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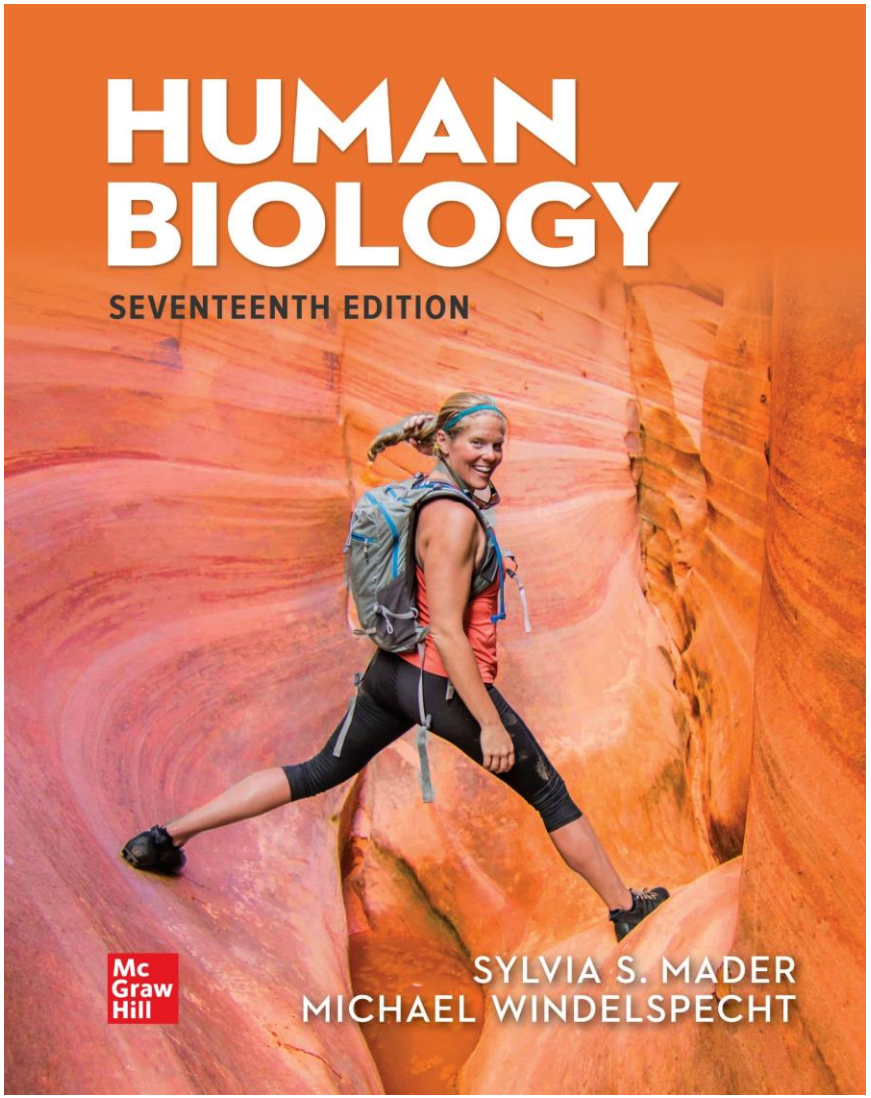

HUMAN BIOLOGY

Seventeenth Edition

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Chapter 3
Cell Structure and Function

3.1 What Is a Cell?

Learning Outcomes:

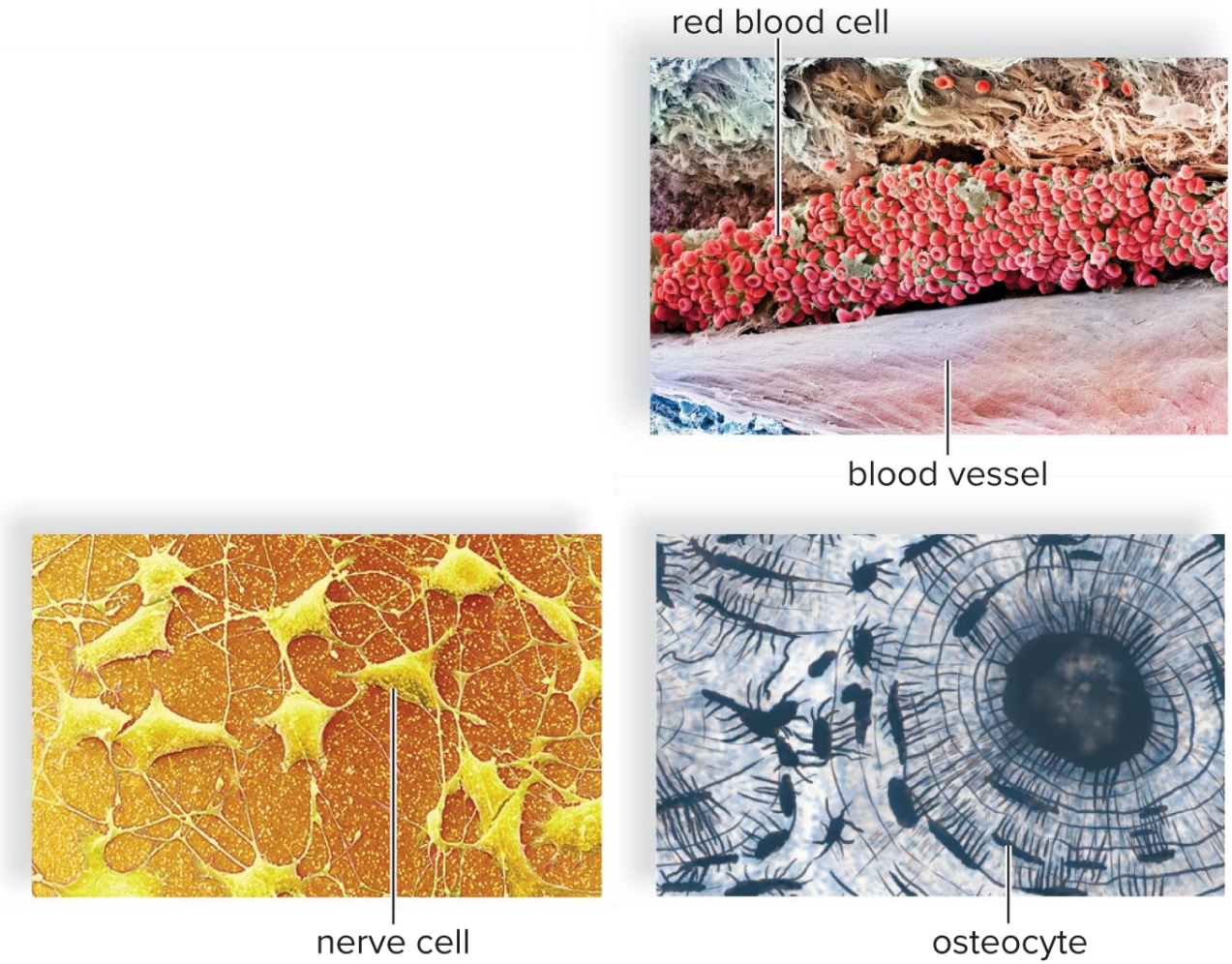
- State the basic principles of the cell theory.
- Explain how the surface-area-to-volume ratio limits cell size.
- Summarize the role of microscopy in the study of cells.

The Cell Theory

The **cell theory**.

- **Cell**—the basic unit of life.
- All living things are made up of cells.
- New cells arise only from preexisting cells.

Cells Vary in Structure and Function (Figure 3.1)



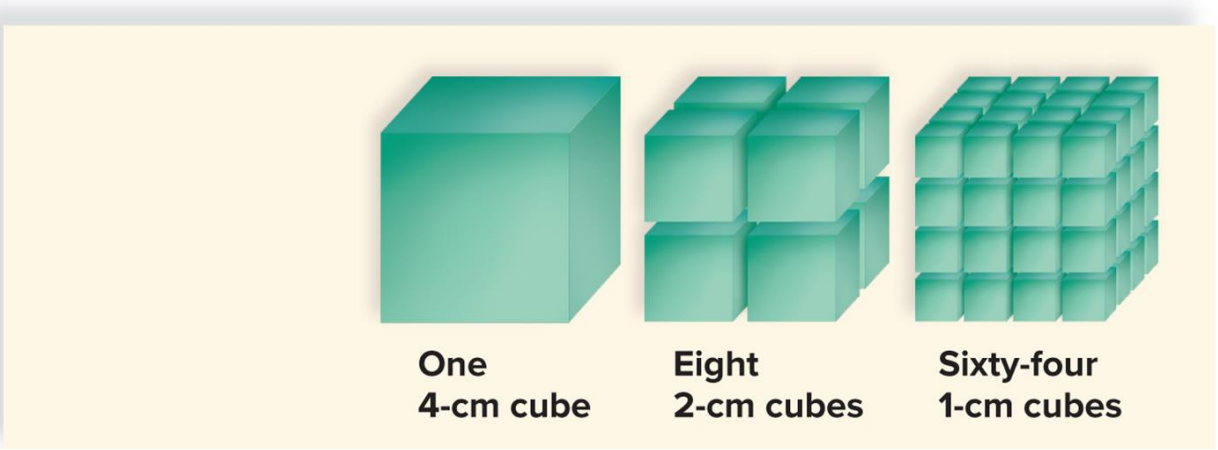
(blood cell and blood vessel): STEVE GSCHMEISSNER/SPL/Getty Images; (nerve cell): SPL/Science Source; (osteocyte): Dennis Strete/McGraw Hill

Cell Size

Cells are small because of their **surface-area-to-volume ratio**.

- Smaller cells have a larger amount of surface area compared to the volume.
- An increase in surface area allows for more nutrients to pass into the cell and more wastes to exit the cell.
- There is a limit to how large a cell can be while remaining efficient and metabolically active.

Surface-Area-to-Volume Ratio Limits Cell Size (Figure 3.2)



Total surface area (height × width × number of sides × number of cubes)	96 cm^2	192 cm^2	384 cm^2
Total volume (height × width × length × number of cubes)	64 cm^3	64 cm^3	64 cm^3
Surface area:	1.5:1	3:1	6:1
Volume per cube (surface area ÷ volume)			

Studying Cells: The Science of Microscopy 1

Resolution of the image varies among different types of microscopes.

Compound light microscope.

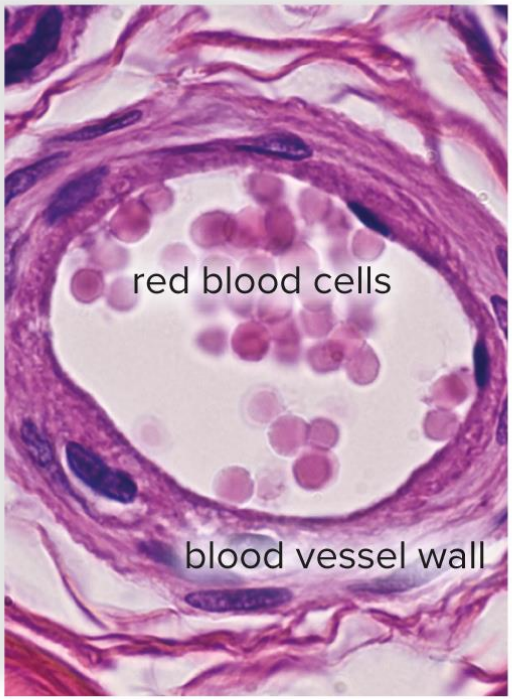
- Lower *magnification* than other microscopes.
- Uses glass lenses and light beams to view images.
- Can view live specimens.

Resolving Power of the Eye and Common Microscopes (Table 3.1)

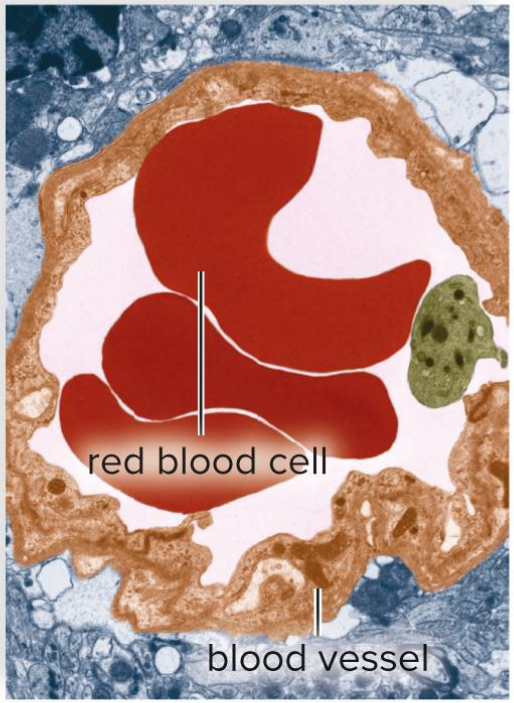
Table 3.1 Resolving Power of the Eye and Common Microscopes

	Magnification	Resolving Power
Eye	N/A	0.1 mm (100 µm)
Light microscope	1.000×	0.0001 mm (0.1 µm)
Transmission electron Microscope	100,000× (or greater)	0.000001 mm (0.01 µm)

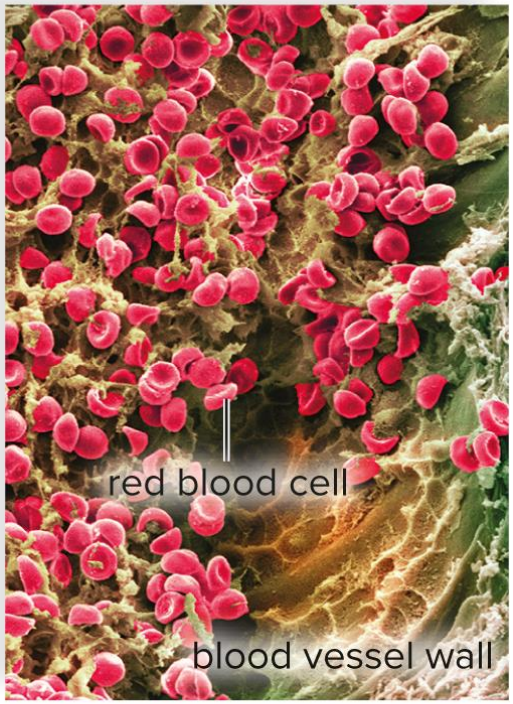
Micrographs of Human Red Blood Cells (Figure 3.3)



a. Light micrograph 250×



b. Transmission electron micrograph 4,000×



c. Scanning electron micrograph

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(a): Ed Reschke/Stone/Getty Images; (b, c): Steve Gschmeissner/Science Photo Library/Getty Images

Studying Cells: The Science of Microscopy 2

Compound light microscope.

- The image can be viewed directly by the human eye.
- Uses a set of glass lenses and light rays passing through the object to magnify objects.
- Often used in a laboratory to view live specimen.
- Does not require a strong vacuum encasement compartment like electron microscopes.

Studying Cells: The Science of Microscopy 3

Transmission electron microscope.

- 2-D image.
- Uses a stream of electrons to view magnified images.
- The human eye cannot see the image; it must be projected onto a screen.
- High magnification, no live specimens.

Studying Cells: The Science of Microscopy 4

Scanning electron microscope.

- 3-D image.
- Uses a beam of electrons to view surface structures of specimens.
- High magnification, no live specimens.

Check Your Progress 3.1

Summarize the cell theory, and state its importance to the study of biology.

Explain how a cell's size relates to its function.

Compare and contrast the information that may be obtained from a light microscope and an electron microscope.

3.2 How Cells Are Organized 1

Learning Outcomes:

- Distinguish between the structure of a prokaryotic cell and that of a eukaryotic cell.
- Identify the roles of the plasma membrane and the organelles of a eukaryotic cell.
- Summarize how eukaryotic cells evolved from prokaryotic cells.

3.2 How Cells Are Organized 2

Cells are classified into two categories: prokaryotes and eukaryotes.

Prokaryotic cells (prokaryotes).

- Lack a nucleus.
- Include two groups of bacteria: eubacteria and archaebacterial.

Eukaryotic cells (eukaryotes).

- Have a nucleus.
- Include animals, plants, fungi, protists.

3.2 How Cells Are Organized 3

Both types of cells have:

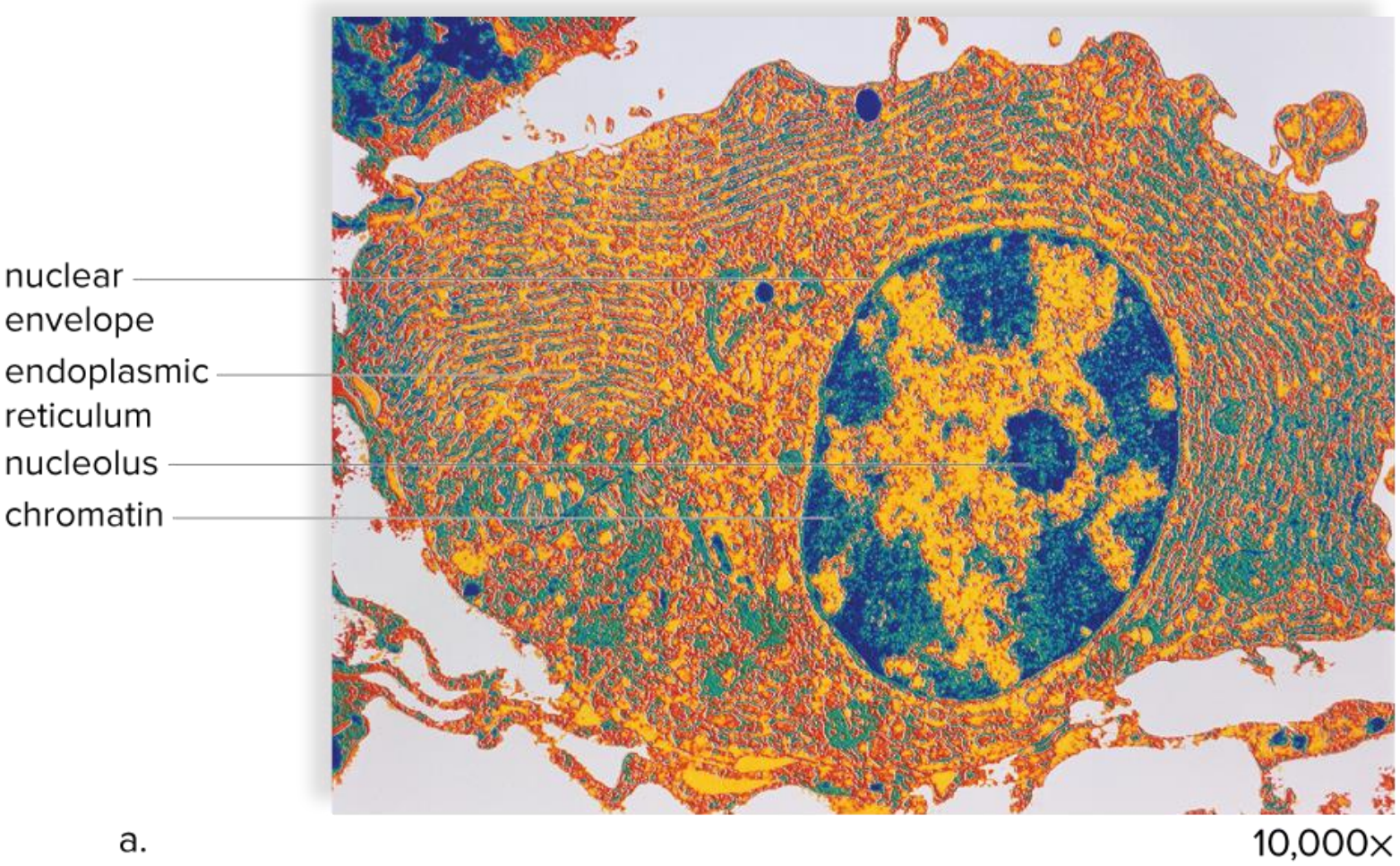
A **plasma membrane.**

- Surrounds the cell.
- Made of a phospholipid bilayer that is **selectively permeable** (regulates what enters and leaves the cell).

A **cytoplasm**: the semifluid substance inside the cell.

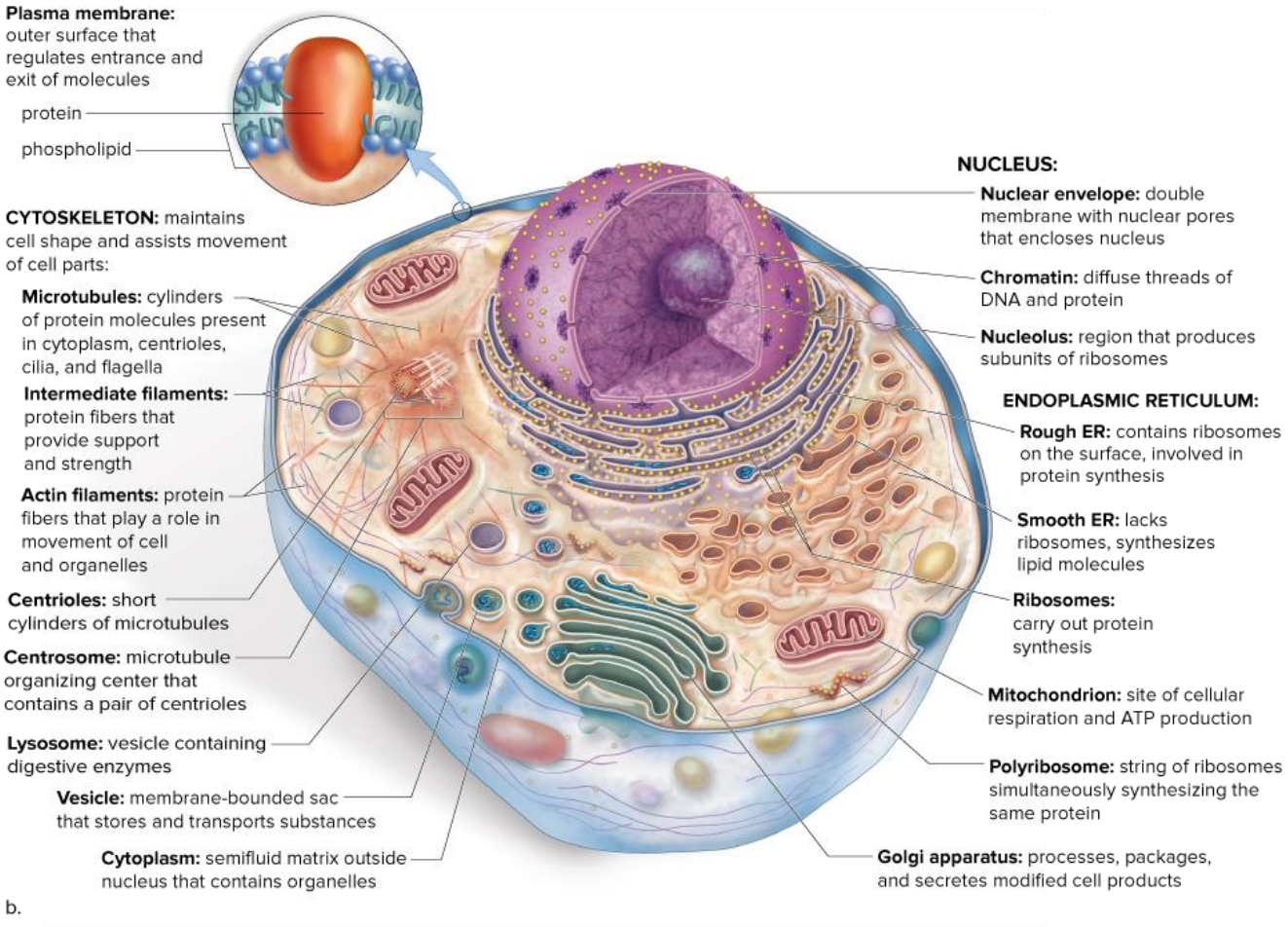
- Includes **organelles** (internal compartments with specialized functions).

The Structure of a Typical Animal Eukaryotic Cell (Figure 3.4a)



(a): Alfred Pasieka/Science Source

The Structure of a Typical Eukaryotic Cell (Figure 3.4b)



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Evolution of the Eukaryotic Cell

The first cells on Earth were prokaryotes (archaeans).

The atmosphere had no oxygen.

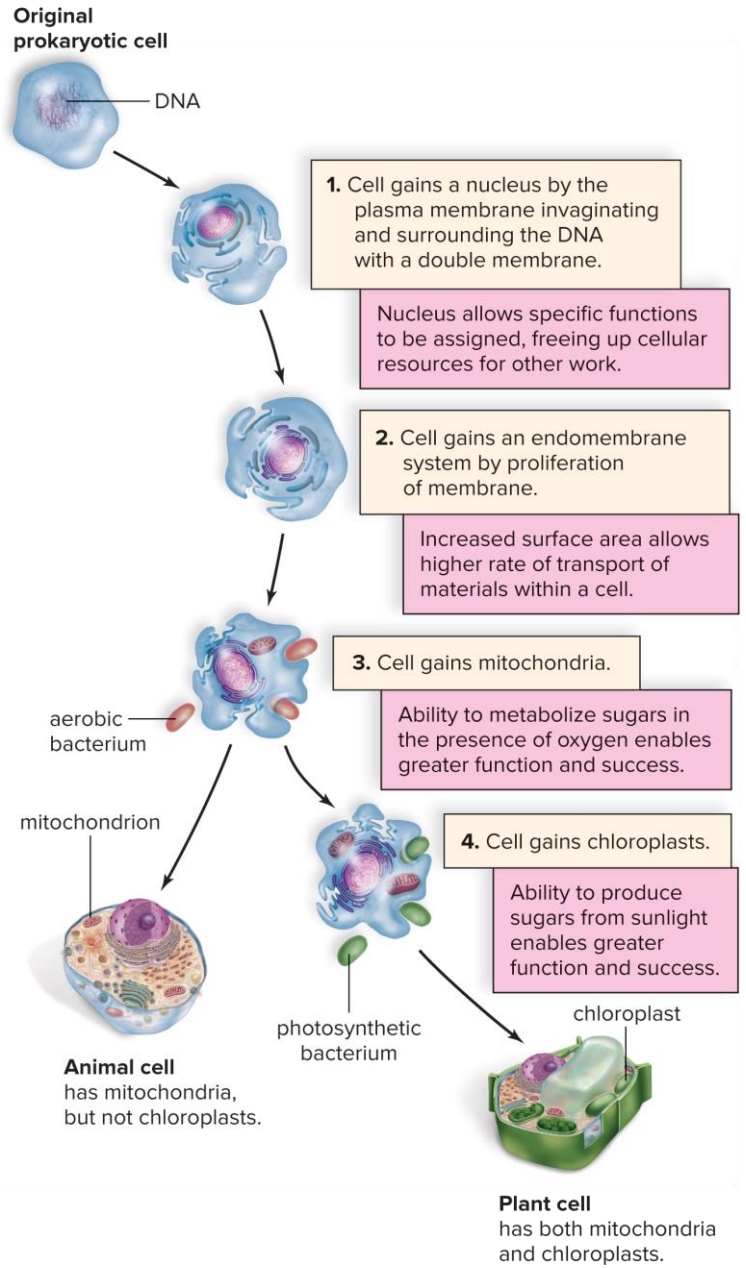
Some archaeans still survive in very inhospitable conditions.

- That is in thermal vents.

Eukaryotic cells evolved from archaea.

- **Endosymbiosis**—organelles may have developed from eukaryotes engulfing prokaryotic cells.

The Evolution of Eukaryotic Cells (Figure 3.5)



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3.4 The Nucleus and Endomembrane System 1

Learning Outcomes:

- Describe the structure of the nucleus and explain its role as the storage place of genetic information.
- Summarize the functions of the organelles of the endomembrane system.
- Explain the role and location of the ribosomes.

3.4 The Nucleus and Endomembrane System 2

The **nucleus** contains the genetic instructions for manufacturing the proteins that are involved in most cellular functions.

The **endomembrane system** is a series of membranous organelles that function to process materials for the cell.

The Nucleus 1

The nucleus.

Contains DNA in the form of **chromatin** most of the time, and **chromosomes** when the cell is dividing.

- DNA is made up of **genes**, which contain instructions for the production of proteins.

Nucleoplasm—the fluid inside the nucleus.

Nucleolus—dark region inside the nucleus.

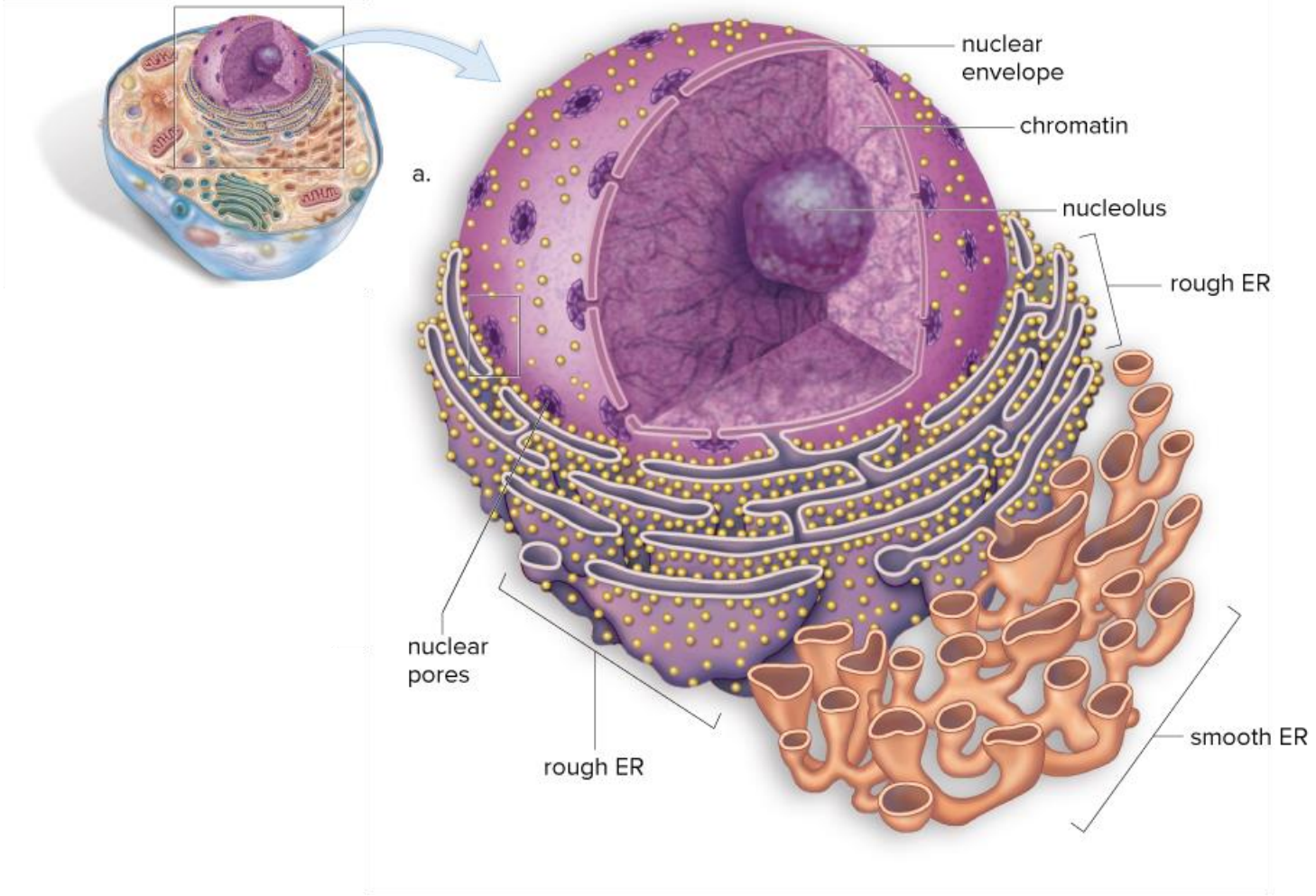
- Produces ribosomes.

The Nucleus 2

The nucleus, continued.

- **Nuclear envelope**—a double membrane around the nucleus.
- **Nuclear pores**—holes in the nuclear envelope; allow passage of substances in and out of the nucleus.

The Nucleus and Endoplasmic Reticulum (Figure 3.13a)



Ribosomes

Ribosomes.

Made of rRNA and protein.

Sites of protein synthesis.

Found attached to the endoplasmic reticulum or free-floating in the cytoplasm.

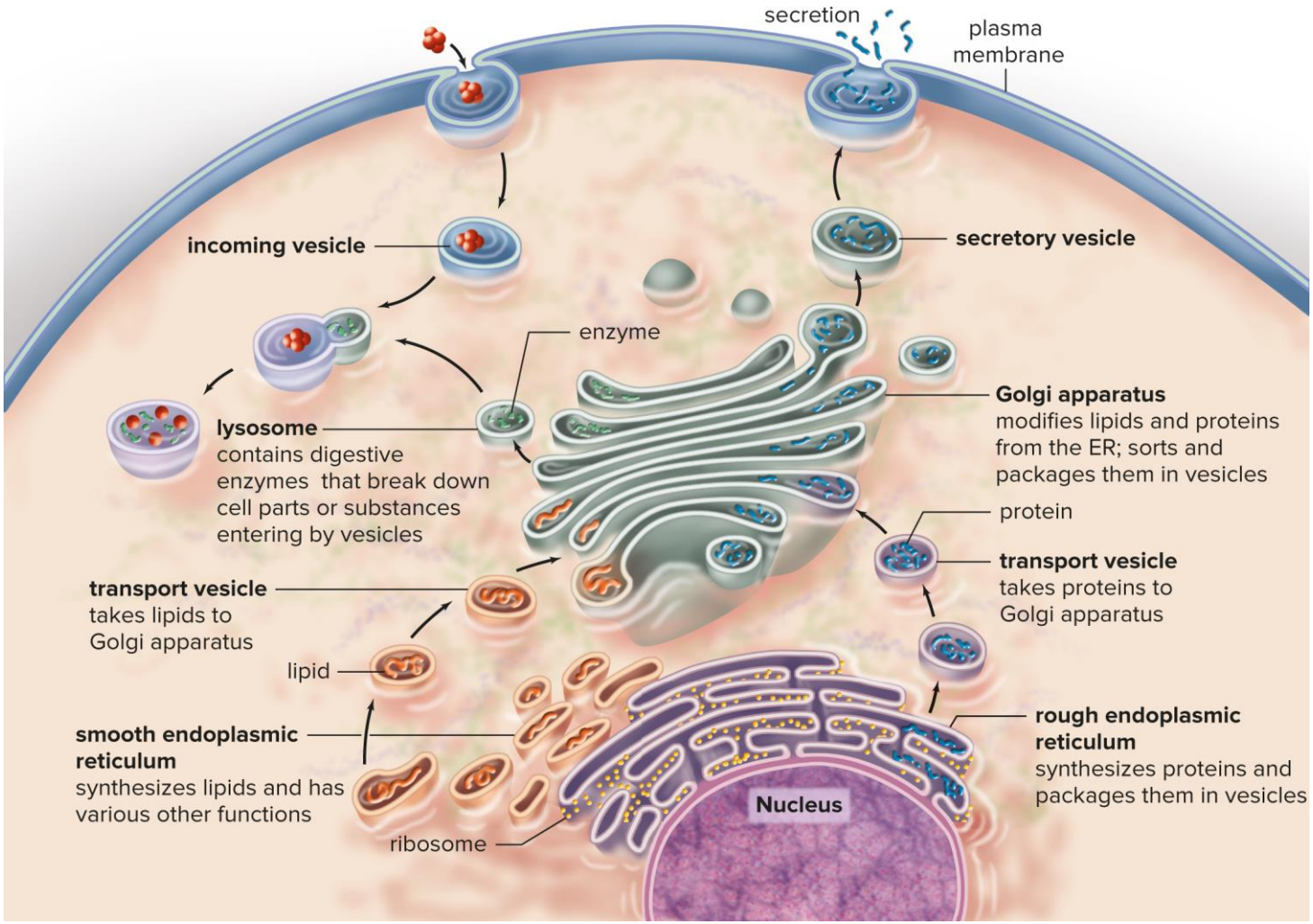
- When free-floating, occur singly or in groups called **polyribosomes.**
- Proteins synthesized at ribosomes attached to the endoplasmic reticulum have a different destination from those made at free-floating ribosomes.

The Endomembrane System 1

The **endomembrane system.**

- Consists of the **nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes,** and **vesicles.**
- Functions to compartmentalize the cell and transport substances throughout the cell.

The Endomembrane System (Figure 3.14)



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The Endomembrane System 2

Rough endoplasmic reticulum (RER)—studded with ribosomes used to make proteins.

Smooth endoplasmic reticulum (SER)—lacks ribosomes; synthesizes lipids.

- Has different functions in various cell types.

Golgi apparatus—flattened sacs; modify proteins and lipids.

- Involved in processing, packaging, and secretion.

The Endomembrane System 3

Vesicles—small membranous sacs used for transport.

Lysosomes—vesicles made by the Golgi that contain **hydrolytic enzymes**, which break down molecules into smaller parts.

- Prevalent in white blood cells that engulf disease-causing microbes.

Mitochondria

Contained by nearly all eukaryotic cells and all plant, algae, and animal cells

Smaller than chloroplast

Numbers vary with metabolic activities and energy requirements of cells

- Liver cells have as many as 1,000

Contain ribosomes and their own DNA

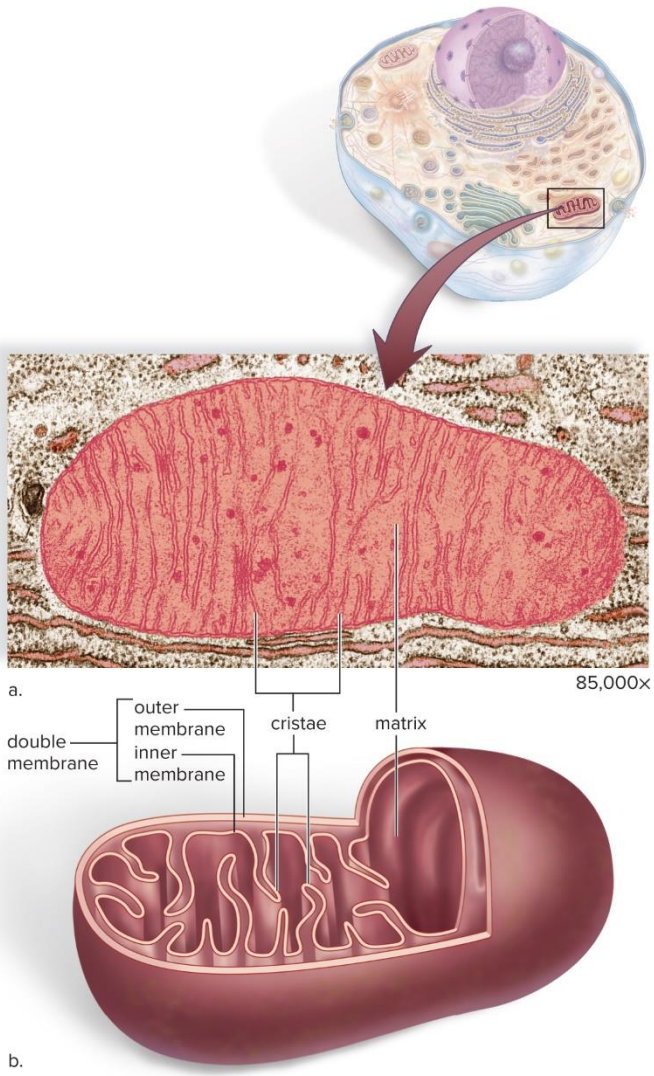
Surrounded by a double membrane

- Inner membrane surrounds the **matrix** and is convoluted (folded) to form **cristae**.
- Matrix – Inner semifluid substance containing respiratory enzymes
  - Break down carbohydrates

Involved in cellular respiration; oxygen used and carbon dioxide given off

Produce most of ATP utilized by the cell

Mitochondrion Structure



(a): ©Keith R. Porter/Science Source

Jump to Mitochondrion Structure Long Description

Check Your Progress 3.4

Describe the functions of the following organelles: endoplasmic reticulum, Golgi apparatus, and lysosomes.

Explain how the nucleus, ribosomes, and rough endoplasmic reticulum contribute to protein synthesis.

Describe the organelles of the endomembrane system involved in the export of a protein from the cell.

3.5 The Cytoskeleton, Cell Movement, and Cell Junctions 1

Learning Outcomes:

- Explain the role of the cytoskeleton in the cell.
- Summarize the major protein fibers in the cytoskeleton.
- Describe the role of flagella and cilia in human cells.
- Compare the functions of adhesion junctions, gap junctions, and tight junctions in human cells.

3.5 The Cytoskeleton, Cell Movement, and Cell Junctions 2

The **cytoskeleton.**

- Protein fibers that maintain cell shape, anchor and/or move organelles in the cell.
- Made of 3 types of fibers: **microtubules**, which are the largest; middle-sized **intermediate filaments**; and thin **actin filaments**.

3.5 The Cytoskeleton, Cell Movement, and Cell Junctions 3

The **cytoskeleton**, continued.

Microtubules.

- Microtubule assembly is controlled by the **centrosome.**
- Help maintain cell shape.
- Act as tracks along which organelles move.
- During cell division, form the spindle apparatus, which helps move chromosomes.

3.5 The Cytoskeleton, Cell Movement, and Cell Junctions 4

The **cytoskeleton**, concluded.

Actin filaments.

- Made of the protein **actin.**
- Long and very thin.
- Involved in movement.

Intermediate filaments.

- Sized in-between actin filaments and microtubules.
- Functions vary.

Cilia and Flagella

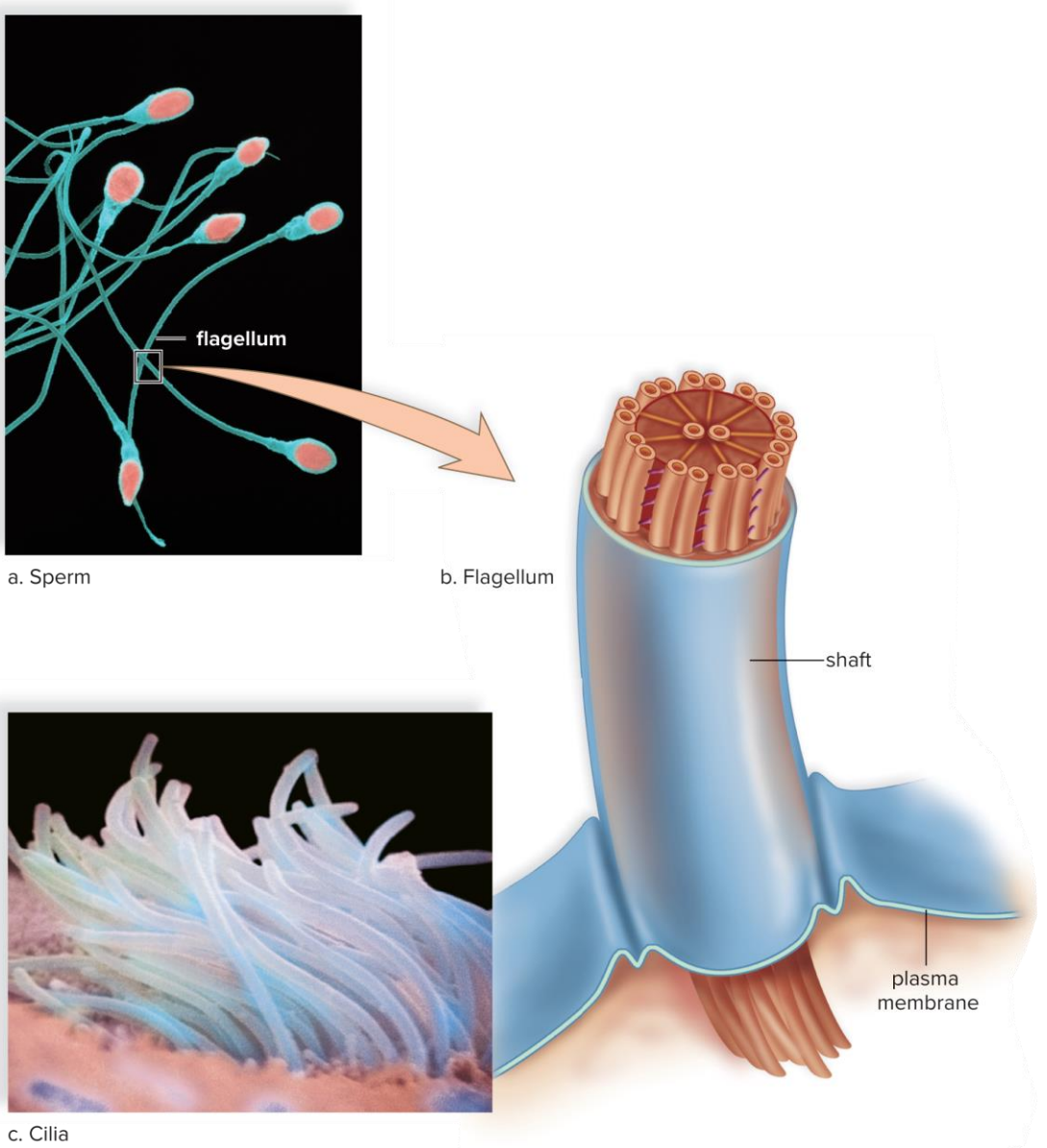
Cilia (*sing.*, cilium) and **flagella** (*sing.*, flagellum).

Both are made of microtubules.

Both are used in movement of materials along the plasma membrane, or cellular movement.

- That is, cilia in the respiratory tract move mucus toward the throat.
- That is, flagella on sperm propel them toward the egg.

Structure and Function of the Flagella and Cilia (Figure 3.15)



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