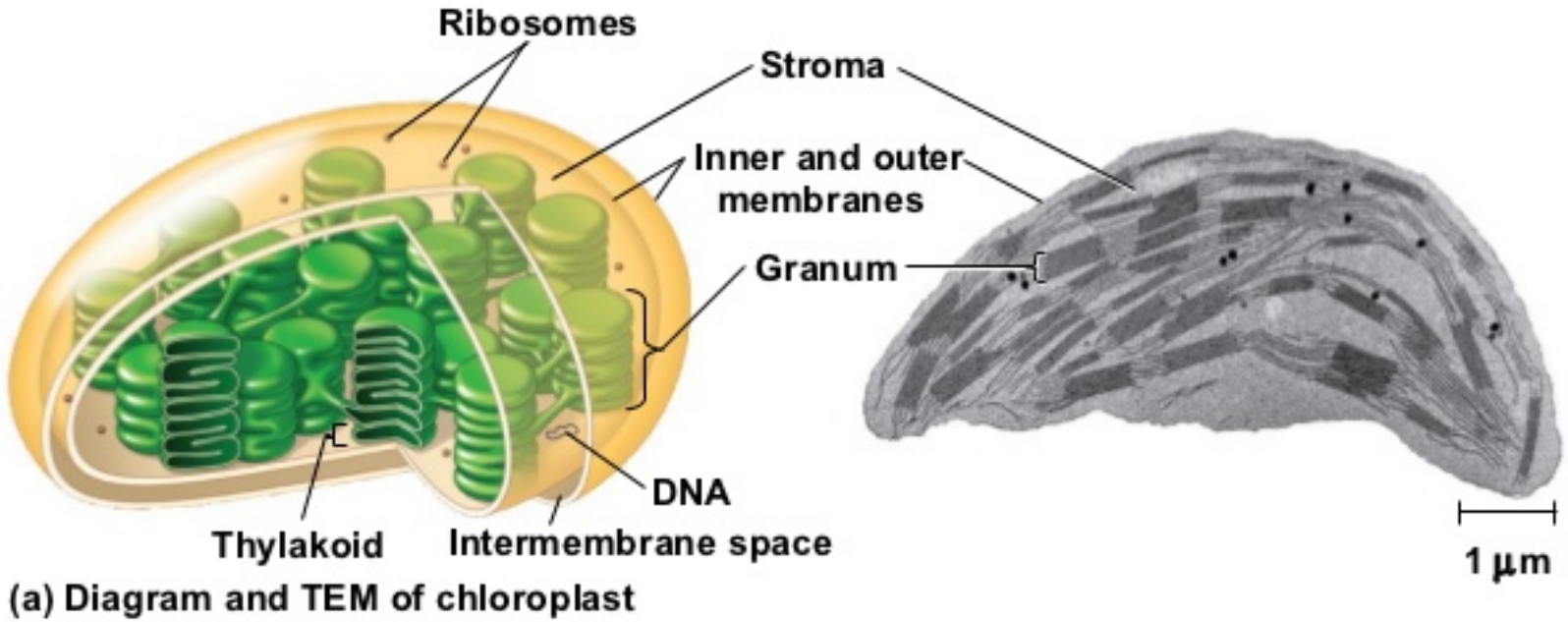
Fig. 6-17



Chloroplasts: Capture of Light Energy

- The chloroplast is a member of a family of organelles called **plastids**
- Chloroplasts contain the green pigment chlorophyll, as well as enzymes and other molecules that function in photosynthesis
- Chloroplasts are found in leaves and other green organs of plants and in algae

Figure 6.18a



(a) Diagram and TEM of chloroplast

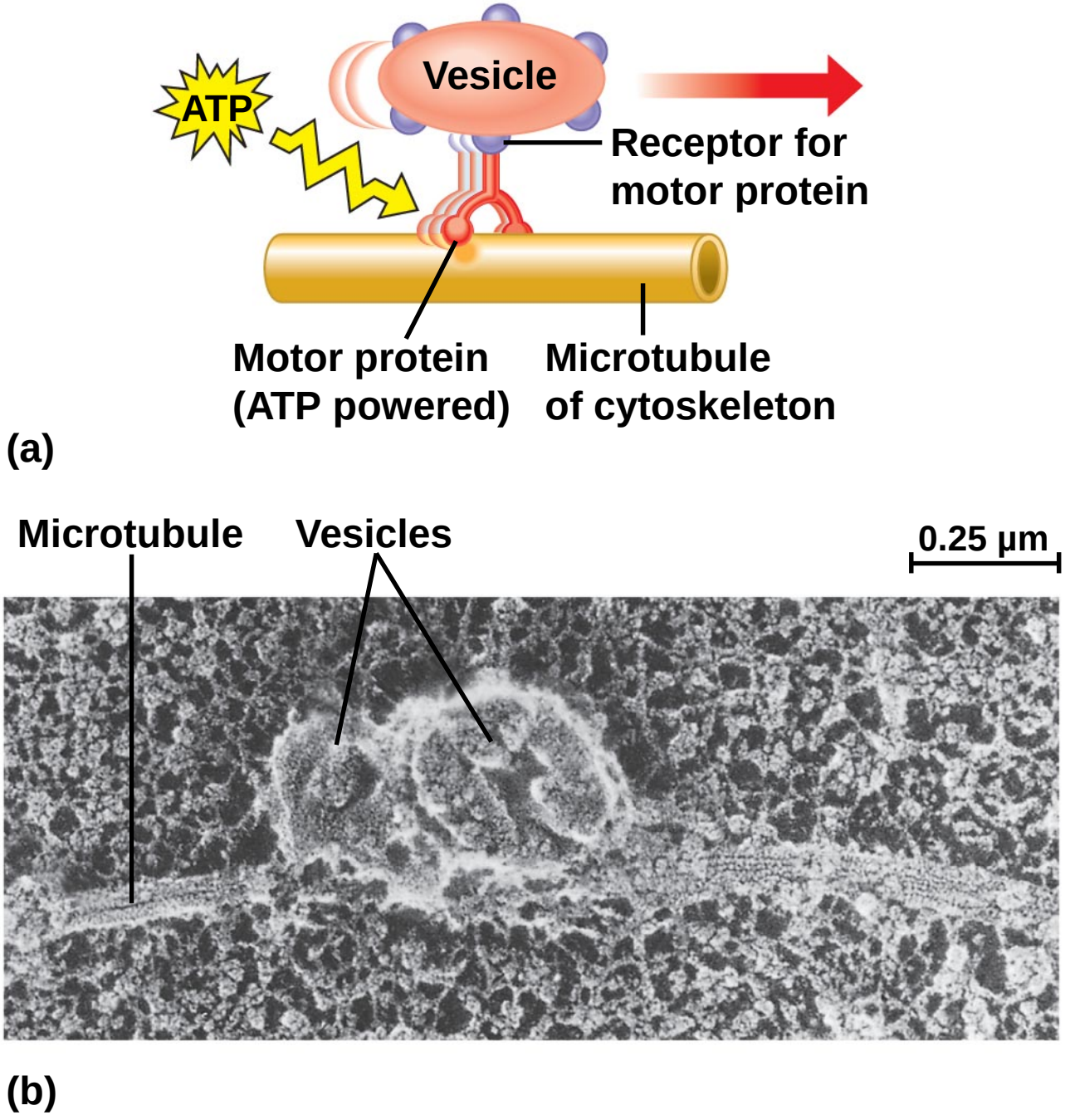
Concept 6.6: The cytoskeleton is a network of fibers that organizes structures and activities in the cell

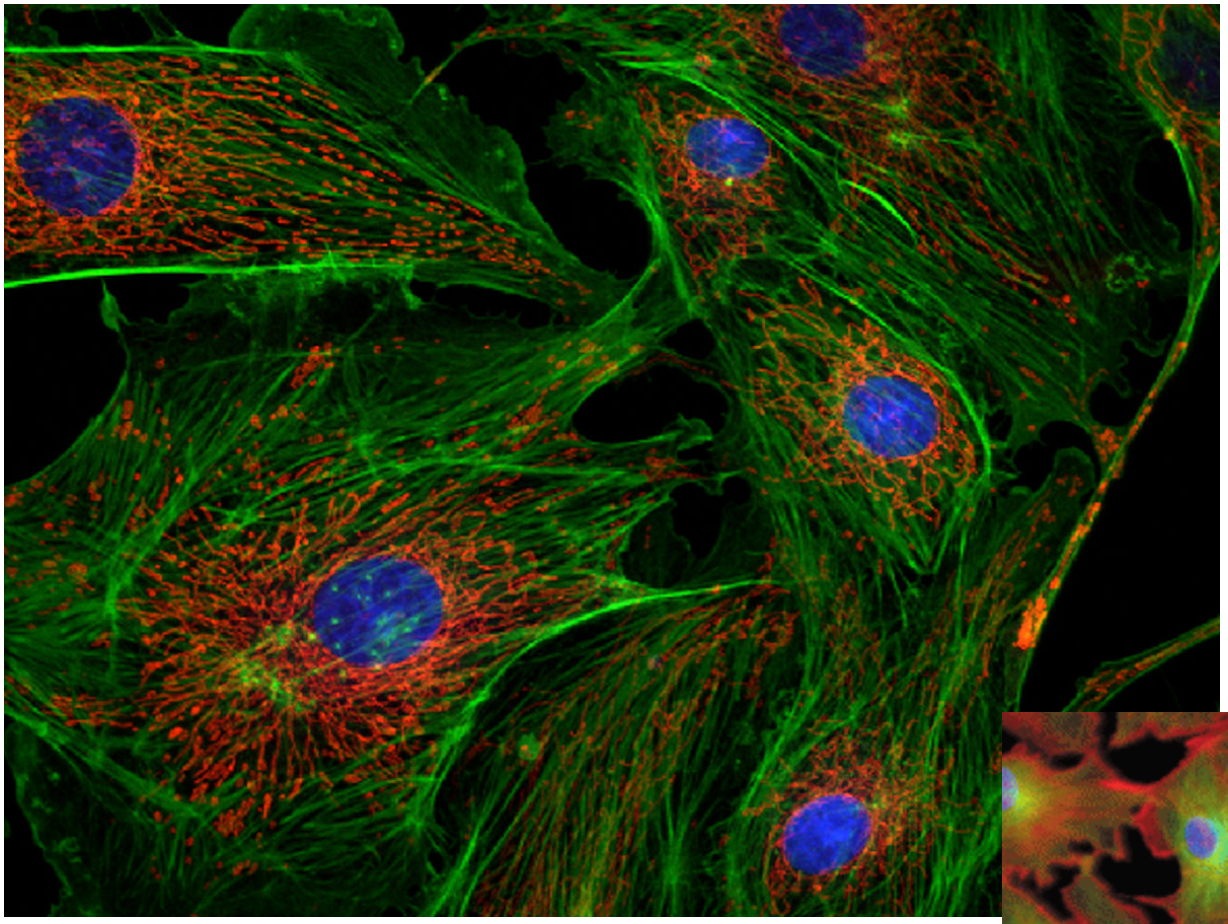
- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm
- It organizes the cell's structures and activities, anchoring many organelles
- It is composed of three types of molecular structures:
  - Microtubules (tubulin)
  - Microfilaments (actin)
  - Intermediate filaments (several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

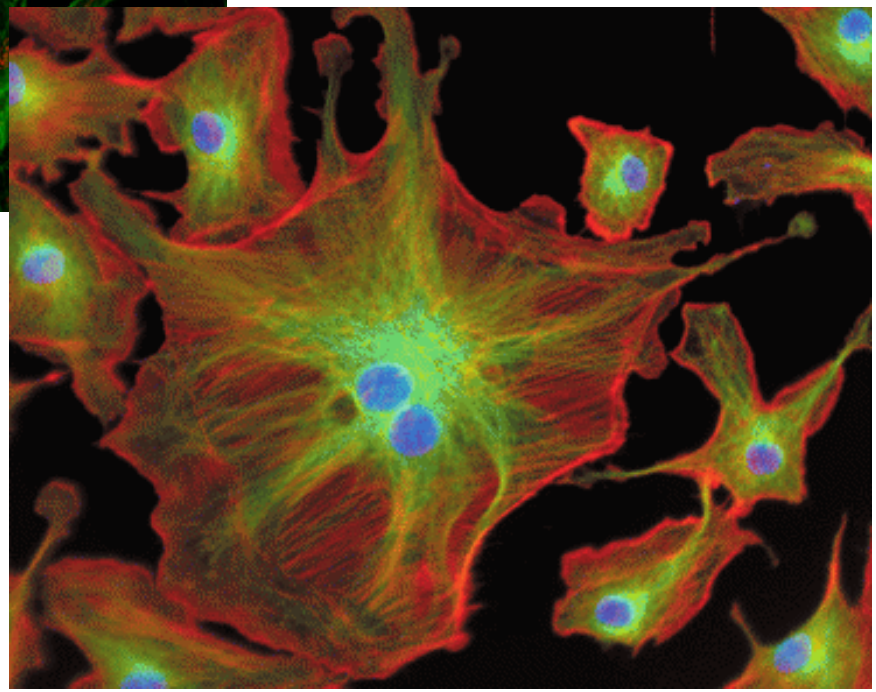
Roles of the Cytoskeleton: Support, Motility, and Regulation

- 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

Fig. 6-21

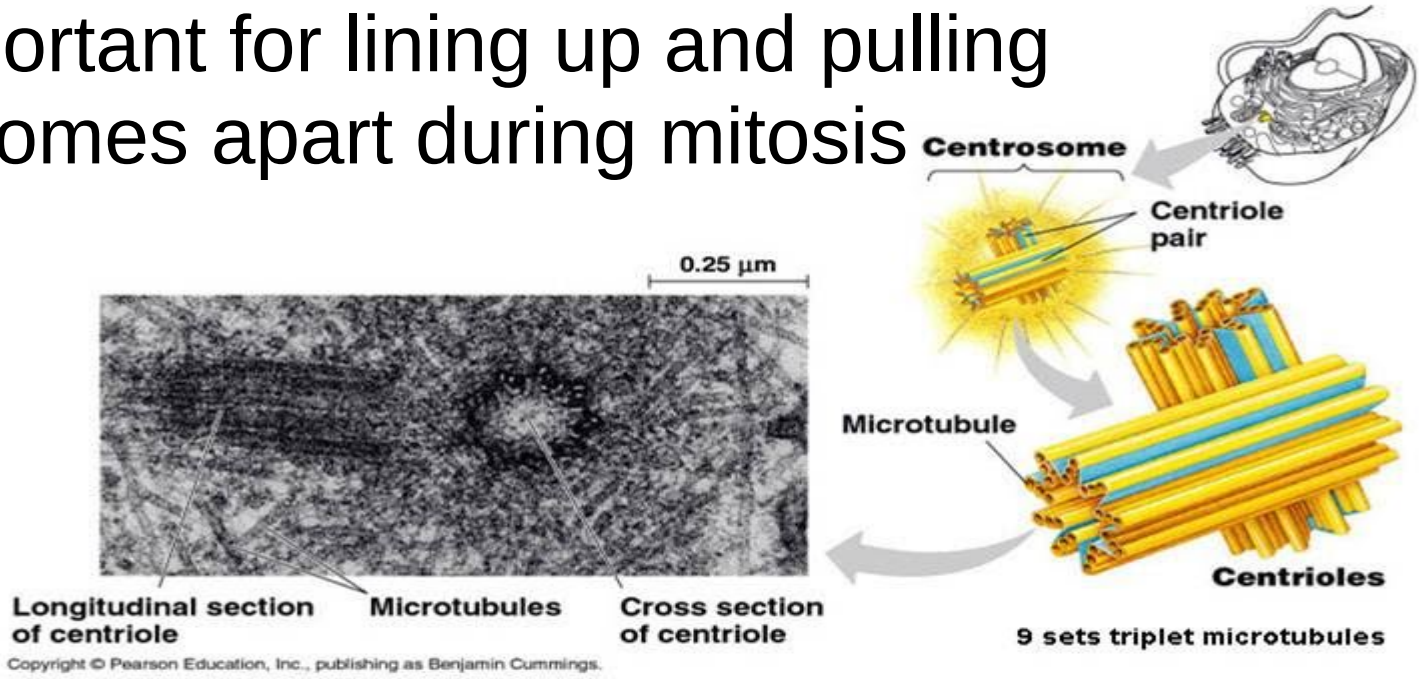






Centrosomes and Centrioles

- In many cells, microtubules grow out from a **centrosome** near the nucleus
- In animal cells, the centrosome has a pair of **centrioles**
- Very important for lining up and pulling chromosomes apart during mitosis



Cilia and Flagella

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

- **Cytoplasmic streaming** is a circular flow of cytoplasm within cells
- This streaming speeds distribution of materials within the cell
- https://www.youtube.com/watch?v=BB5rvjZzgFU

Cell Walls of Plants

- The **cell wall** is an extracellular structure that distinguishes plant cells from animal cells
- Prokaryotes, fungi, and some protists 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

You should now be able to:

1. Distinguish between the following pairs of terms: magnification and resolution; prokaryotic and eukaryotic cell; free and bound ribosomes; smooth and rough ER
2. Describe the structure and function of the components of the endomembrane system
3. Briefly explain the role of mitochondria, chloroplasts, and peroxisomes
4. Describe the functions of the cytoskeleton

5. Compare the structure and functions of microtubules, microfilaments, and intermediate filaments

6. Explain how the ultrastructure of cilia and flagella relate to their functions

7. Describe the structure of a plant cell wall

8. Describe the structure and roles of the extracellular matrix in animal cells

9. Describe four different intercellular junctions