Common ancestor

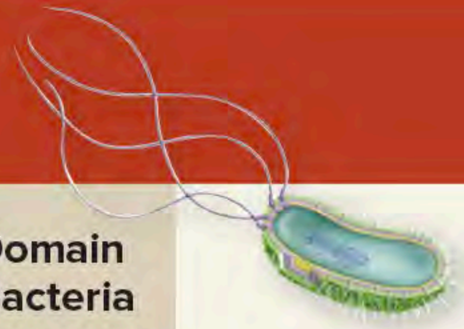
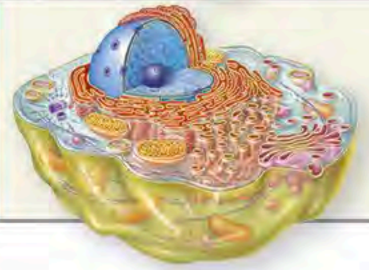
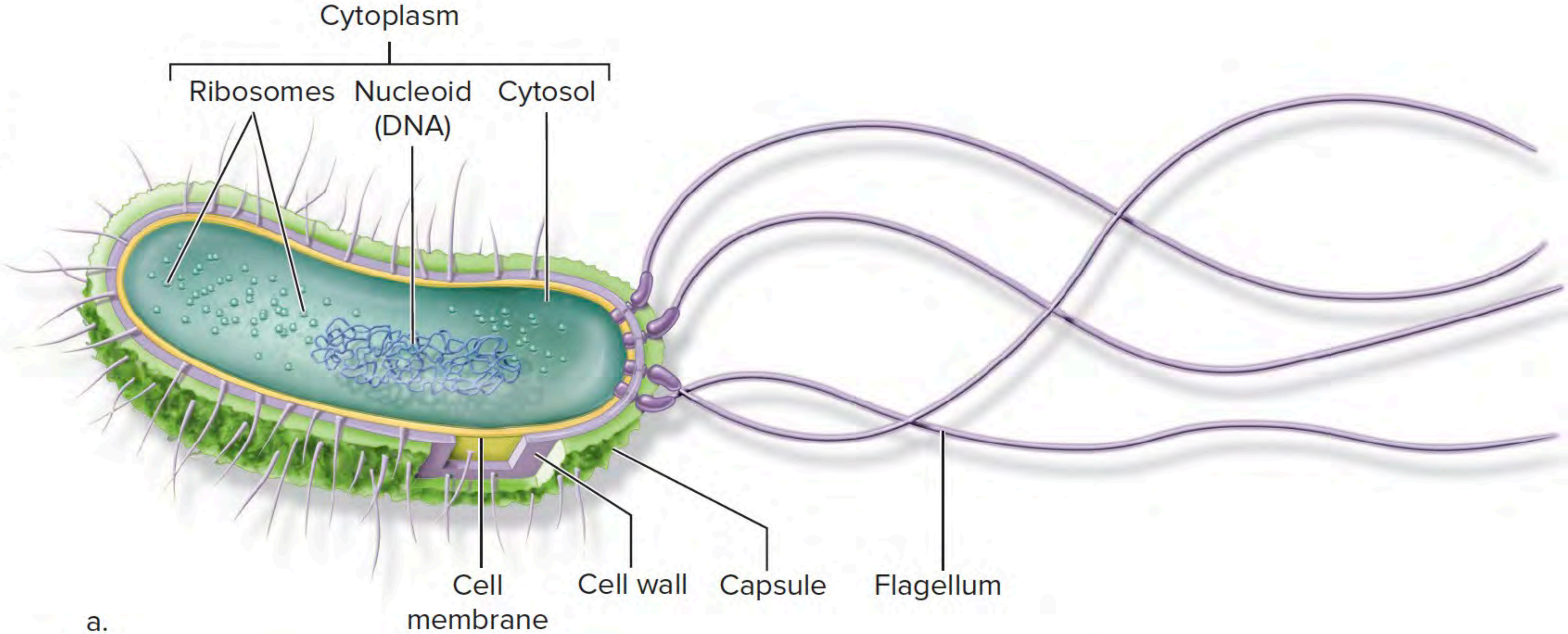
Domain		Cell Type	Nucleus	Membrane-Bounded Organelles	Membrane Chemistry	Typical Cell Size
Domain Bacteria		Prokaryotic	Absent	Absent	Fatty acids	1–10 µm
Domain Archaea		Prokaryotic	Absent	Absent	Nonfatty acid lipids	1–10 µm
Domain Eukarya		Eukaryotic	Present	Present	Fatty acids	10–100 µm

Figure 3.5 **The Three Domains of Life.** Biologists distinguish domains Bacteria, Archaea, and Eukarya based on unique features of cell structure and biochemistry. The small evolutionary tree shows that archaea are the closest relatives of the eukaryotes.

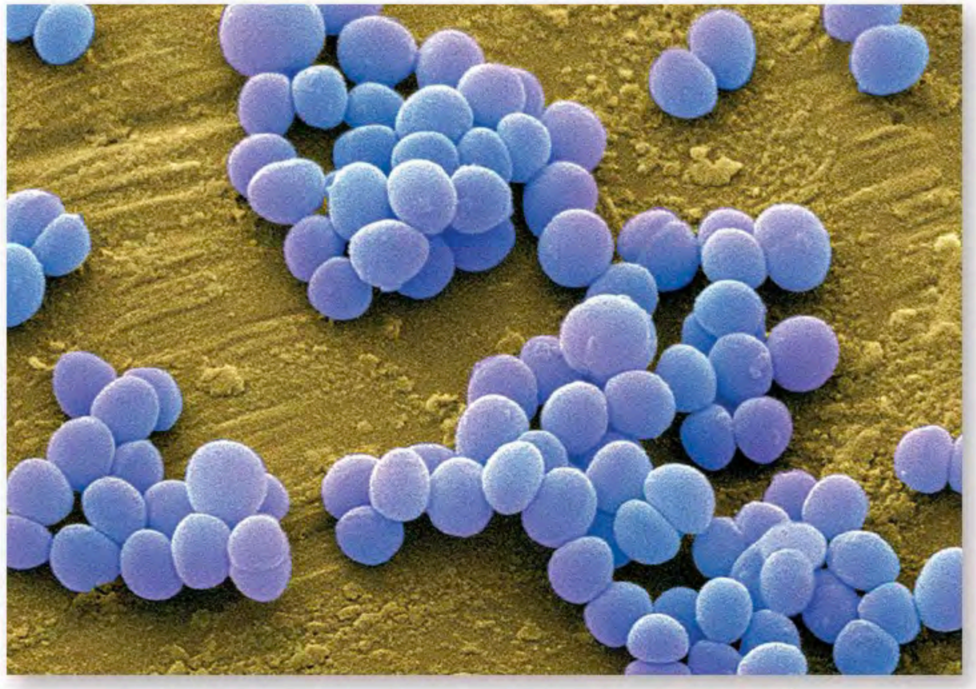
Figure 3.6 Anatomy of a Bacterium. (a) Bacterial cells lack internal compartments. (b) Rod-shaped cells of *E. coli* inhabit human intestines. (c) Spherical *Staphylococcus aureus* cells cause "staph" infections that range from mild to deadly. (d) Corkscrew-shaped *Campylobacter* cells often cause diarrhea.

(b): Science Photo Library/Getty Images; (c): David McCarthy/Science Source; (d): Source: Melissa Brower/CDC



a.

b. SEM (false color) 2 µm

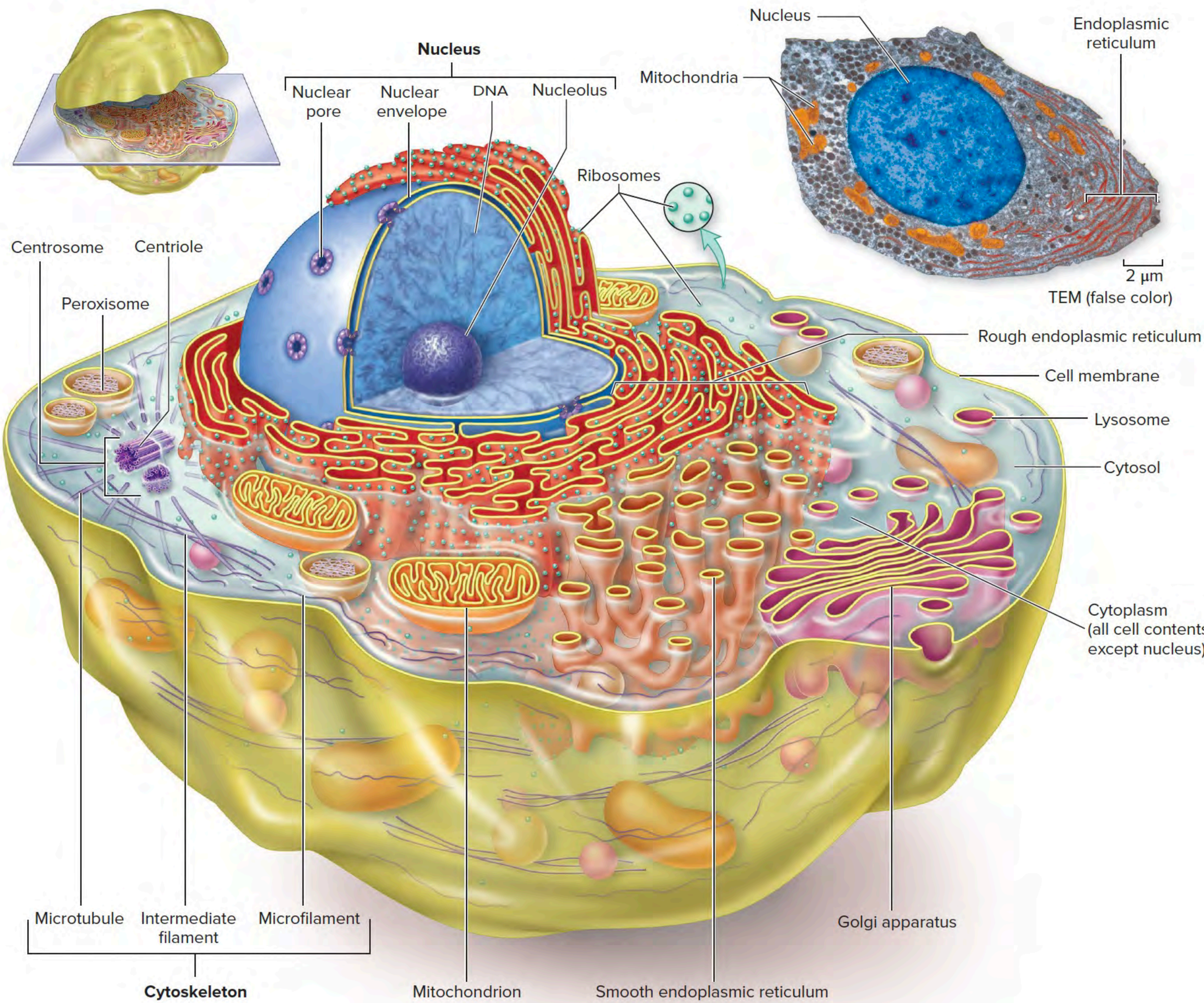


c. SEM (false color) 2 µm

d. SEM (false color) 2 µm

Figure 3.8 Anatomy of an Animal Cell. The large, generalized view shows the relative sizes and locations of a typical animal cell's components. The electron micrograph at right shows a rat's pancreas cell with a prominent nucleus and many mitochondria.

Photo: Biophoto Associates/Science Source



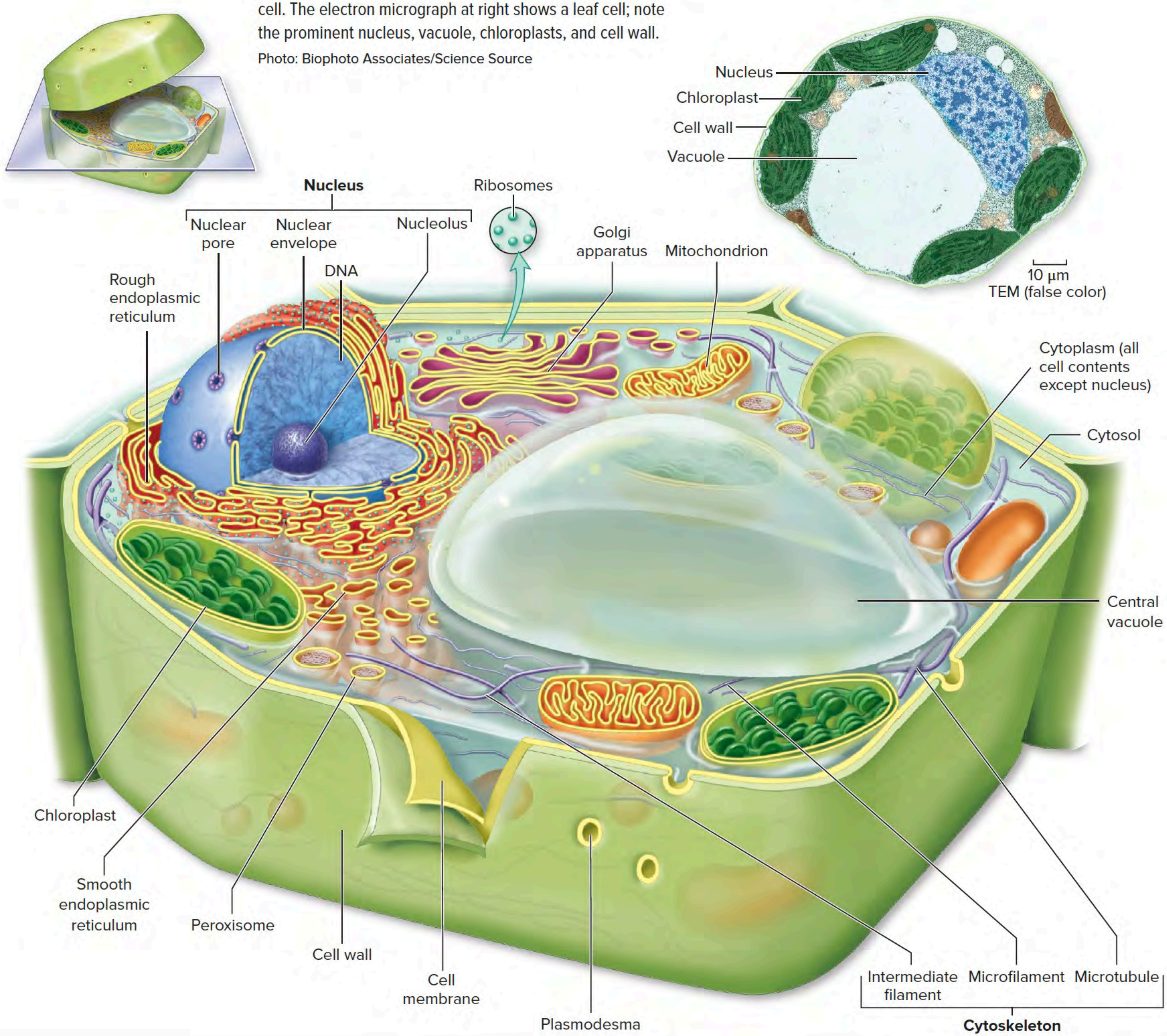


Figure 3.9 Anatomy of a Plant Cell. The large, generalized view illustrates key features of a typical plant cell. The electron micrograph at right shows a leaf cell; note the prominent nucleus, vacuole, chloroplasts, and cell wall.

Photo: Biophoto Associates/Science Source

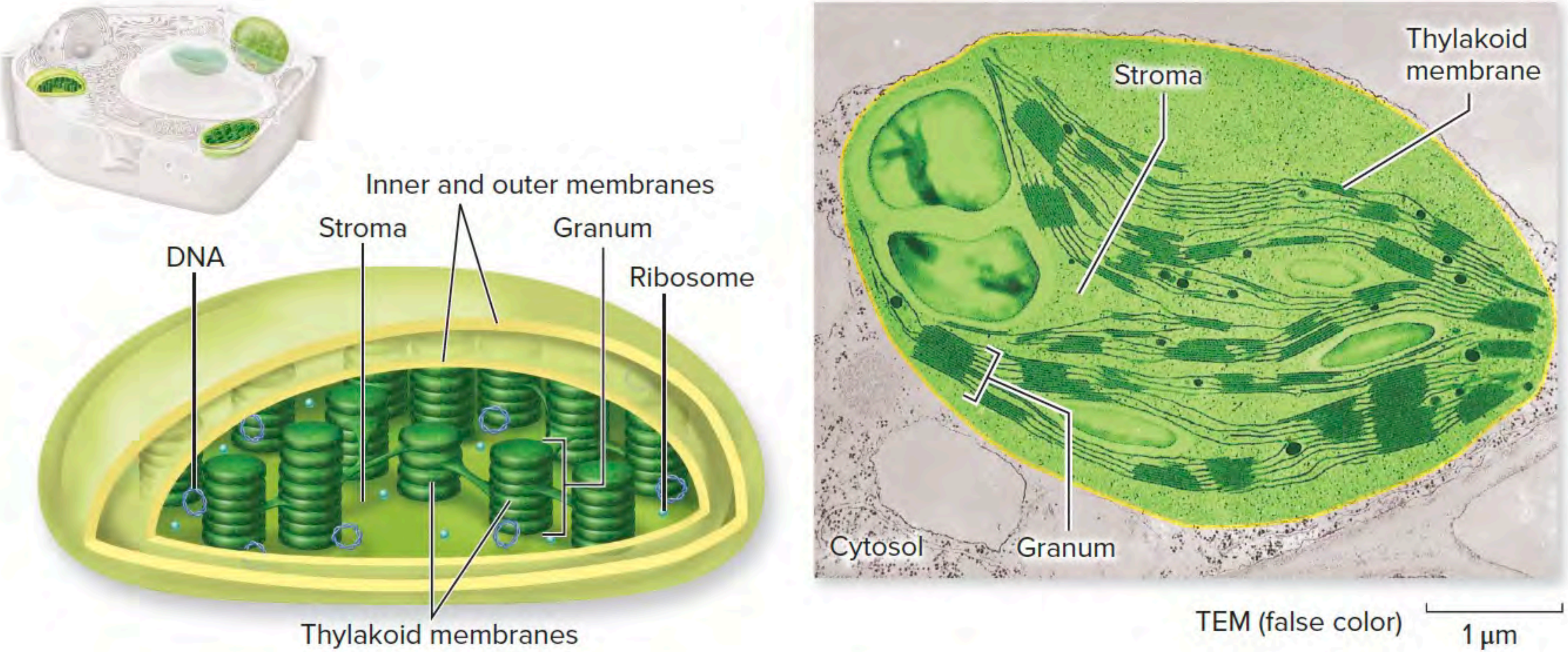
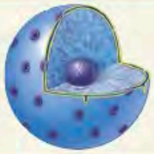
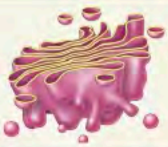
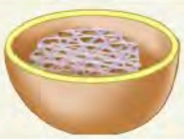


Figure 3.22
Chloroplasts.
Photosynthesis occurs inside chloroplasts. Each chloroplast contains stacks of thylakoids that form the grana within the inner compartment, the stroma. Enzymes and light-harvesting pigments embedded in the thylakoid membranes convert the energy in sunlight to chemical energy.
Photo: Biophoto Associates/ Science Source

TABLE 3.3 Structures in Eukaryotic Cells: A Summary

Structure		Description	Function(s)	Plant Cells?	Animal Cells?
Nucleus		Perforated sac containing DNA, proteins, and RNA; surrounded by double membrane	Separates DNA from rest of cell; site of first step in protein synthesis; nucleolus produces ribosomal subunits	Yes	Yes
Ribosome		Two globular subunits composed of RNA and protein	Location of protein synthesis	Yes	Yes
Endoplasmic reticulum (ER)		Membrane network studded with ribosomes (rough ER) or lacking ribosomes (smooth ER)	Rough ER produces proteins destined for secretion from the cell; smooth ER synthesizes lipids and detoxifies drugs and poisons	Yes	Yes
Golgi apparatus		Stacks of flat, membranous sacs	Packages materials to be secreted; produces lysosomes	Yes	Yes
Lysosome		Sac containing digestive enzymes; surrounded by single membrane	Dismantles and recycles components of food, debris, captured bacteria, and worn-out organelles	Rarely	Yes
Central vacuole		Sac containing enzymes, acids, water-soluble pigments, and other solutes; surrounded by single membrane	Produces turgor pressure; recycles cell contents; contains pigments	Yes	No
Peroxisome		Sac containing enzymes, often forming visible protein crystals; surrounded by single membrane	Disposes of toxins; breaks down fatty acids; eliminates hydrogen peroxide	Yes	Yes
Mitochondrion		Two membranes; inner membrane is folded into enzyme-studded cristae; contains DNA and ribosomes	Releases energy from food by cellular respiration	Yes	Yes
Chloroplast		Two membranes enclosing stacks of membrane sacs, which contain photosynthetic pigments and enzymes; contains DNA and ribosomes	Produces food (sugars) by photosynthesis	Yes	No
Cytoskeleton		Network of protein filaments and tubules	Transports organelles within cell; maintains cell shape; structural basis for flagella/cilia; connects adjacent cells	Yes	Yes
Cell wall		Porous barrier of cellulose and other substances (in plants)	Protects cell; provides shape; connects adjacent cells	Yes	No

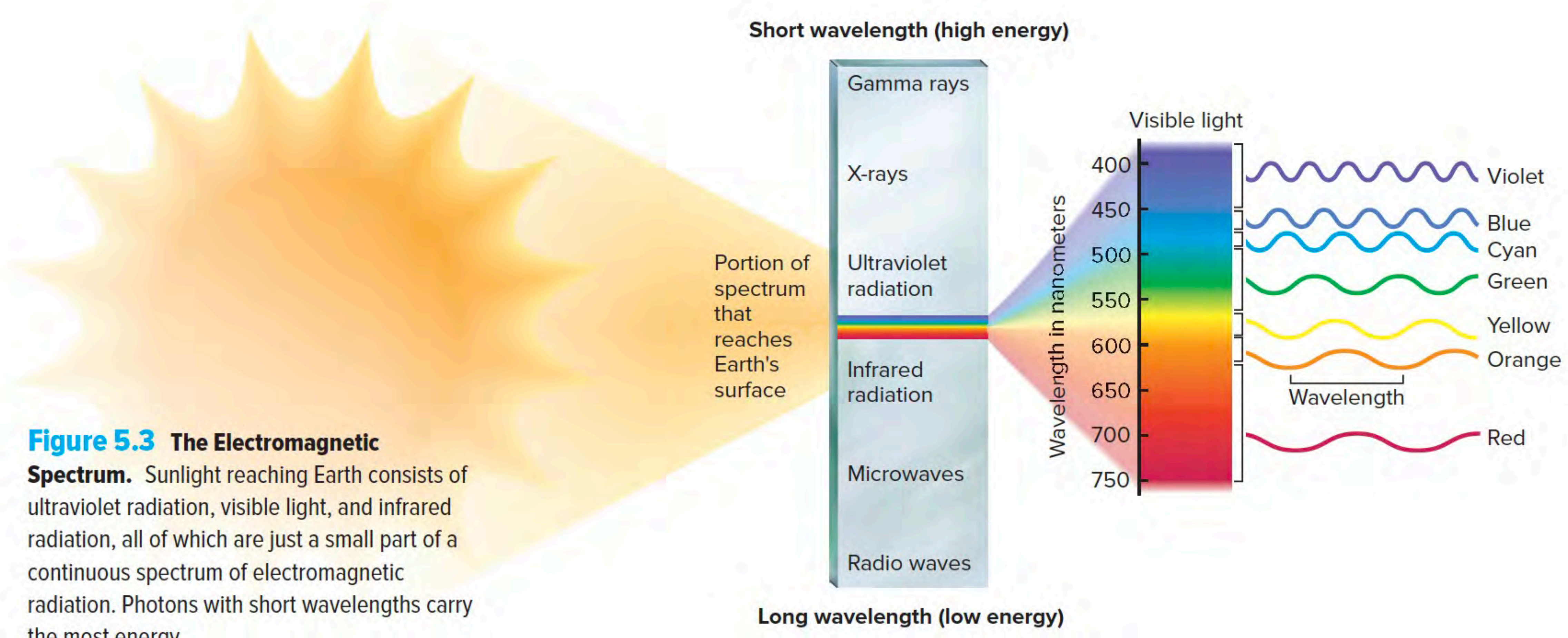


Figure 5.3 **The Electromagnetic Spectrum.** Sunlight reaching Earth consists of ultraviolet radiation, visible light, and infrared radiation, all of which are just a small part of a continuous spectrum of electromagnetic radiation. Photons with short wavelengths carry the most energy.

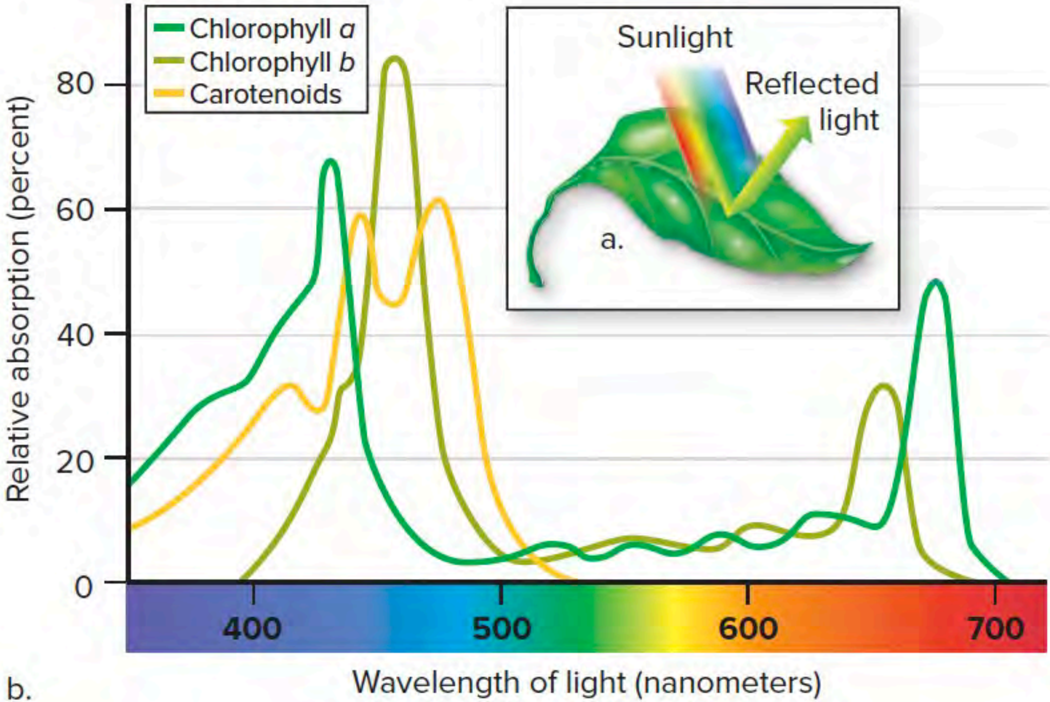


Figure 5.4 **Everything but Green.** (a) Overall, a leaf reflects green and yellow wavelengths of light and absorbs the other wavelengths. (b) Each type of pigment absorbs some wavelengths of light and reflects others.

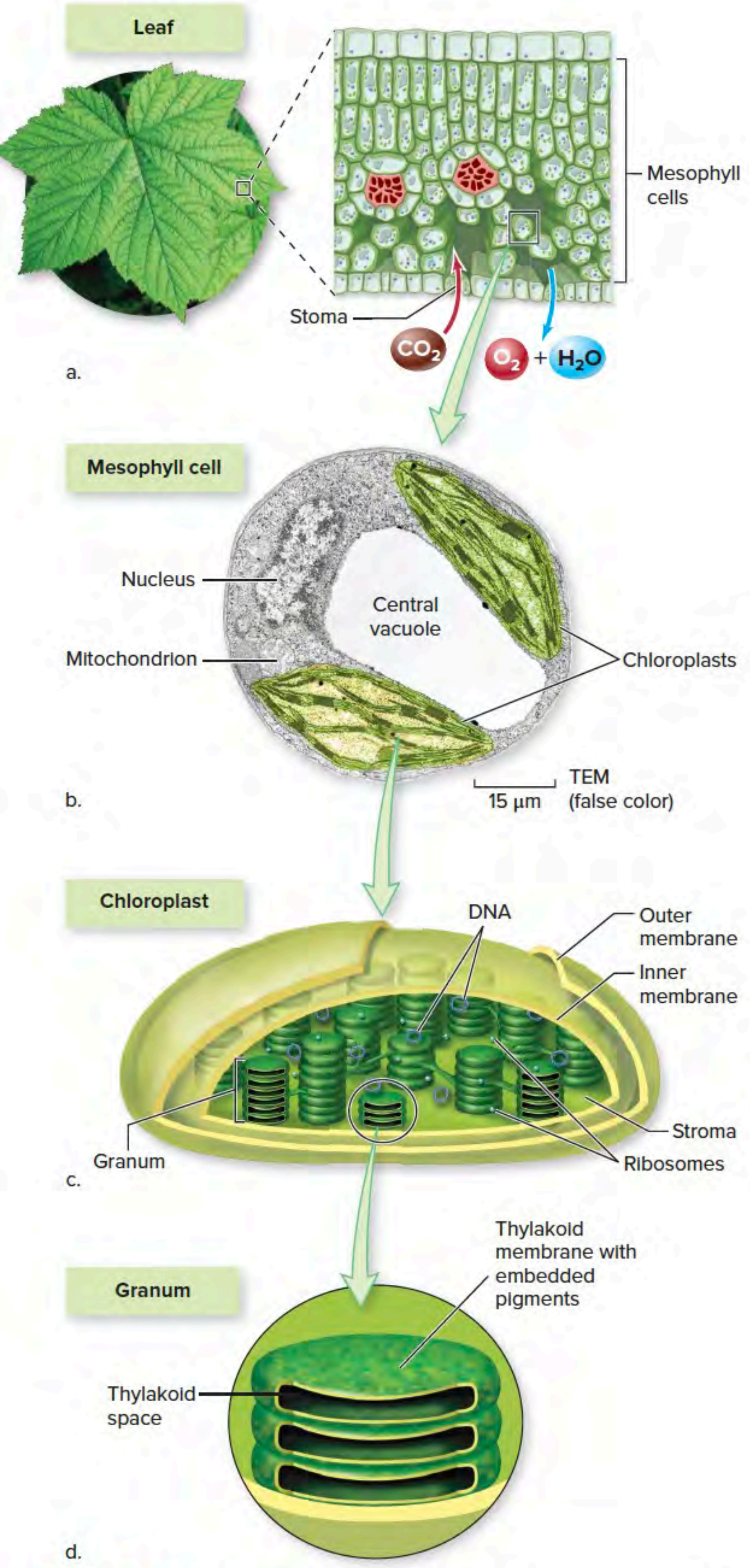
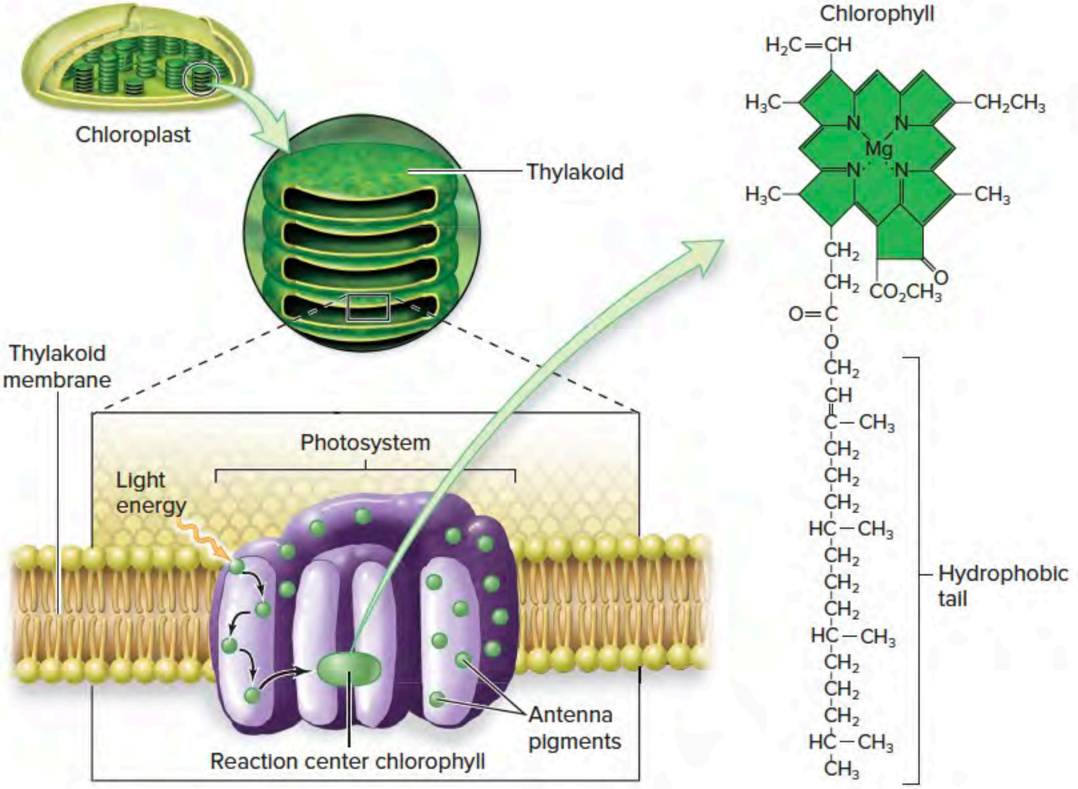


Figure 5.5 **Leaf and Chloroplast Anatomy.** (a) The tissue inside a leaf is called mesophyll. (b) Each mesophyll cell contains many chloroplasts. (c) A chloroplast contains light-harvesting pigments, embedded in (d) the stacks of thylakoid membranes that make up each granum.

Photos: (leaf): Robert Glusic/Corbis; (mesophyll): Electron micrograph by Wm. P. Wergin, courtesy of Eldon H. Newcomb, University of Wisconsin-Madison

Figure 5.6 **Photosystem.** This diagram shows one of the many photosystems embedded in a typical thylakoid membrane. Each photosystem consists of proteins (*purple*) and pigments (*green*). Antenna pigments, which include chlorophyll *a* and accessory pigments, transfer energy to chlorophyll *a* at the reaction center.



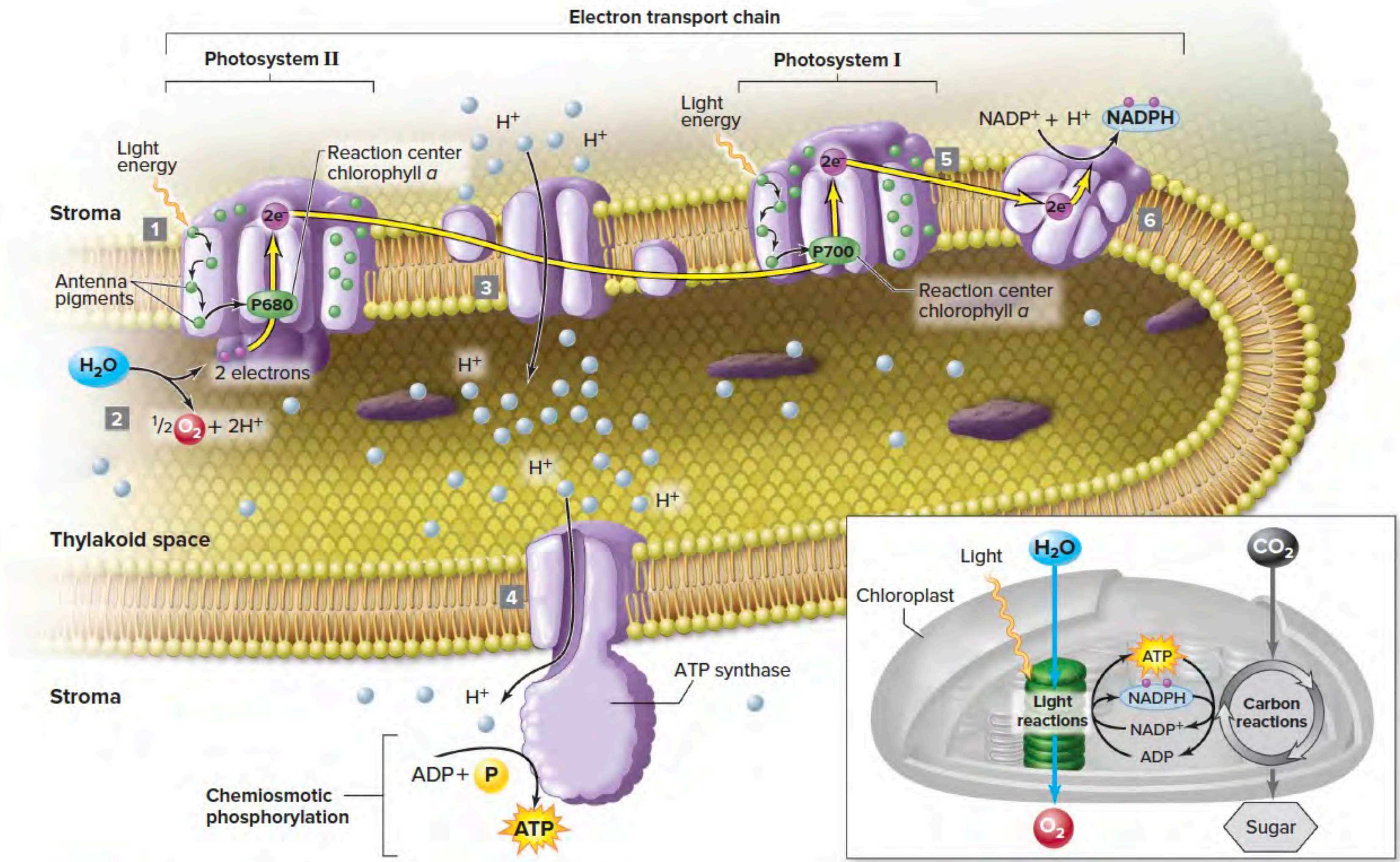


Figure 5.8 **The Light Reactions.** (*1*) Chlorophyll molecules in photosystem II transfer light energy to electrons. (*2*) Electrons are stripped from water molecules, releasing O_2. (*3*) The energized electrons pass to photosystem I along a series of proteins. Each transfer releases energy that is used to pump protons (H^+) into the thylakoid space. (*4*) The resulting proton gradient is used to generate ATP. (*5*) In photosystem I, the electrons absorb more light energy and (*6*) are passed to $NADP^+$, creating the energy-rich NADPH. The inset (*lower right*) shows the light reactions in the context of the overall process of photosynthesis.

5.5 The Carbon Reactions Produce Carbohydrates

The carbon reactions, also called the Calvin cycle, occur in the chloroplast's stroma. The **Calvin cycle** is the metabolic pathway that uses NADPH and ATP to assemble CO_2 molecules into three-carbon carbohydrate molecules (figure 5.9). These products are eventually assembled into glucose and other sugars.

The first step of the Calvin cycle is **carbon fixation**—the incorporation of carbon from CO_2 into an organic compound. Specifically, CO_2 combines with **ribulose bisphosphate (RuBP),** a five-carbon sugar with two phosphate groups. **Rubisco** is the enzyme that catalyzes this first reaction. As an essential component of every plant, rubisco is one of the most abundant and important proteins on Earth.

The six-carbon product of the initial reaction immediately breaks down into two three-carbon molecules called phosphoglycerate (PGA). Further steps in the cycle convert PGA to phosphoglyceraldehyde (PGAL), which is the carbohydrate product that leaves the Calvin cycle. The cell can use PGAL to build larger carbohydrate molecules such as glucose and sucrose. Some of the PGAL, however, is rearranged to form additional RuBP, perpetuating the cycle.

ATP and NADPH produced in the light reactions provide the potential energy and electrons necessary to reduce CO_2. As long as ATP and NADPH are plentiful, the Calvin cycle continuously "fixes" the carbon from CO_2 into small organic molecules.

It is difficult to overstate the Calvin cycle's importance. Plants use it to build organic molecules that make up their cells; animals, in turn, consume plant tissues. The Calvin cycle is therefore the foundation of the food web.

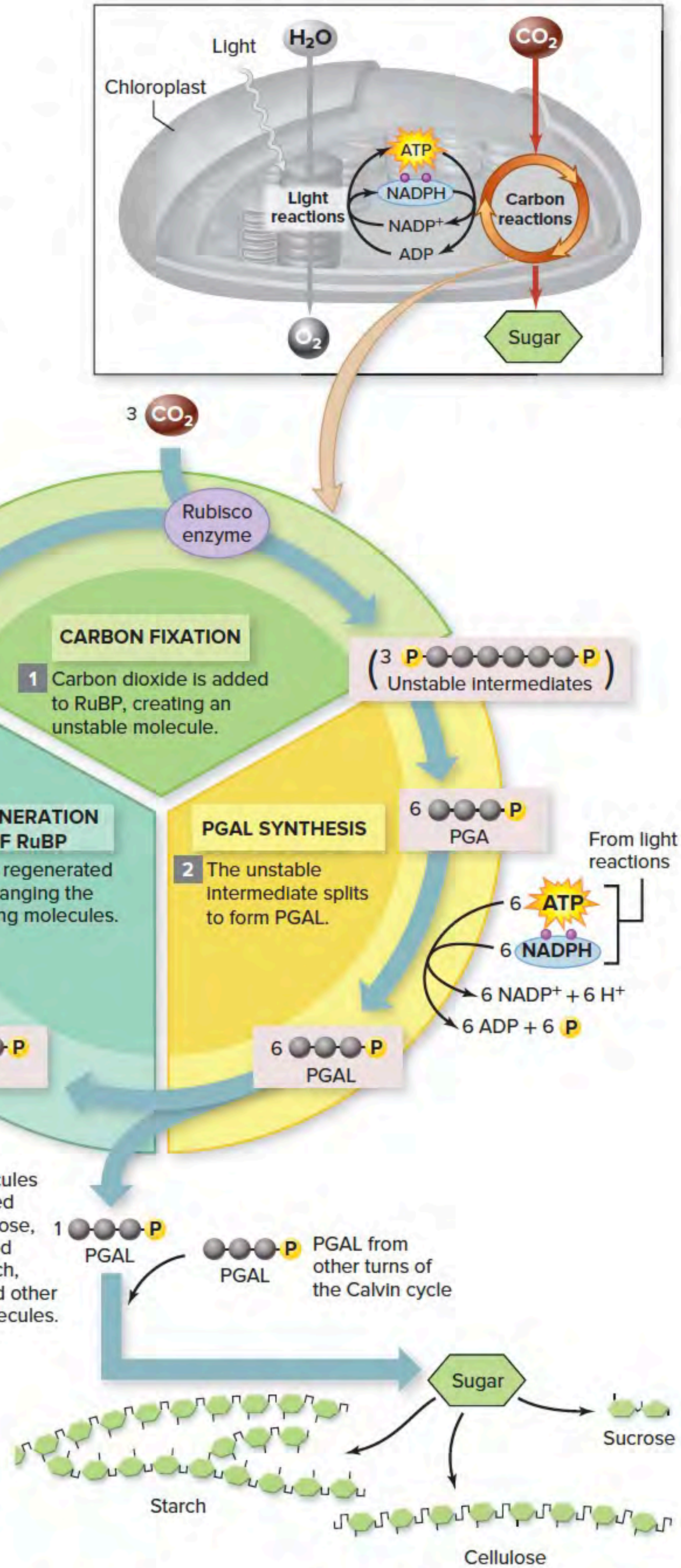


Figure 5.9 **The Carbon Reactions.** ATP and NADPH from the light reactions power the Calvin cycle, which assembles CO_2 molecules into carbohydrates.

5.5 MASTERING CONCEPTS

1. What is the relationship between the light reactions and the carbon reactions?
2. Use figure 5.9 to determine how many ATP and NADPH molecules are used to produce a six-carbon glucose molecule.