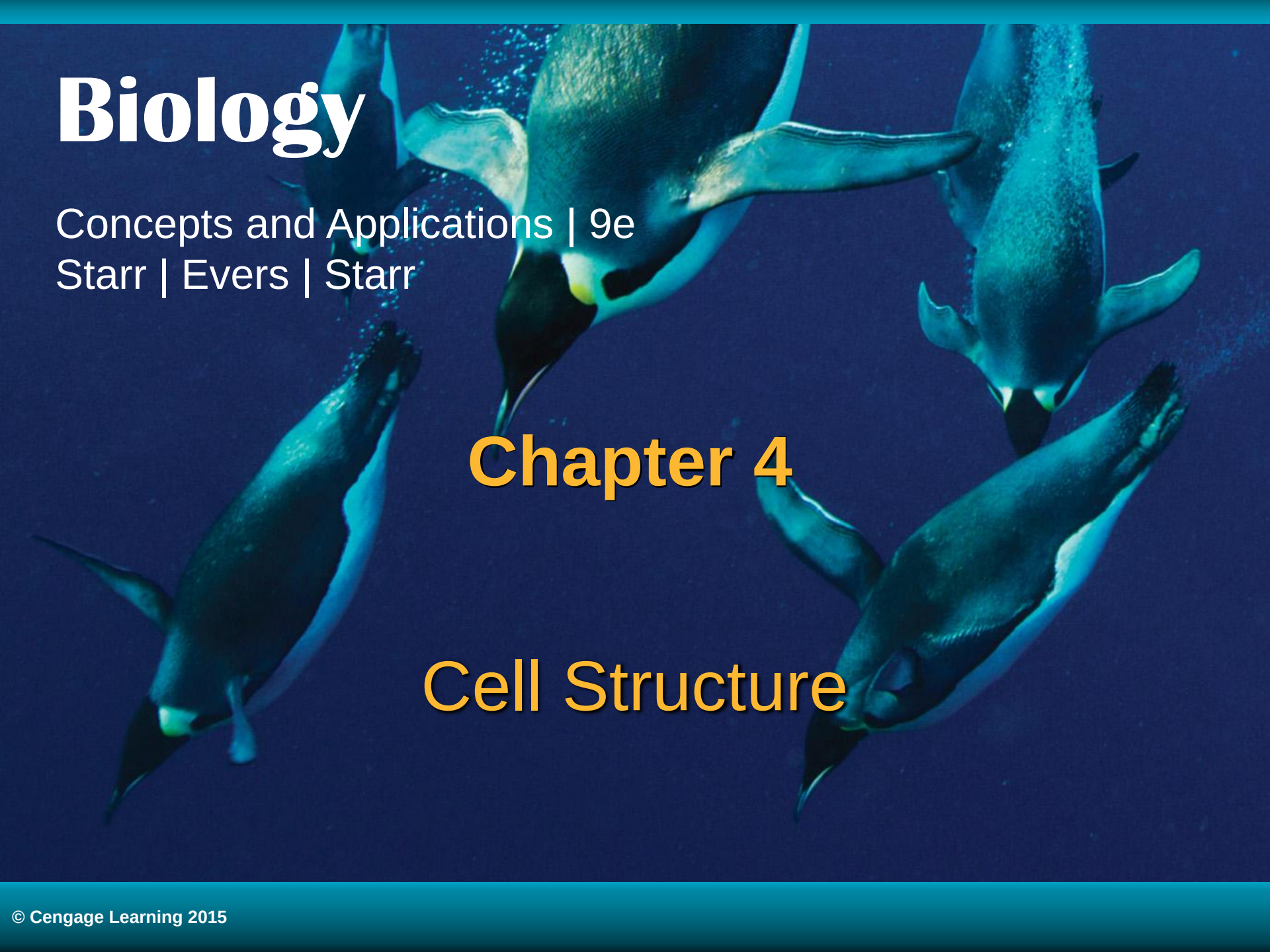

Biology

Concepts and Applications | 9e
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Chapter 4

Cell Structure

4.1 What Is a Cell?

- Cell theory
  - Prior to the invention of the microscope, the existence of cells was unknown
  - Mid-1600s: Antoni van Leeuwenhoek constructed a crude microscope and observed “animalcules”
    - These animalcules were in fact microbes

Cell Theory (cont'd.)

- Components of the cell theory:
  - All organisms consist of one or more cells, which are the basic unit of life
  - All cells come from division of preexisting cells
  - All cells pass hereditary material to offspring

Cell Theory (cont'd.)

TABLE 4.1

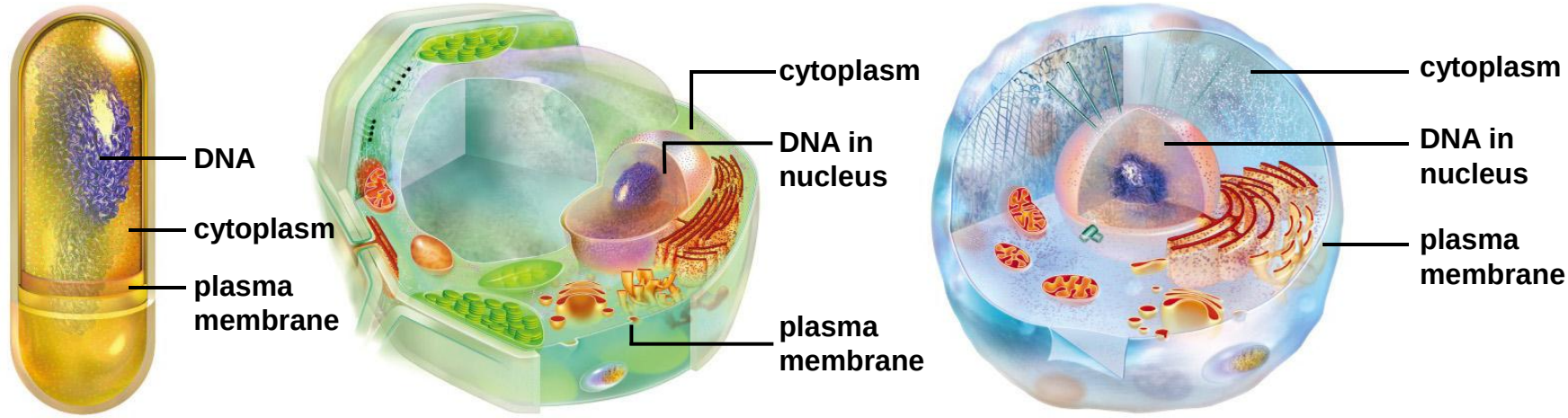
Cell Theory

1. Every living organism consists of one or more cells.
2. The cell is the structural and functional unit of all organisms. A cell is the smallest unit of life, individually alive even as part of a multicelled organism.
3. All living cells arise by division of preexisting cells.
4. Cells contain hereditary material, which they pass to their offspring when they divide.

Components of All Cells

- All cells have at least three components in common:
  - Plasma membrane
  - Cytoplasm
  - DNA

Components of All Cells (cont'd.)



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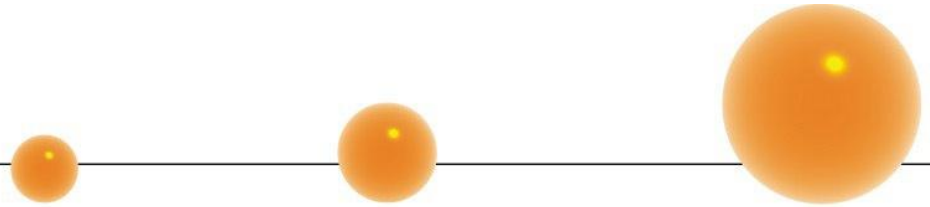
Components of All Cells (cont'd.)

- The *plasma membrane* is the outermost membrane of a cell
- The plasma membrane encloses a jellylike mixture called *cytoplasm*
- Suspended in the cytoplasm are specialized *organelles*
- All cells start out life with *DNA*
  - In eukaryotic cells, DNA is contained within the *nucleus*

Constraints on Cell Size

- Cell size is limited by a physical relationship called the *surface-to-volume ratio*
  - The volume of an object increases with the cube of the diameter
  - The surface area increases with the square
- When a cell expands in diameter, its volume increases faster than its surface area does

Constraints on Cell Size (cont'd.)

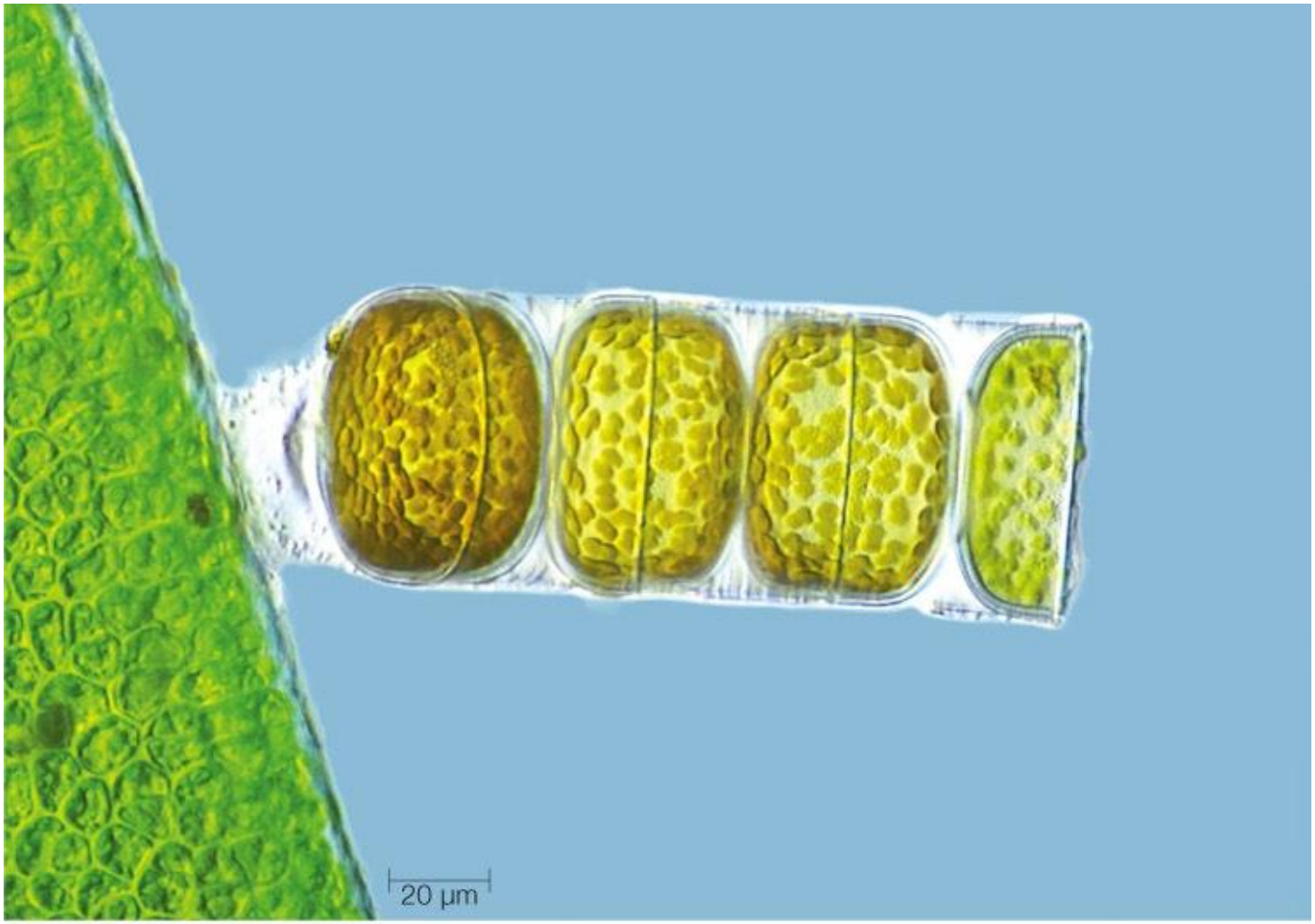


Diameter (cm)	2	3	6
Surface area (cm^2)	12.6	28.2	113
Volume (cm^3)	4.2	14.1	113
Surface-to-volume ratio	3:1	2:1	1:1

Constraints on Cell Size (cont'd.)

- Surface-to-volume limits affect the form of colonial types and multicelled types
- Examples:
  - Strandlike algae cells attach end to end
  - Muscle cells are long and thin

Constraints on Cell Size (cont'd.)



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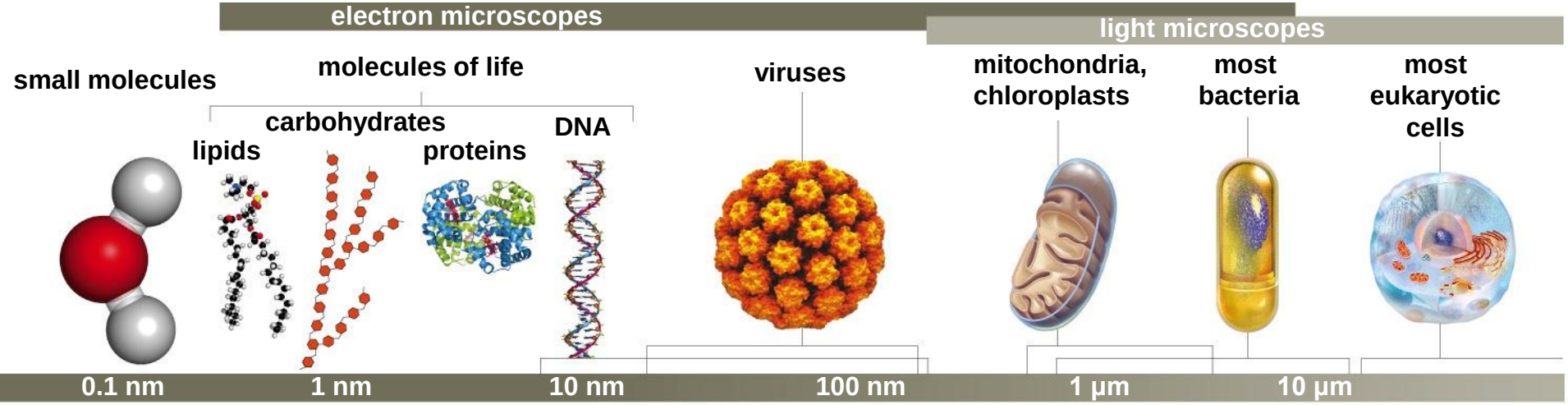
4.2 How Do We See Cells?

- Most cells are 10–20 micrometers in diameter
  - About fifty times smaller than the unaided human eye can perceive
- Microscopes are used to observe objects in the micrometer range of size

How Do We See Cells? (cont'd.)



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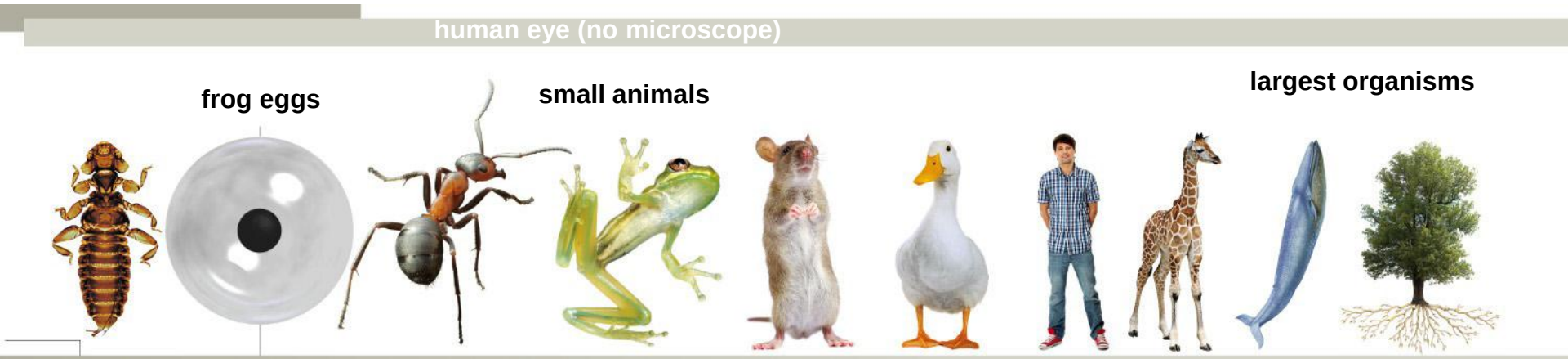
How Do We See Cells? (cont'd.)



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How Do We See Cells? (cont'd.)

TABLE 4.2

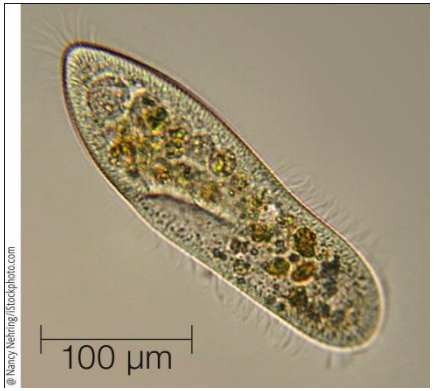
Equivalent Units of Length

Unit	Equivalent	
	Meter	**Inch**
centimeter (cm)	1/100	0.4
millimeter (mm)	1/1000	0.04
micrometer (μm)	1/1,000,000	0.00004
nanometer (nm)	1/1,000,000,000	0.00000004
meter (m)	100 cm 1,000 mm 1,000,000 μm 1,000,000,000 nm	

How Do We See Cells? (cont'd.)

- Light microscopes use visible light to illuminate samples
  - Curved lenses inside the microscope focus light into a magnified image
  - Researchers use stains or light-emitting tracers to see the details inside cells
- Electron microscopes use magnetic fields to focus a beam of electrons onto a sample

How Do We See Cells? (cont'd.)



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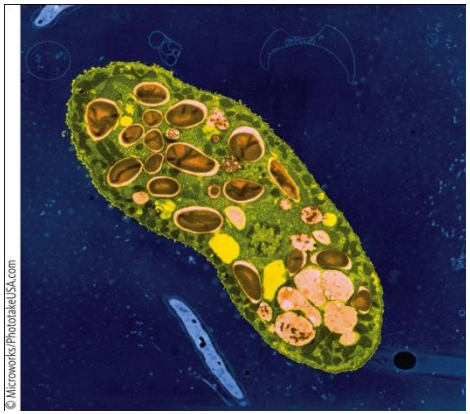

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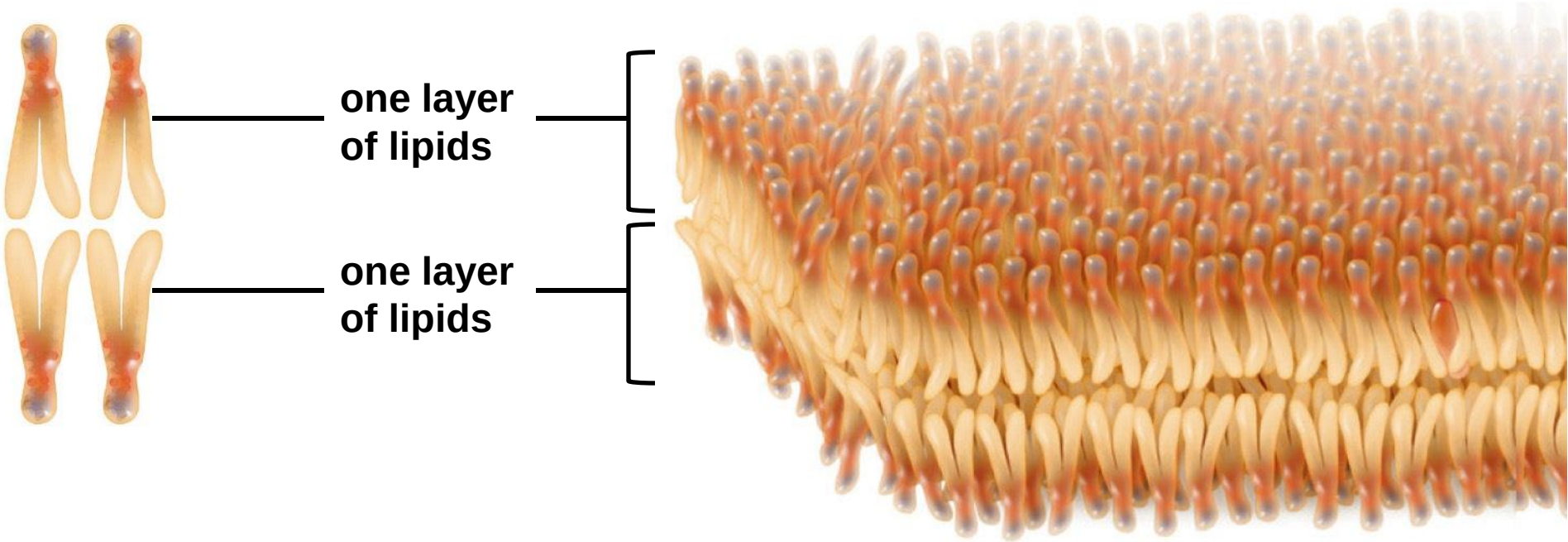
4.3 What Is a Membrane?

- The plasma membrane's function is not limited to physically separating a cell's external environment from its internal one
- Other functions include regulating the crossing of substances into and out of cells

The Fluid Mosaic Model

- Several molecules are embedded within or attached to the lipid bilayer:
  - Cholesterol, proteins, glycoproteins, glycolipids
- Fluid mosaic: model of a cell membrane as a two-dimensional fluid of mixed composition

The Fluid Mosaic Model (cont'd.)



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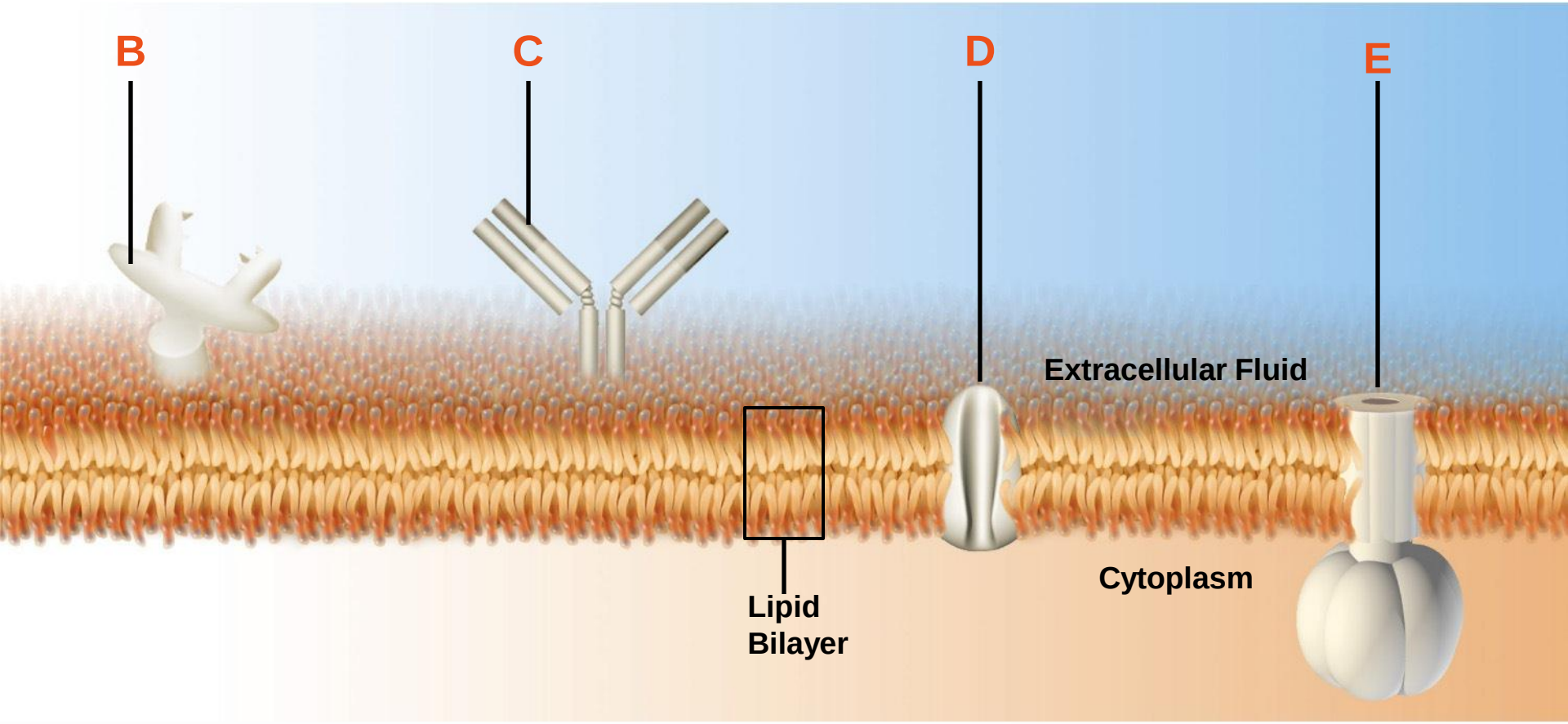
Proteins Add Function

- Many types of proteins are associated with a cell membrane
  - Adhesion proteins: helps cells stick together
  - Recognition proteins: identifies “self” cells
  - Receptor proteins: triggers a change in cell activity
  - Transport proteins: assists the movement of ions or molecules across the membrane

Proteins Add Function (cont'd.)



4.4 How Are Bacteria and Archaea Alike?

- All bacteria and archaea are single-celled organisms
- Archaea and bacteria were once formally grouped together as prokaryotes
  - Archaea are more closely related to eukaryotes than to bacteria
- Archaea now have their own separate domain

How Are Bacteria and Archaea Alike? (cont'd.)

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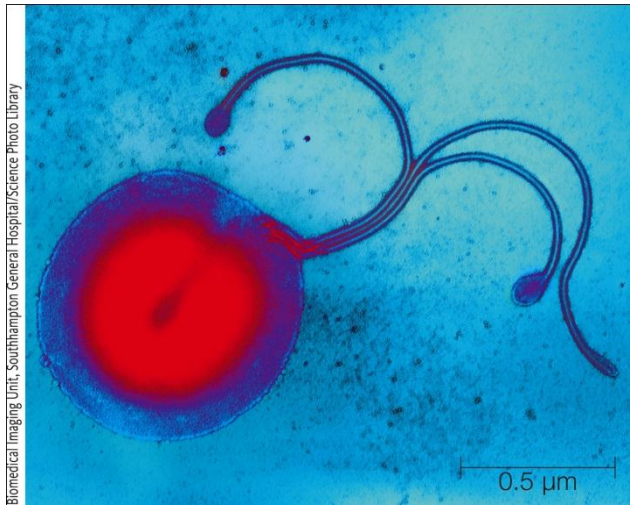

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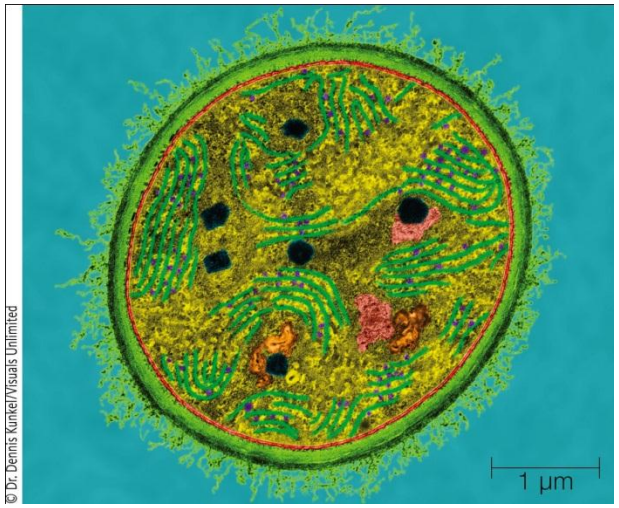

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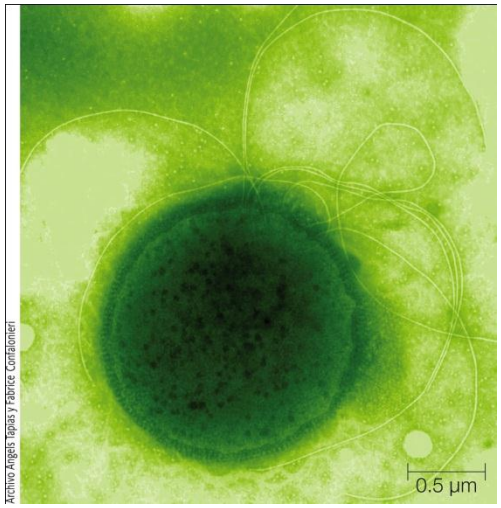

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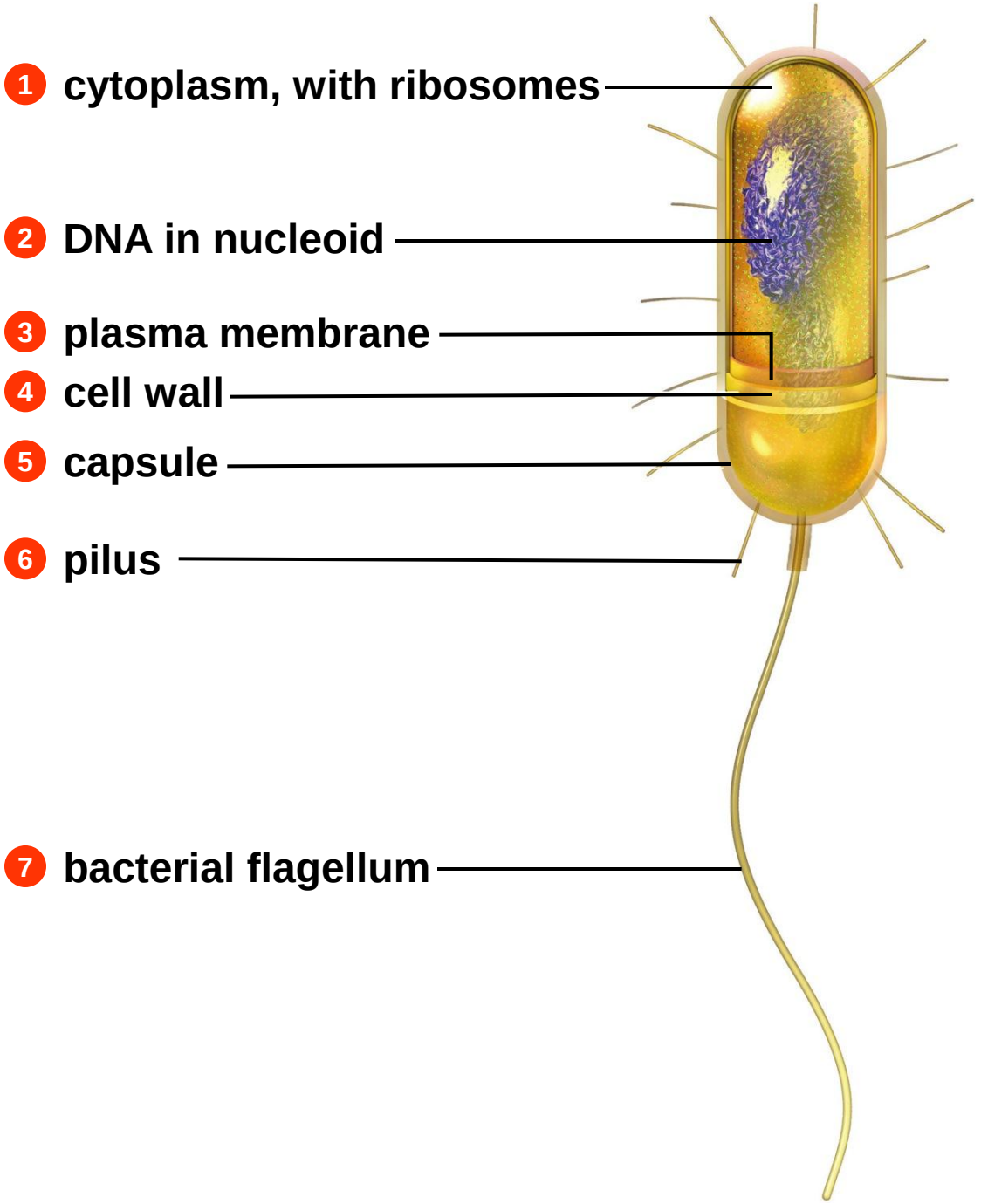
How Are Bacteria and Archaea Alike? (cont'd.)

- Structural similarities between bacteria and archaea:
  - Protein filaments reinforce cell shape
  - Numerous *ribosomes* for protein synthesis
  - Cytoplasm contains *plasmids* (small circular DNAs)
  - DNA is concentrated in a *nucleoid*

How Are Bacteria and Archaea Alike? (cont'd.)

- Structural similarities between bacteria and archaea: (cont'd.)
  - Rigid *cell wall* surrounds the plasma membrane
  - Polysaccharides form a slime layer or capsule around cell wall
  - *Pili* (protein filaments) project from the surface
  - Long, slender cellular structures called *flagella* are used for motion

How Are Bacteria and Archaea Alike? (cont'd.)



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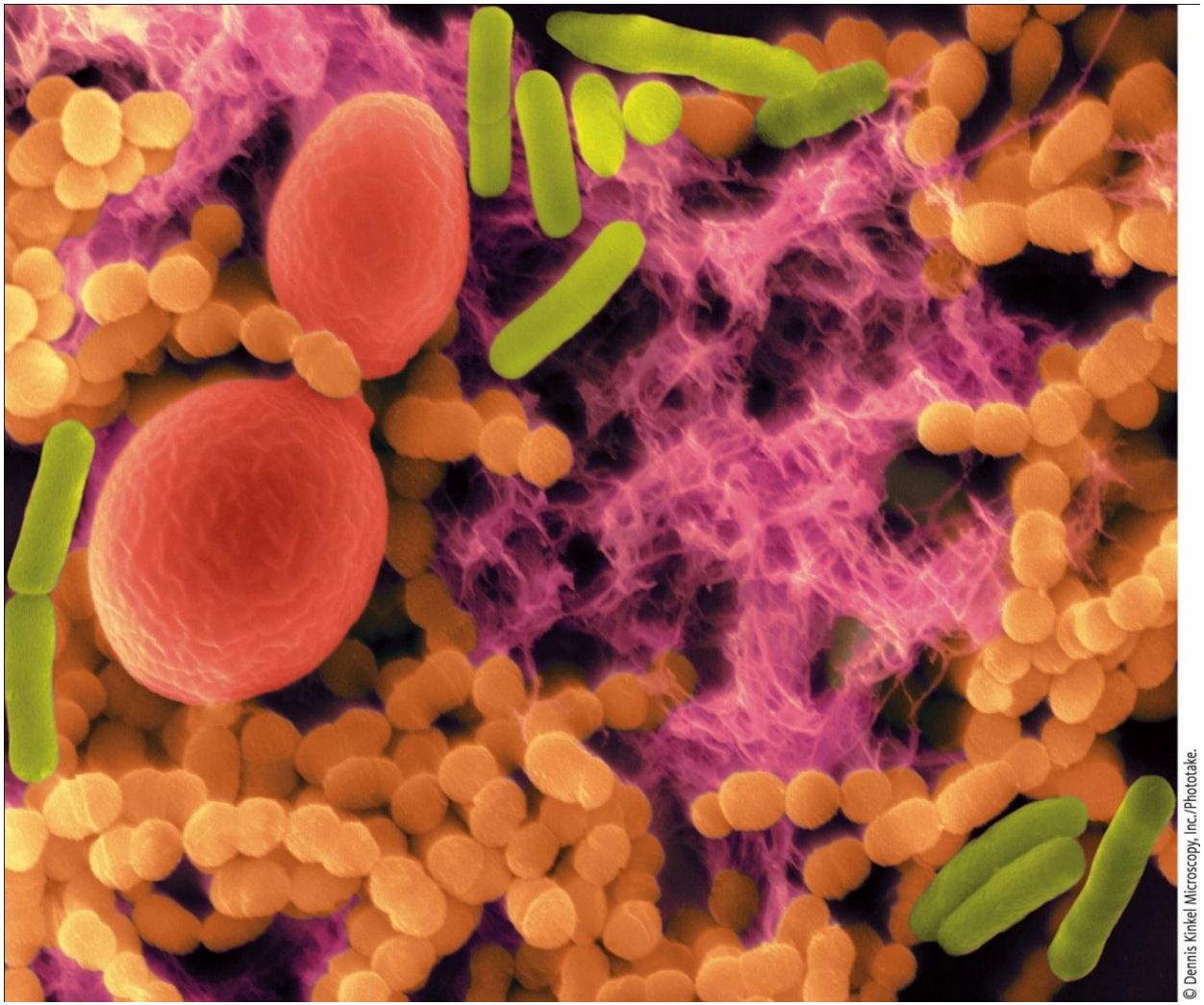
Biofilms

- Bacterial cells often share a layer of secreted polysaccharides and proteins
  - Biofilm: community of microorganisms living within a shared mass of secreted slime
- A biofilm is often attached to a solid surface, and may include:
  - Bacteria, algae, fungi, protists, and/or archaea

Biofilms (cont'd.)



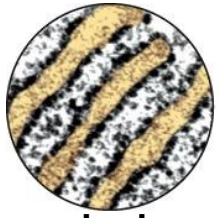
4.5 What Do Eukaryotic Cells Have in Common?

TABLE 4.4

Some Organelles in Eukaryotic Cells

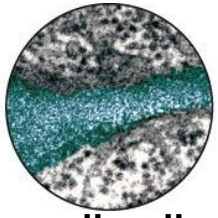
Organelles with membranes	
Nucleus	Protecting and controlling access to DNA
Endoplasmic reticulum (ER)	Making, modifying new polypeptides and lipids; other tasks
Golgi body	Modifying and sorting new polypeptides and lipids
Vesicle	Transporting, storing, or breaking down substances
Mitochondrion	Making ATP by glucose breakdown
Chloroplast	Making sugars in plants, some protists
Lysosome	Intracellular digestion
Peroxisome	Breaking down fatty acids, amino acids, toxins
Vacuole	Storage, breaking down food or waste
Organelles without membranes	
Ribosome	Assembling polypeptides
Centriole	Anchor for cytoskeleton
Other components	
Cytoskeleton	Contributes to cell shape, internal organization, movement

What Do Eukaryotic Cells Have in Common? (cont'd.)

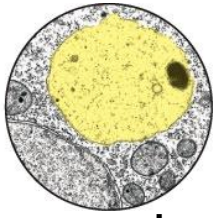

endoplasmic reticulum

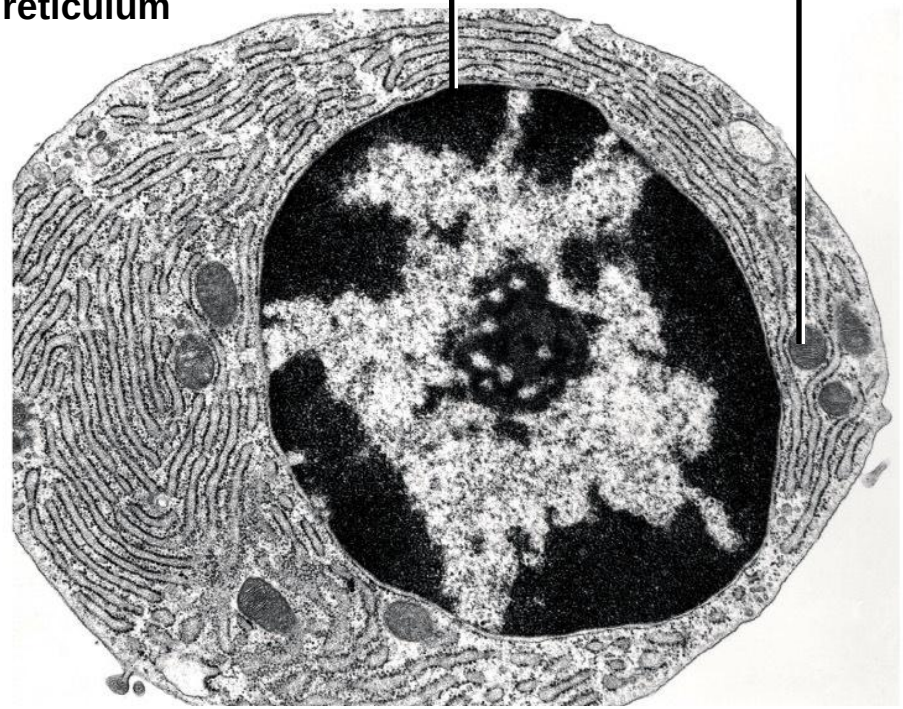

nucleus


mitochondrion

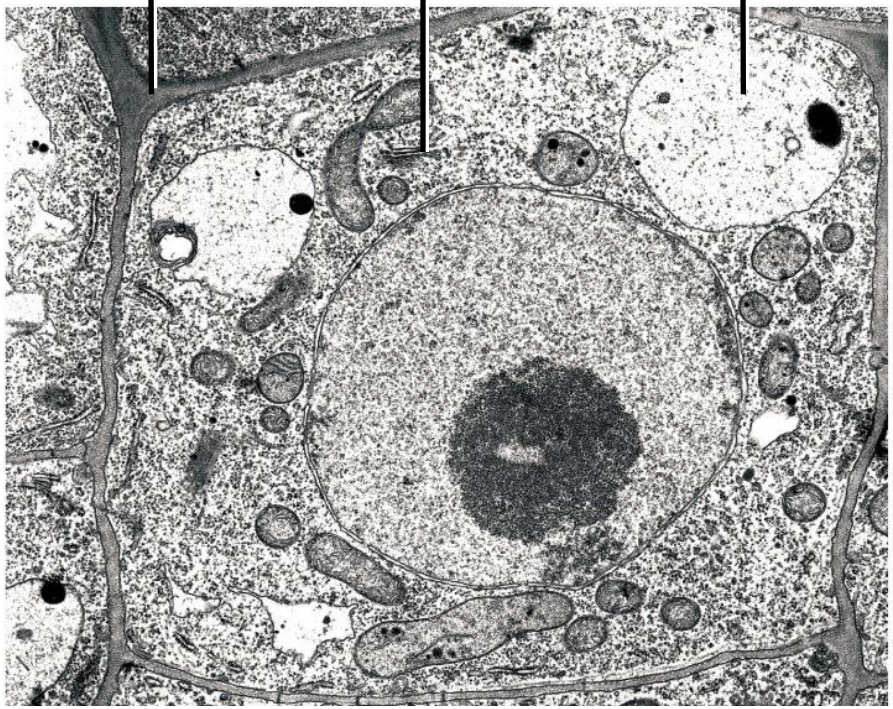

cell wall


Golgi body


vacuole



An animal cell (a white blood cell of a guinea pig)



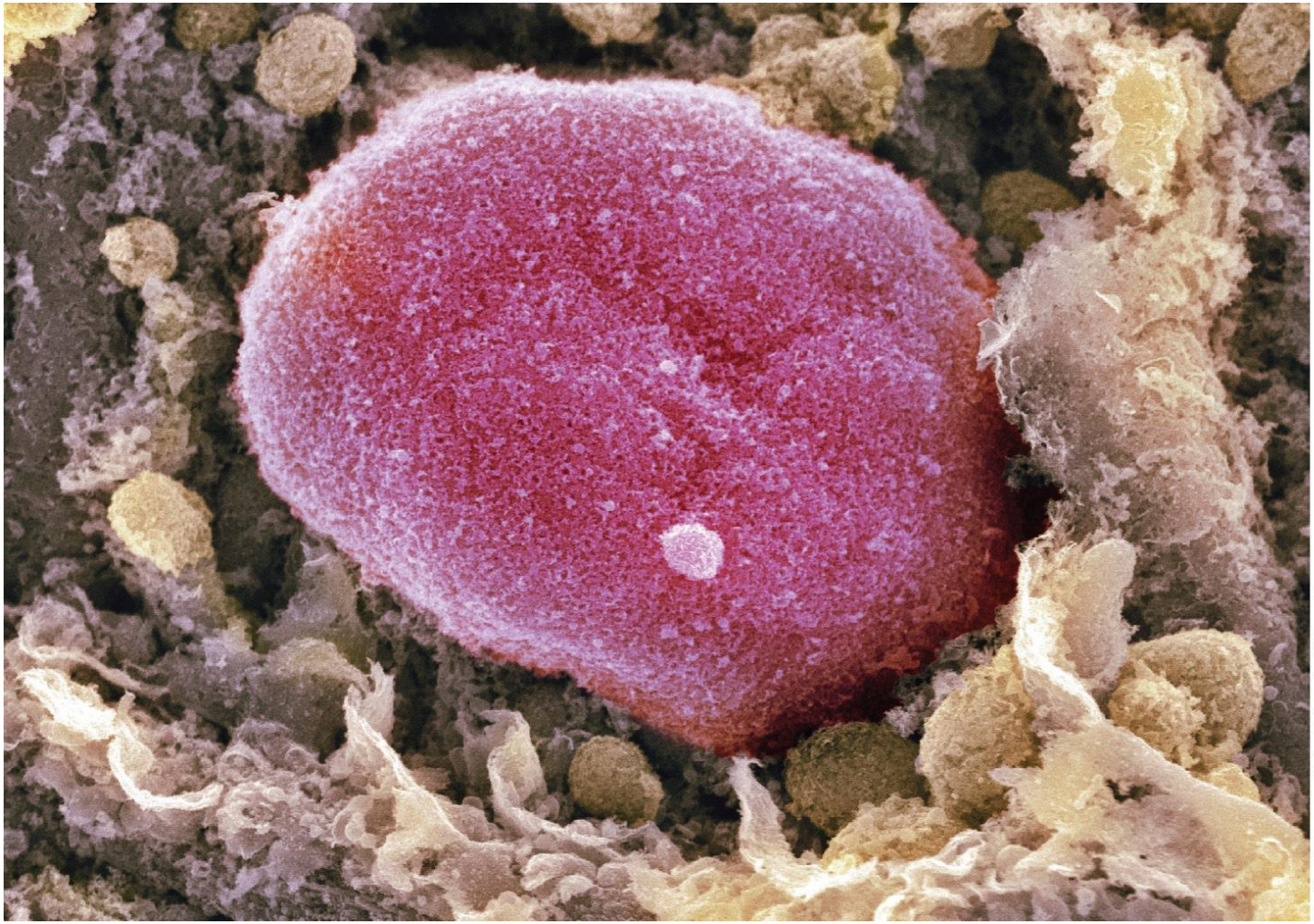
A plant cell (from a root of thale cress)

left, Don W. Fawcett/Science Source; right, Biophoto Associates/Science Source

The Nucleus

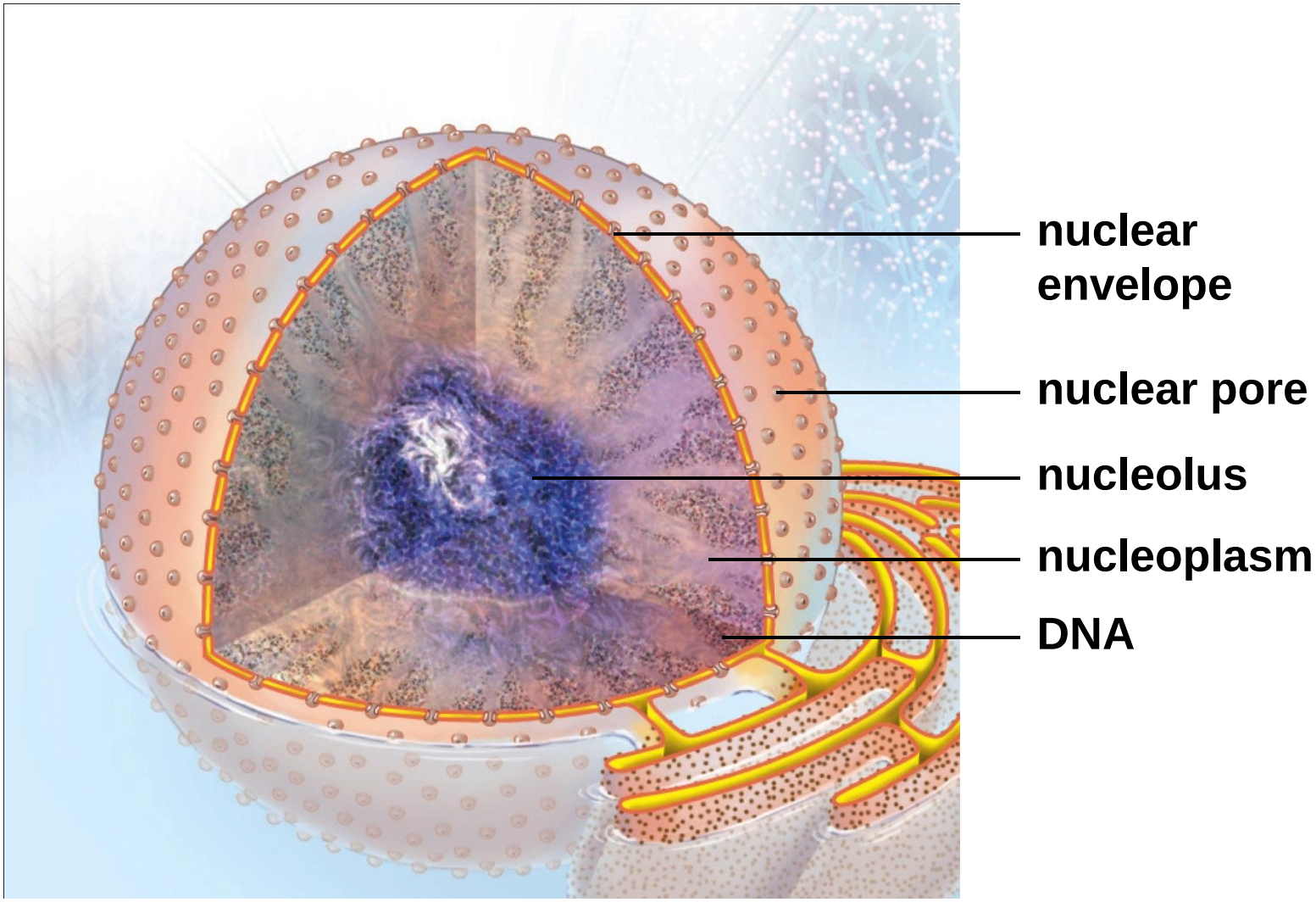
- The nucleus protects DNA from the metabolic processes of the cell
- Nuclear envelope: outer boundary of the nucleus; controls access to DNA
- Nucleoplasm: viscous fluid enclosed by the nuclear envelope
- Nucleolus: dense, irregularly shaped region where ribosomal subunits are assembled

The Nucleus (cont'd.)

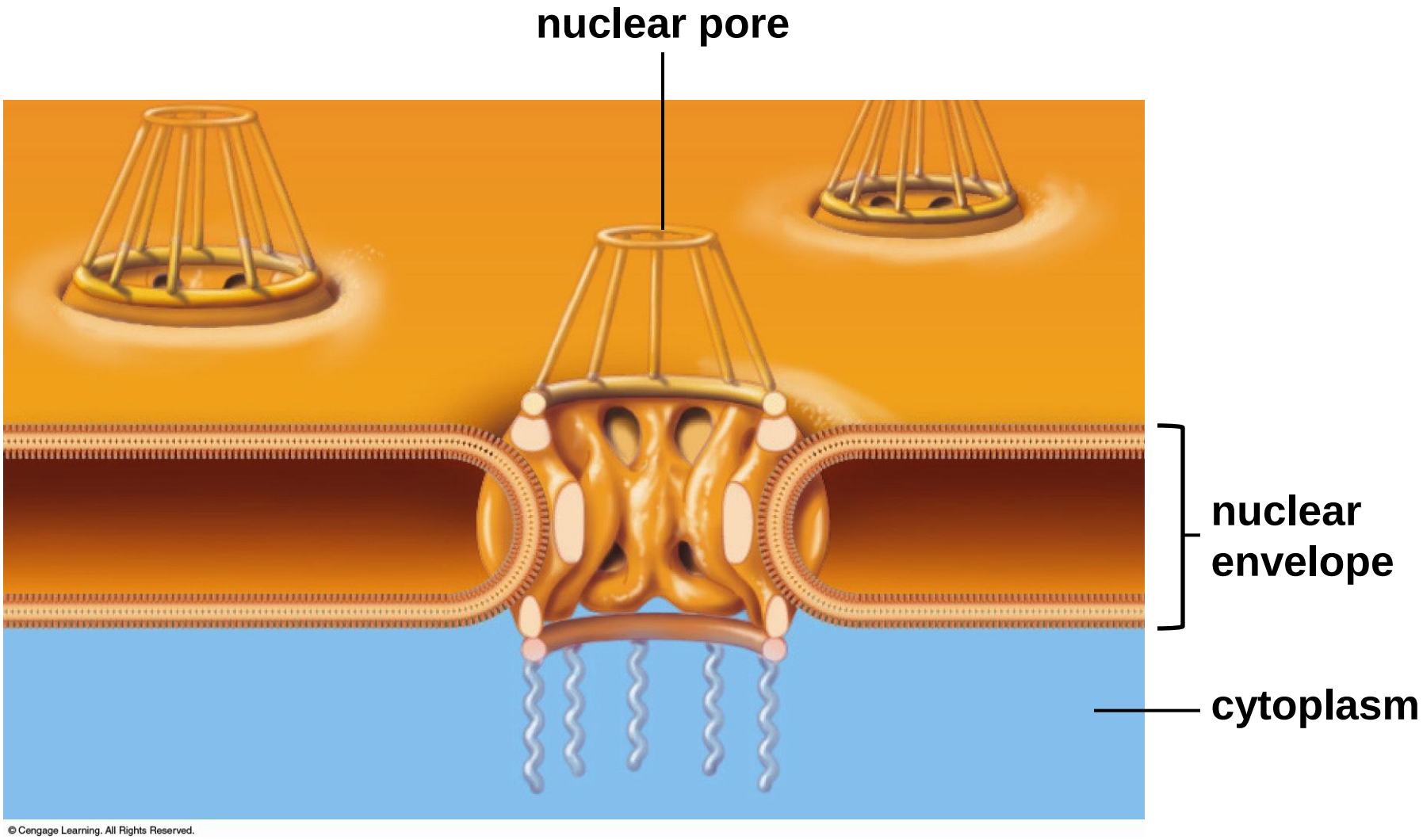


Dr. David Furness, Keele University/Science Source

The Nucleus (cont'd.)



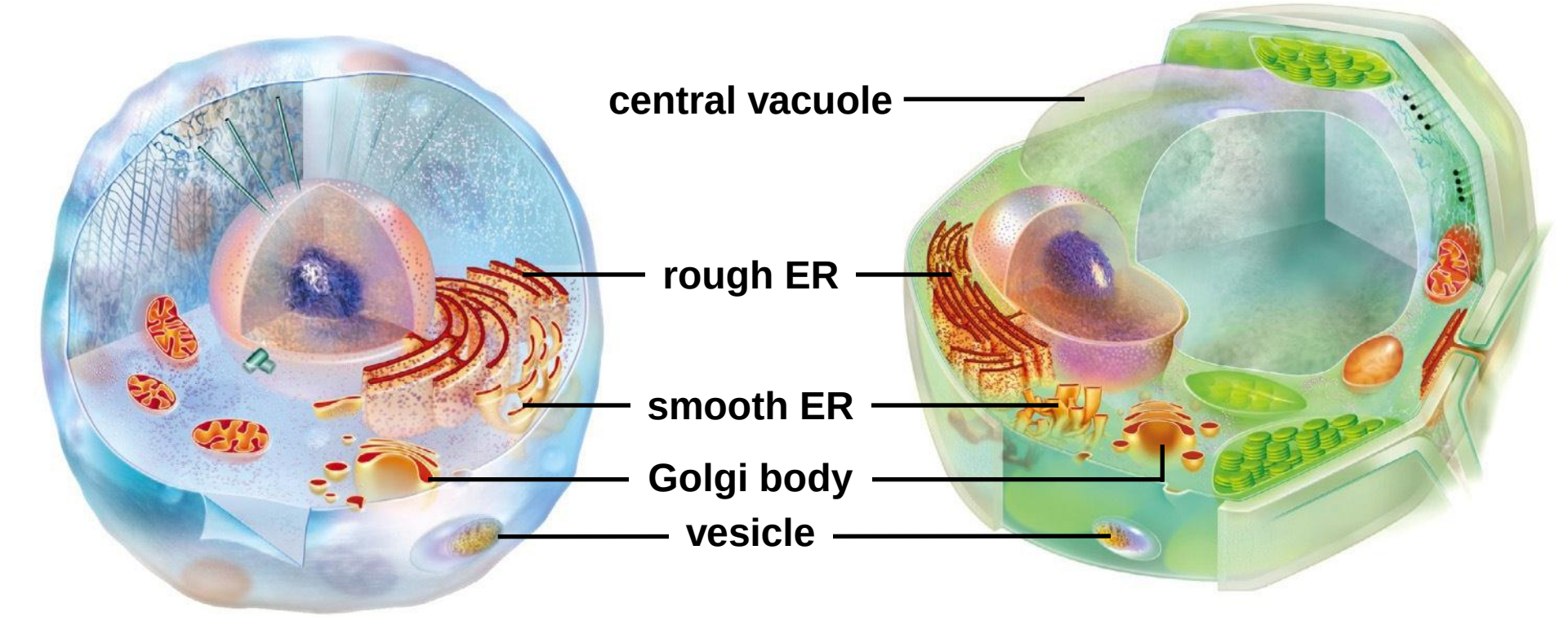
The Nucleus (cont'd.)



4.6 What Is the Endomembrane System?

- Endomembrane system
  - Series of interacting organelles between nucleus and plasma membrane
    - Endoplasmic reticulum, Golgi bodies, and vesicles
  - Produces lipids and proteins

What Is the Endomembrane System? (cont'd.)



A Variety of Vesicles

- Vesicle: small, membrane-enclosed organelle
- Functions:
  - Transports substances
  - Collects and disposes of waste, debris, or toxins

A Variety of Vesicles (cont'd.)

- Peroxisome: breaks down amino acids, fatty acids, and toxic substances
- Lysosome: breaks down cellular wastes and debris
- Vacuoles: fluid filled; isolates or disposes of waste, debris, or toxic materials
- Central vacuole: fluid-filled vesicle in many plant cells

A Variety of Vesicles (cont'd.)

© Michael Plewka

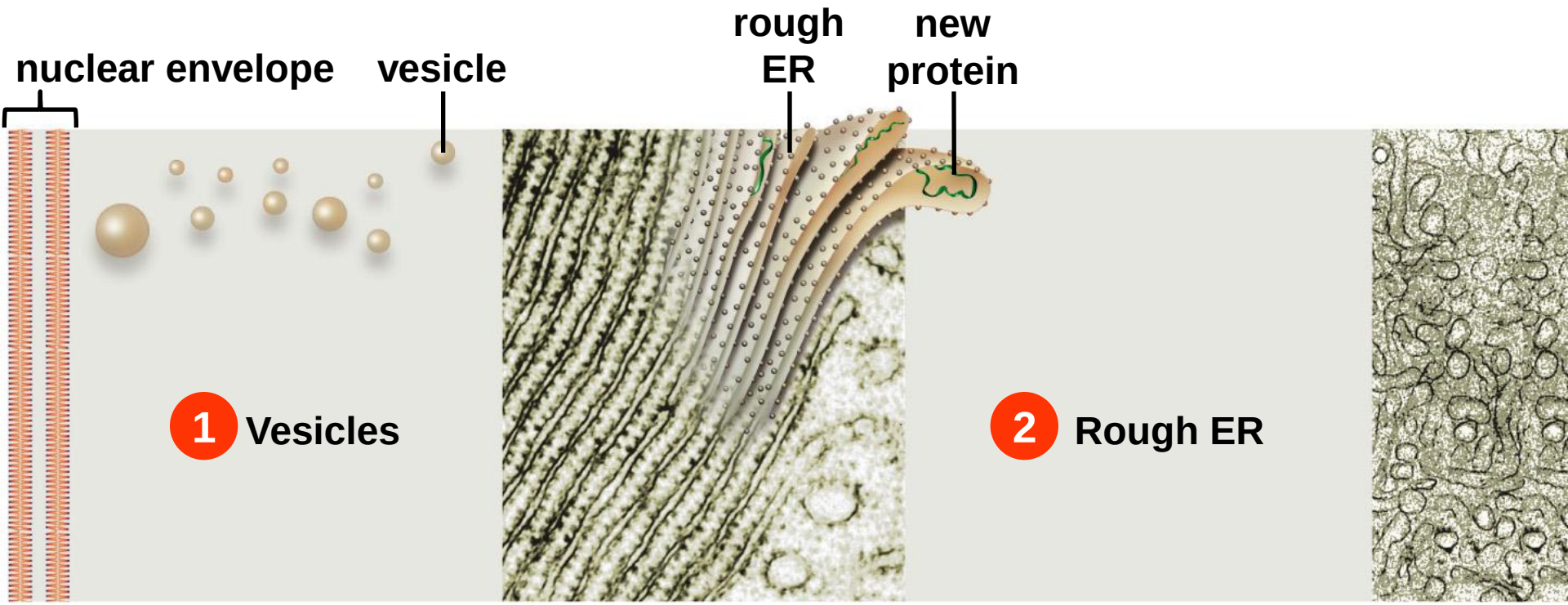
Endoplasmic Reticulum

- Endoplasmic reticulum (ER): A continuous system of sacs and tubes extending from the nuclear envelope
  - Smooth ER: makes lipids and breaks down carbohydrates and fatty acids
  - Rough ER: ribosomes on the surface synthesize proteins

Golgi Bodies

- Golgi body:
  - Modifies proteins
  - Packages the finished products into vesicles
  - Some of the vesicles deliver their cargo to the plasma membrane; others become lysosomes

What Is the Endomembrane System? (cont'd.)



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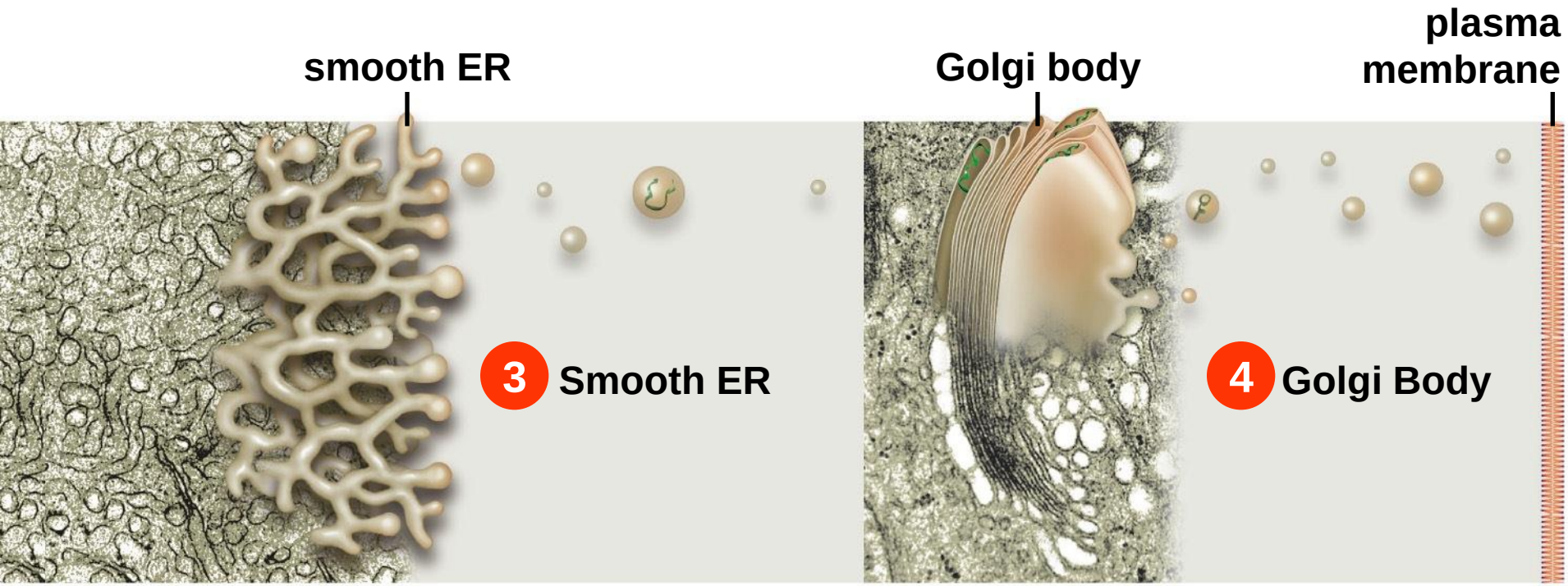
What Is the Endomembrane System? (cont'd.)

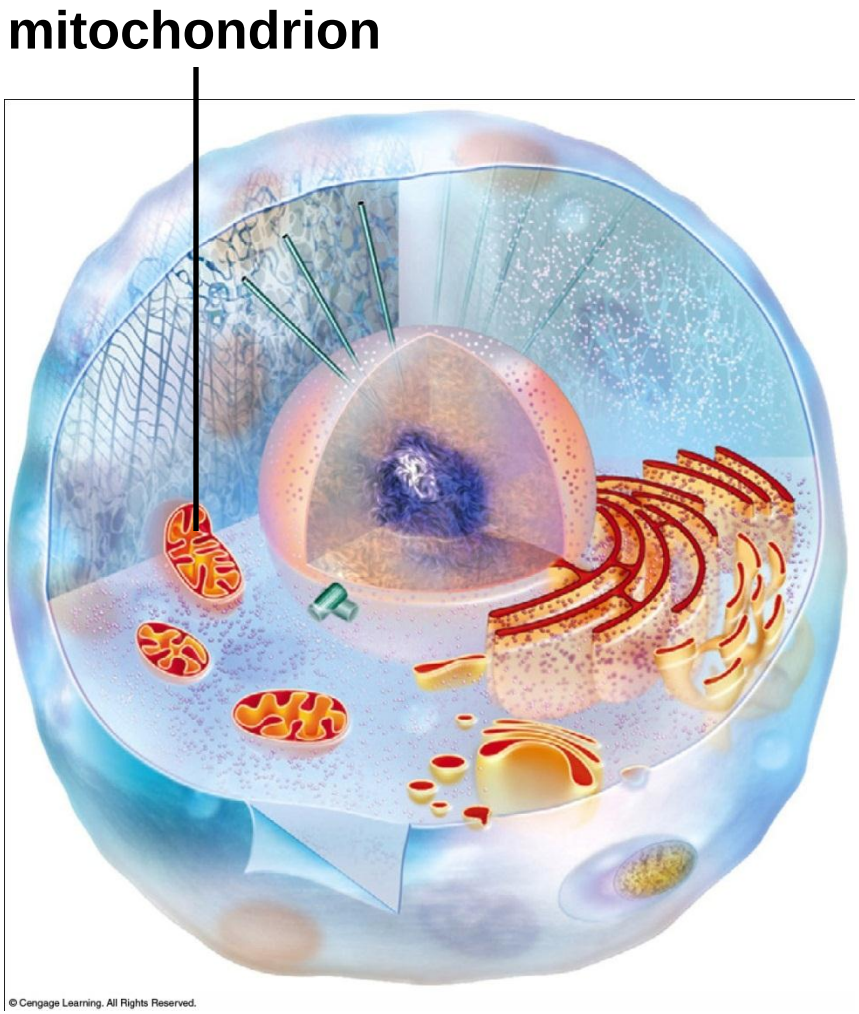


(12-3) Don W. Fawcett/Visuals Unlimited; (12-4) Micrograph, Gary Grimes; (12) art, © Cengage Learning 2015.

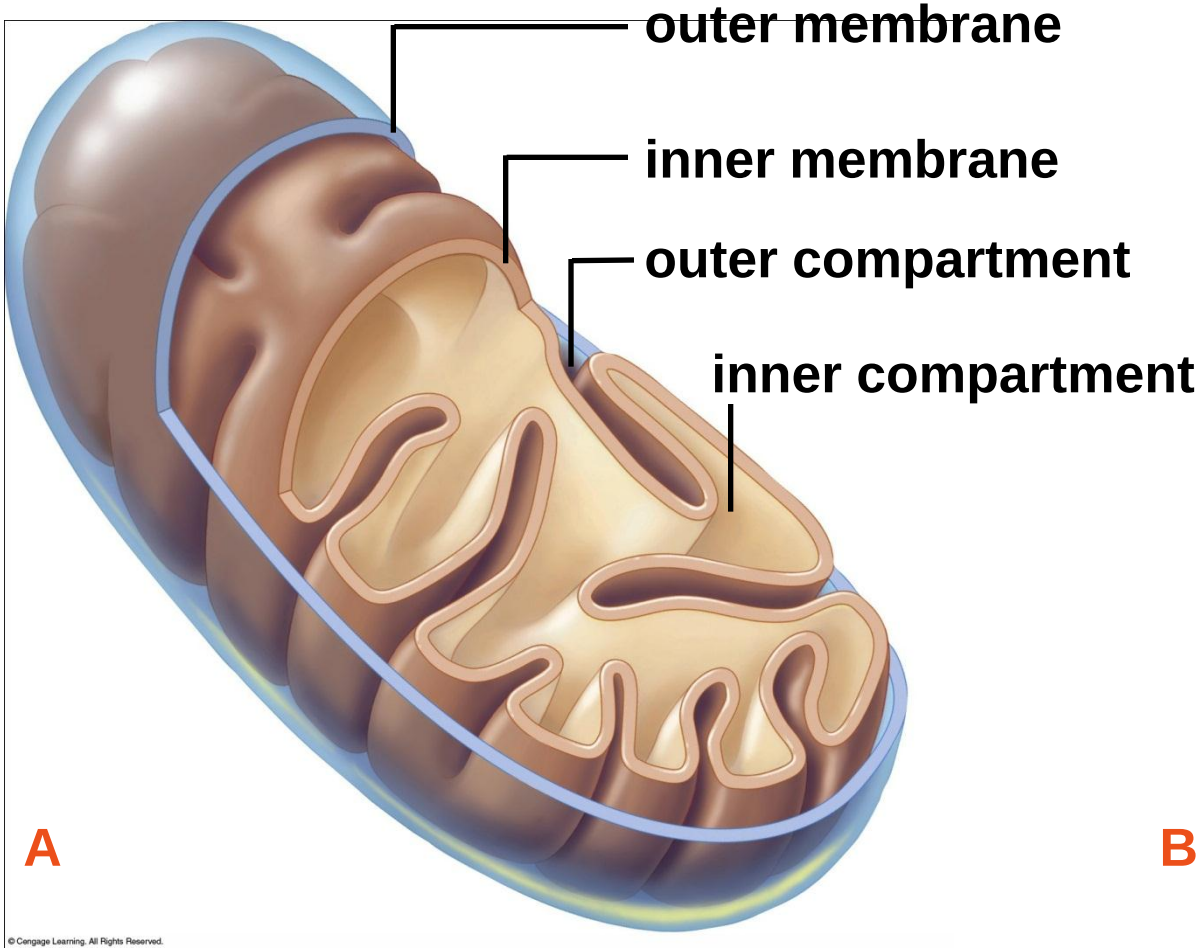
4.7 What Do Mitochondria Do?

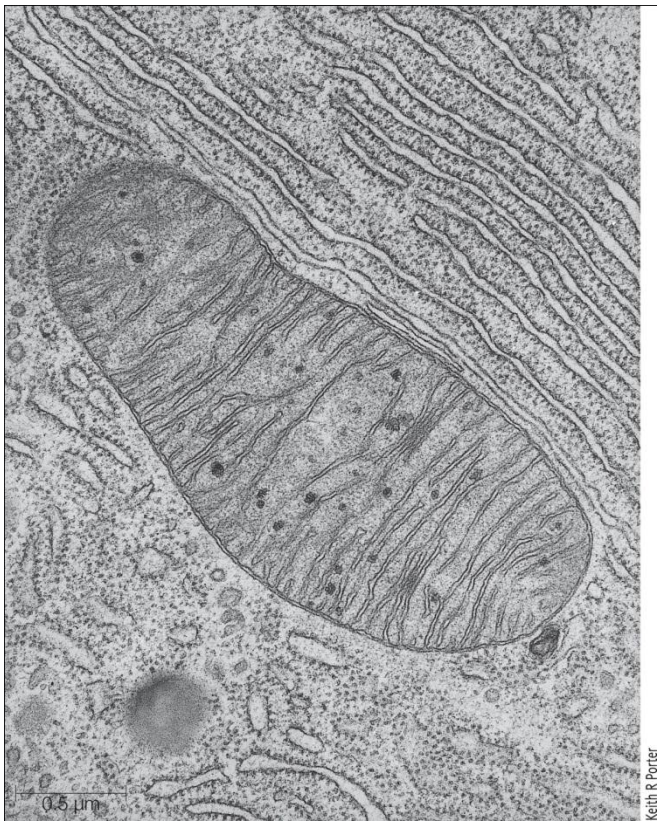
- Mitochondrion: double-membraned organelle that produces ATP by aerobic respiration in eukaryotes
- Nearly all eukaryotic cells (including plant cells) have mitochondria
  - The number varies by the type of cell and by the organism

What Do Mitochondria Do? (cont'd.)



What Do Mitochondria Do? (cont'd.)

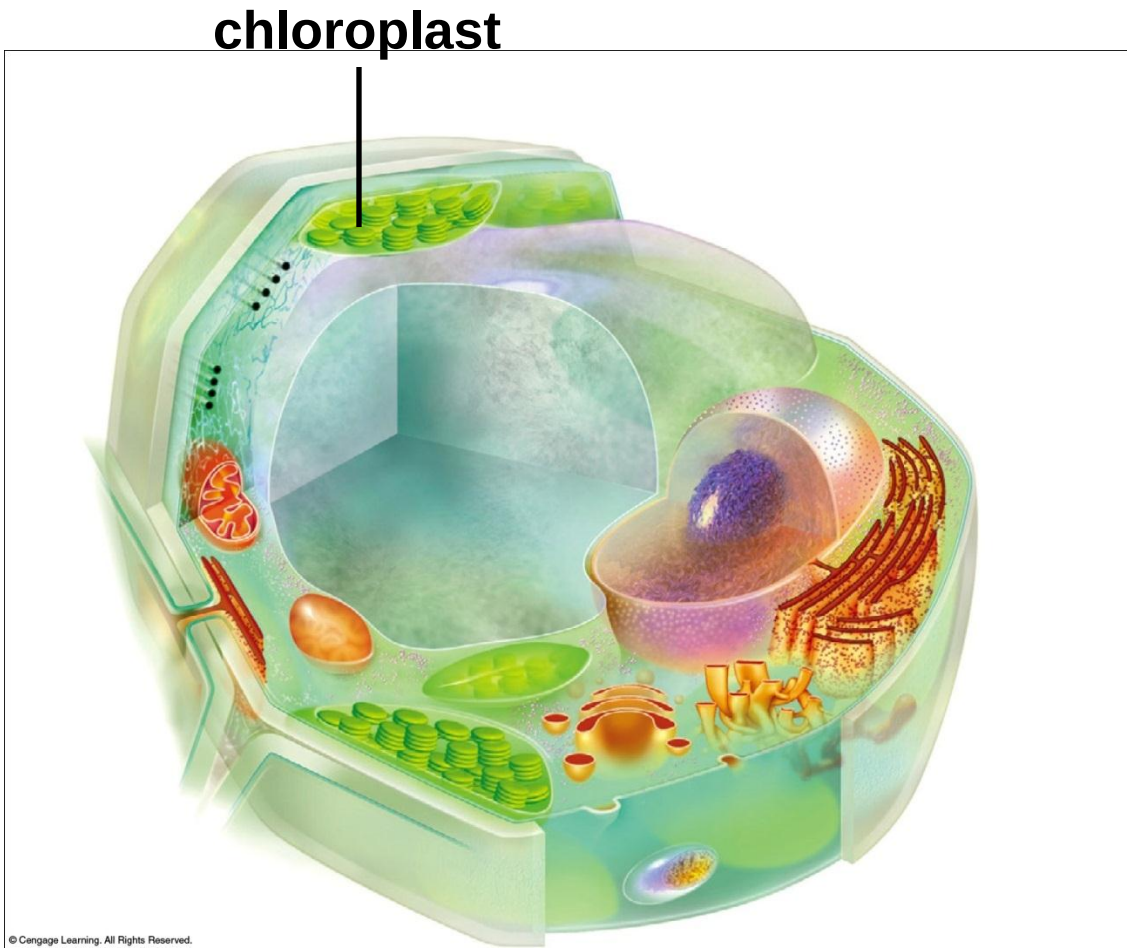




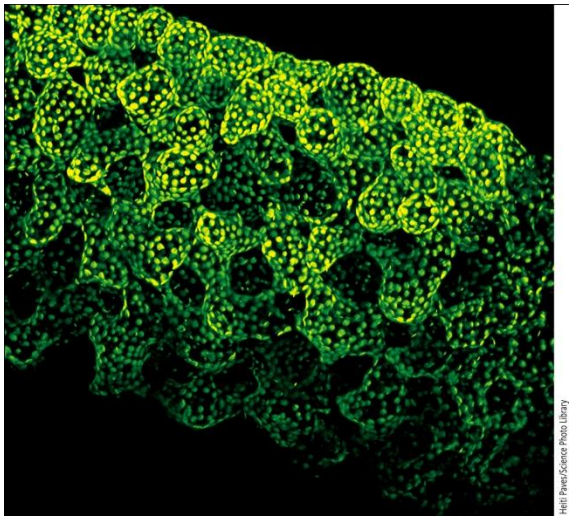
4.8 What Are Plastids?

- Plastids: double-membraned organelles that function in photosynthesis, storage, or pigmentation in plant and algal cells
  - Examples: chloroplasts, chromoplasts, amyloplasts
  - *Chloroplasts:* specialized plastid for photosynthesis in some protists and plant cells

What Are Plastids? (cont'd.)



What Are Plastids? (cont'd.)



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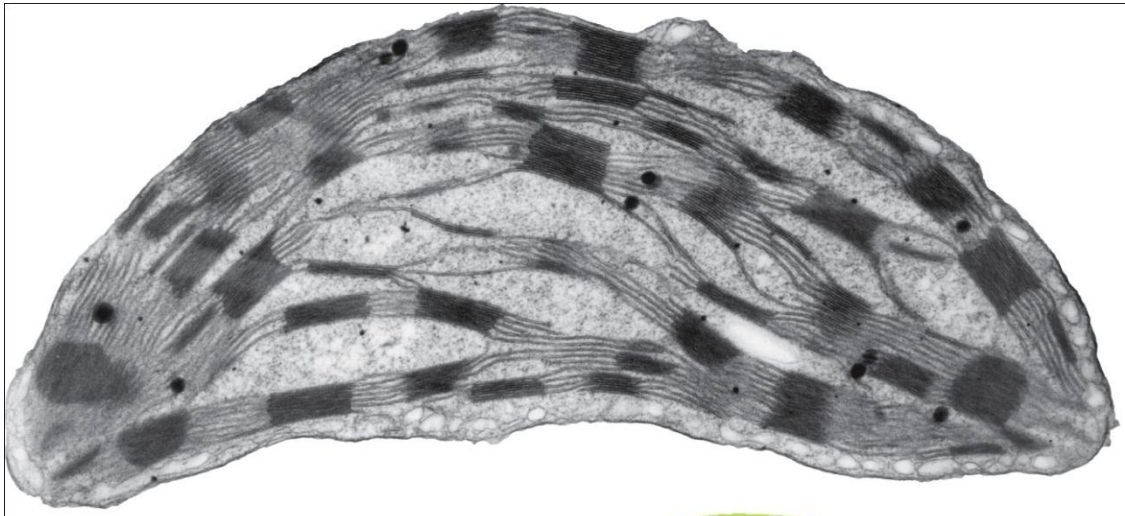

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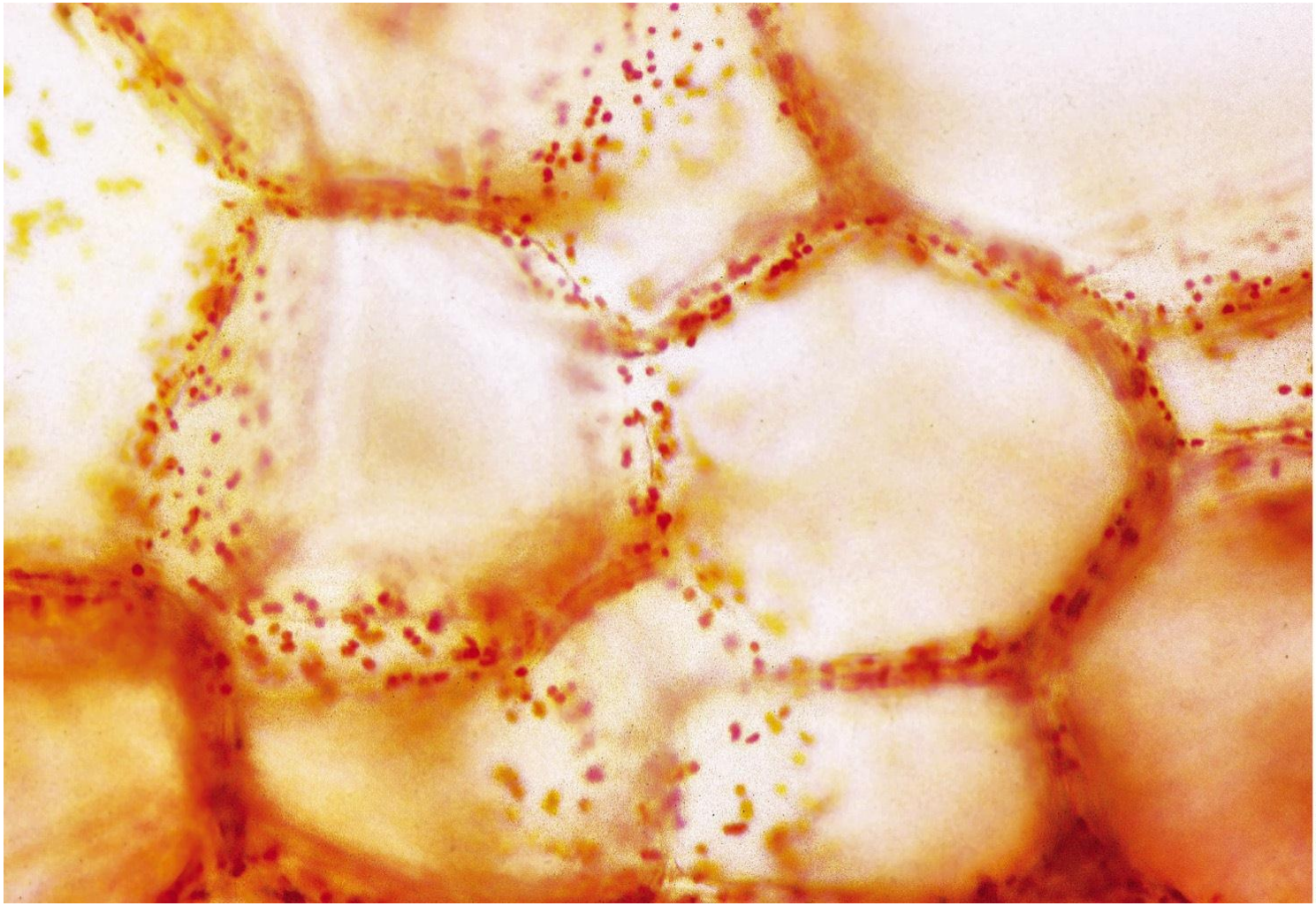
What Are Plastids? (cont'd.)



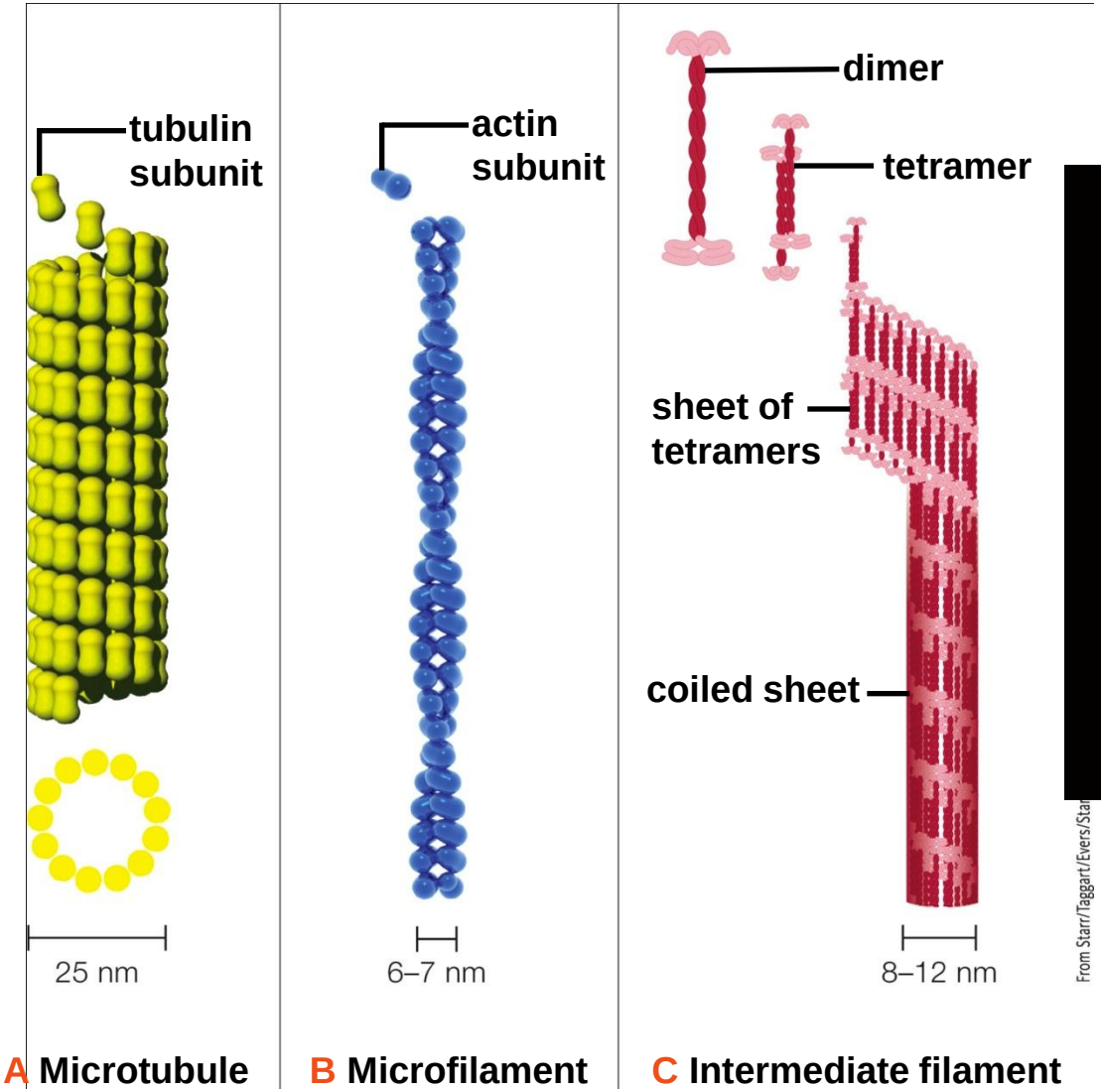
4.9 What Is a Cytoskeleton?

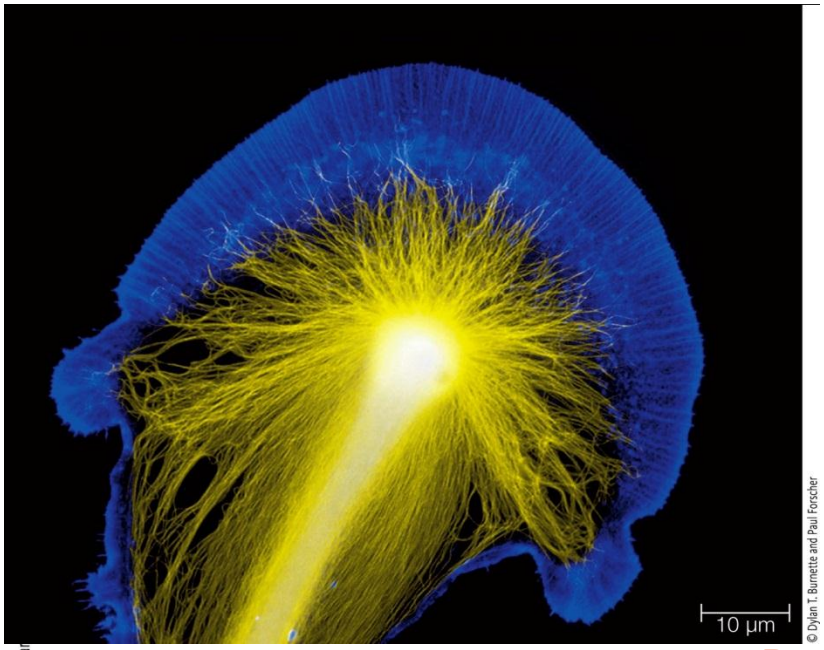
- Cytoskeleton:
  - Network of interconnected protein filaments
  - Supports, organizes, and moves eukaryotic cells and their parts

What Is a Cytoskeleton? (cont'd.)

- Microtubules: hollow filament of tubulin subunits
  - Involved in movement
- Microfilaments: fiber of actin subunits
  - Reinforces membranes; involved in muscle contractions
- Intermediate filament: stable cytoskeletal element
  - Structurally supports membranes and tissues

What Is a Cytoskeleton? (cont'd.)





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What Is a Cytoskeleton? (cont'd.)

- Motor proteins
  - Associate with cytoskeletal elements
  - Move cell parts when energized by a phosphate-group transfer from ATP
  - Drag cellular cargo along tracks of microtubules and microfilaments

What Is a Cytoskeleton? (cont'd.)

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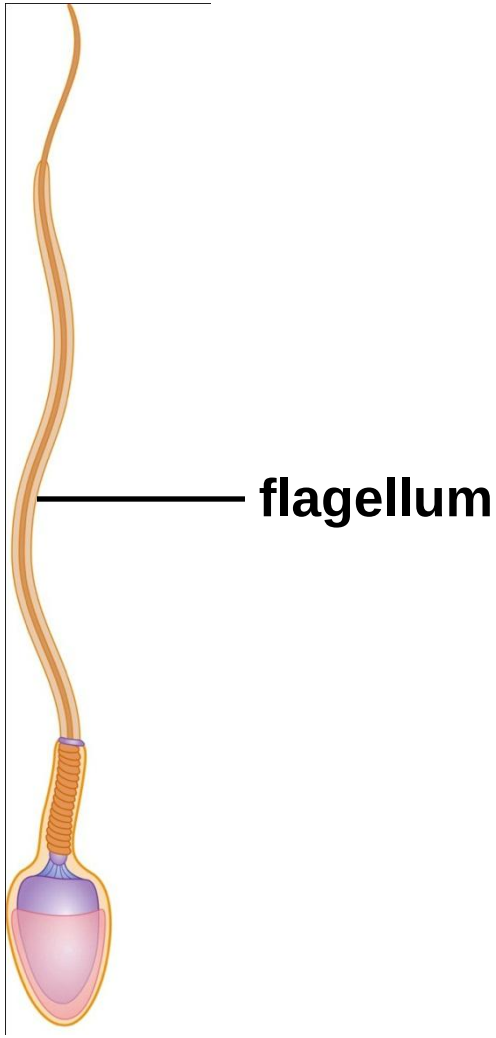
What Is a Cytoskeleton? (cont'd.)

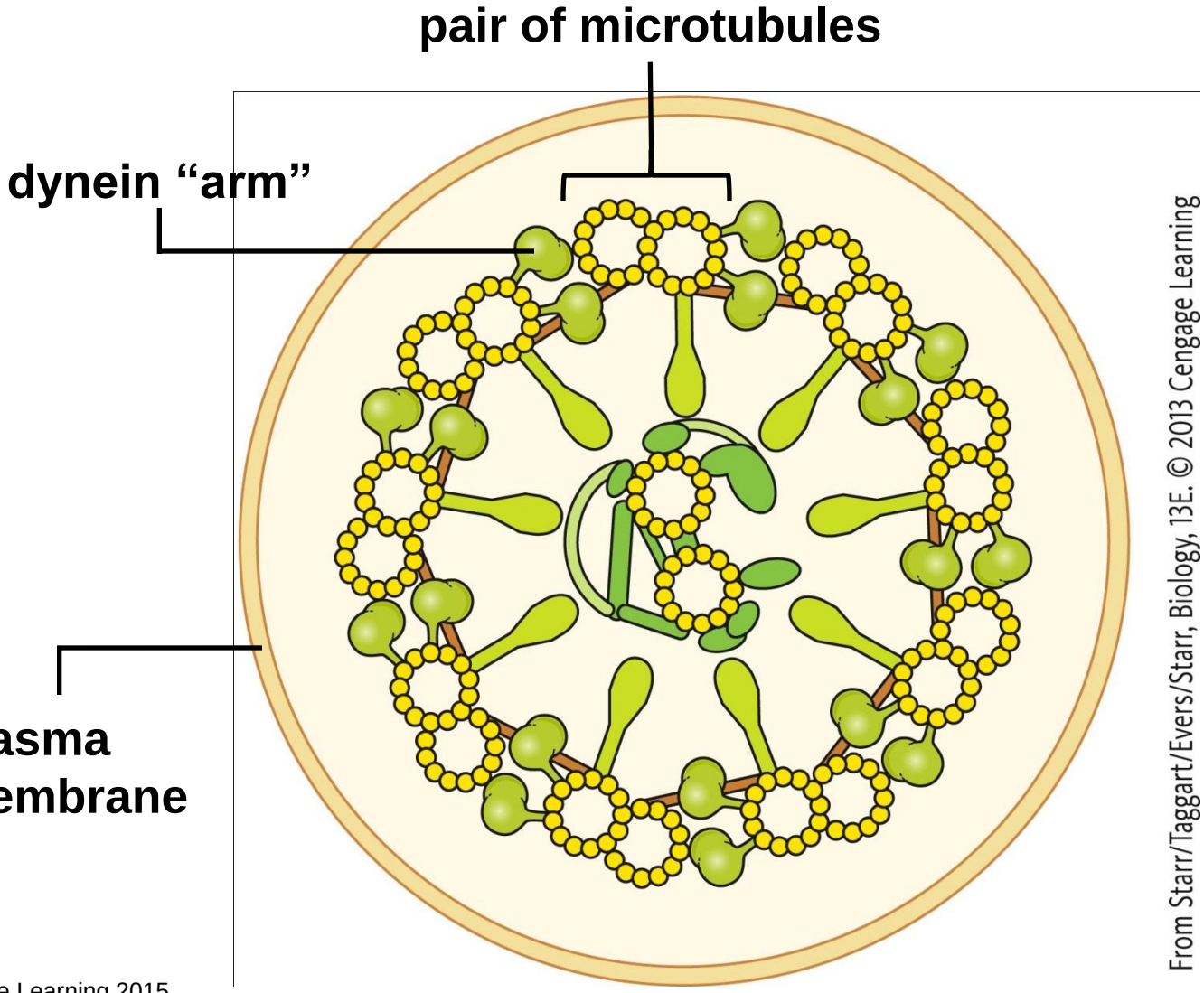
- Flagella: propel cells
- Cilia: short, movable structures that project from the plasma membrane
- Centriole: barrel-shaped organelle from which microtubules grow
- Basal body: develops from a centriole
- Pseudopod: temporary protrusion; facilitates movement and engulfs prey

What Is a Cytoskeleton? (cont'd.)

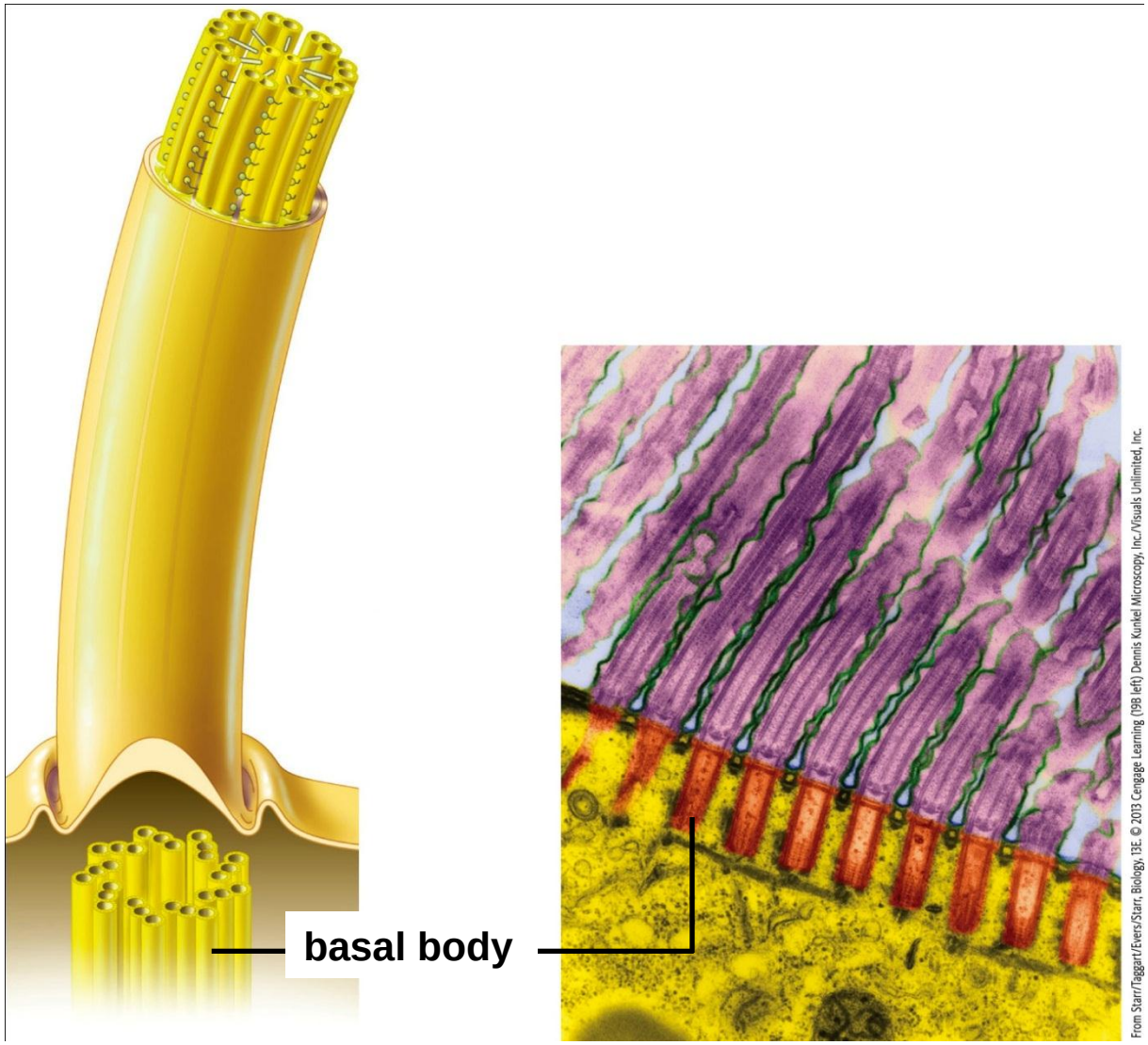


sperm

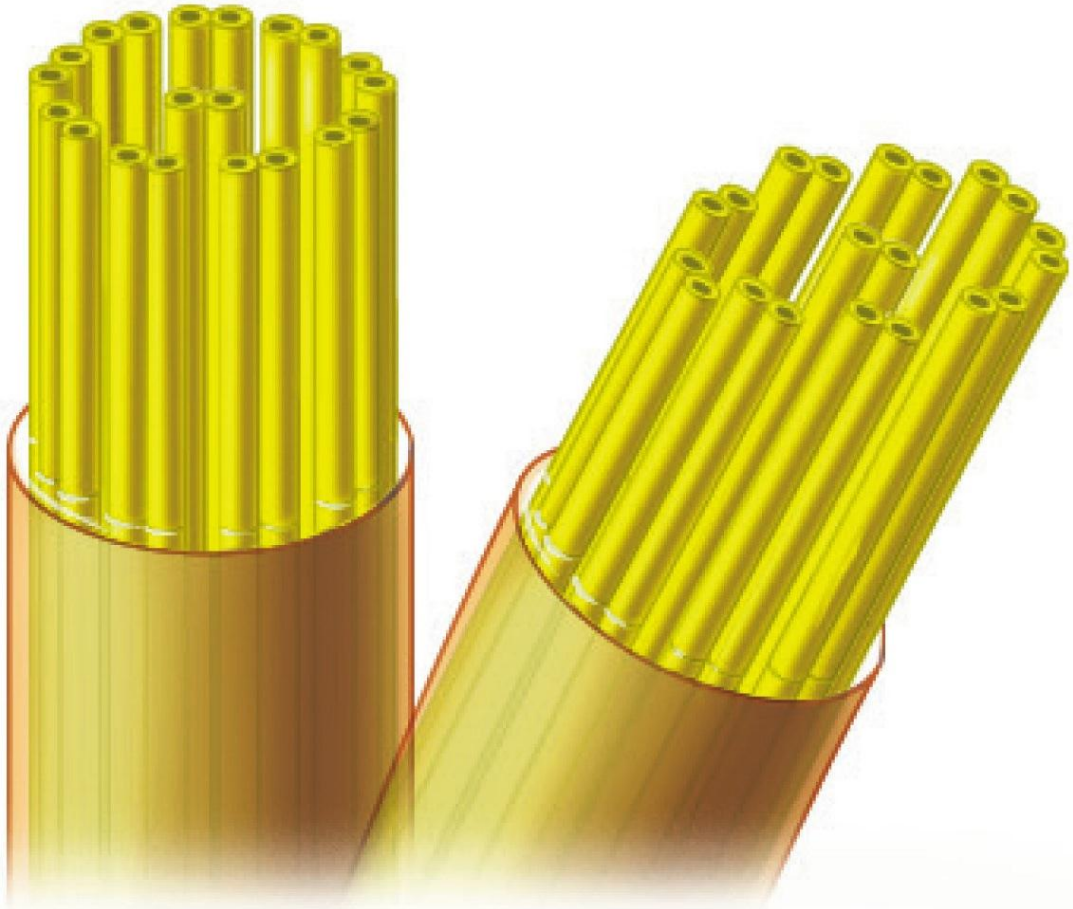
What Is a Cytoskeleton? (cont'd.)



What Is a Cytoskeleton? (cont'd.)



What Is a Cytoskeleton? (cont'd.)



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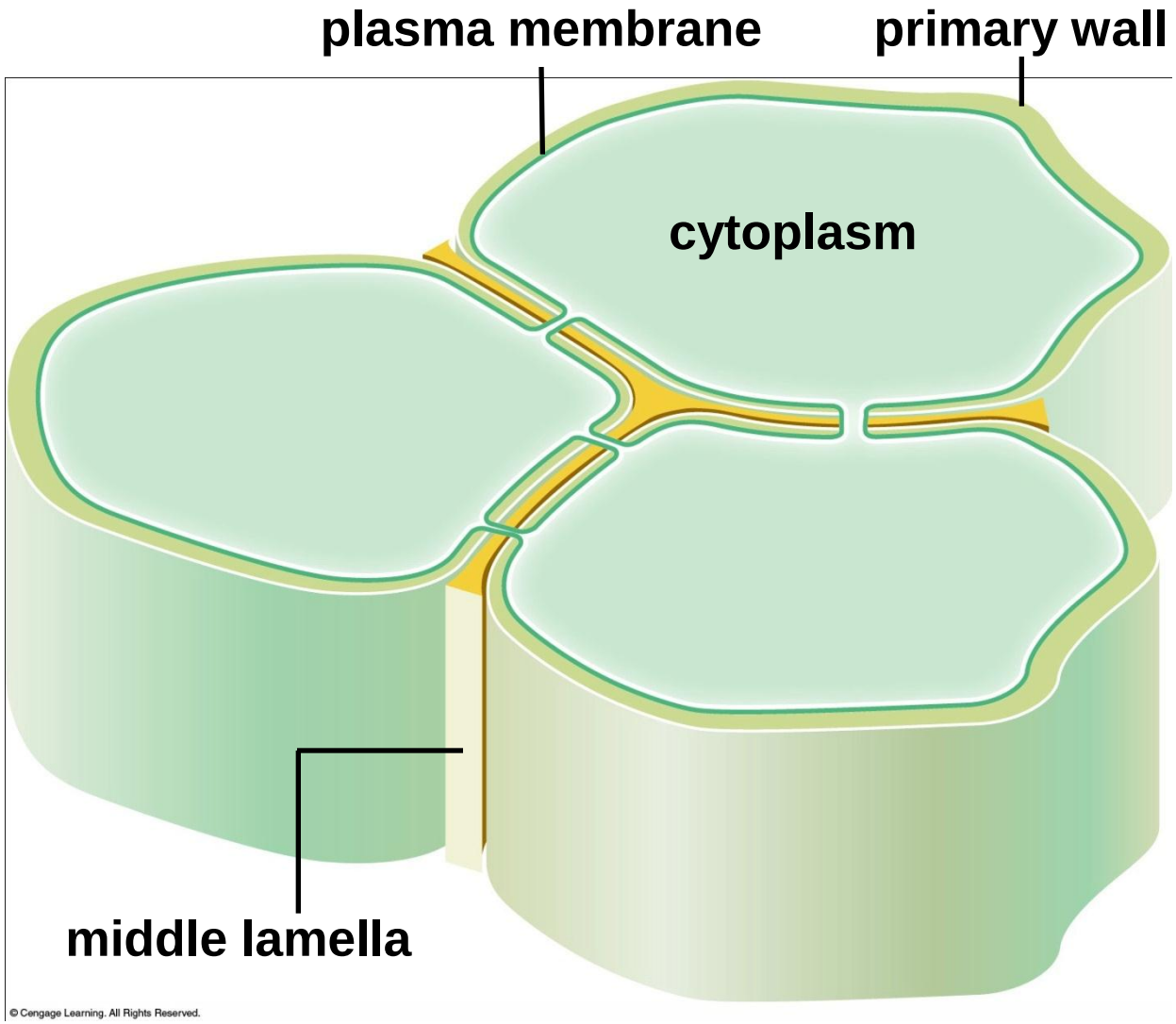
C

4.10 What Structures Form on the Outside of Eukaryotic Cells?

- Cell matrixes
  - Extracellular matrix: complex mixture of cell secretions
  - Primary wall: first cell wall of young plant cells
  - Secondary wall: lignin-reinforced wall that forms inside the primary wall of a plant cell
    - Lignin: stiffens cell walls of vascular plants

What Structures Form on the Outside of Eukaryotic Cells? (cont'd.)



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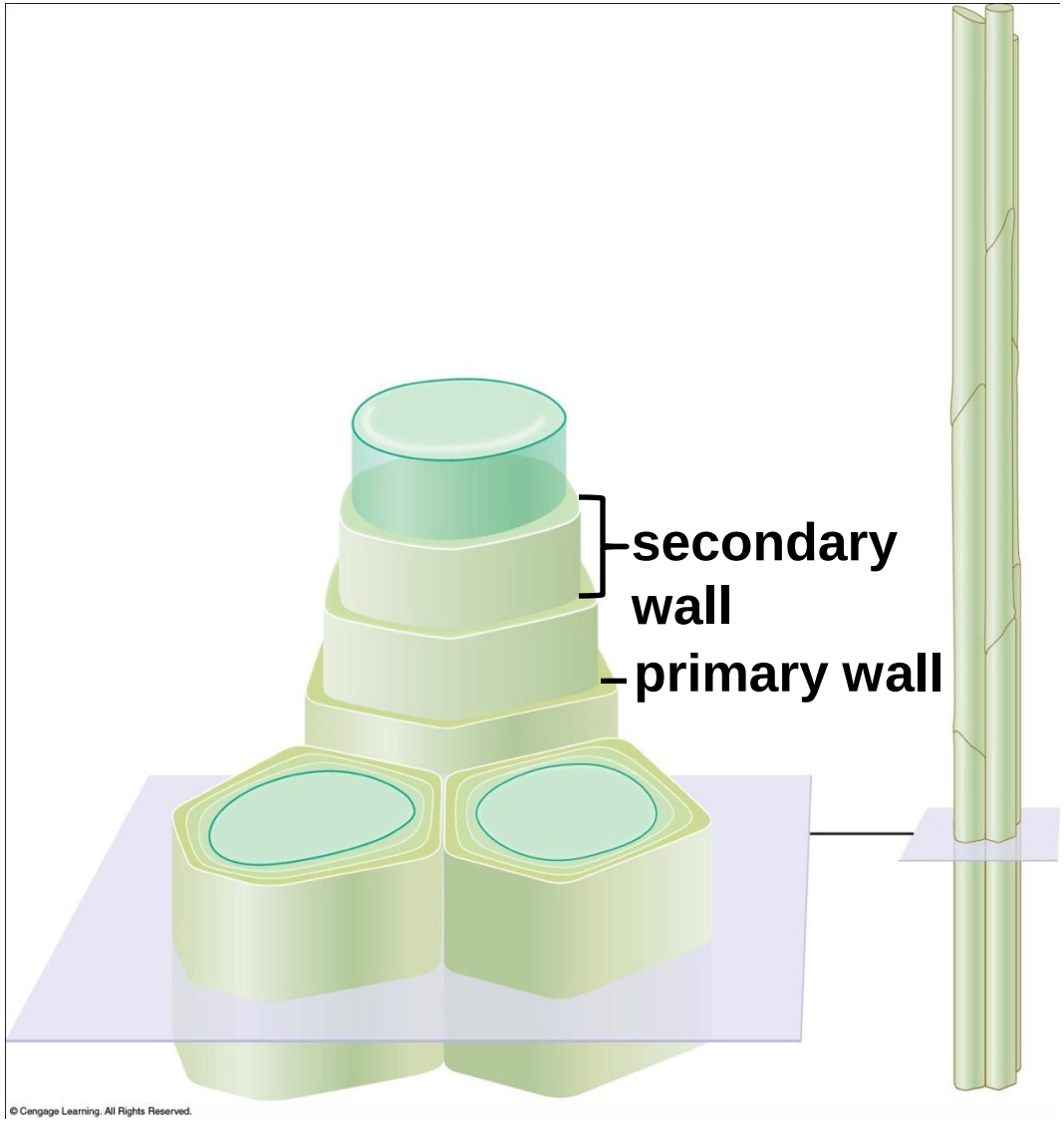
What Structures Form on the Outside of Eukaryotic Cells? (cont'd.)



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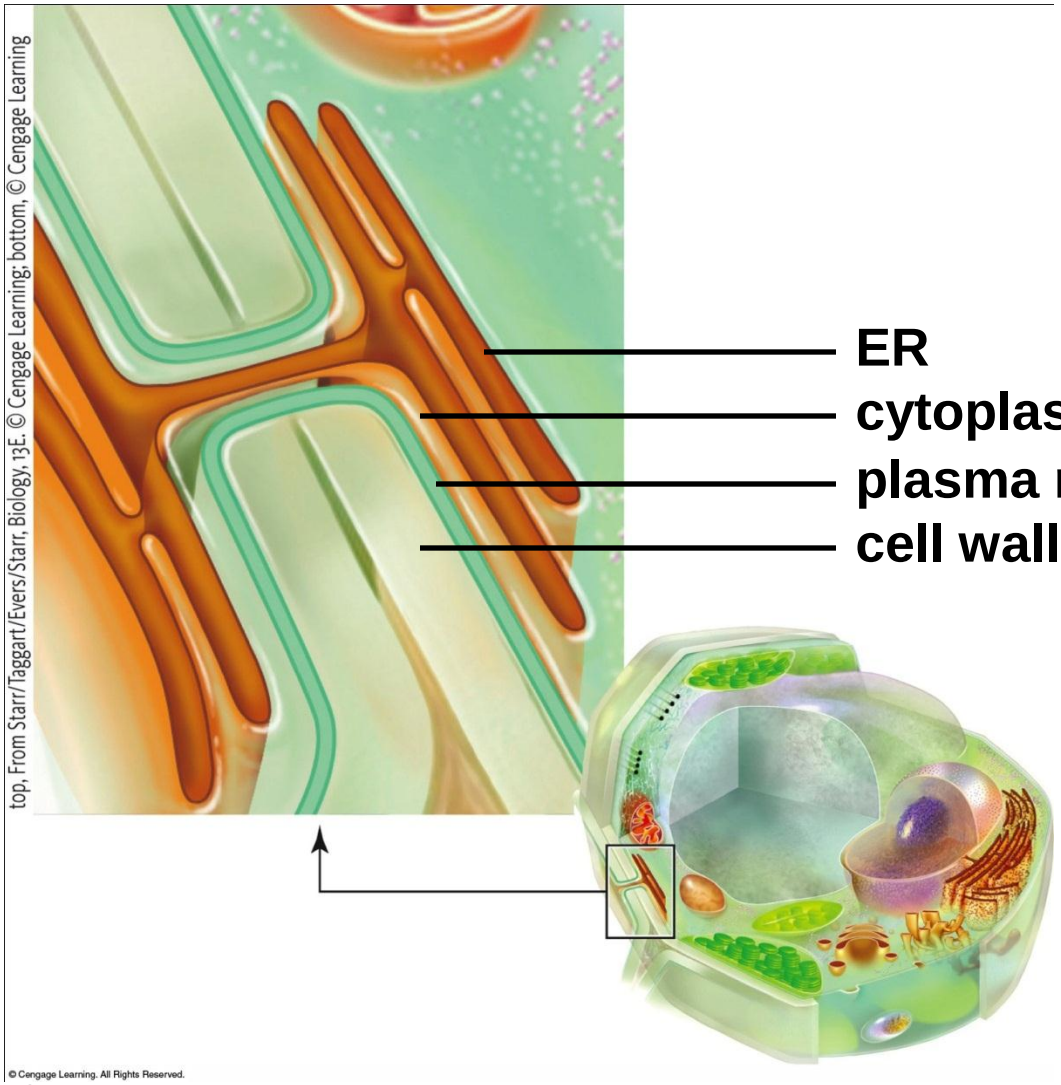
What Structures Form on the Outside of Eukaryotic Cells? (cont'd.)

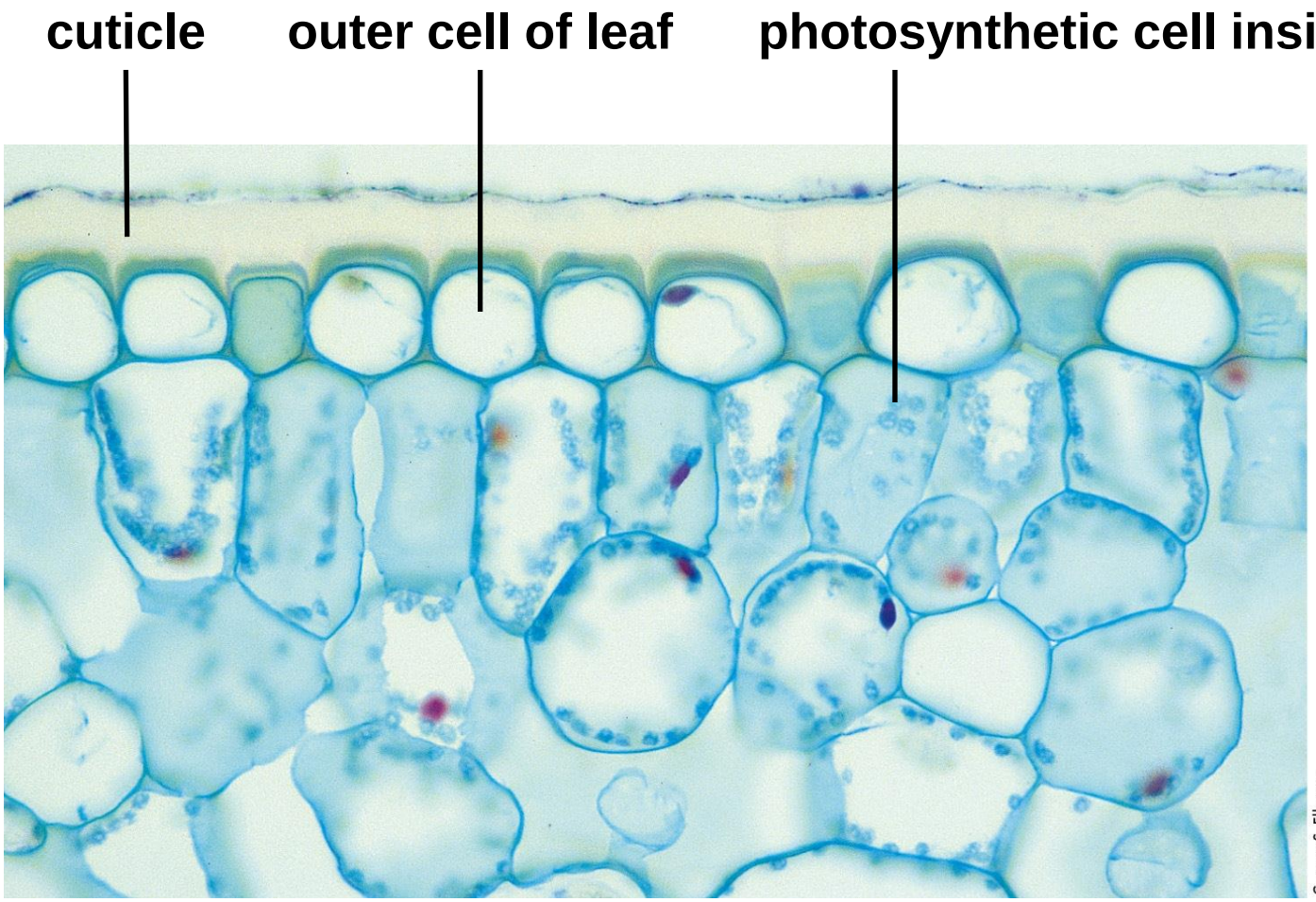


C

What Structures Form on the Outside of Eukaryotic Cells? (cont'd.)

- Cell matrixes (cont'd.)
  - Cuticle: secreted covering at a body surface
  - In plants, a cuticle of waxes and proteins helps stems and leaves fend off insects and retain water

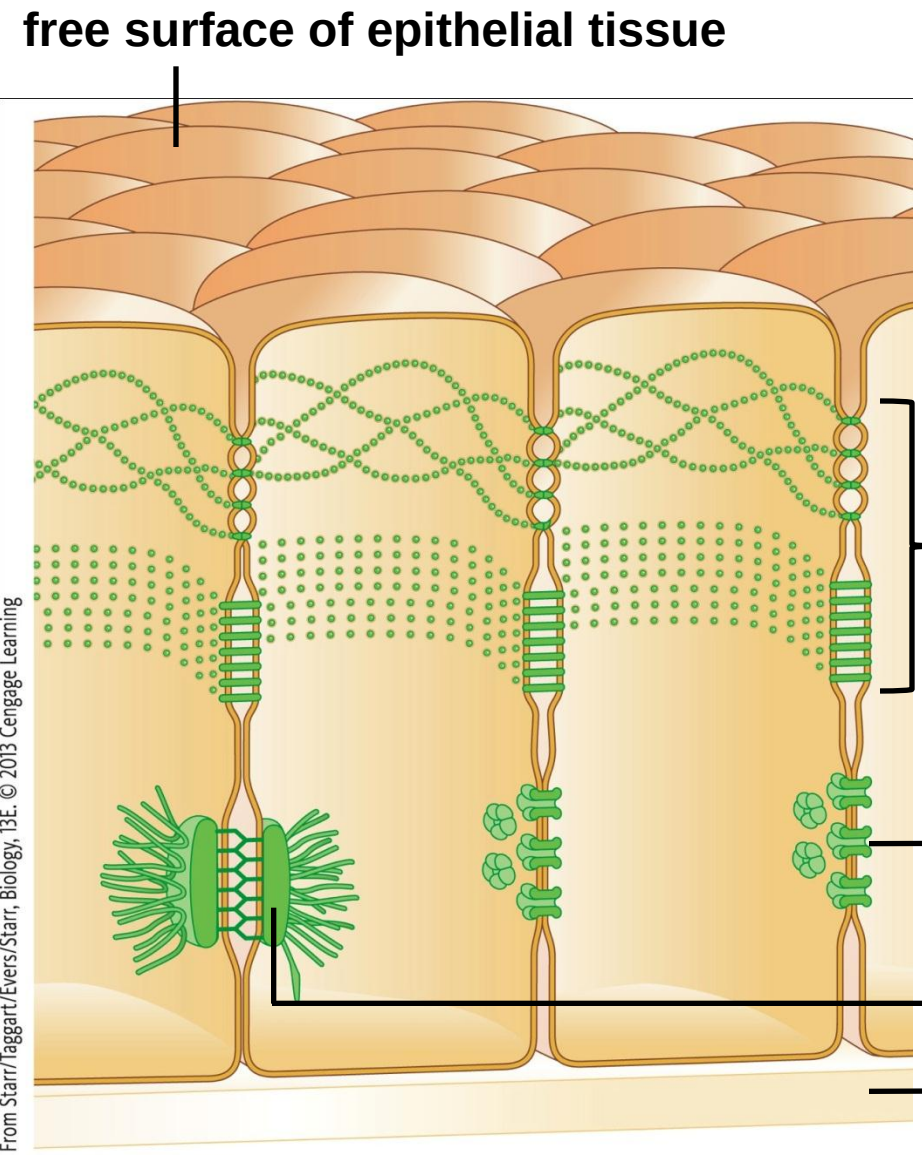
What Structures Form on the Outside of Eukaryotic Cells? (cont'd.)



Cell Junctions

- Cell junction: connects a cell to another cell or to an extracellular matrix
- Tight junction: adhesion proteins that join epithelial cells
  - Prevents fluids from leaking between cells

Cell Junctions (cont'd.)



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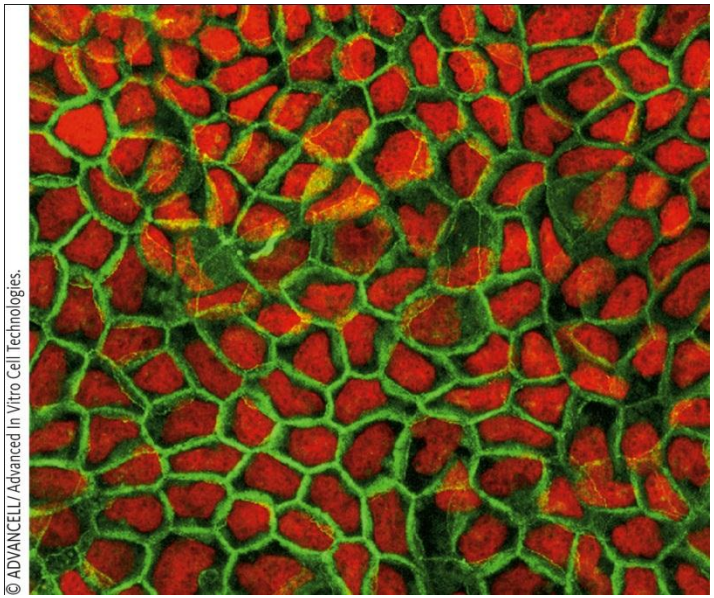

B

Cell Junctions (cont'd.)

- Adhering junctions: connect to cytoskeletal elements
  - Fastens cells to each other and basement membrane
  - Gap junctions: closeable channels formed across the plasma membranes of adjoining animal cells
  - Plasmodesmata: open channel formed between the cytoplasm of adjacent plant cells

4.11 What Is Life?

- "Life" is a long list of properties that collectively describe living things
  1. Make and use the organic molecules of life
  2. Consist of one or more cells
  3. Engage in self-sustaining biological processes (e.g., metabolism and homeostasis)
  4. Change over their lifetime (e.g., growing, maturing, and aging)

What Is Life? (cont'd.)

- "Life" is a long list of properties that collectively describe living things (cont'd.)
  5. Use DNA as their hereditary material when they reproduce
  6. Capacity to change over successive generations (e.g., adapting to environmental pressures)

4.12 Application: Food for Thought

- Strains of *E. coli* that are toxic to people live in the intestines of other animals
  - Humans are exposed when they come into contact with feces of animals that harbor it
    - Example: eating contaminated ground beef or contaminated fresh fruits and vegetables
- Food workers are working to reduce the number and scope of harmful *E. coli* outbreaks

Application: Food for Thought (cont'd.)

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