Chapter 6

A Tour of the Cell

Lecture 2

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: The Fundamental Units of Life

- All organisms are made of cells
- The cell is the simplest collection of matter that can live
- Cell structure is correlated to cellular function
- All cells are related by their descent from earlier cells

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

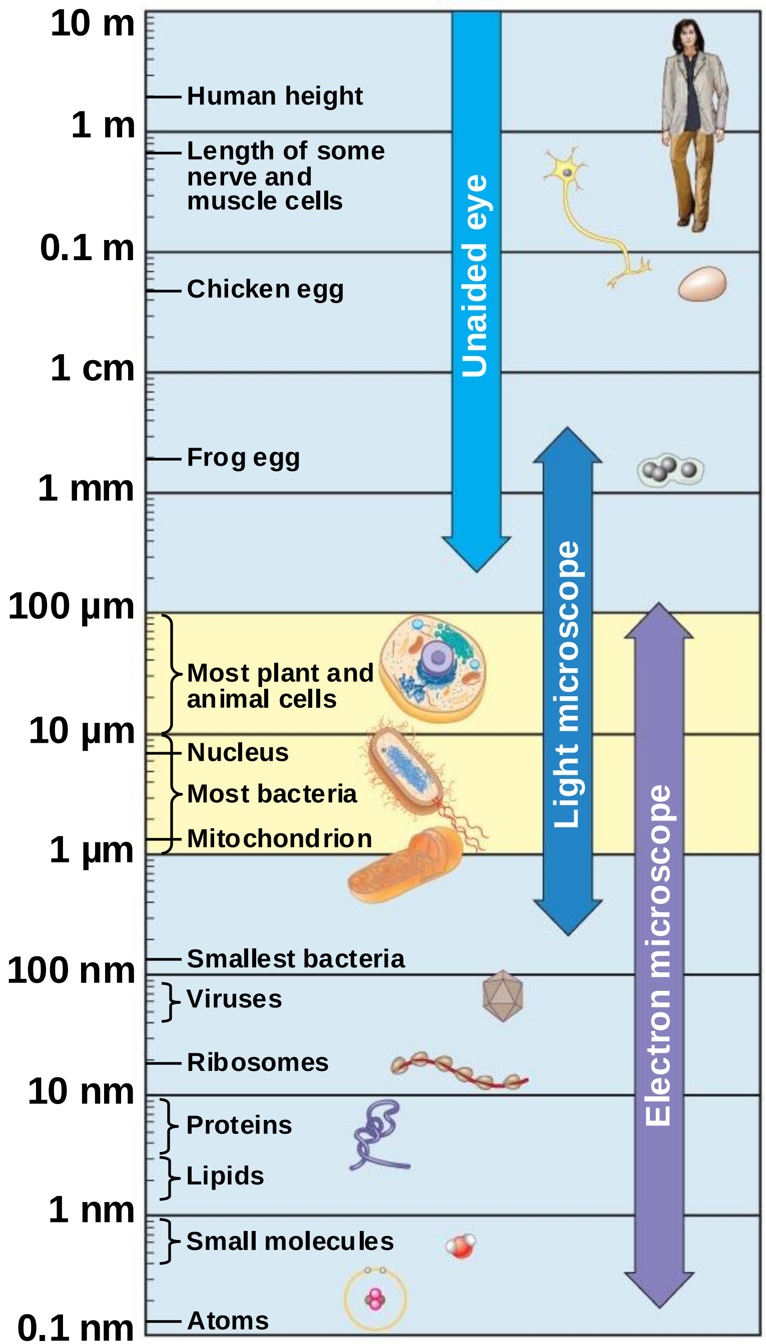
- Though usually too small to be seen by the unaided eye, cells can be complex

Microscopy

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

- 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, or the minimum distance of two distinguishable points
  - *Contrast*, visible differences in parts of the sample

Fig. 6-2


10 m
1 m
0.1 m
1 cm
1 mm
100 µm
10 µm
1 µm
100 nm
10 nm
1 nm
0.1 nm
Human height
Length of some nerve and muscle cells
Chicken egg
Frog egg
Most plant and animal cells
Nucleus
Most bacteria
Mitochondrion
Smallest bacteria
Viruses
Ribosomes
Proteins
Lipids
Small molecules
Atoms
Unaided eye
Light microscope
Electron microscope

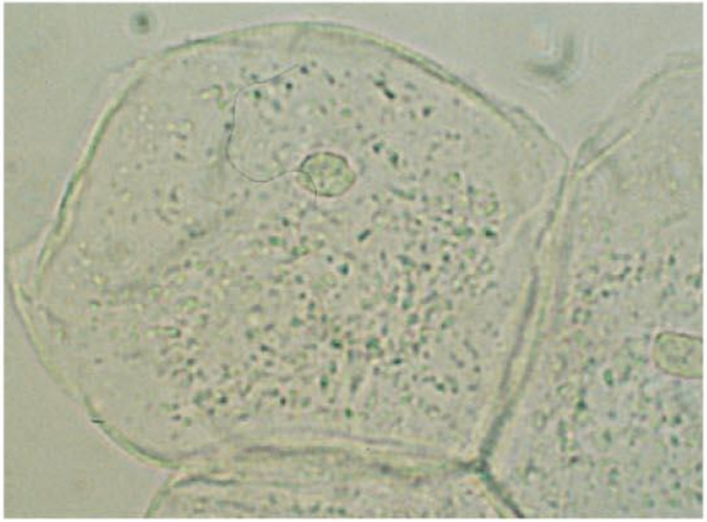
- LMs can magnify effectively to about 1,000 times the size of the actual specimen
- Various techniques enhance contrast and enable cell components to be stained or labeled
- Most subcellular structures, including **organelles** (membrane-enclosed compartments), are too small to be resolved by an LM

Fig. 6-3ab

TECHNIQUE

RESULTS

(a) Brightfield (unstained specimen)



50 µm

(b) Brightfield (stained specimen)

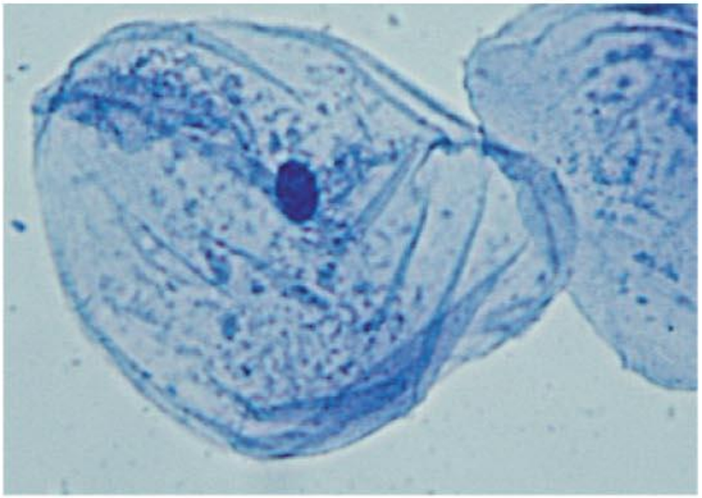


Fig. 6-3cd

TECHNIQUE

RESULTS

(c) Phase-contrast

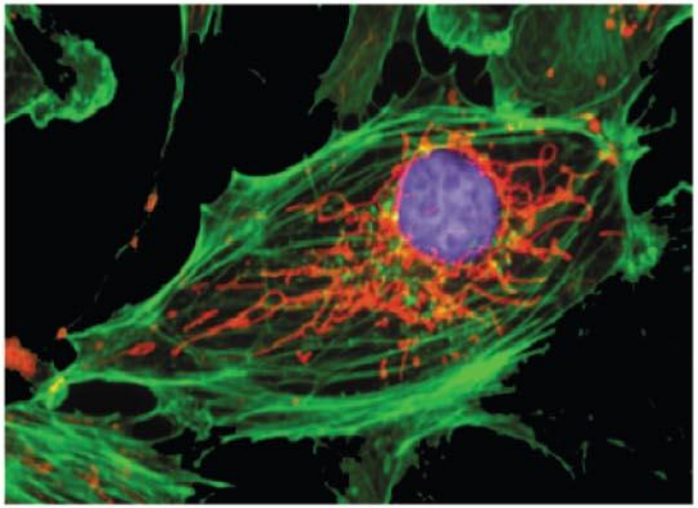
(d) Differential-interference-contrast (Nomarski)

Fig. 6-3e

TECHNIQUE

(e) Fluorescence

RESULTS



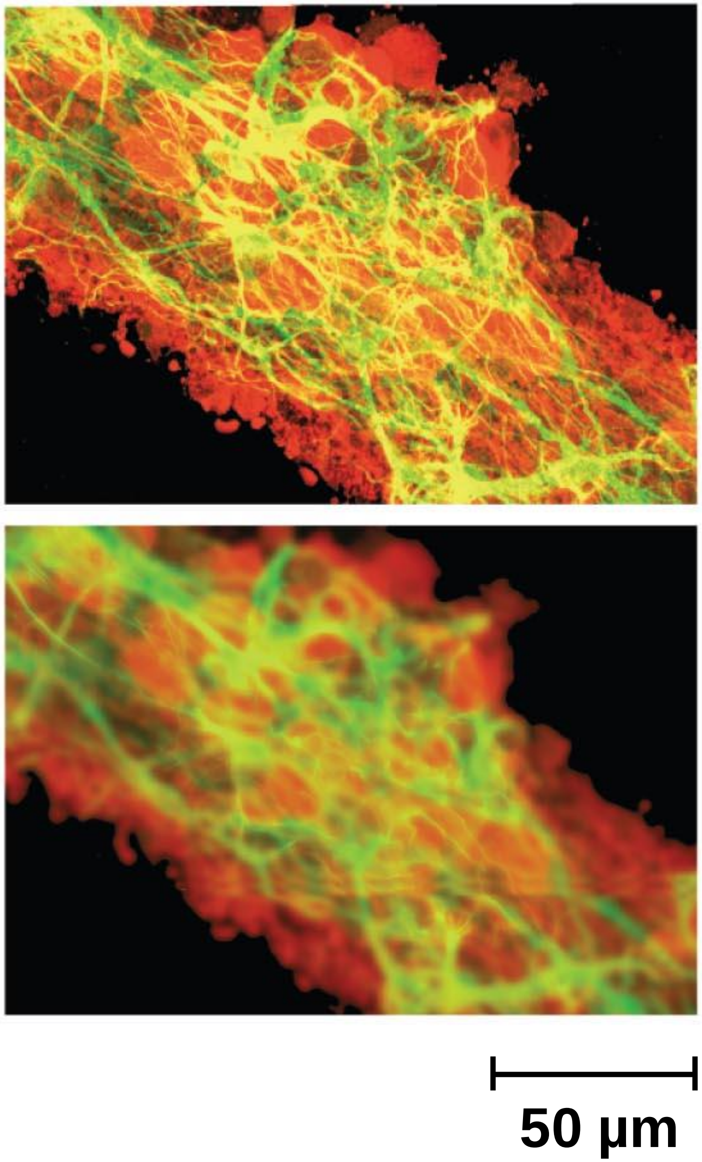
50 µm

Fig. 6-3f

TECHNIQUE

RESULTS

(f) Confocal



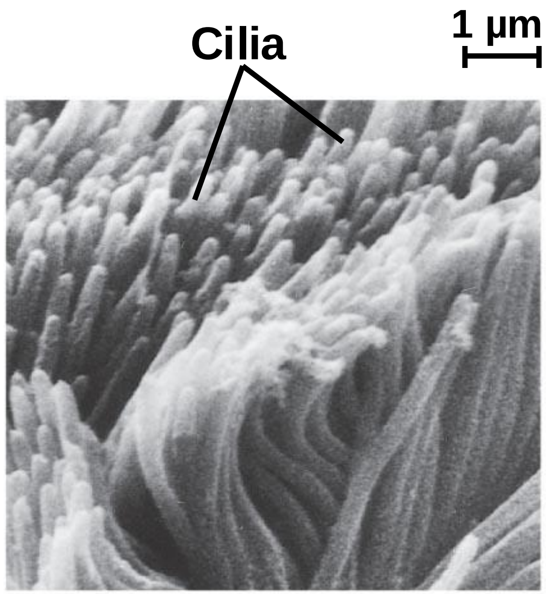
- Two basic types of **electron microscopes (EMs)** are used to study subcellular structures
- **Scanning electron microscopes (SEMs)** focus a beam of electrons onto the surface of a specimen, providing images that look 3-D
- **Transmission electron microscopes (TEMs)** focus a beam of electrons through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

Fig. 6-4

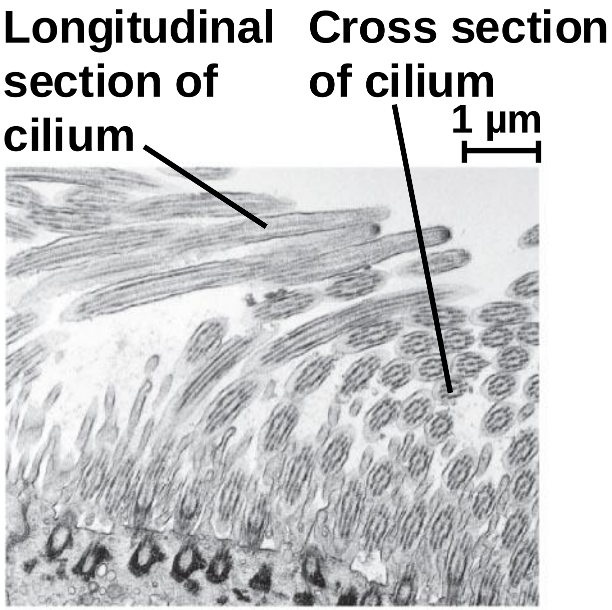
TECHNIQUE

RESULTS

(a) Scanning electron microscopy (SEM)



(b) Transmission electron microscopy (TEM)



Cell Fractionation

- **Cell fractionation** takes cells apart and separates the major organelles from one another
- Ultracentrifuges fractionate cells into their component parts
- Cell fractionation enables scientists to determine the functions of organelles
- Biochemistry and cytology help correlate cell function with structure

Fig. 6-5

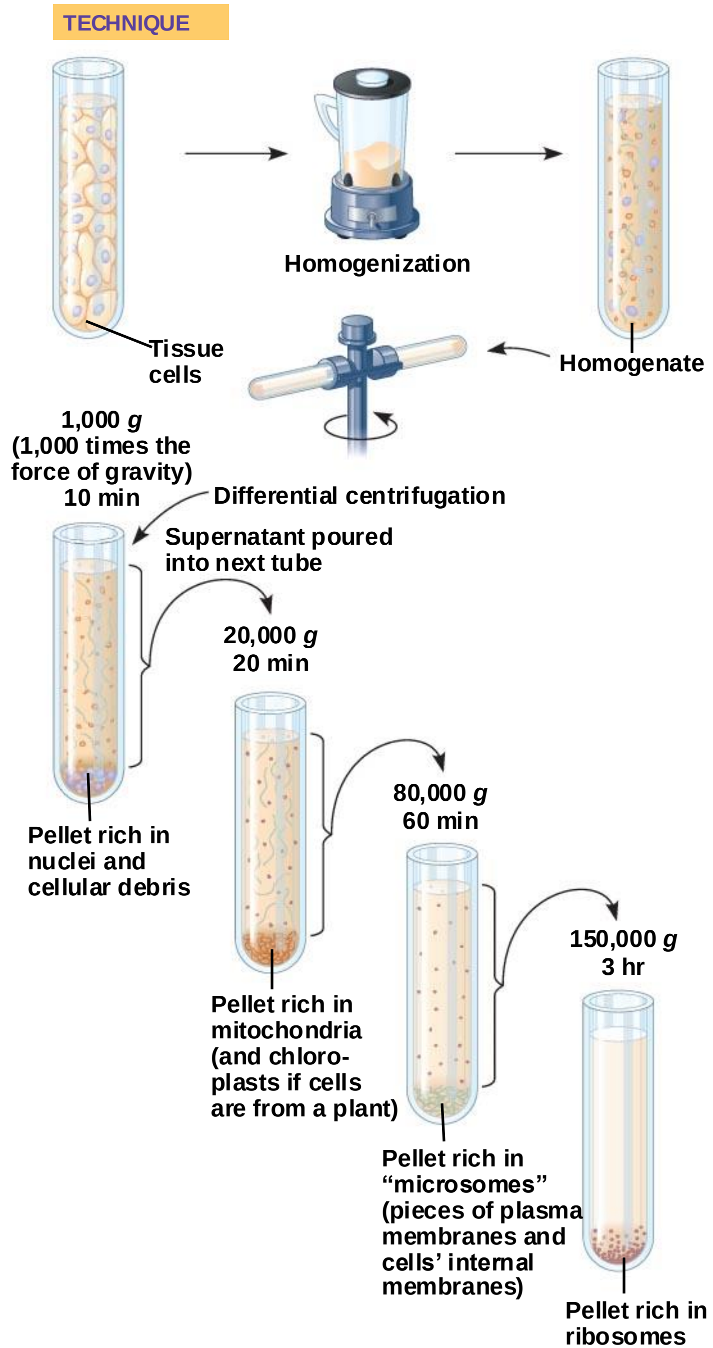

TECHNIQUE
Homogenization
Tissue cells
Homogenate
1,000 g (1,000 times the force of gravity) 10 min
Differential centrifugation
Supernatant poured into next tube
20,000 g 20 min
80,000 g 60 min
150,000 g 3 hr
Pellet rich in nuclei and cellular debris
Pellet rich in mitochondria (and chloro-plasts if cells are from a plant)
Pellet rich in "microsomes" (pieces of plasma membranes and cells' internal membranes)
Pellet rich in ribosomes

Fig. 6-5a

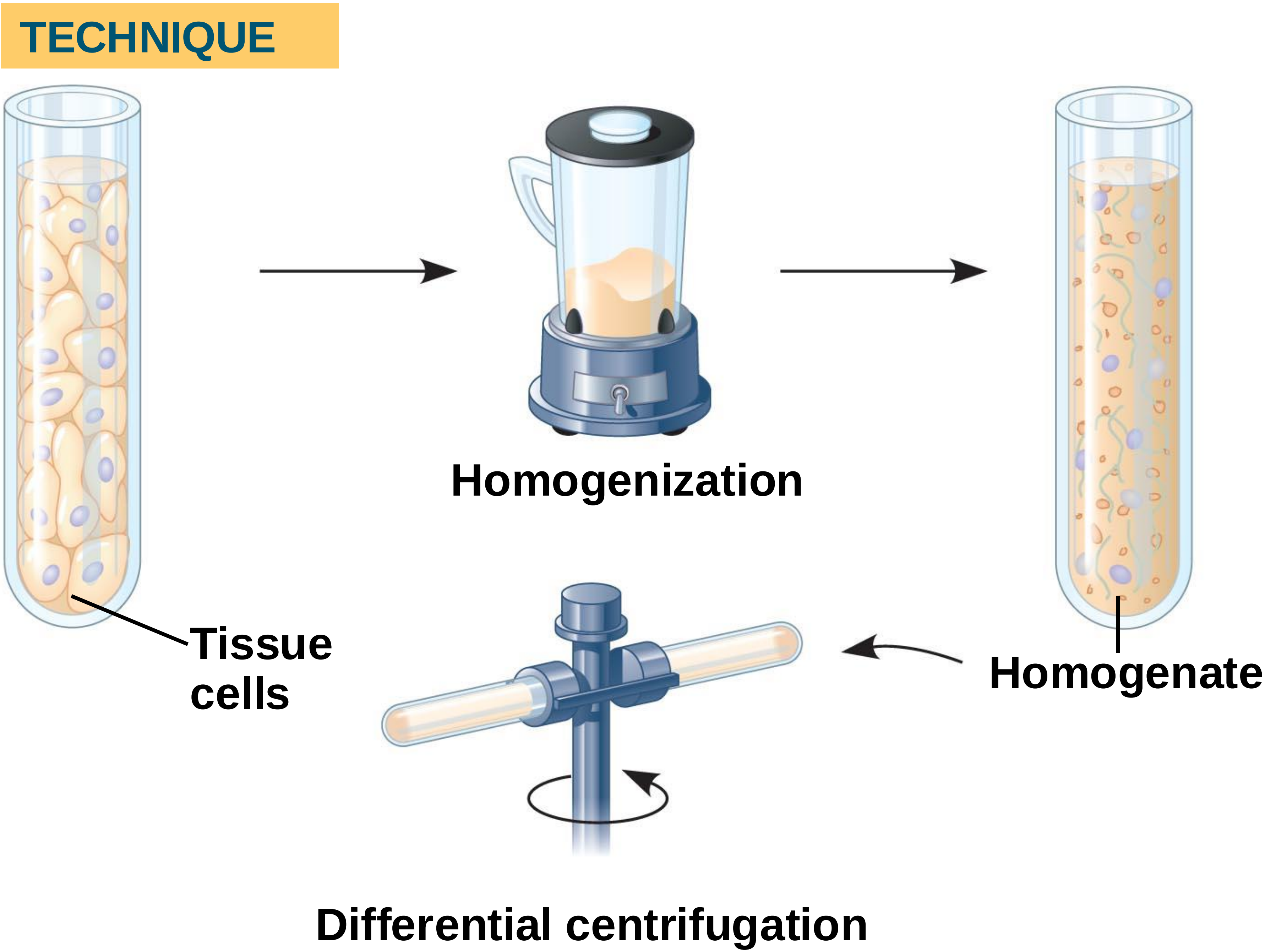
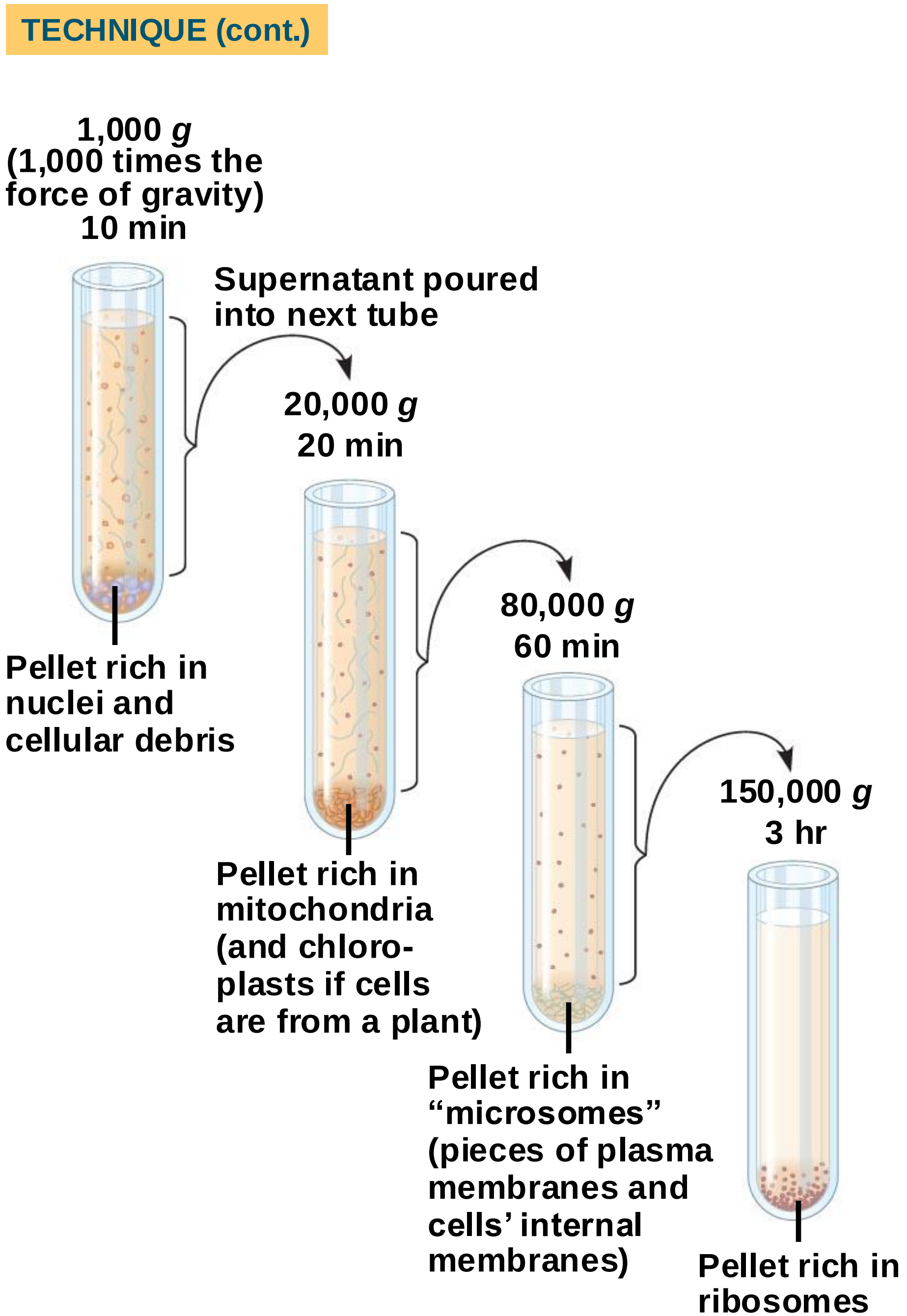

TECHNIQUE
Homogenization
Tissue cells
Homogenate
Differential centrifugation

Fig. 6-5b



TECHNIQUE (cont.)
1,000 *g*
(1,000 times the
force of gravity)
10 min
Supernatant poured
into next tube
20,000 *g*
20 min
80,000 *g*
60 min
150,000 *g*
3 hr
Pellet rich in
nuclei and
cellular debris
Pellet rich in
mitochondria
(and chloro-
plasts if cells
are from a plant)
Pellet rich in
“microsomes”
(pieces of plasma
membranes and
cells’ internal
membranes)
Pellet rich in
ribosomes

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

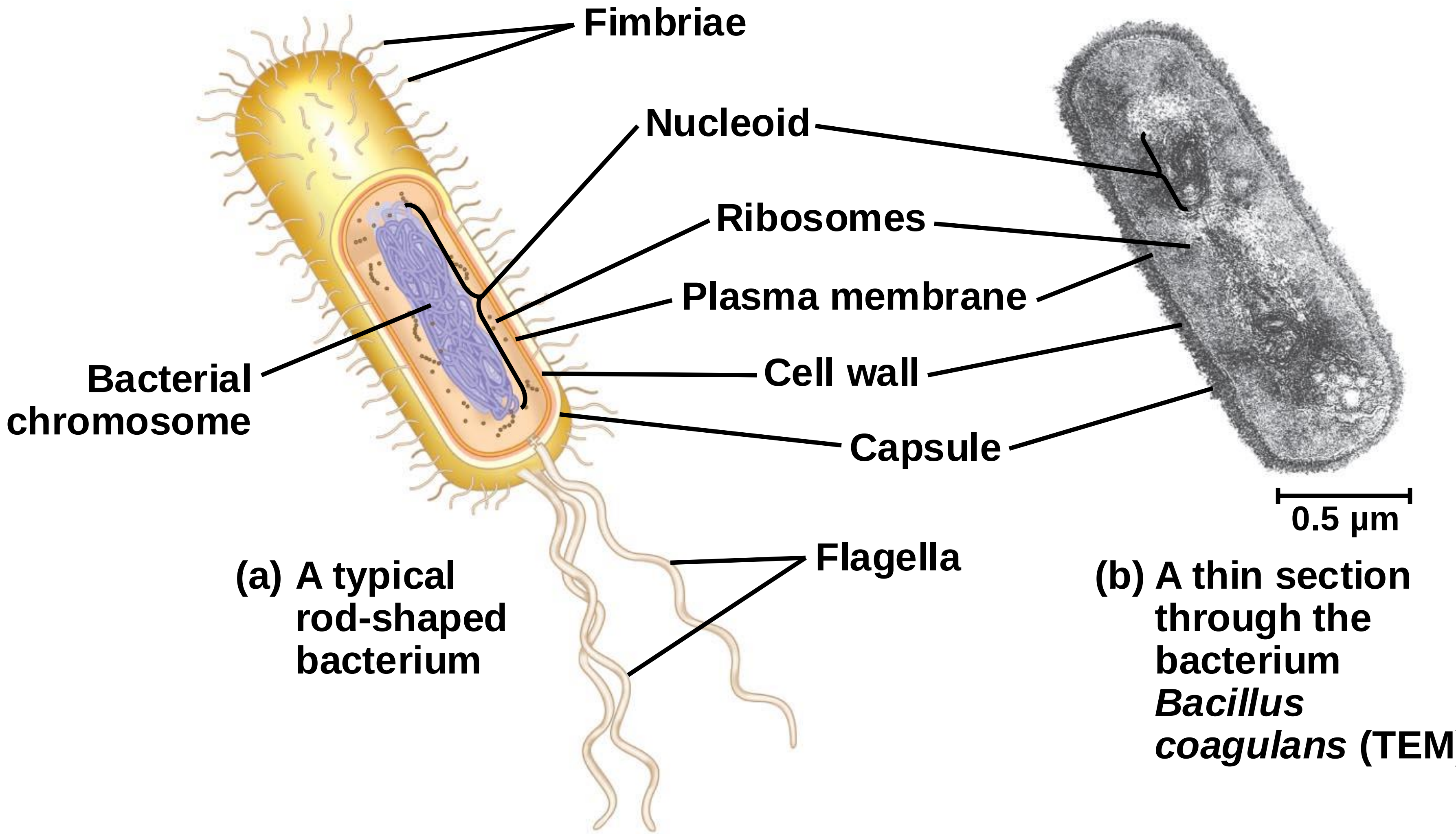
- The basic structural and functional unit of every organism is one of two types of cells: prokaryotic or eukaryotic
- Only organisms of the domains Bacteria and Archaea consist of prokaryotic cells
- Protists, fungi, animals, and plants all consist of eukaryotic cells

Comparing Prokaryotic and Eukaryotic Cells

- Basic features of all cells:
  - Plasma membrane
  - Semifluid substance called **cytosol**
  - 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

Fig. 6-6



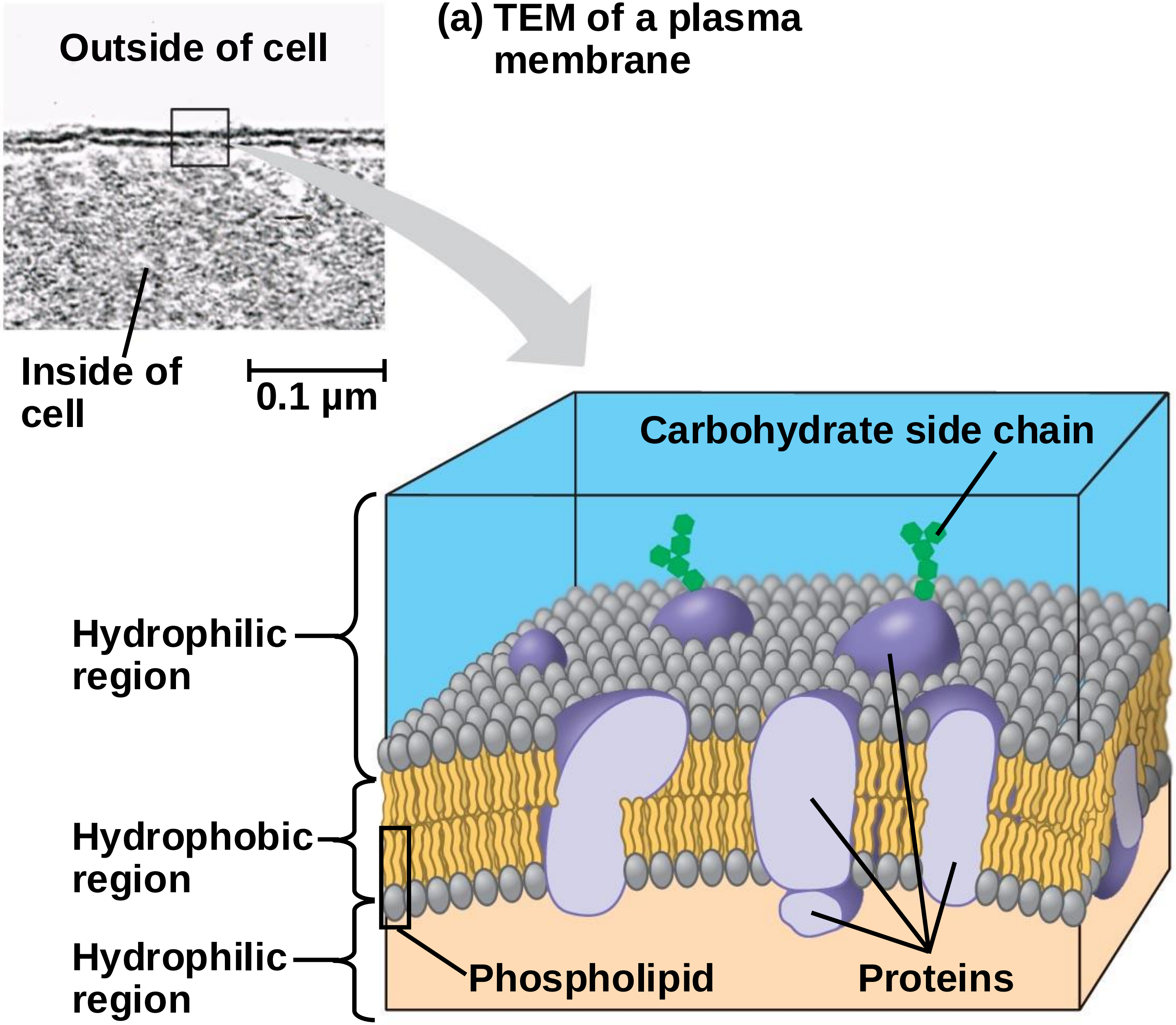
(a) A typical rod-shaped bacterium

(b) A thin section through the bacterium *Bacillus coagulans* (TEM)

- **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

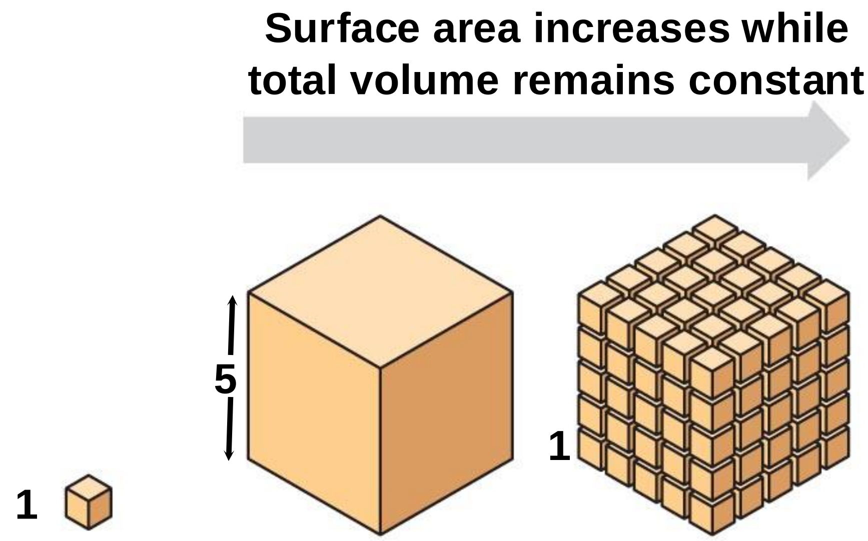


(a) TEM of a plasma membrane

(b) Structure of the plasma membrane

- 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



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**

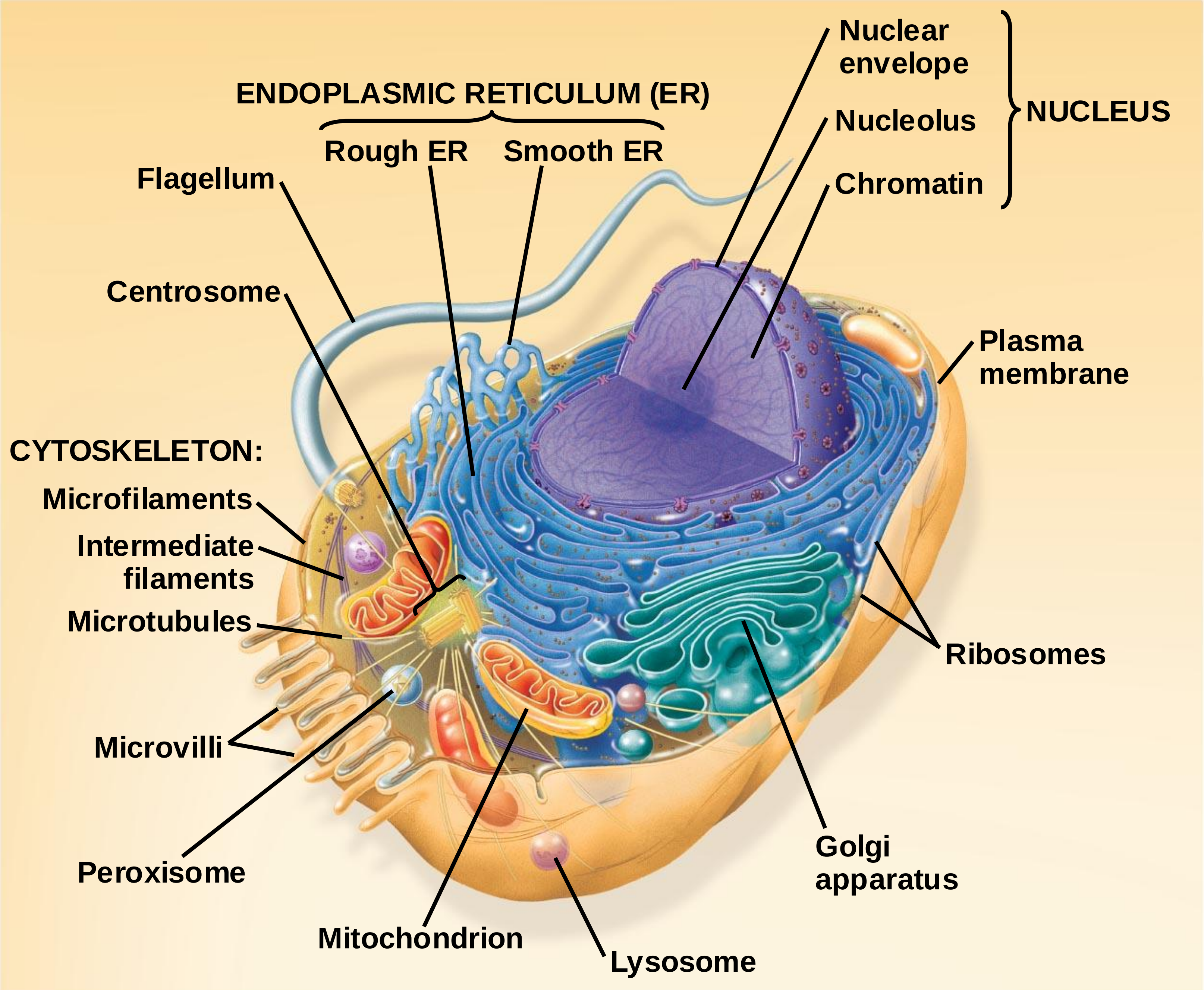
A Panoramic View of the Eukaryotic Cell

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

PLAY BioFlix: Tour Of An Animal Cell

PLAY BioFlix: Tour Of A Plant Cell

Fig. 6-9a



ENDOPLASMIC RETICULUM (ER)
Rough ER
Smooth ER
Nuclear envelope
Nucleolus
Chromatin
NUCLEUS
Flagellum
Centrosome
Plasma membrane
CYTOSKELETON:
Microfilaments
Intermediate filaments
Microtubules
Ribosomes
Microvilli
Peroxisome
Golgi apparatus
Mitochondrion
Lysosome

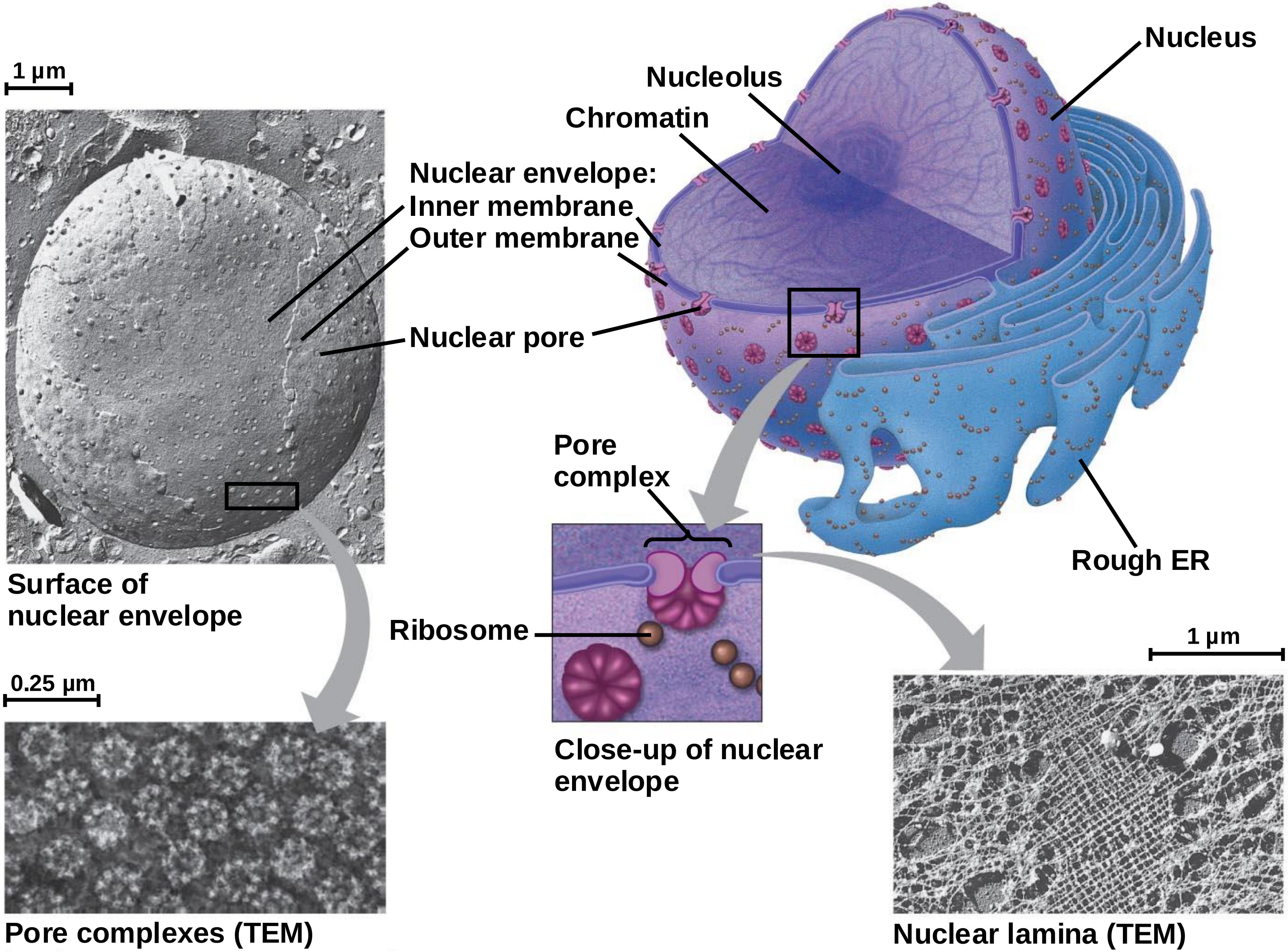
Concept 6.3: The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes

- 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

Fig. 6-10



1 µm
Nucleolus
Chromatin
Nucleus
Nuclear envelope:
Inner membrane
Outer membrane
Nuclear pore
Surface of nuclear envelope
Pore complex
Rough ER
Ribosome
1 µm
0.25 µm
Close-up of nuclear envelope
Pore complexes (TEM)
Nuclear lamina (TEM)

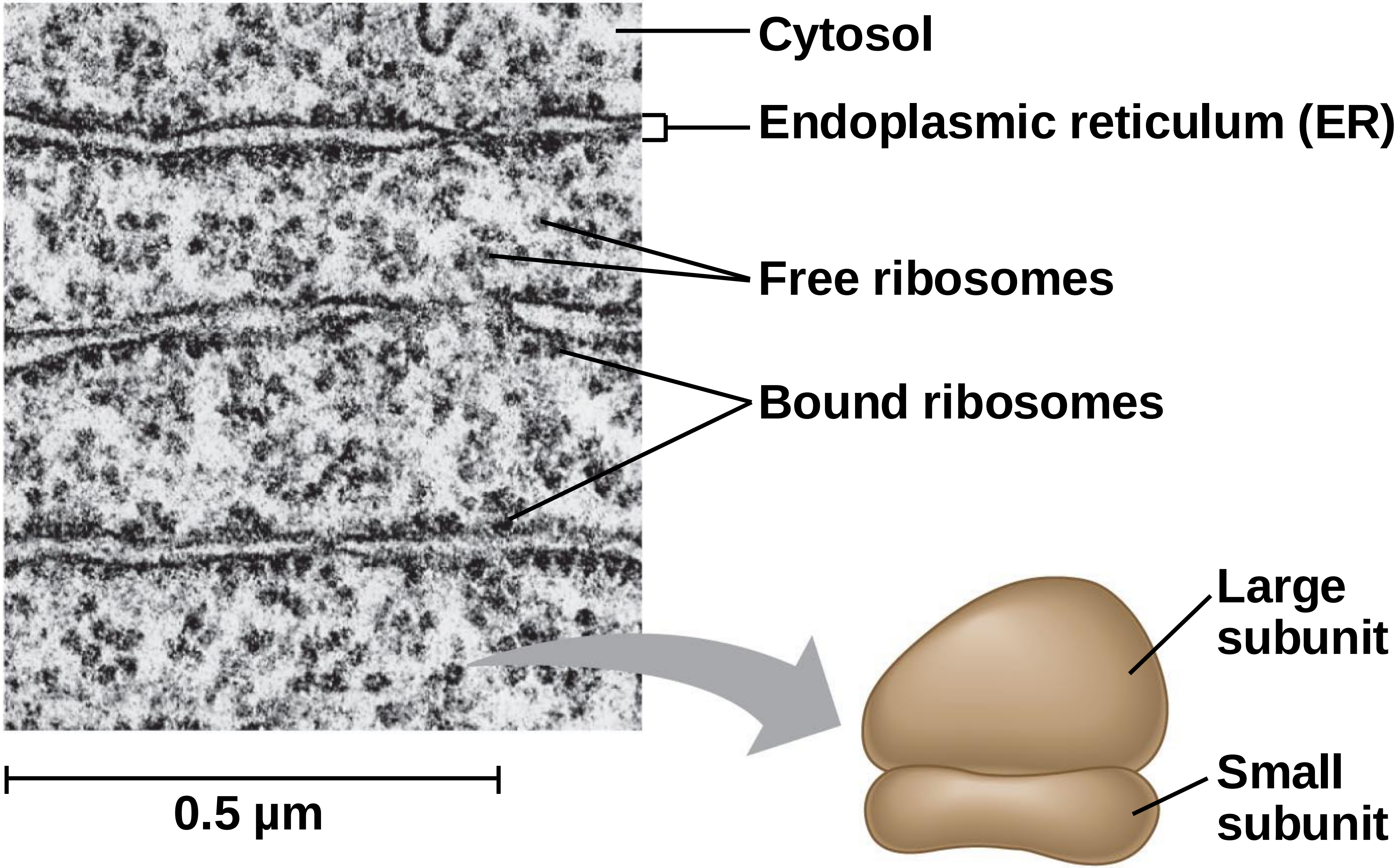
- Pores regulate the entry and exit of molecules from the nucleus
- The shape of the nucleus is maintained by the **nuclear lamina**, which is composed of protein

- 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

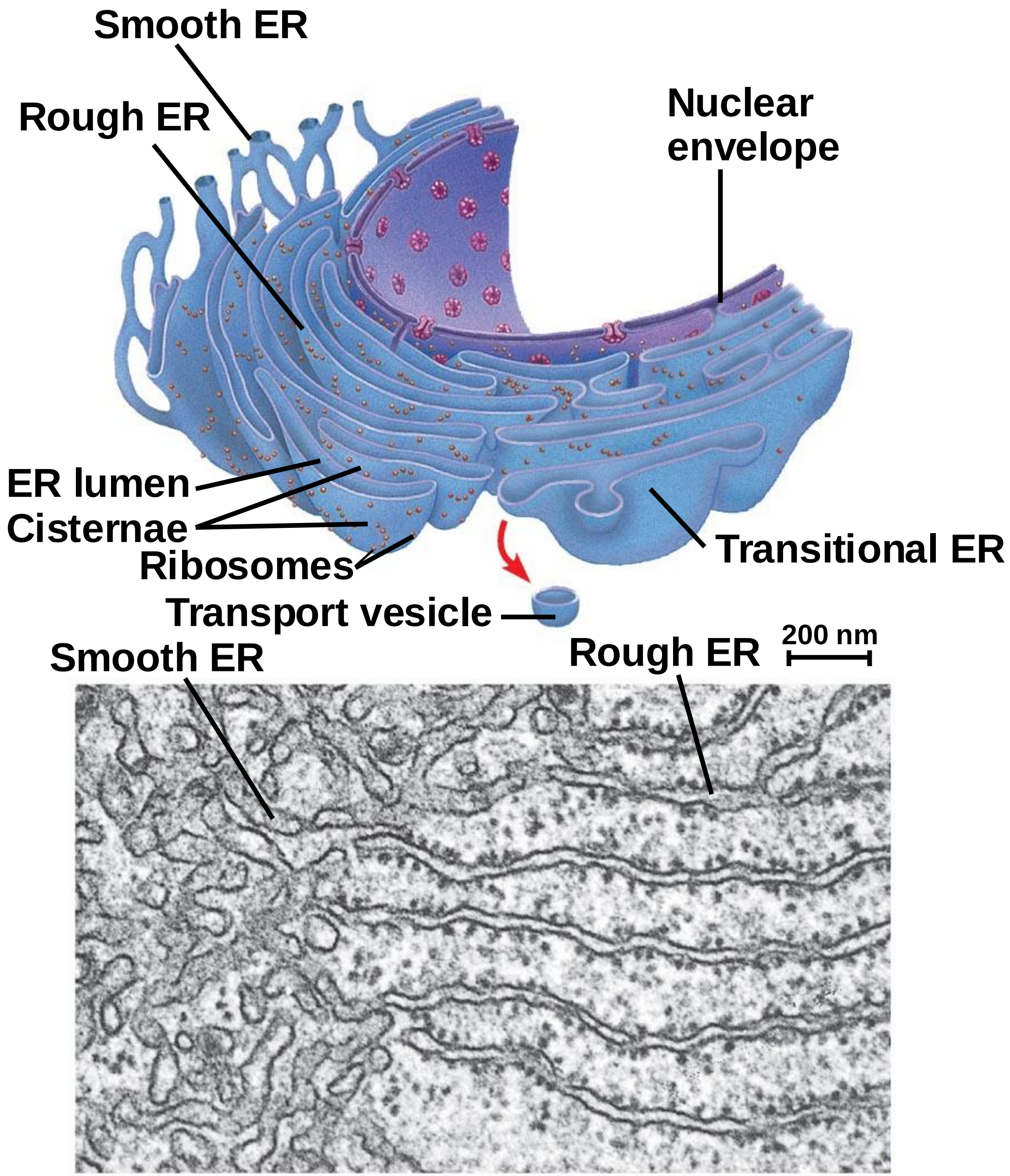
Concept 6.4: The endomembrane system regulates protein traffic and performs metabolic functions in the cell

- 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


Smooth ER
Rough ER
Nuclear envelope
ER lumen
Cisternae
Ribosomes
Transport vesicle
Transitional ER
Smooth ER
Rough ER
200 nm

Functions of Smooth ER

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

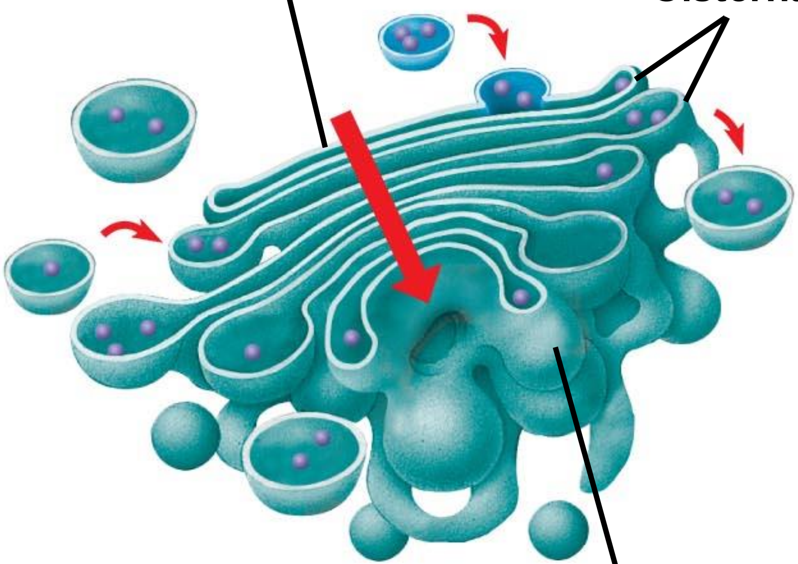
Functions of Rough ER

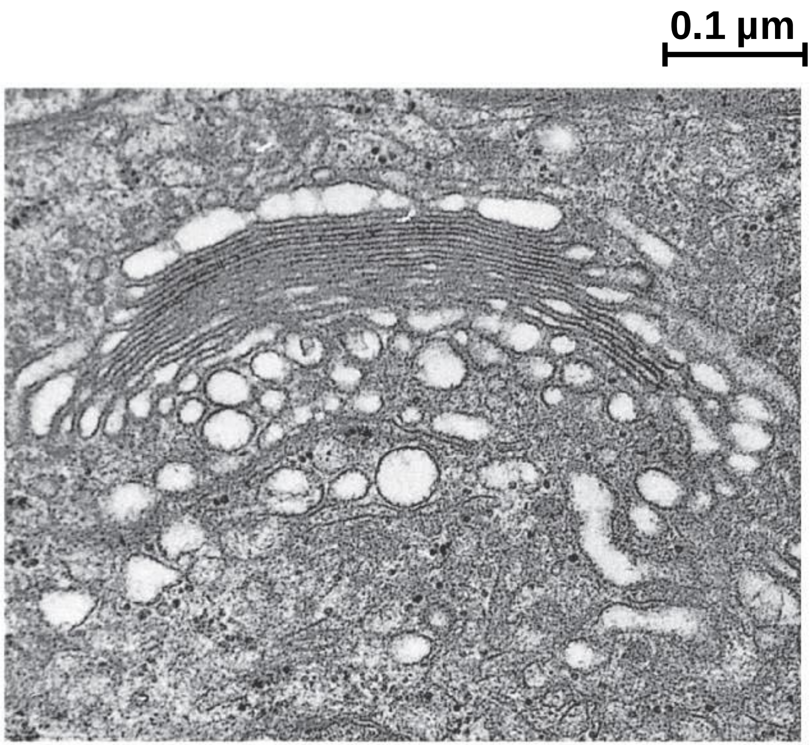
- The rough ER
  - Has bound ribosomes, which secrete **glycoproteins** (proteins covalently bonded to carbohydrates)
  - Distributes **transport vesicles,** proteins surrounded by membranes
  - Is a membrane factory for the cell

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
  - Manufactures certain macromolecules
  - Sorts and packages materials into transport vesicles

Fig. 6-13





TEM of Golgi apparatus

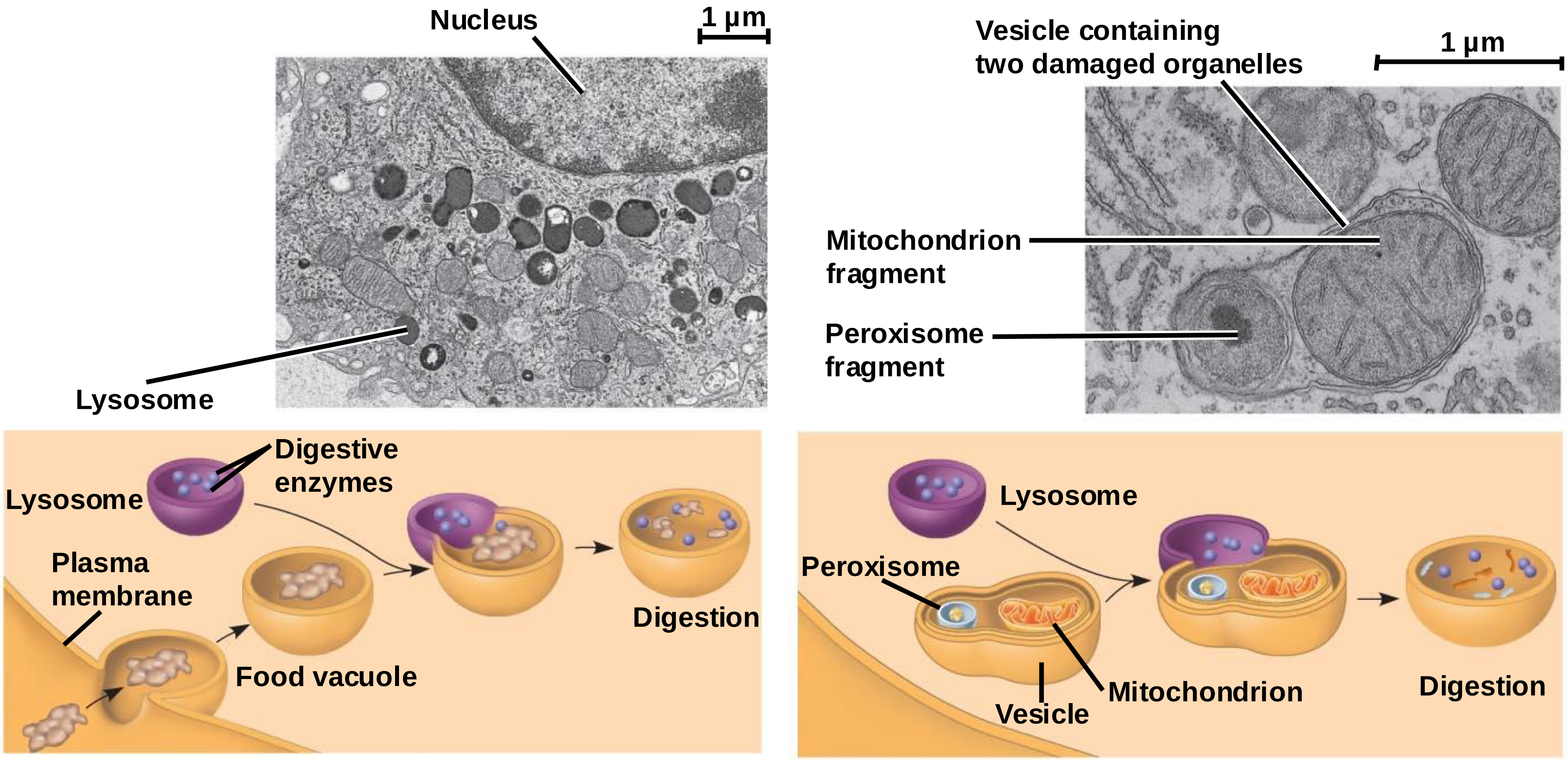
Lysosomes: Digestive Compartments

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

PLAY Animation: Lysosome Formation

- 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

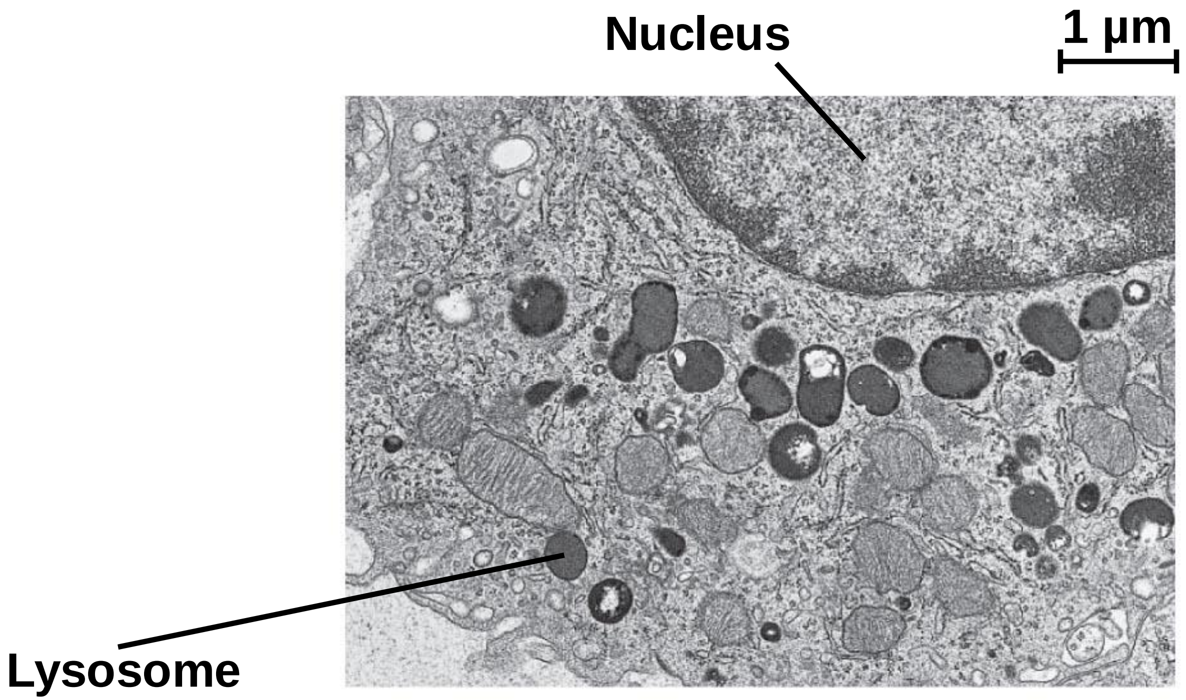
Fig. 6-14

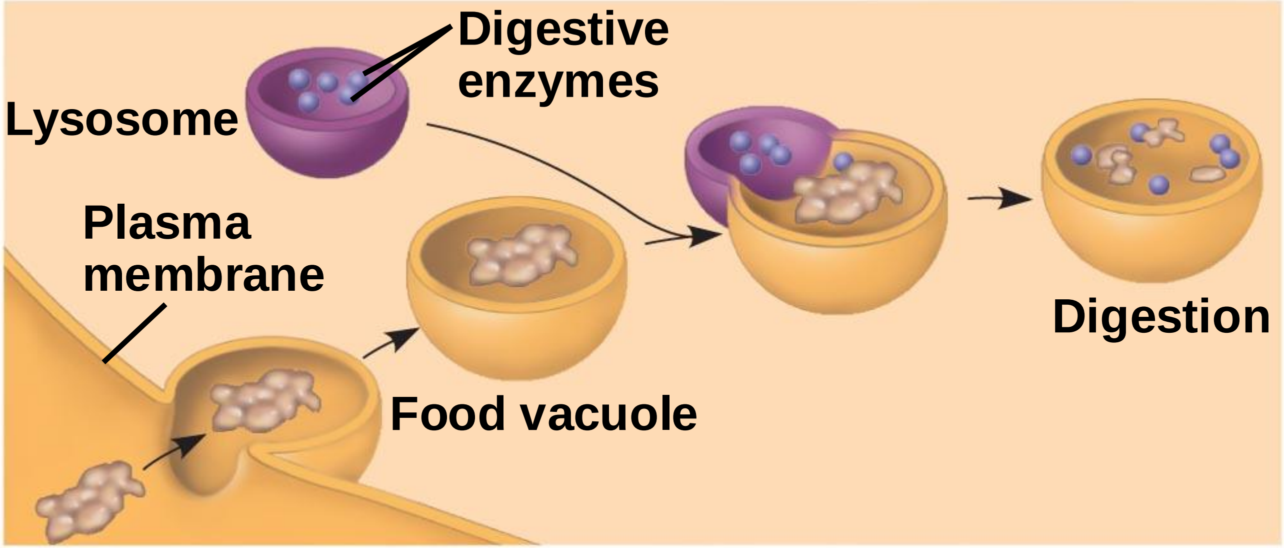


(a) Phagocytosis

(b) Autophagy

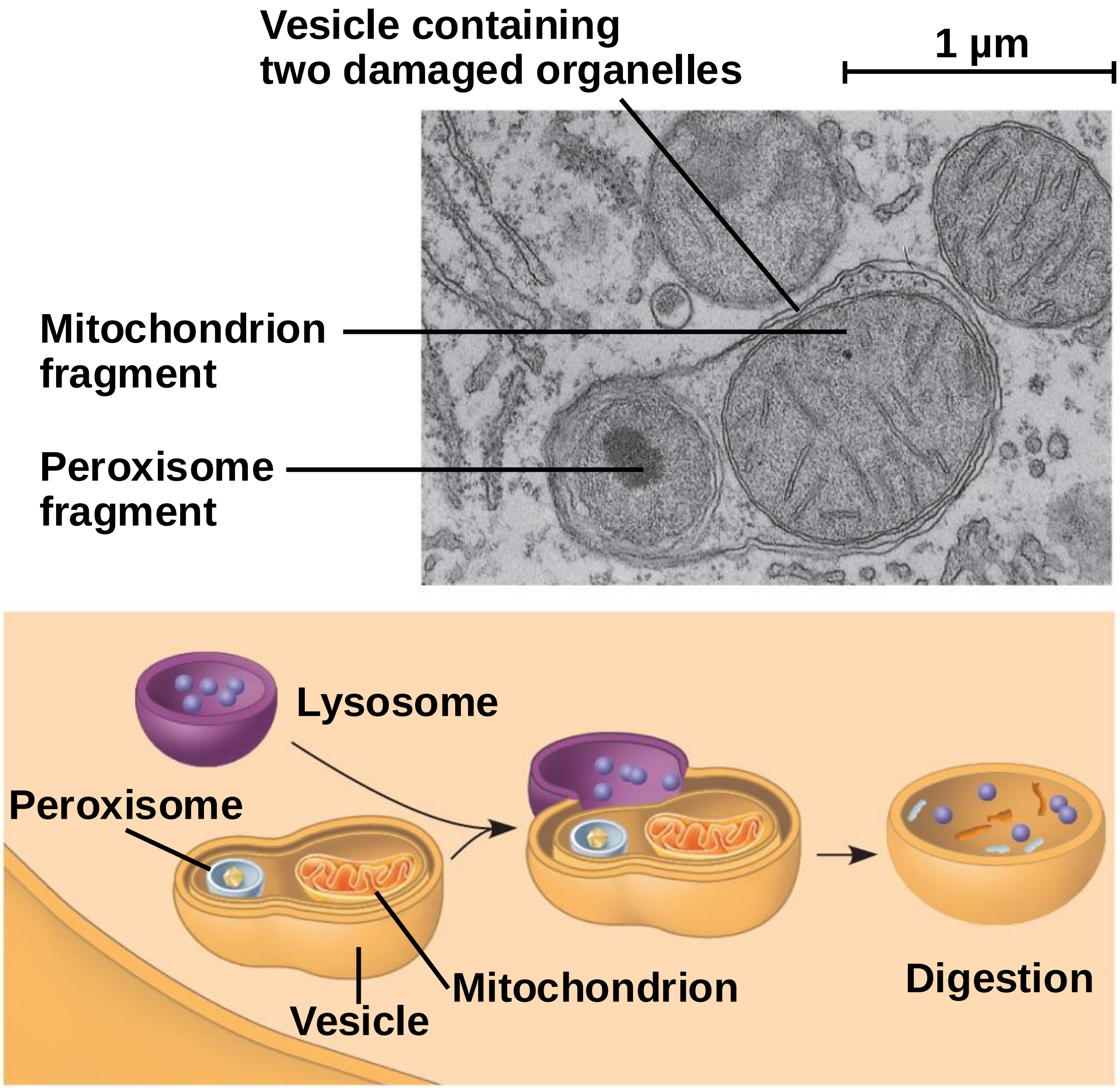
Fig. 6-14a





(a) Phagocytosis

Fig. 6-14b



(b) Autophagy

Vacuoles: Diverse Maintenance Compartments

- A plant cell or fungal cell may have one or several vacuoles

- **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

PLAY Video: Paramecium Vacuole

The Endomembrane System: *A Review*

- The endomembrane system is a complex and dynamic player in the cell's compartmental organization

Fig. 6-16-1

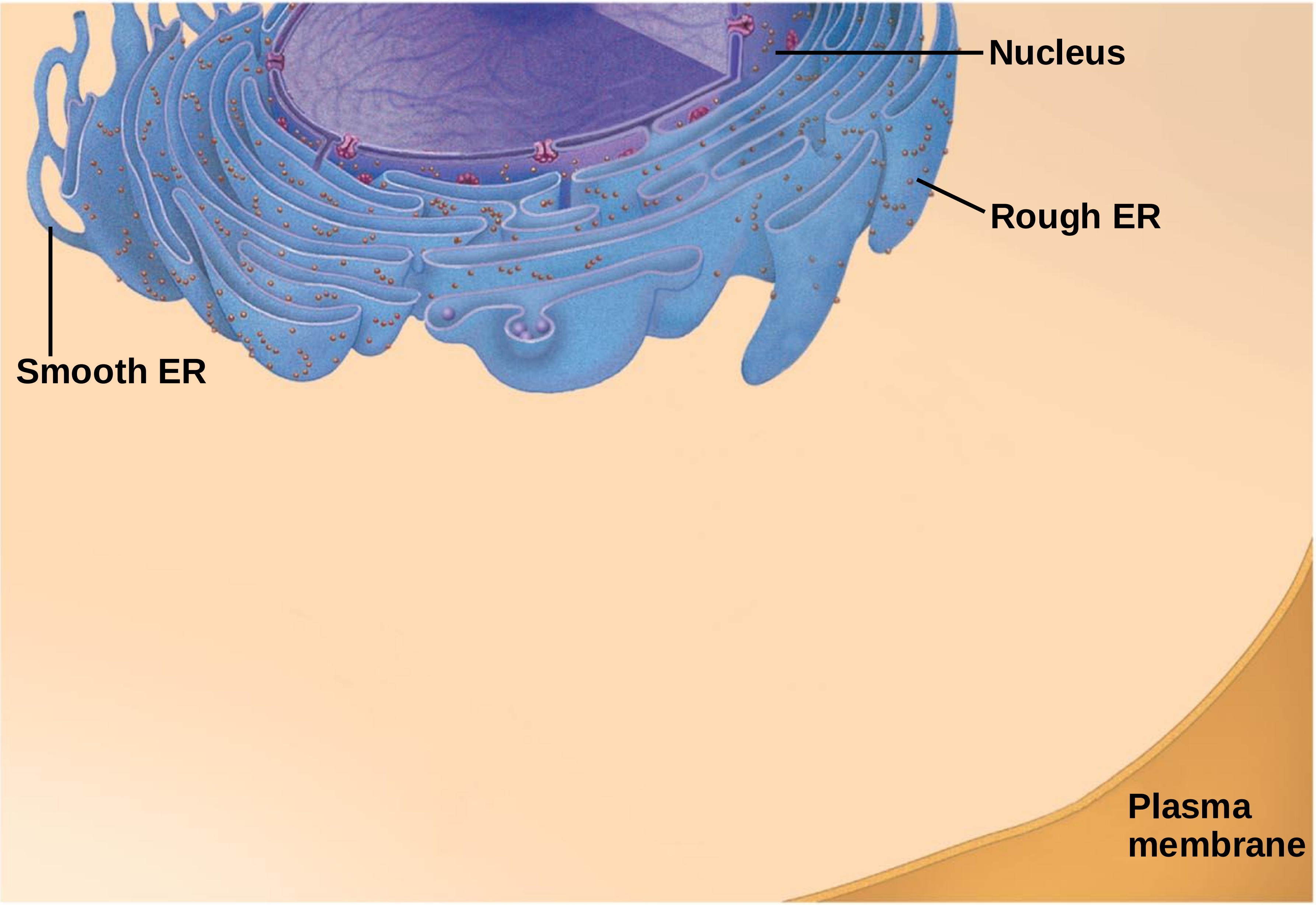


Fig. 6-16-2

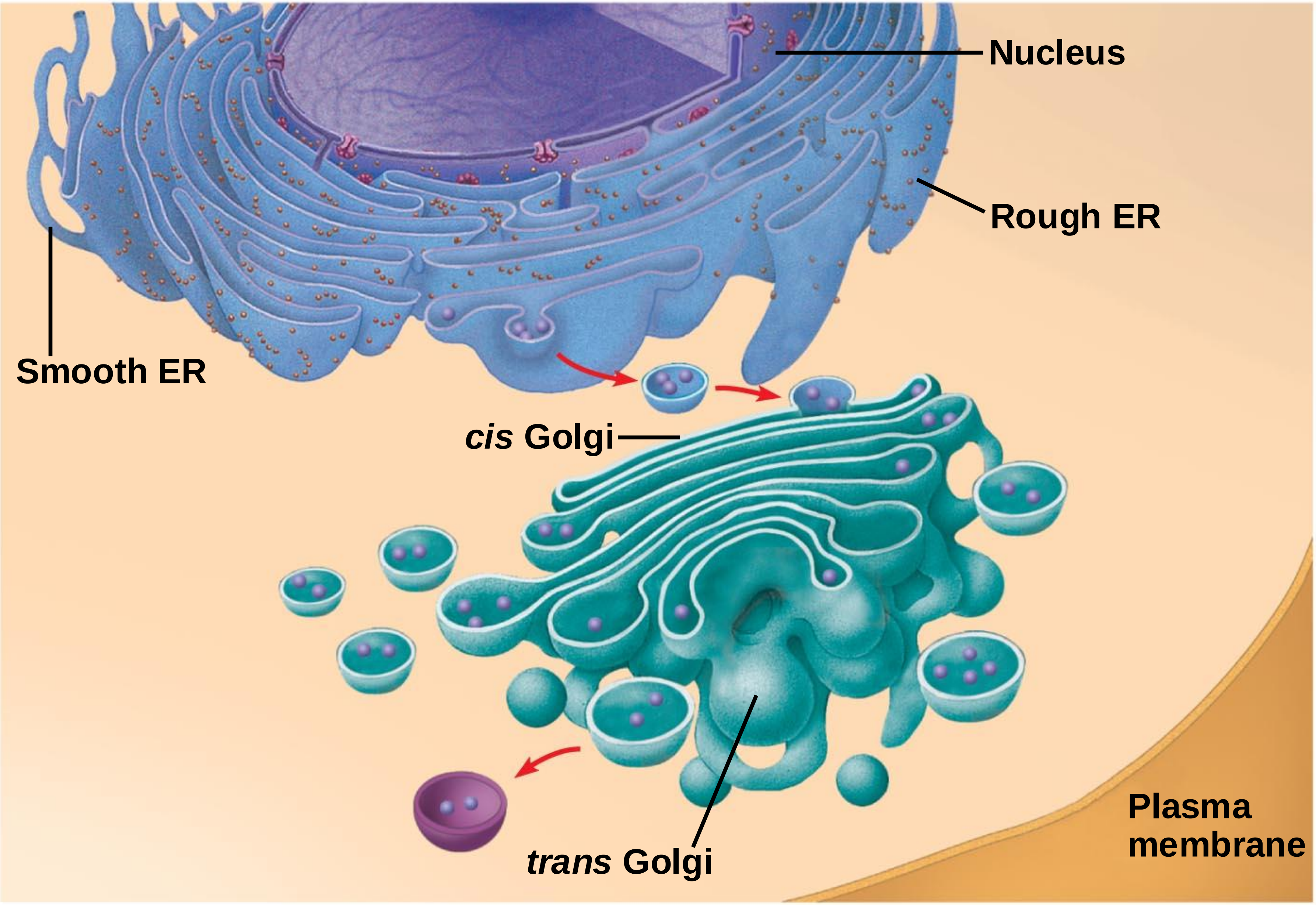
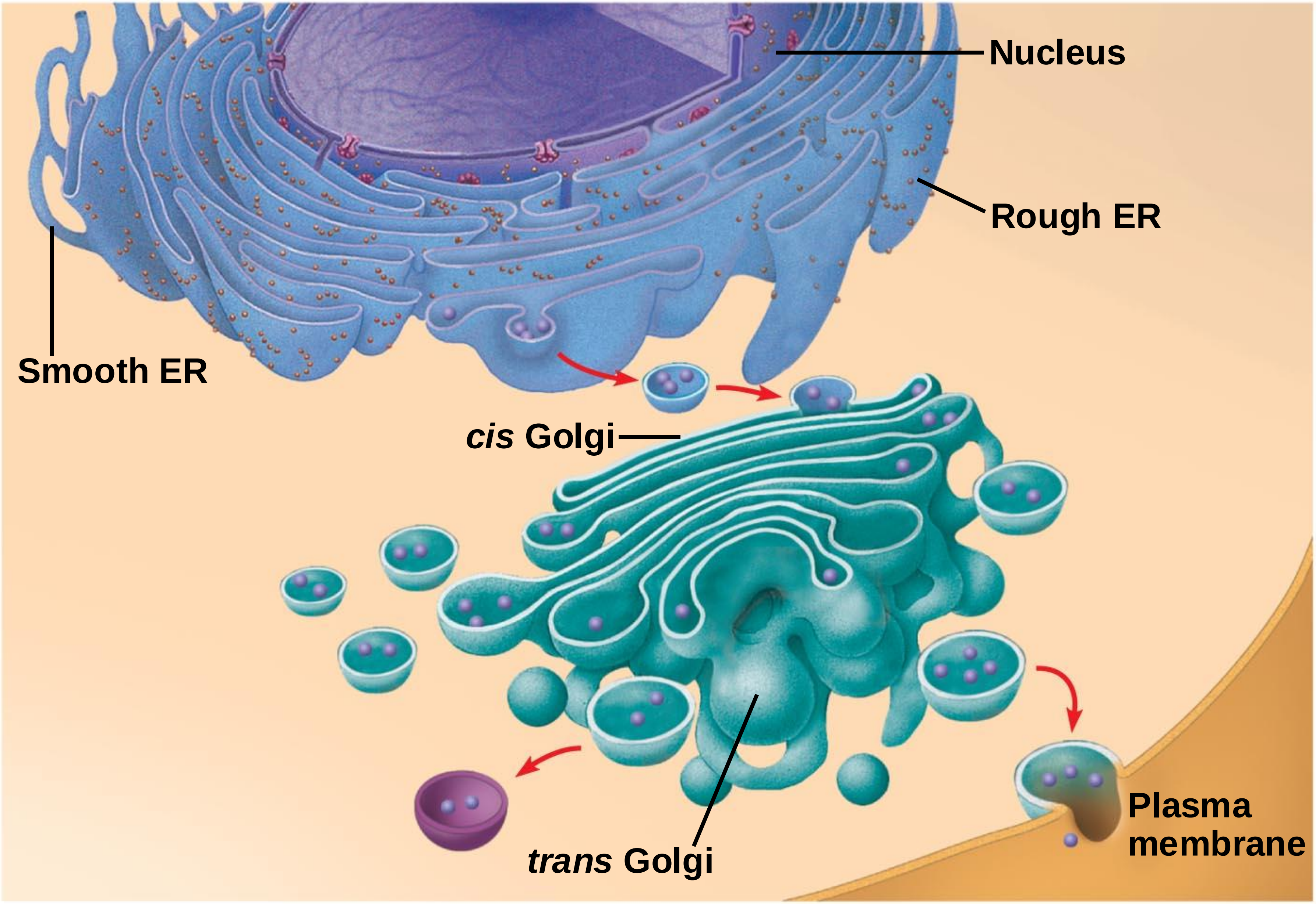

Nucleus
Rough ER
Smooth ER
cis Golgi
trans Golgi
Plasma membrane

Fig. 6-16-3



Nucleus
Rough ER
Smooth ER
cis Golgi
trans Golgi
Plasma membrane

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

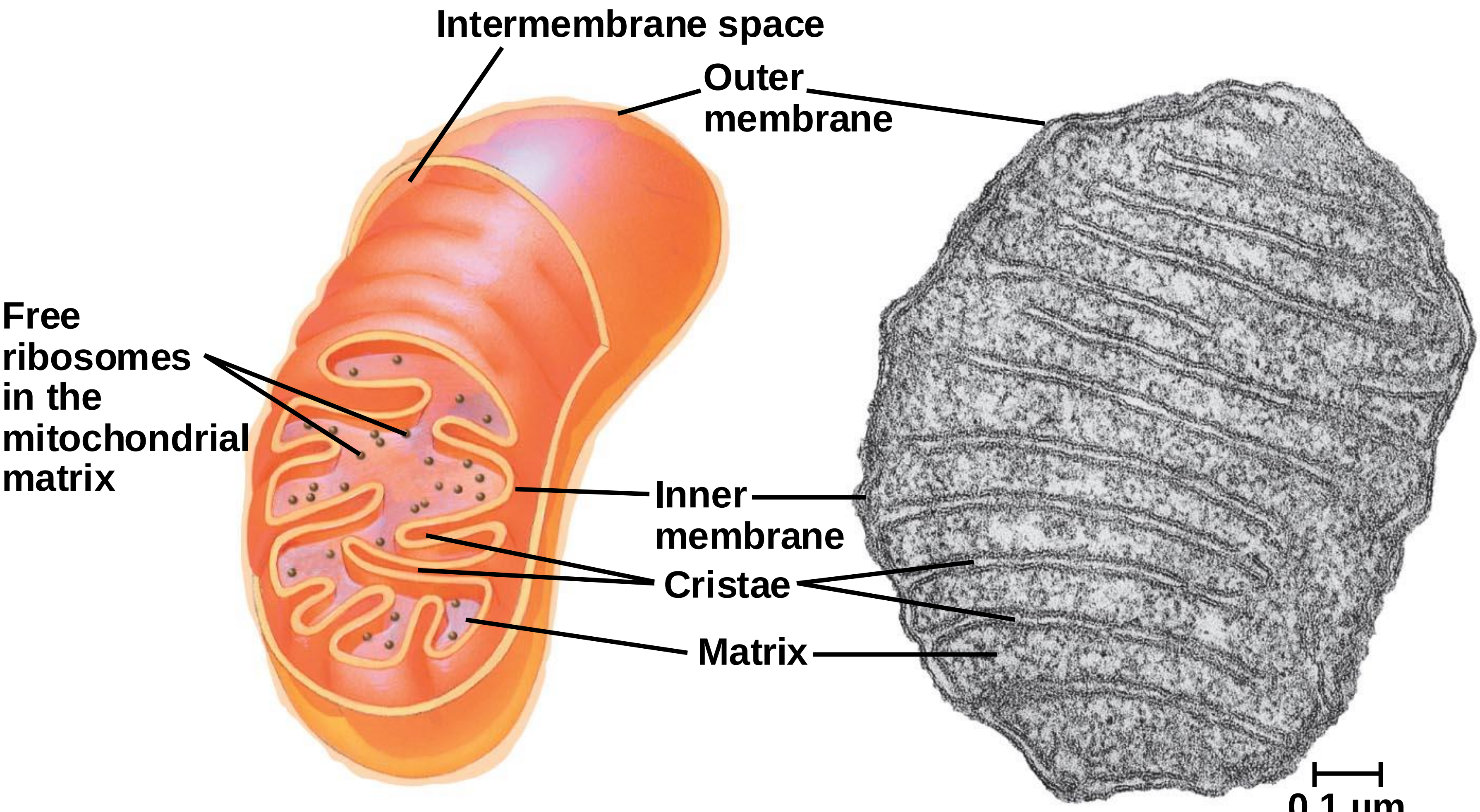
- **Mitochondria** are the sites of cellular respiration, a metabolic process that generates ATP
- **Chloroplasts**, found in plants and algae, are the sites of photosynthesis
- **Peroxisomes** are oxidative organelles

- 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



Intermembrane space
Outer membrane
Free ribosomes in the mitochondrial matrix
Inner membrane
Cristae
Matrix
0.1 µm

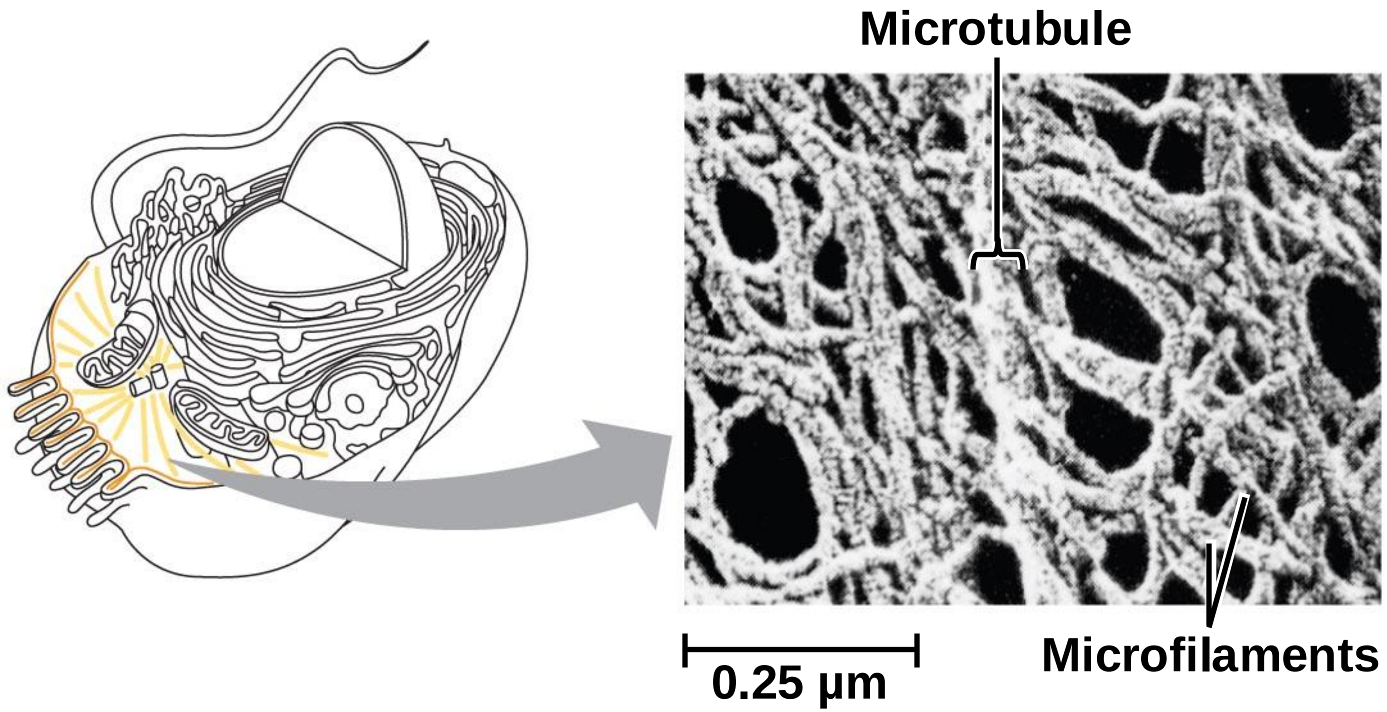
Peroxisomes: Oxidation

- Peroxisomes are specialized metabolic compartments bounded by a single membrane
- Peroxisomes produce hydrogen peroxide and convert it to water
- Oxygen is used to break down different types of molecules

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
  - Microfilaments
  - Intermediate filaments

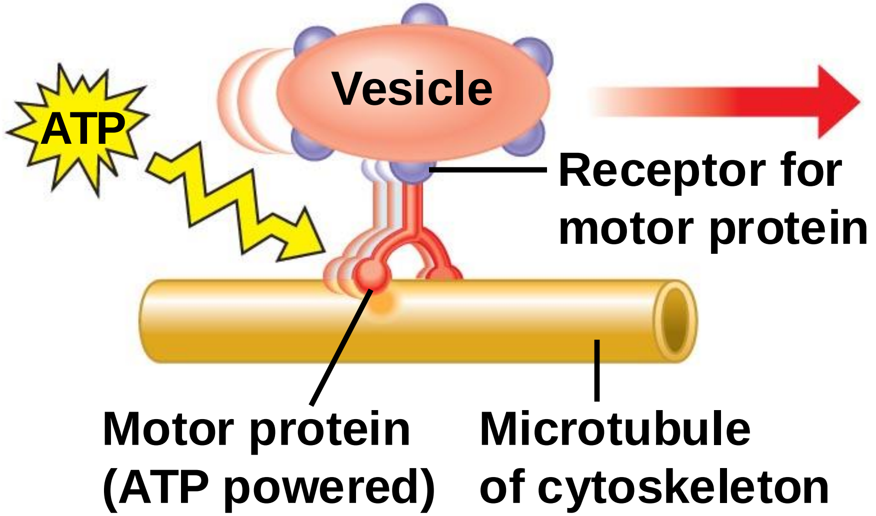
Fig. 6-20



Roles of the Cytoskeleton: Support, Motility, and Regulation

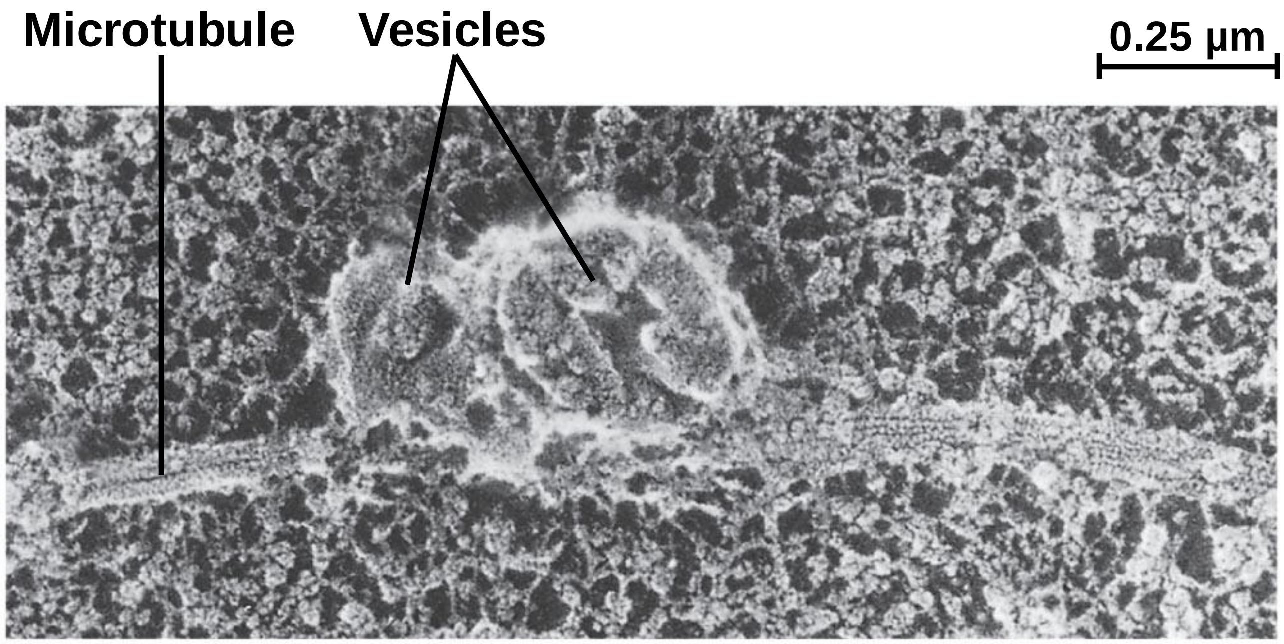
- The cytoskeleton helps to support the cell and maintain its shape
- It interacts with **motor proteins** to produce motility
- Inside the cell, vesicles can travel along “monorails” provided by the cytoskeleton
- Recent evidence suggests that the cytoskeleton may help regulate biochemical activities

Fig. 6-21



ATP
Vesicle
Receptor for motor protein
Motor protein (ATP powered)
Microtubule of cytoskeleton

(a)



Microtubule
Vesicles
0.25 µm

(b)

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 6-1a

Property	Microtubules (Tubulin Polymers)
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules
Diameter	25 nm with 15-nm lumen
Protein subunits	Tubulin
Main functions	Maintenance of cell shape Cell motility Chromosome movements in cell division Organelle movements

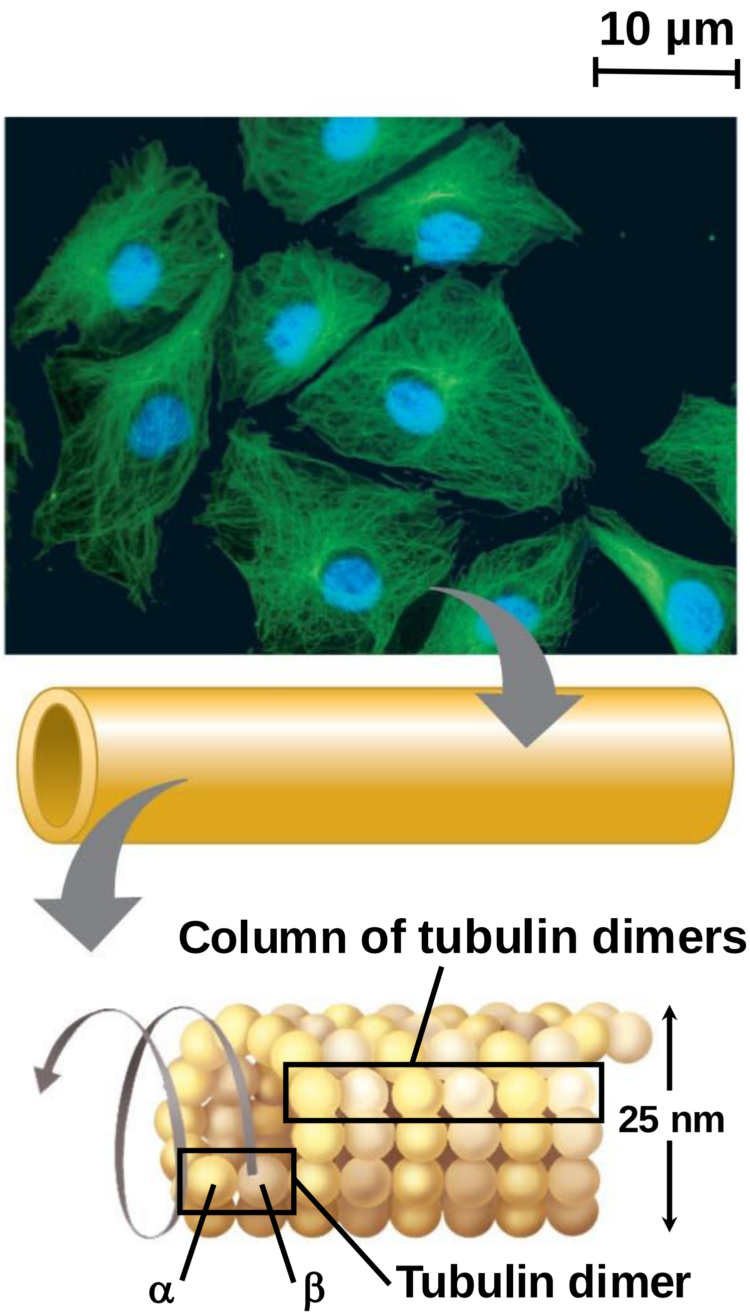


Table 6-1b

Property	Microfilaments (Actin Filaments)
Structure	Two intertwined strands of actin
Diameter	7 nm
Protein subunits	Actin
Main functions	Maintenance of cell shape Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility Cell division

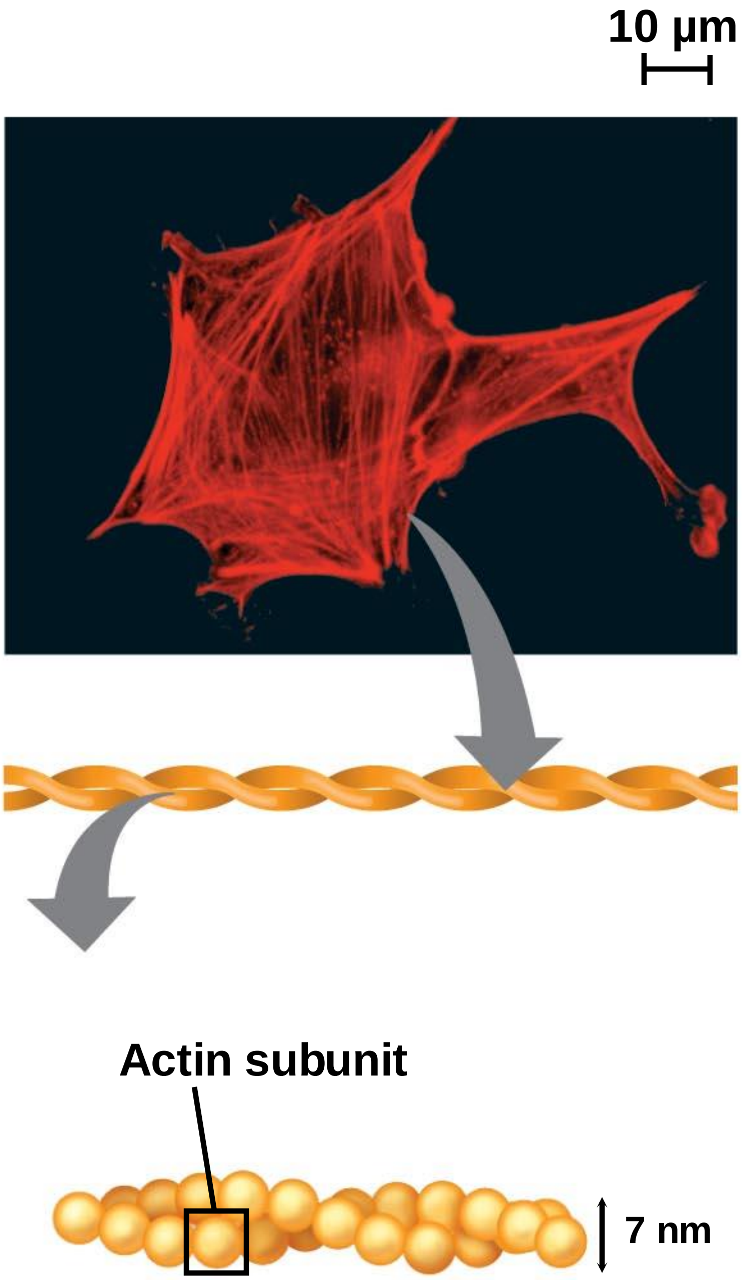
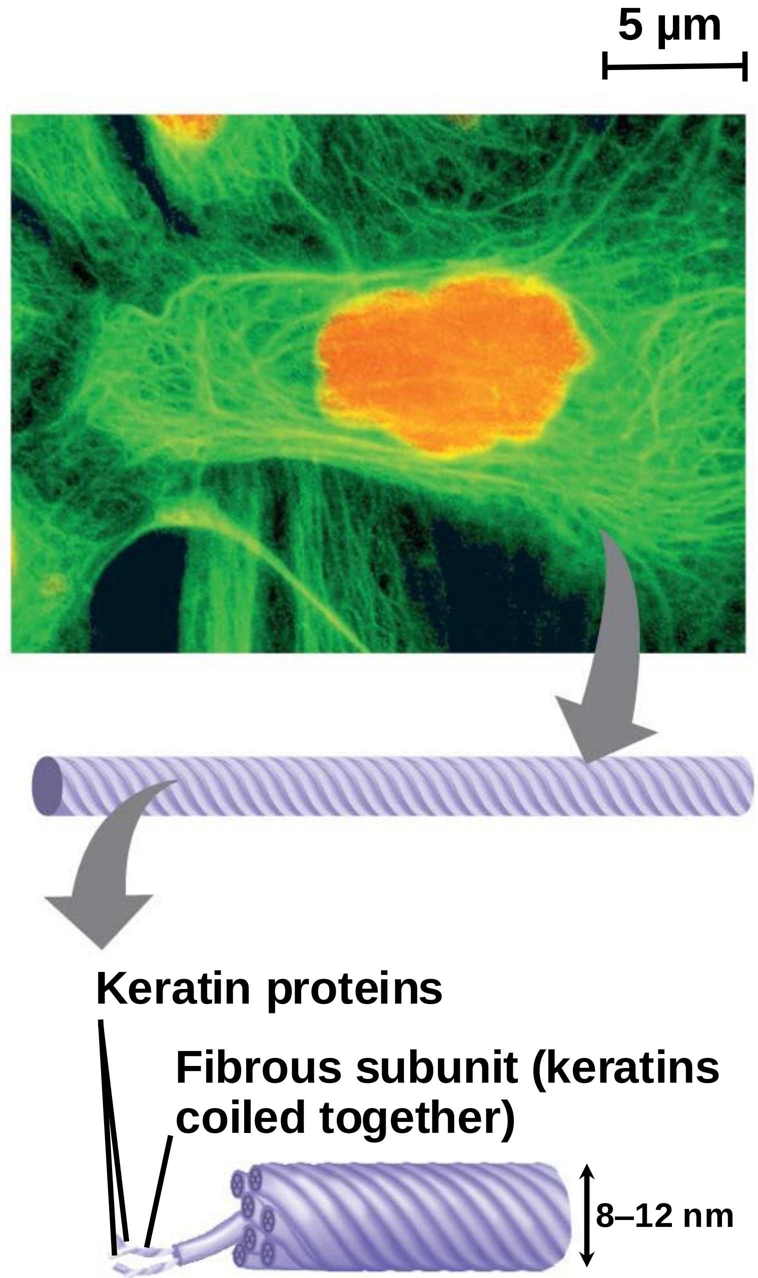


Table 6-1c

Property	Intermediate Filaments
Structure	Fibrous proteins supercoiled into thicker cables
Diameter	8–12 nm
Protein subunits	One of several different proteins of the keratin family
Main functions	Maintenance of cell shape Anchorage of nucleus and certain other organelles Formation of nuclear lamina



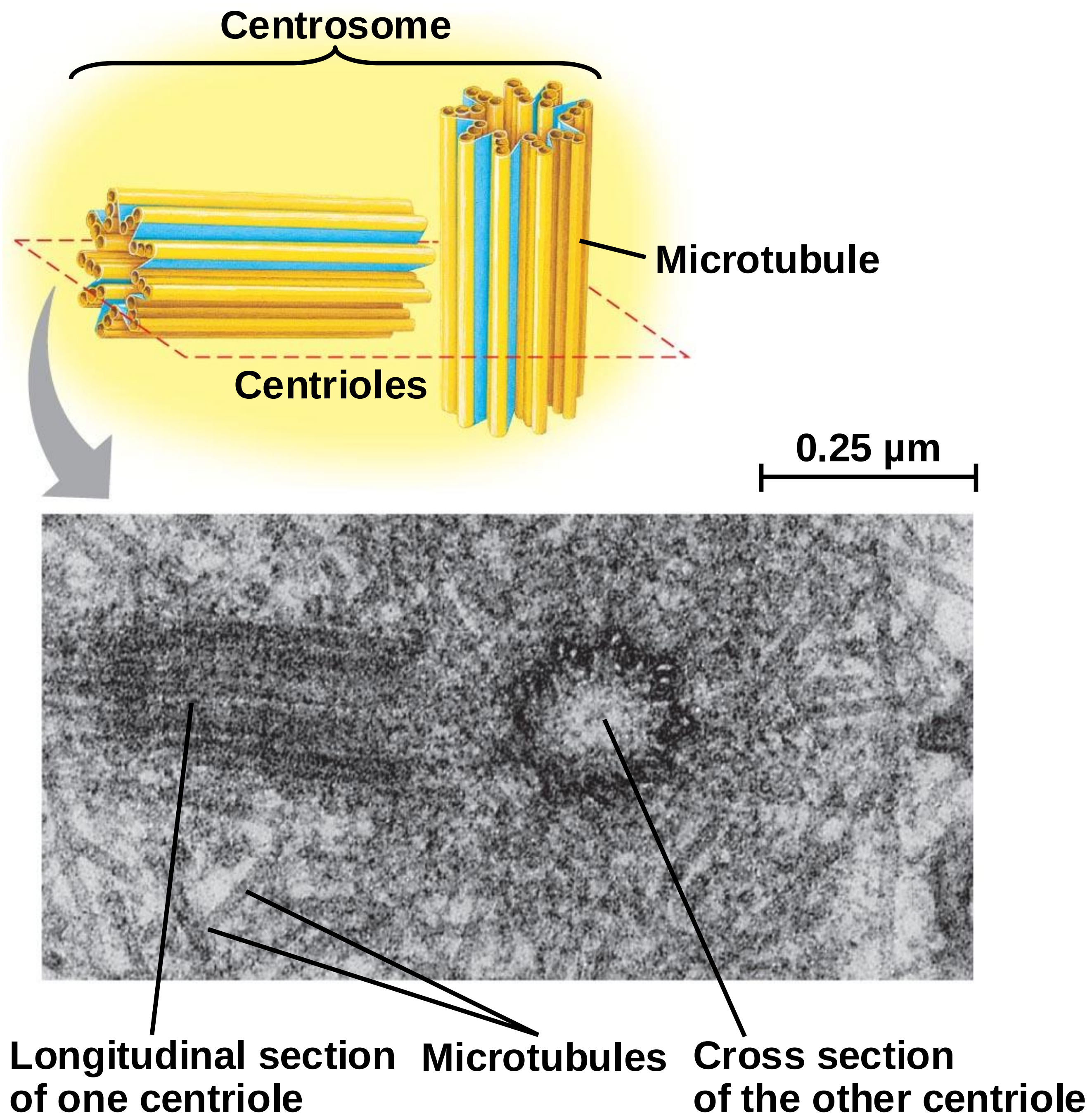
Microtubules

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

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


Centrosome
Microtubule
Centrioles
0.25 µm
Longitudinal section of one centriole
Microtubules
Cross section of the other centriole

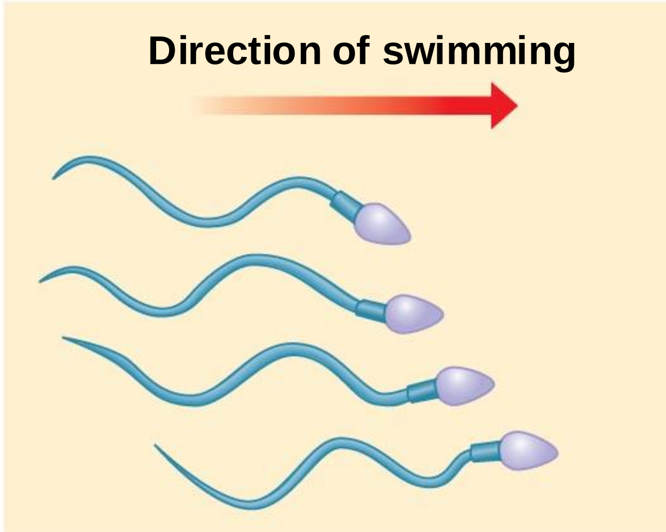
Cilia and Flagella

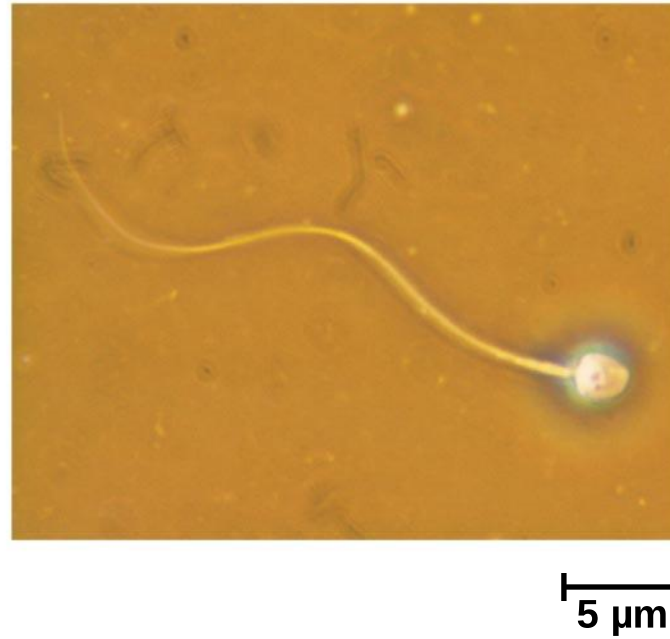
- Microtubules control the beating of **cilia** and **flagella**, locomotor appendages of some cells
- Cilia and flagella differ in their beating patterns

PLAY Video: *Chlamydomonas*

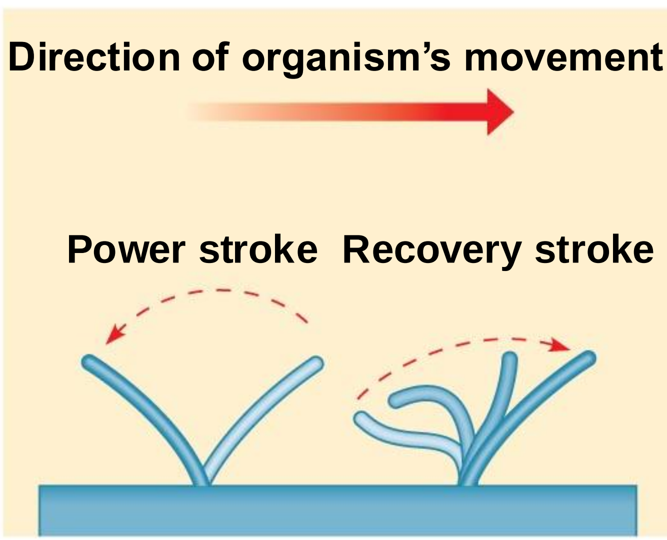
PLAY Video: *Paramecium* Cilia

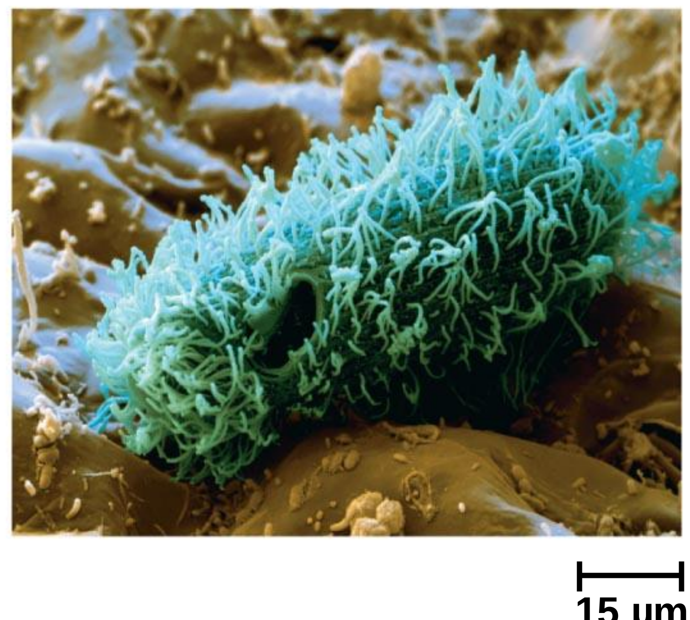
Fig. 6-23





(a) Motion of flagella



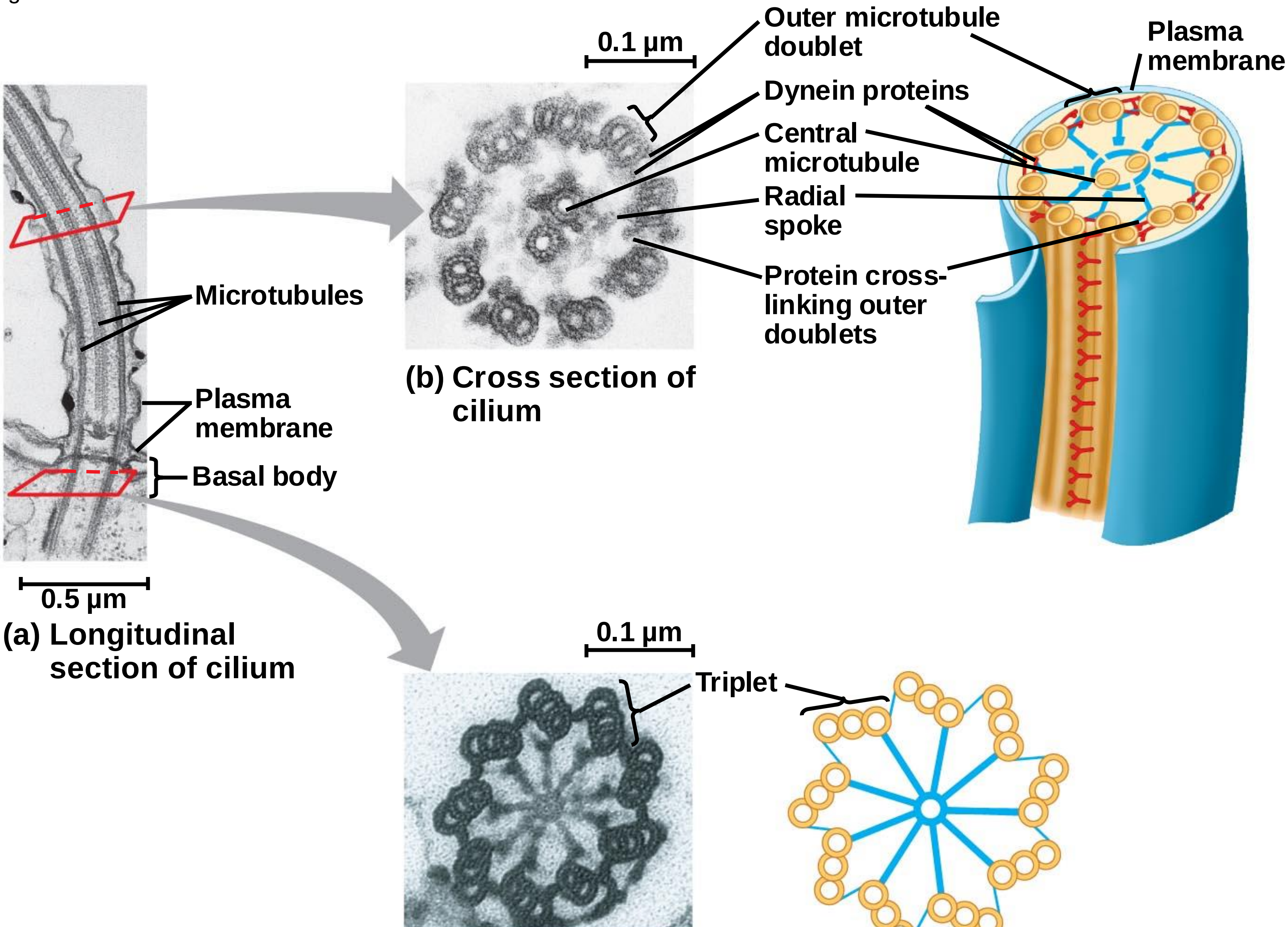


(b) Motion of cilia

- Cilia and flagella share a common ultrastructure:
  - A core of microtubules sheathed by 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

PLAY Animation: Cilia and Flagella

Fig. 6-24



(a) Longitudinal section of cilium

(b) Cross section of cilium

(c) Cross section of basal body

- How dynein “walking” moves flagella and cilia:
  - Dynein arms alternately grab, move, and release the outer microtubules
  - Protein cross-links limit sliding
  - Forces exerted by dynein arms cause doublets to curve, bending the cilium or flagellum

Fig. 6-25

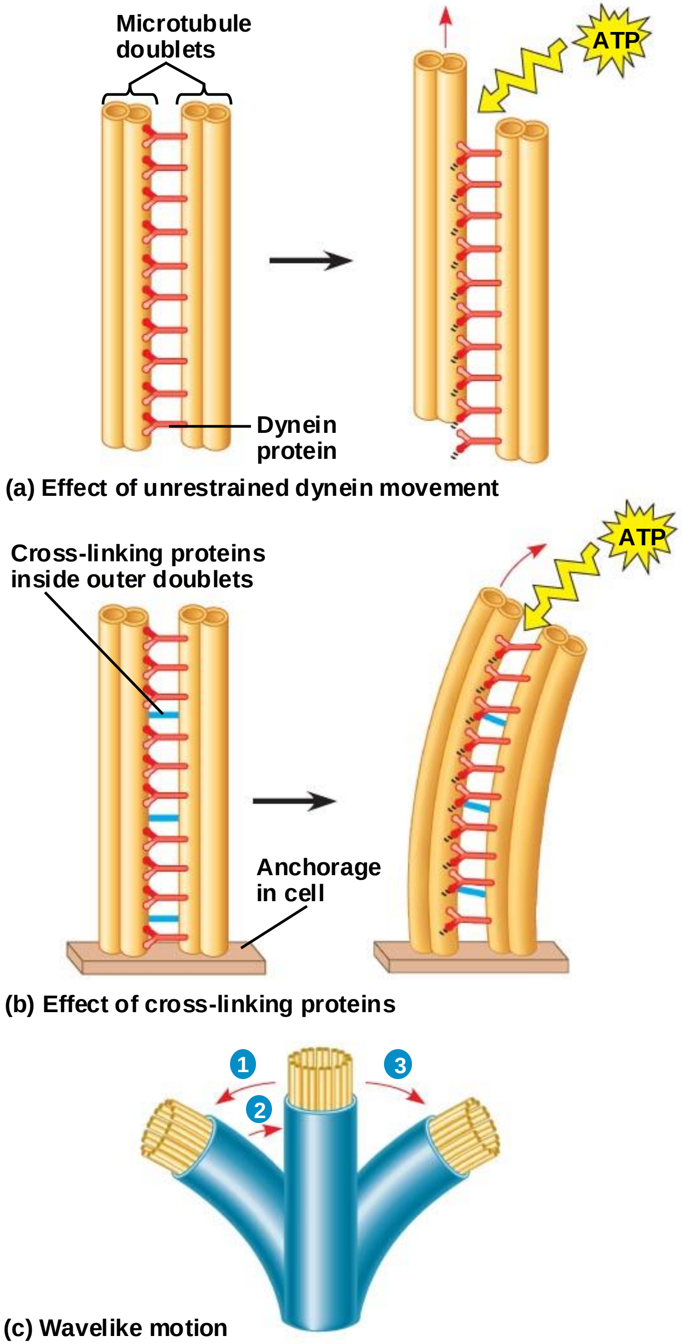
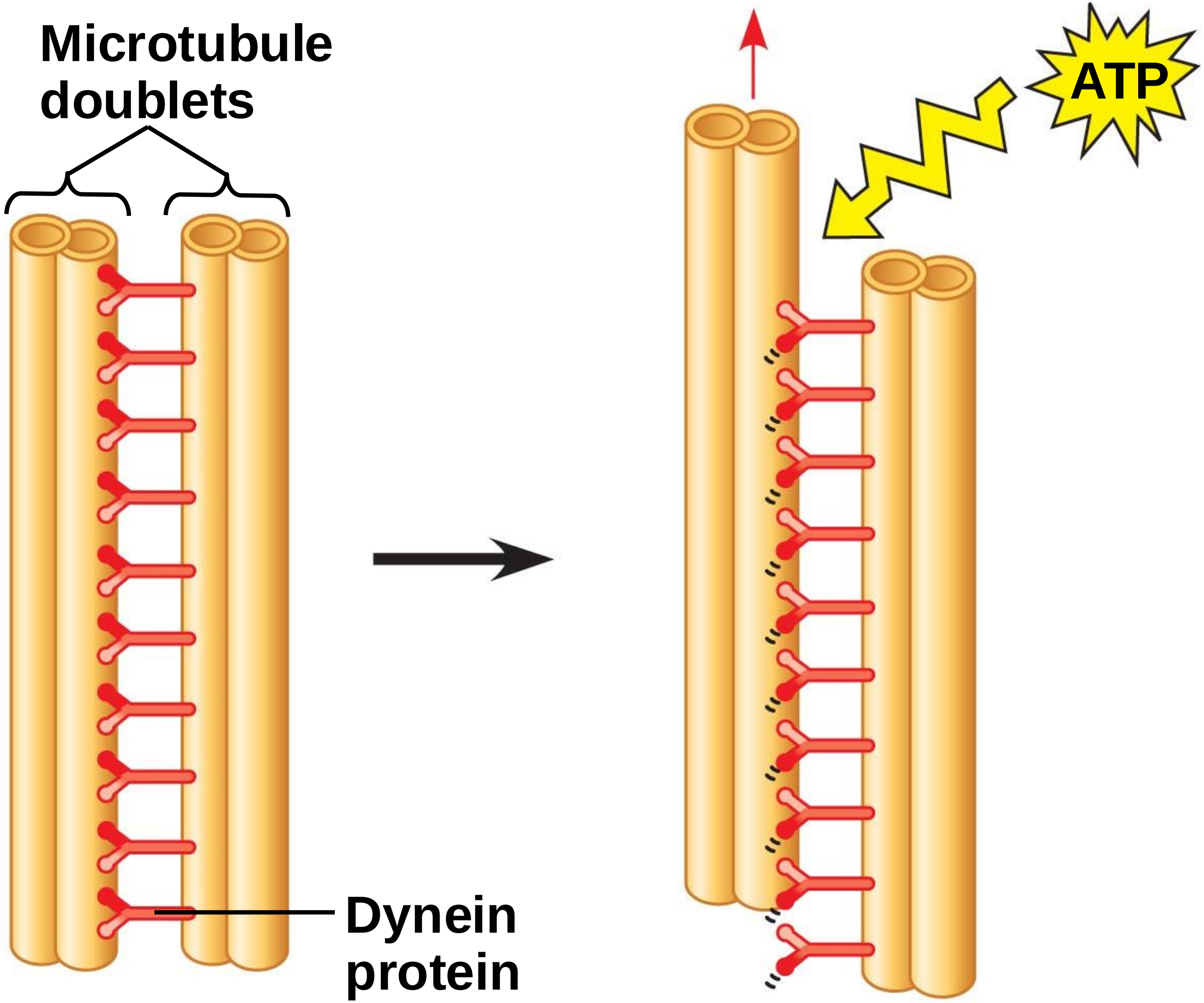
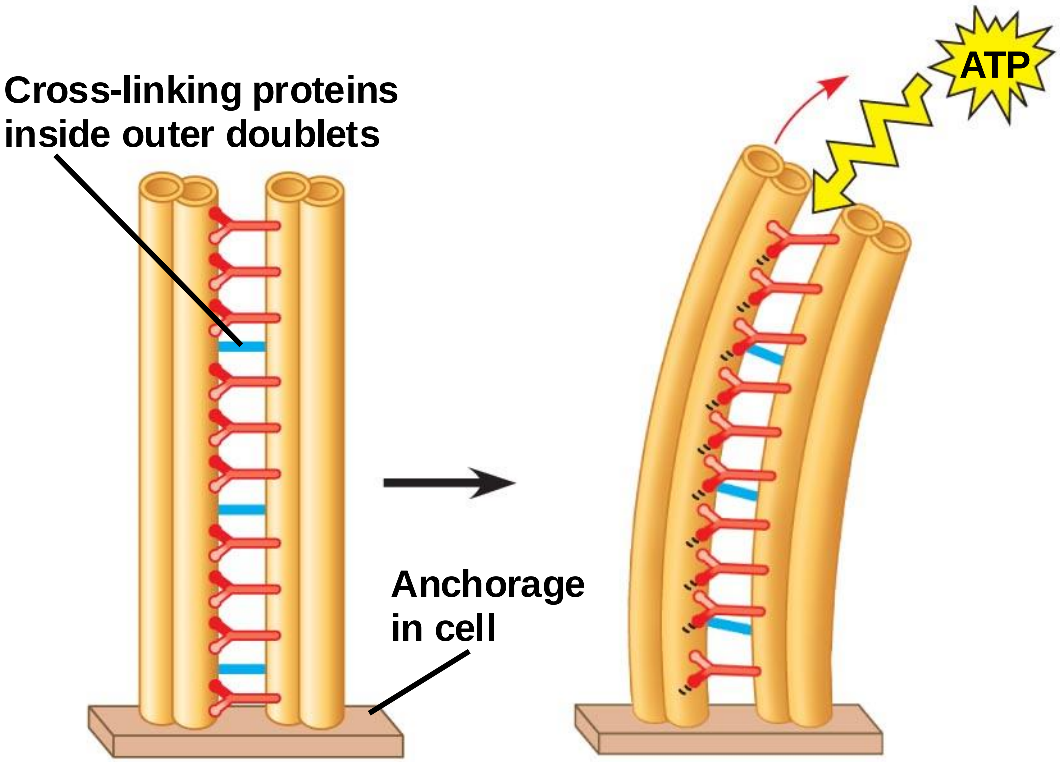

Microtubule doublets
ATP
Dynein protein
(a) Effect of unrestrained dynein movement
Cross-linking proteins inside outer doublets
ATP
Anchorage in cell
(b) Effect of cross-linking proteins
1
2
3
(c) Wavelike motion

Fig. 6-25a

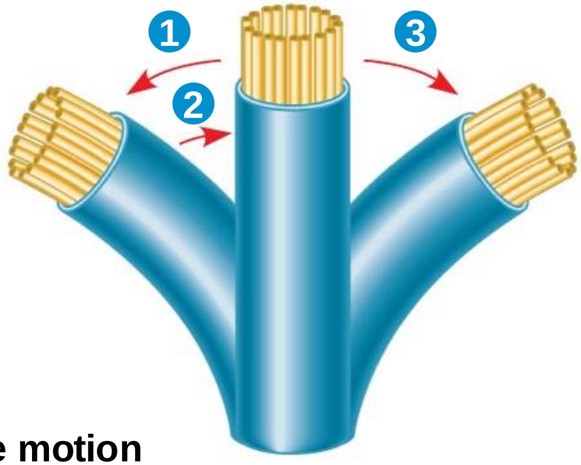


(a) Effect of unrestrained dynein movement

Fig. 6-25b



(b) Effect of cross-linking proteins

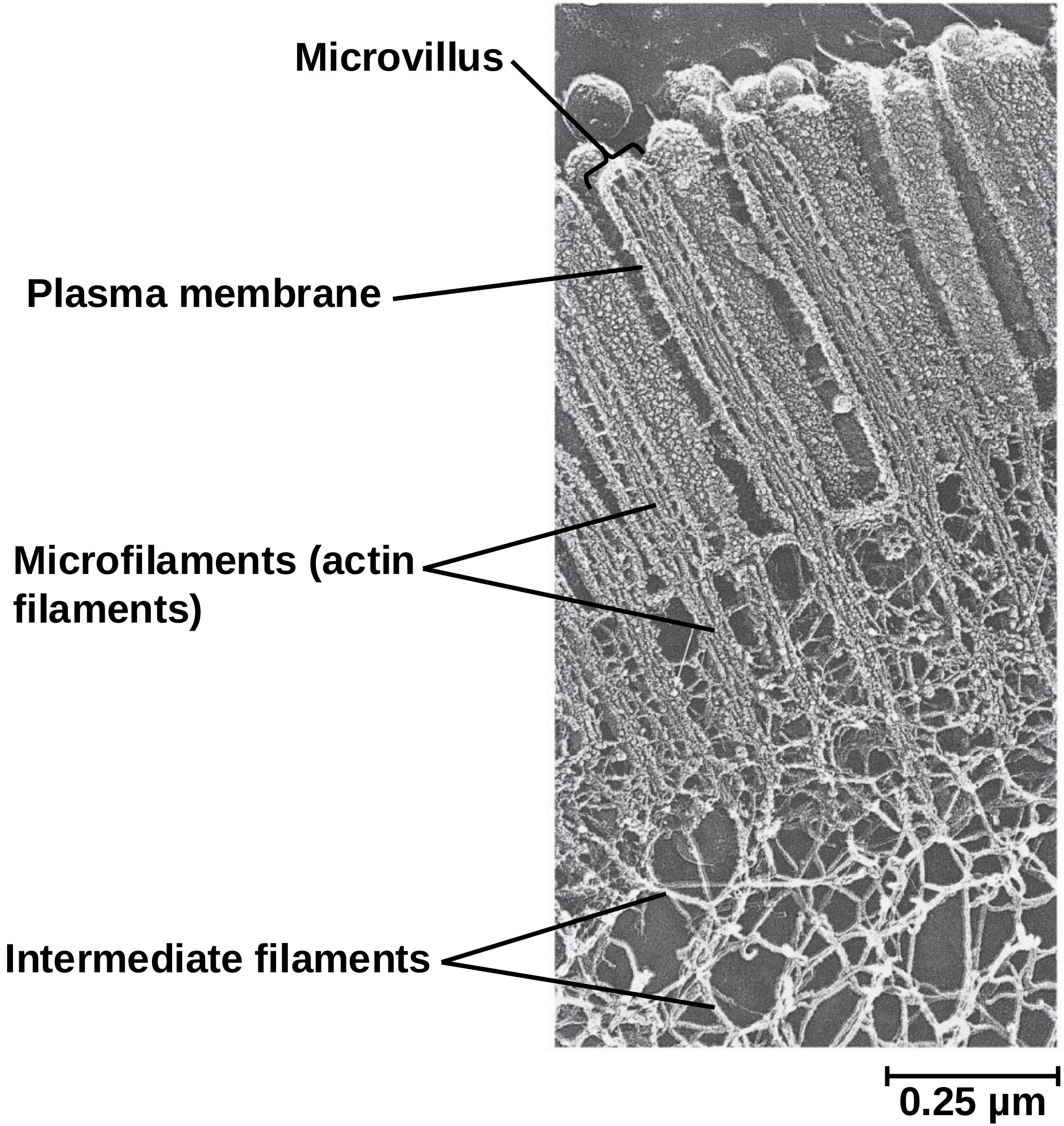


(c) Wavelike motion

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

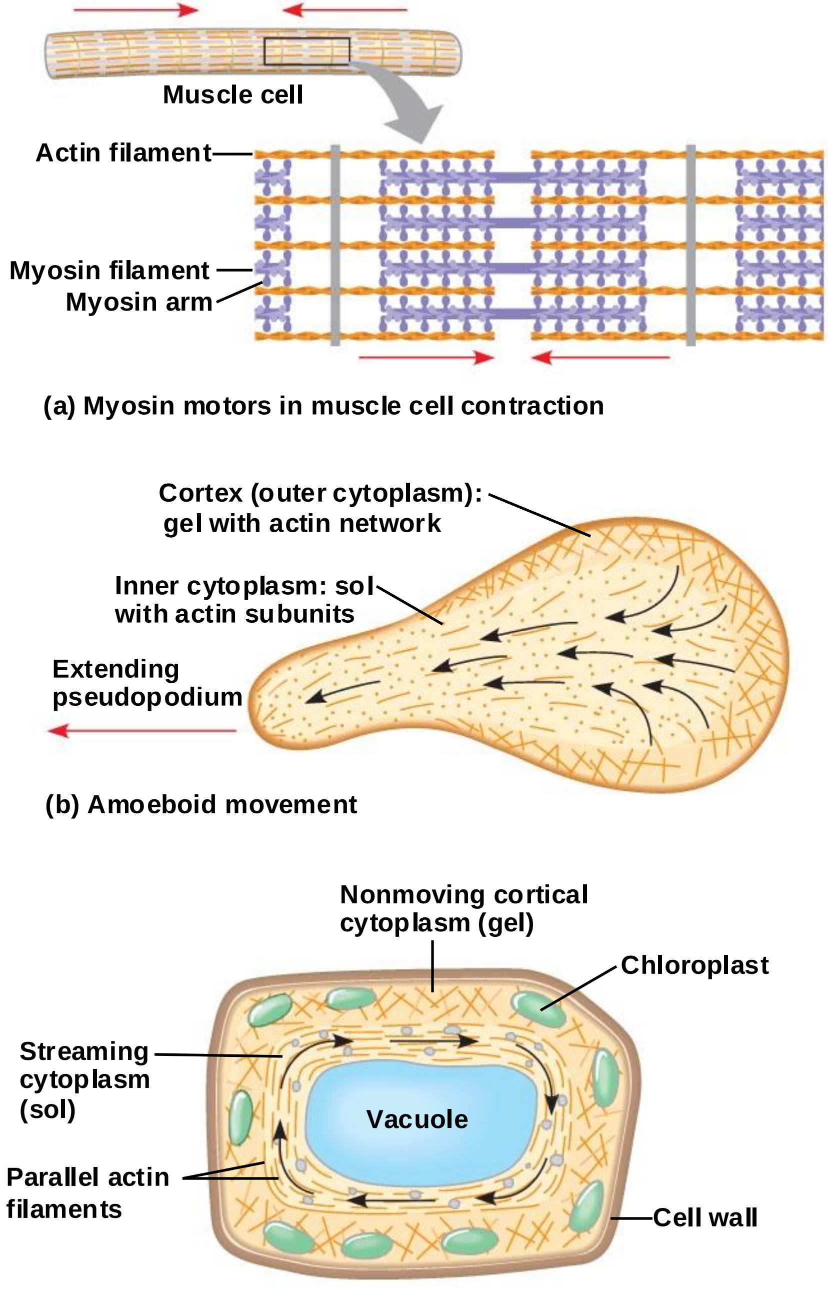
Fig. 6-26



Microvillus
Plasma membrane
Microfilaments (actin filaments)
Intermediate filaments
0.25 µm

- 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. 6-27

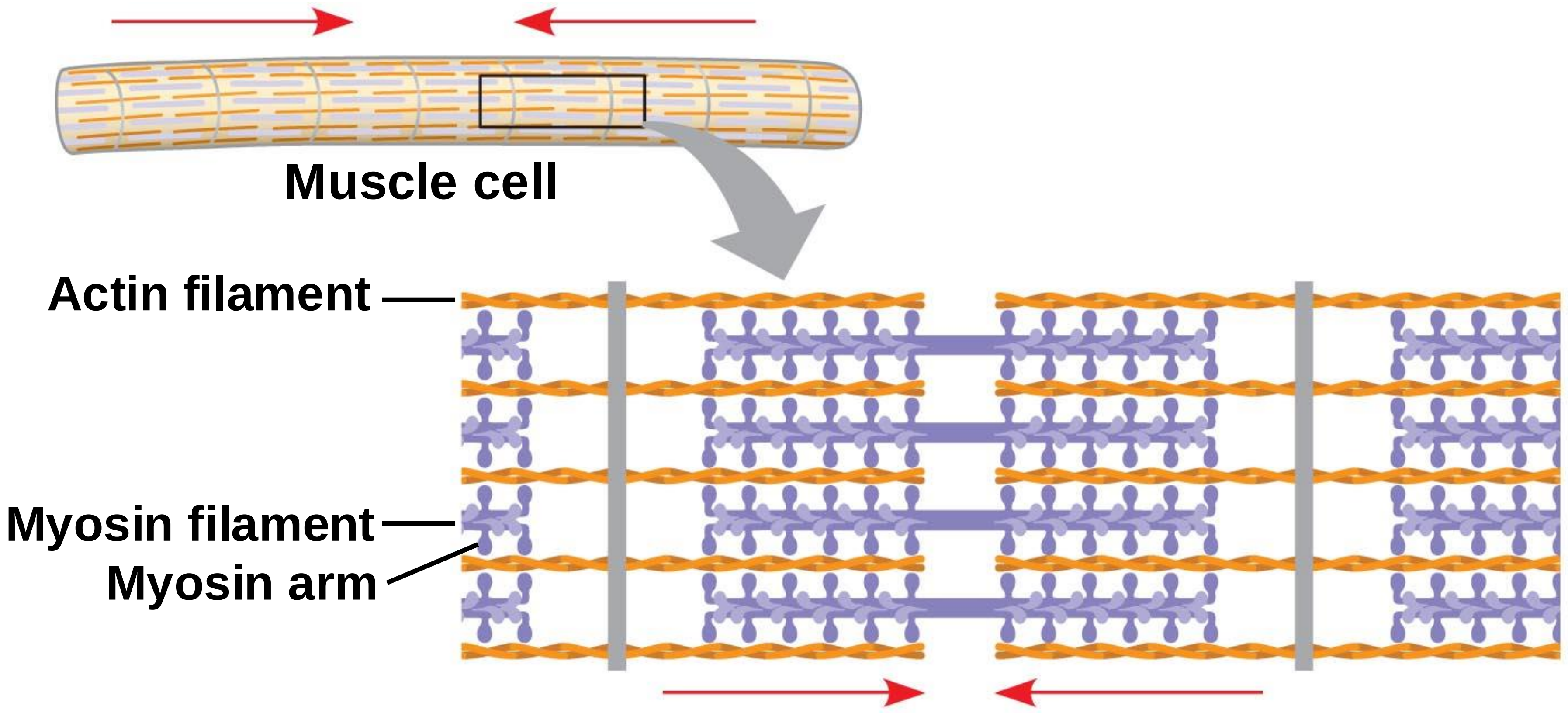


(a) Myosin motors in muscle cell contraction

(b) Amoeboid movement

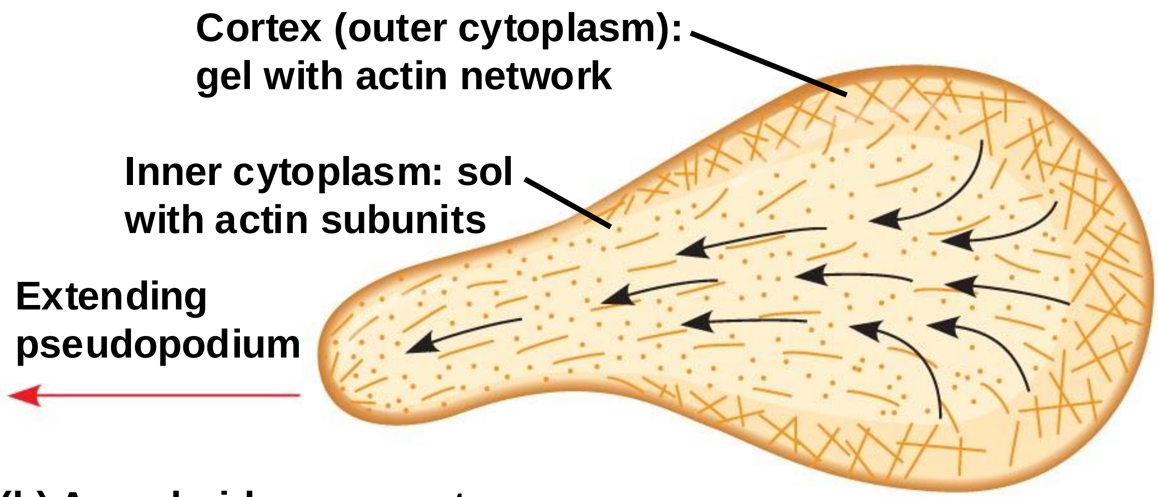
(c) Cytoplasmic streaming in plant cells

Fig, 6-27a

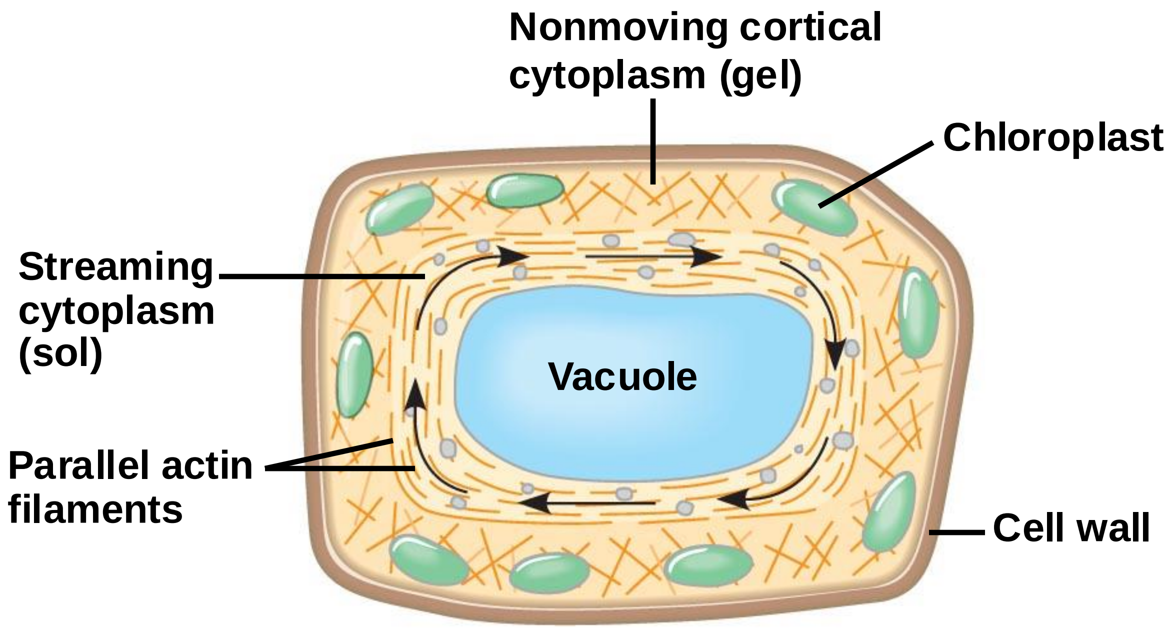


(a) Myosin motors in muscle cell contraction

Fig. 6-27bc



(b) Amoeboid movement



(c) Cytoplasmic streaming in plant cells

- Localized contraction brought about by actin and myosin also drives amoeboid movement
- **Pseudopodia** (cellular extensions) extend and contract through the reversible assembly and contraction of actin subunits into microfilaments

- **Cytoplasmic streaming** is a circular flow of cytoplasm within cells
- This streaming speeds distribution of materials within the cell
- In plant cells, actin-myosin interactions and sol-gel transformations drive cytoplasmic streaming

PLAY Video: Cytoplasmic Streaming

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

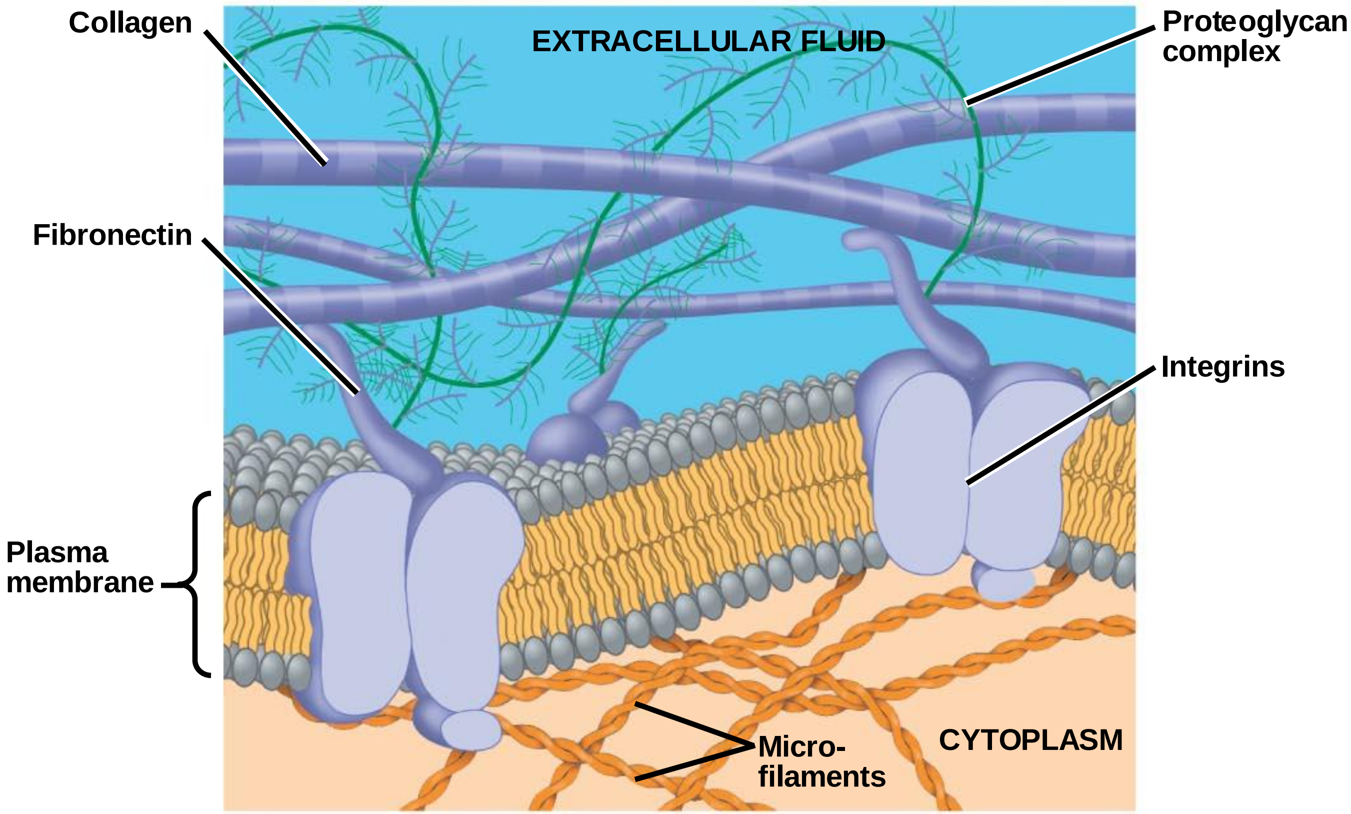
Concept 6.7: Extracellular components and connections between cells help coordinate cellular activities

- Most cells synthesize and secrete materials that are external to the plasma membrane
- These extracellular structures include:
  - Cell walls of plants
  - The extracellular matrix (ECM) of animal cells
  - Intercellular junctions

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**

Fig. 6-30


Collagen
EXTRACELLULAR FLUID
Proteoglycan complex
Fibronectin
Integrins
Plasma membrane
Micro-filaments
CYTOPLASM

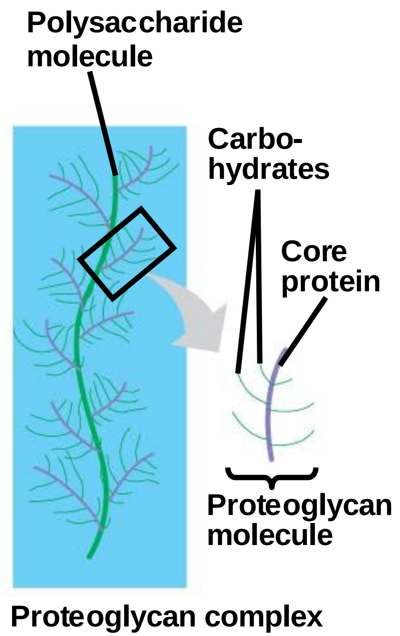
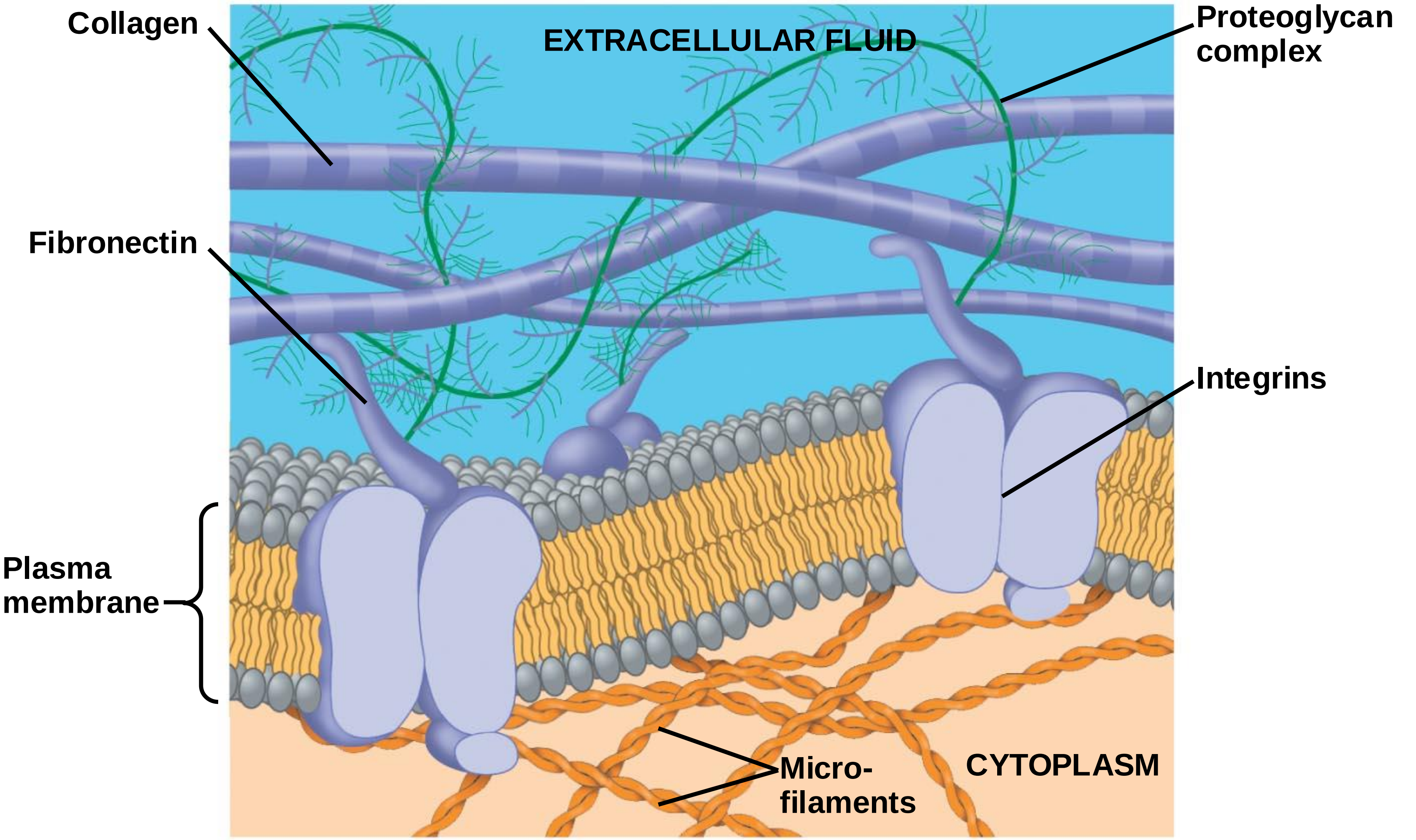
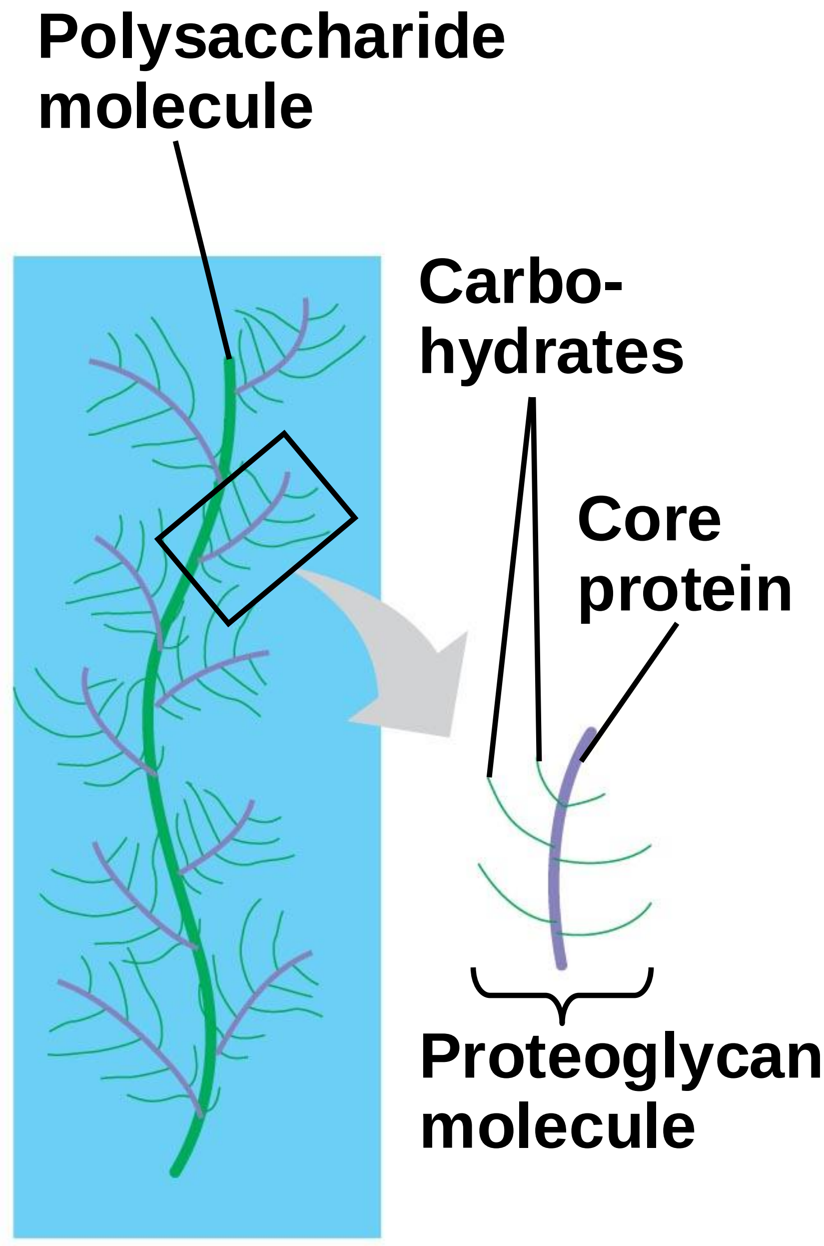

Polysaccharide molecule
Carbo-hydrates
Core protein
Proteoglycan molecule
Proteoglycan complex

Fig. 6-30a



Collagen
EXTRACELLULAR FLUID
Proteoglycan complex
Fibronectin
Integrins
Plasma membrane
Micro-filaments
CYTOPLASM

Fig. 6-30b



Proteoglycan complex

- Functions of the ECM:
  - Support
  - Adhesion
  - Movement
  - Regulation

Intercellular Junctions

- Neighboring cells in tissues, organs, or organ systems often adhere, interact, and communicate through direct physical contact
- Intercellular junctions facilitate this contact
- There are several types of intercellular junctions
  - Plasmodesmata
  - Tight junctions
  - Desmosomes
  - Gap junctions

Tight Junctions, Desmosomes, and Gap Junctions in Animal Cells

- 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

PLAY Animation: Tight Junctions

PLAY Animation: Desmosomes

PLAY Animation: Gap Junctions

Fig. 6-32

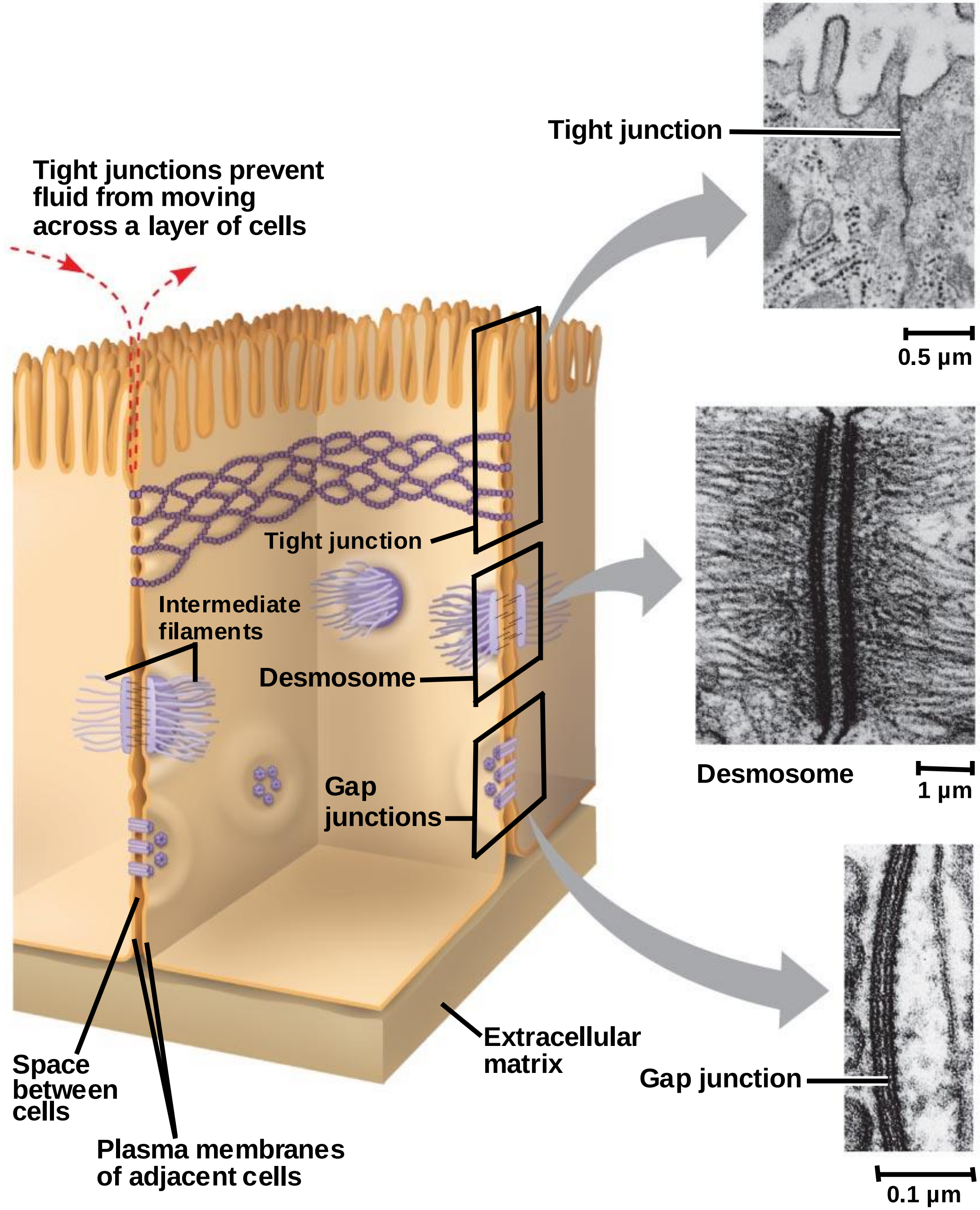

Tight junctions prevent fluid from moving across a layer of cells
Tight junction
Intermediate filaments
Desmosome
Gap junctions
Space between cells
Plasma membranes of adjacent cells
Extracellular matrix
Tight junction
0.5 µm
Desmosome
1 µm
Gap junction
0.1 µm

Fig. 6-32a

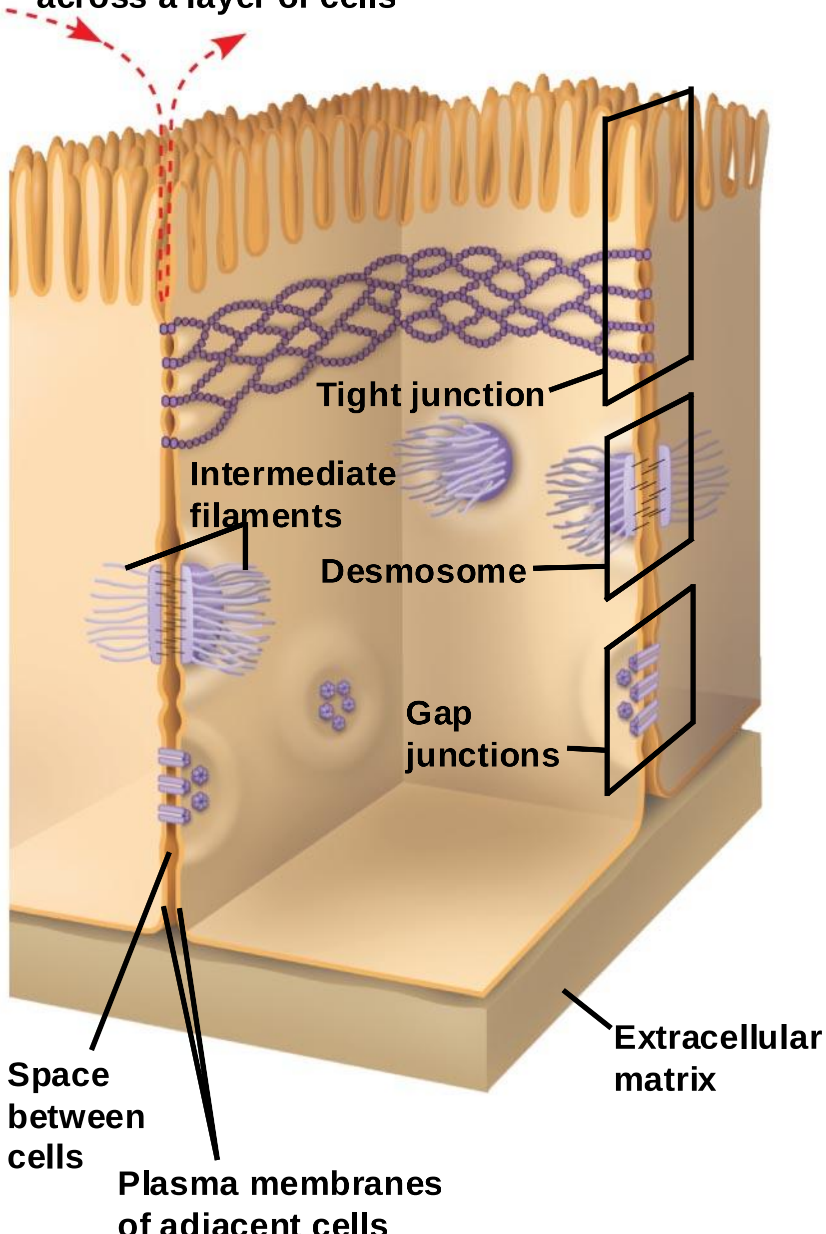
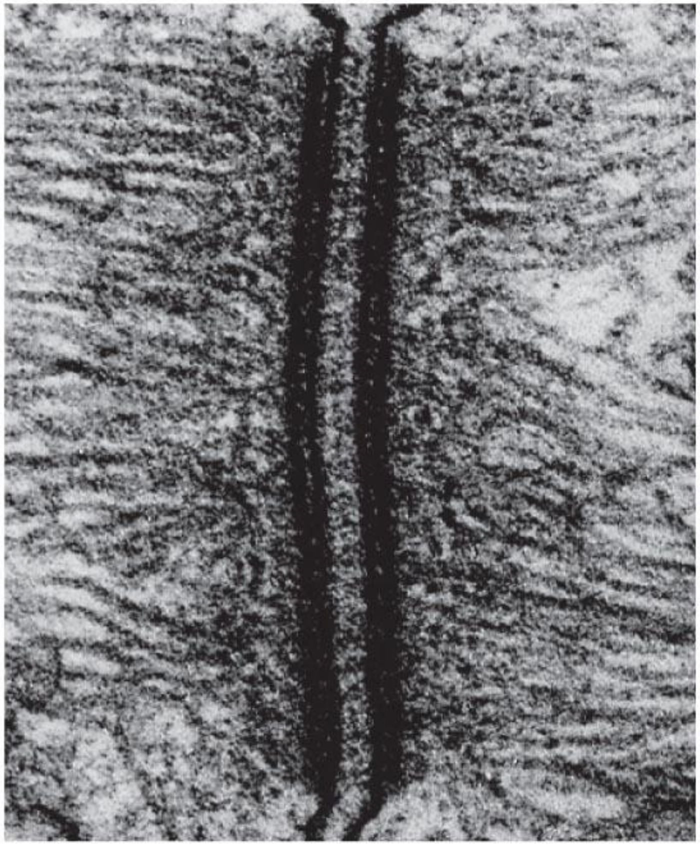

Tight junctions prevent fluid from moving across a layer of cells
Tight junction
Intermediate filaments
Desmosome
Gap junctions
Extracellular matrix
Space between cells
Plasma membranes of adjacent cells

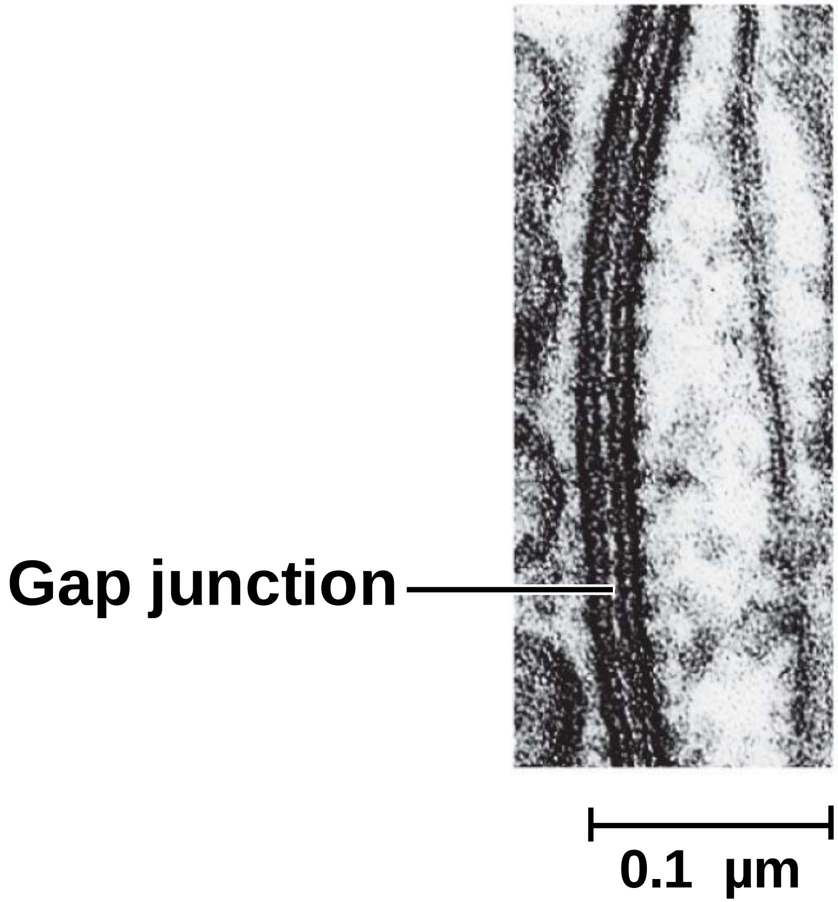
Fig. 6-32b

Fig. 6-32c



Desmosome

Fig. 6-32d



The Cell: A Living Unit 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

Fig. 6-33

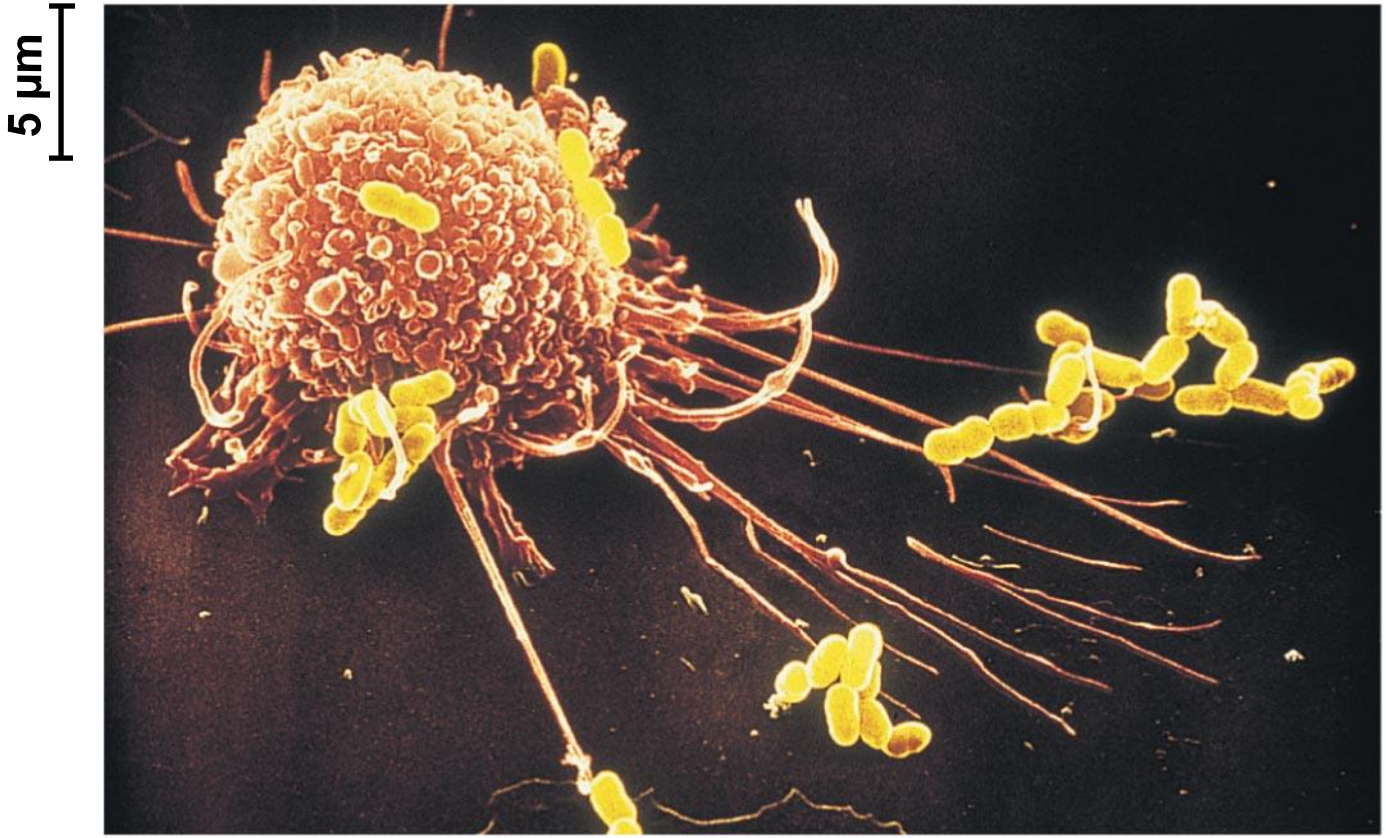


Fig. 6-UN1

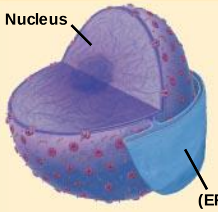
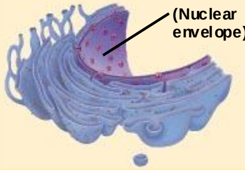
	Cell Component	Structure	Function
Concept 6.3 The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes	Nucleus 	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores. The nuclear envelope is continuous with the endoplasmic reticulum (ER).	Houses chromosomes, made of chromatin (DNA, the genetic material, and proteins); contains nucleoli, where ribosomal subunits are made. Pores regulate entry and exit of materials.
	Ribosome 	Two subunits made of ribosomal RNA and proteins; can be free in cytosol or bound to ER	Protein synthesis
Concept 6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell	Endoplasmic reticulum 	Extensive network of membrane-bound tubules and sacs; membrane separates lumen from cytosol; continuous with the 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 from bound ribosomes; adds carbohydrates to 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 in plants	Digestion, storage, waste disposal, water balance, cell growth, and protection
Concept 6.5 Mitochondria and chloroplasts change energy from one form to another	Mitochondrion 	Bounded by double membrane; inner membrane has infoldings (cristae)	Cellular respiration
	Chloroplast 	Typically two membranes around fluid stroma, which contains membranous thylakoids stacked into grana (in plants)	Photosynthesis
	Peroxisome 	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer hydrogen to water, producing hydrogen peroxide (H_2O_2) as a by-product, which is converted to water by other enzymes in the peroxisome

Fig. 6-UN1a

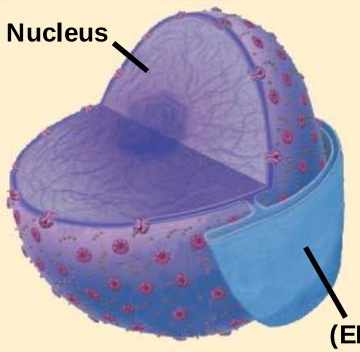
	Cell Component	Structure	Function
Concept 6.3 The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes	Nucleus 	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores. The nuclear envelope is continuous with the endoplasmic reticulum (ER).	Houses chromosomes, made of chromatin (DNA, the genetic material, and proteins); contains nucleoli, where ribosomal subunits are made. Pores regulate entry and exit os materials.
	Ribosome 	Two subunits made of ribosomal RNA and proteins; can be free in cytosol or bound to ER	Protein synthesis

Fig. 6-UN1b

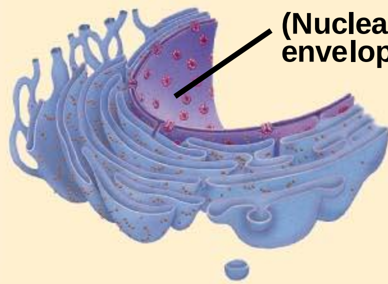
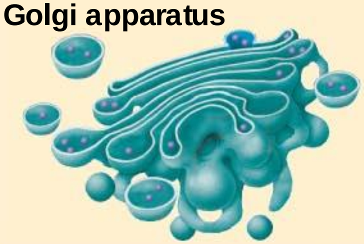
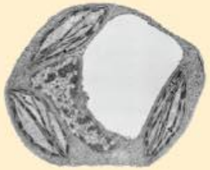
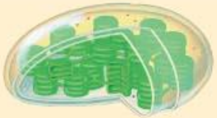
	Cell Component	Structure	Function
Concept 6.4 **The endomembrane system regulates protein traffic and performs metabolic functions in the cell**	**Endoplasmic reticulum** 	**Extensive network of membrane-bound tubules and sacs; membrane separates lumen from cytosol; continuous with the nuclear envelope.**	**Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons** **Rough ER: Aids in sythesis of secretory and other proteins from bound ribosomes; adds carbohydrates to 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 in plants**	**Digestion, storage, waste disposal, water balance, cell growth, and protection**

Fig. 6-UN1c

	Cell Component	Structure	Function
Concept 6.5 Mitochondria and chloro-plasts change energy from one form to another	Mitochondrion 	Bounded by double membrane; inner membrane has infoldings (cristae)	Cellular respiration
	Chloroplast 	Typically two membranes around fluid stroma, which contains membranous thylakoids stacked into grana (in plants)	Photosynthesis
	Peroxisome 	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer hydrogen to water, producing hydrogen peroxide (H_2O_2) as a by-product, which is converted to water by other enzymes in the peroxisome