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Biology: Life on Earth

Eighth Edition

Lecture for Chapter 4

Cell Structure and Function

Chapter 4 Outline

- 4.1 What Is the Cell Theory? p. 59
- 4.2 What Are the Basic Attributes of Cells? p. 59
- 4.3 What Are the Major Features of Eukaryotic Cells? p. 63
- 4.4 What Are the Major Features of Prokaryotic Cells? p. 75

Section 4.1 Outline

- **4.1 What Is the Cell Theory?**
 - All Living Things Are Composed of One or More Cells

What Is the Cell Theory?

- Tenets of Modern Cell Theory
 - Every living organism is made of one or more cells
 - The smallest organisms are made of single cells while multicellular organisms are made of many cells
 - All cells arise from pre-existing cells

Section 4.2 Outline

- **4.2 What Are the Basic Attributes of Cells?**
 - Cell Function Limits Cell Size
 - All Cells Share Common Features
 - There Are Two Basic Types of Cells: Prokaryotic and Eukaryotic

Cell Function Limits Cell Size

- Most cells are small, ranging from 1 to 100 micrometers in diameter

Cell Function Limits Cell Size

- Cells need to exchange nutrients and wastes with the environment
- No part of the cell can be far away from the external environment

All Cells Share Common Features

- A **plasma membrane** encloses all cells and regulates material flow

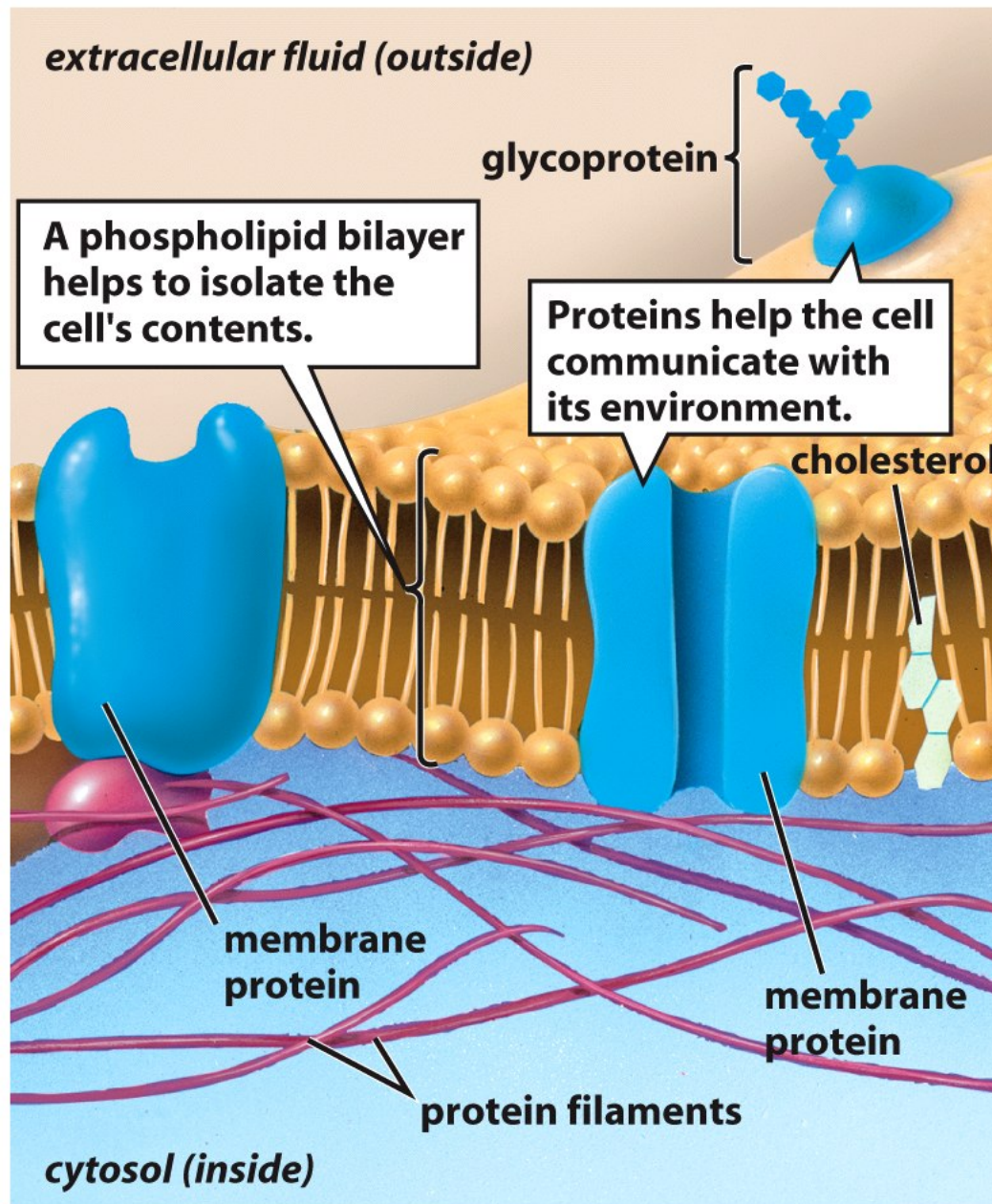


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All Cells Share Common Features

- **Cytoplasm** is the fluid interior where a cell's metabolic reactions occur
 - Contains organelles
 - Fluid portion (**cytosol**) contains water, salts, and organic molecules

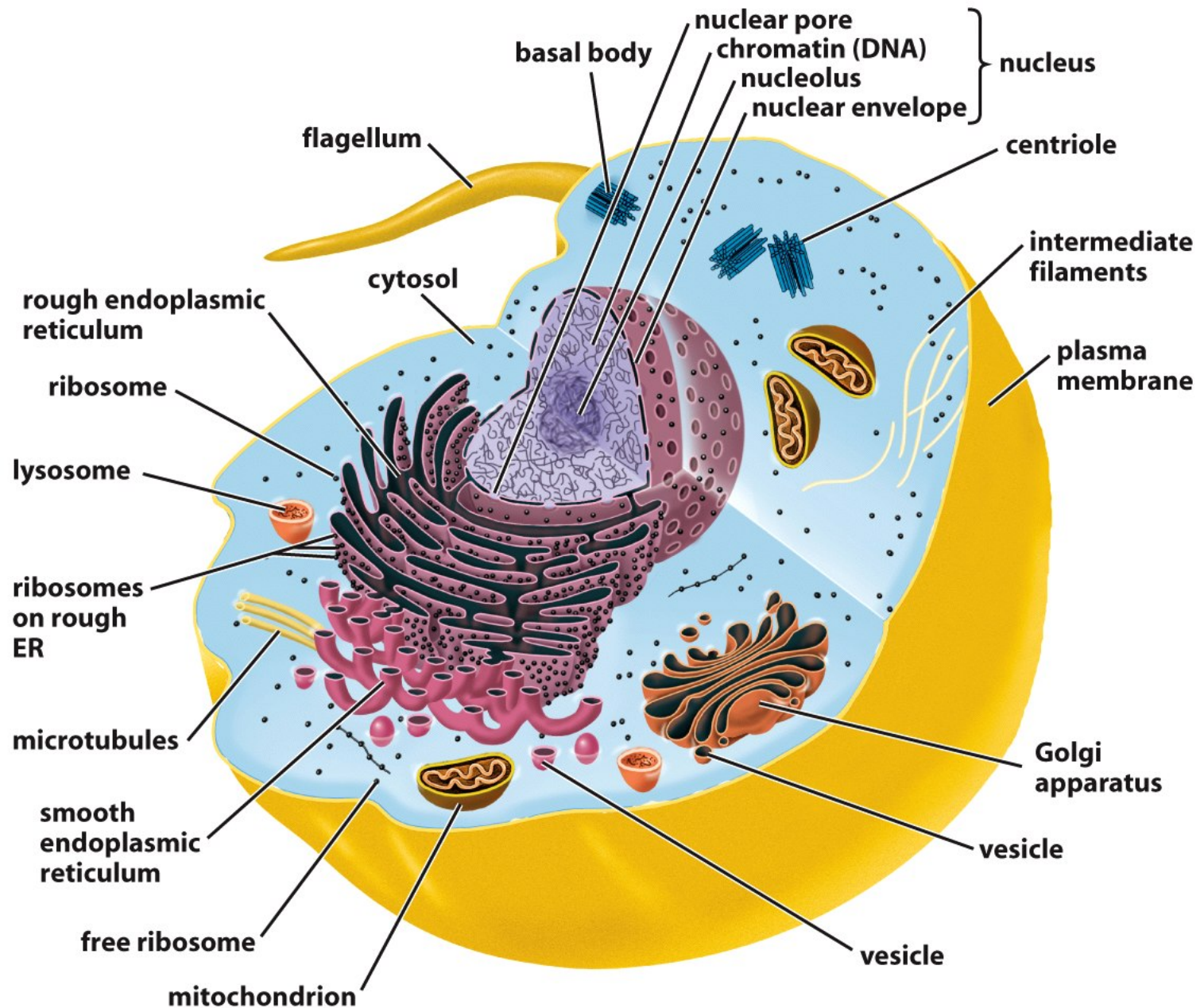


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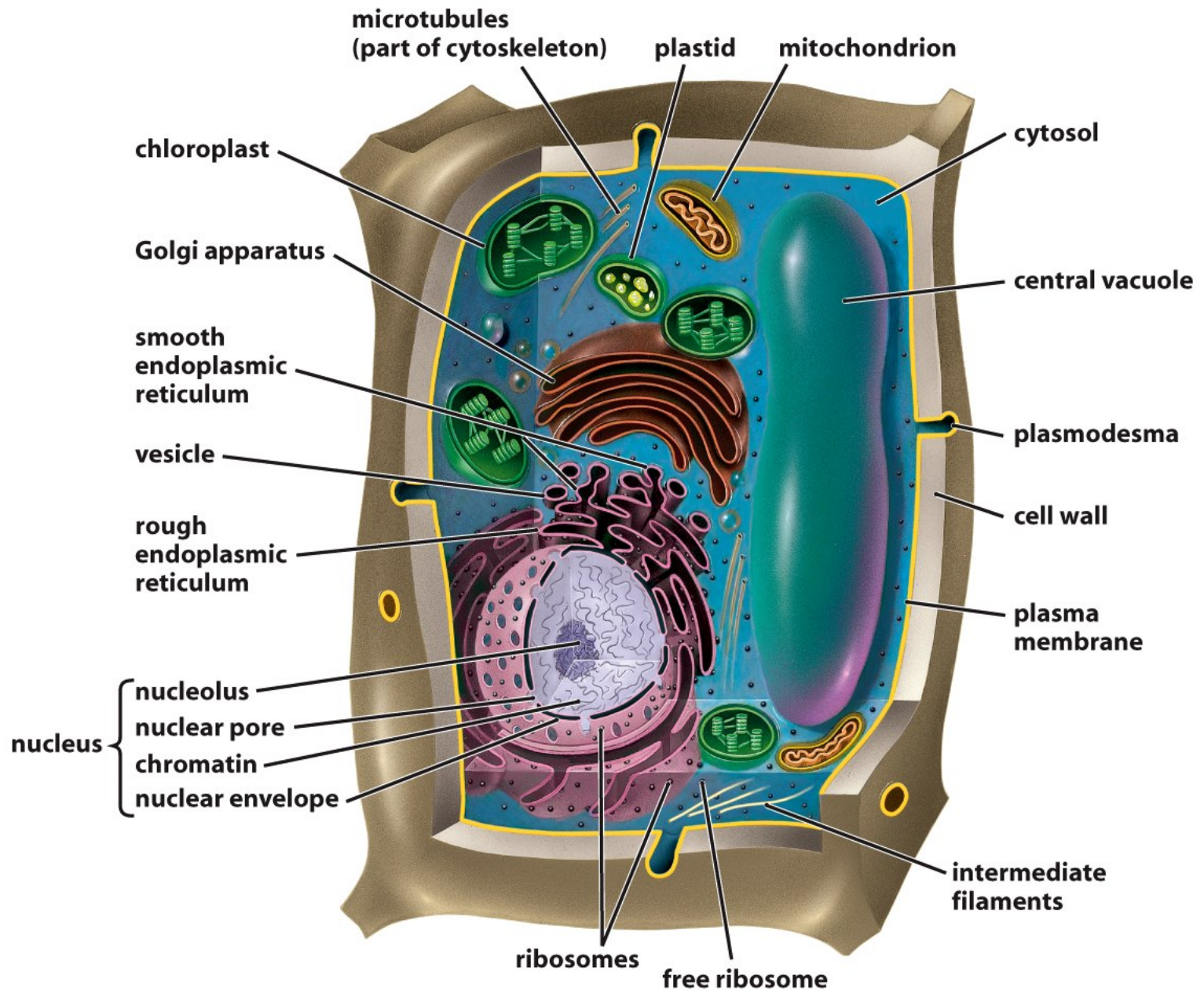


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There Are Two Basic Cell Types

- Cells are either
 - **Prokaryotic**
 - **Eukaryotic**

There Are Two Basic Cell Types

- **Prokaryotic**
 - Before nucleus

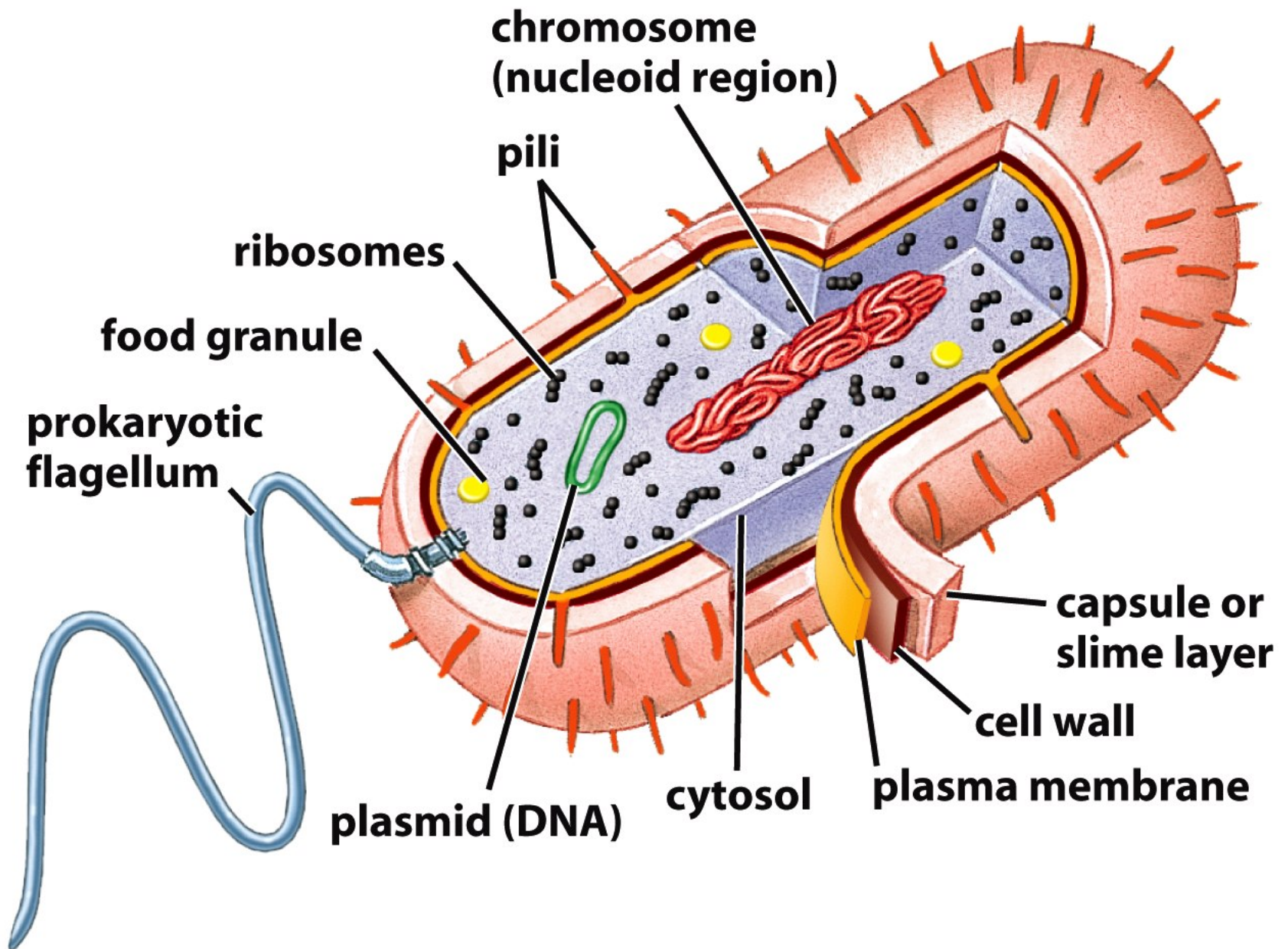


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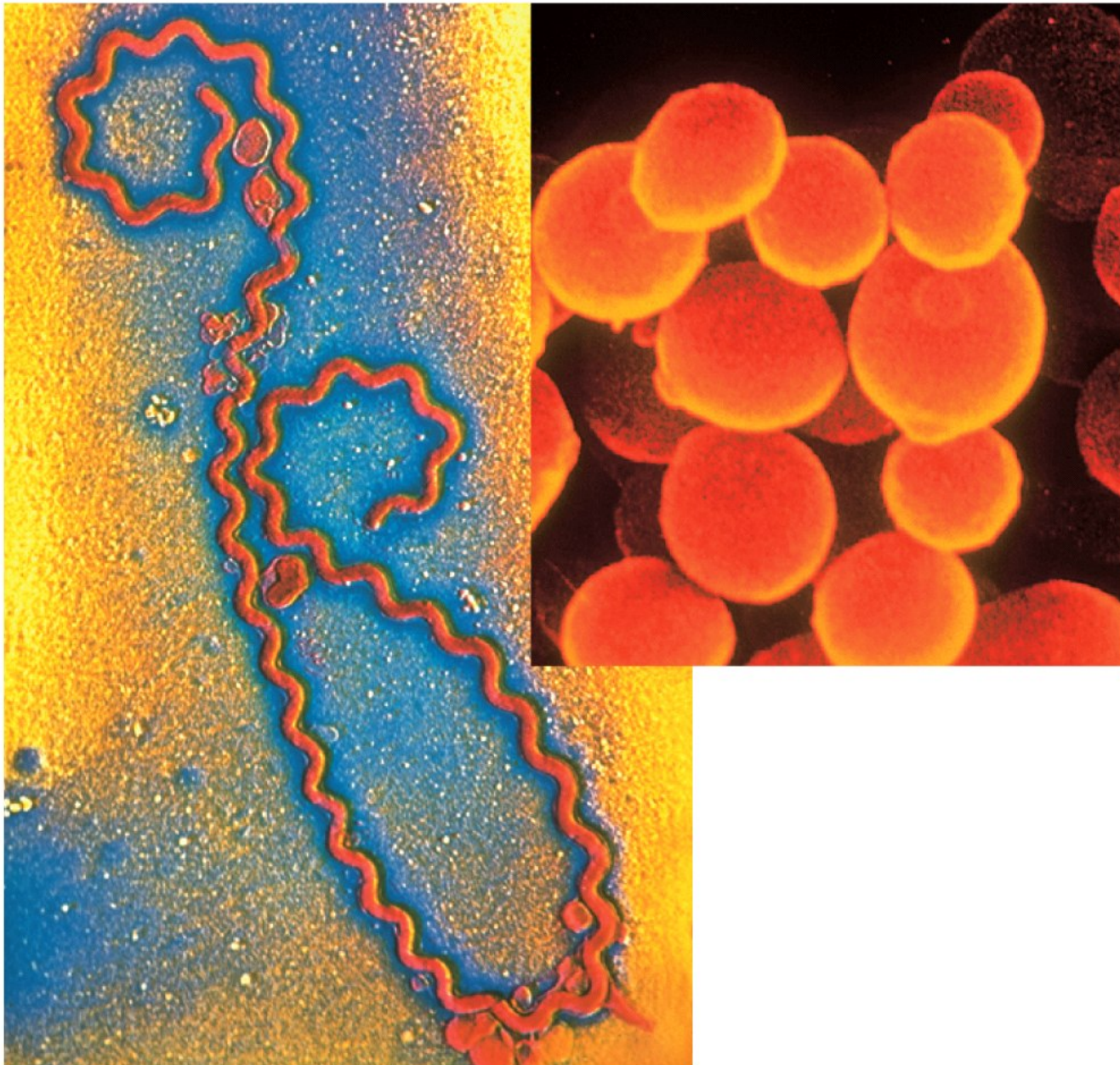


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There Are Two Basic Cell Types

- **Eukaryotic**
 - True nucleus

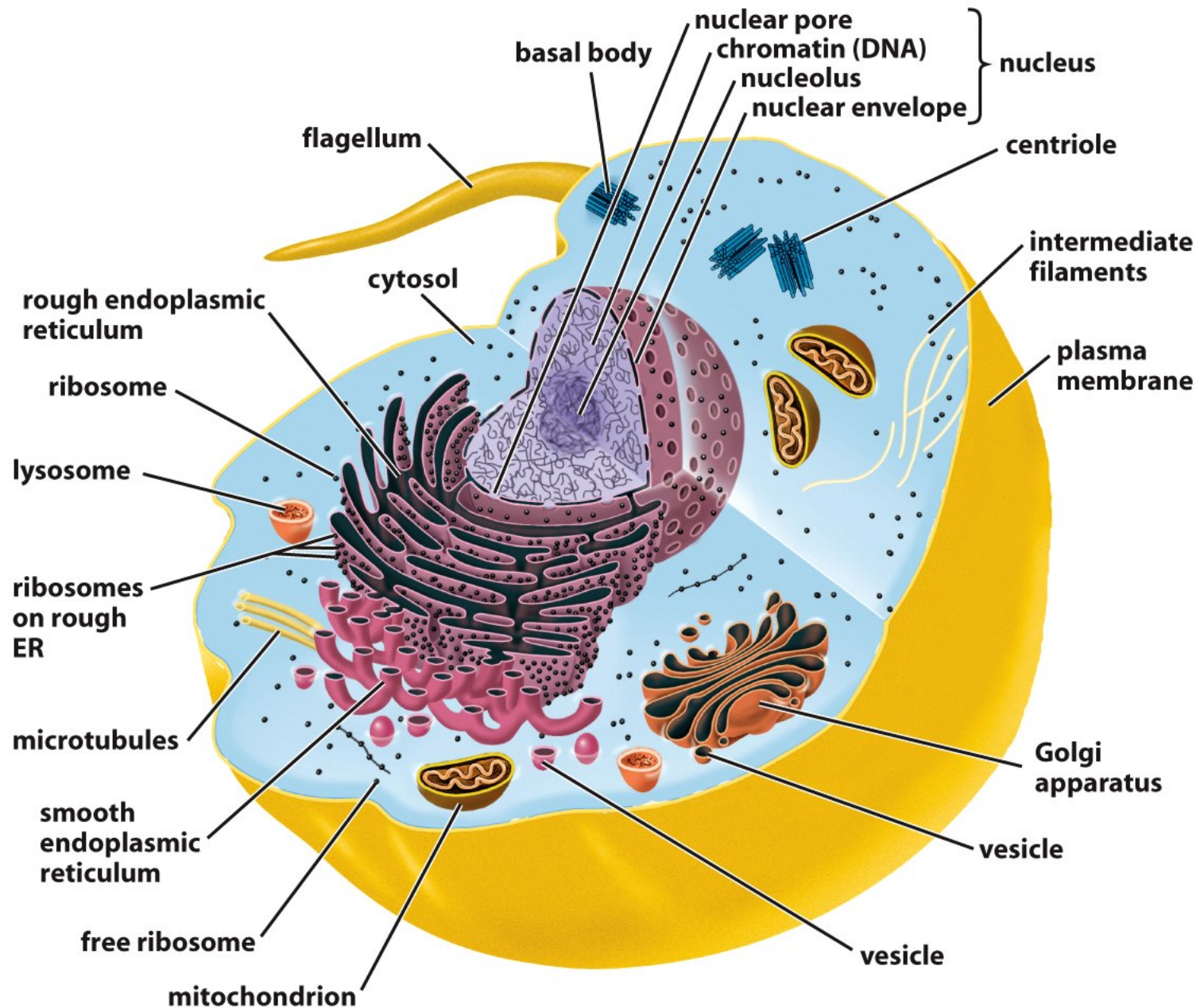


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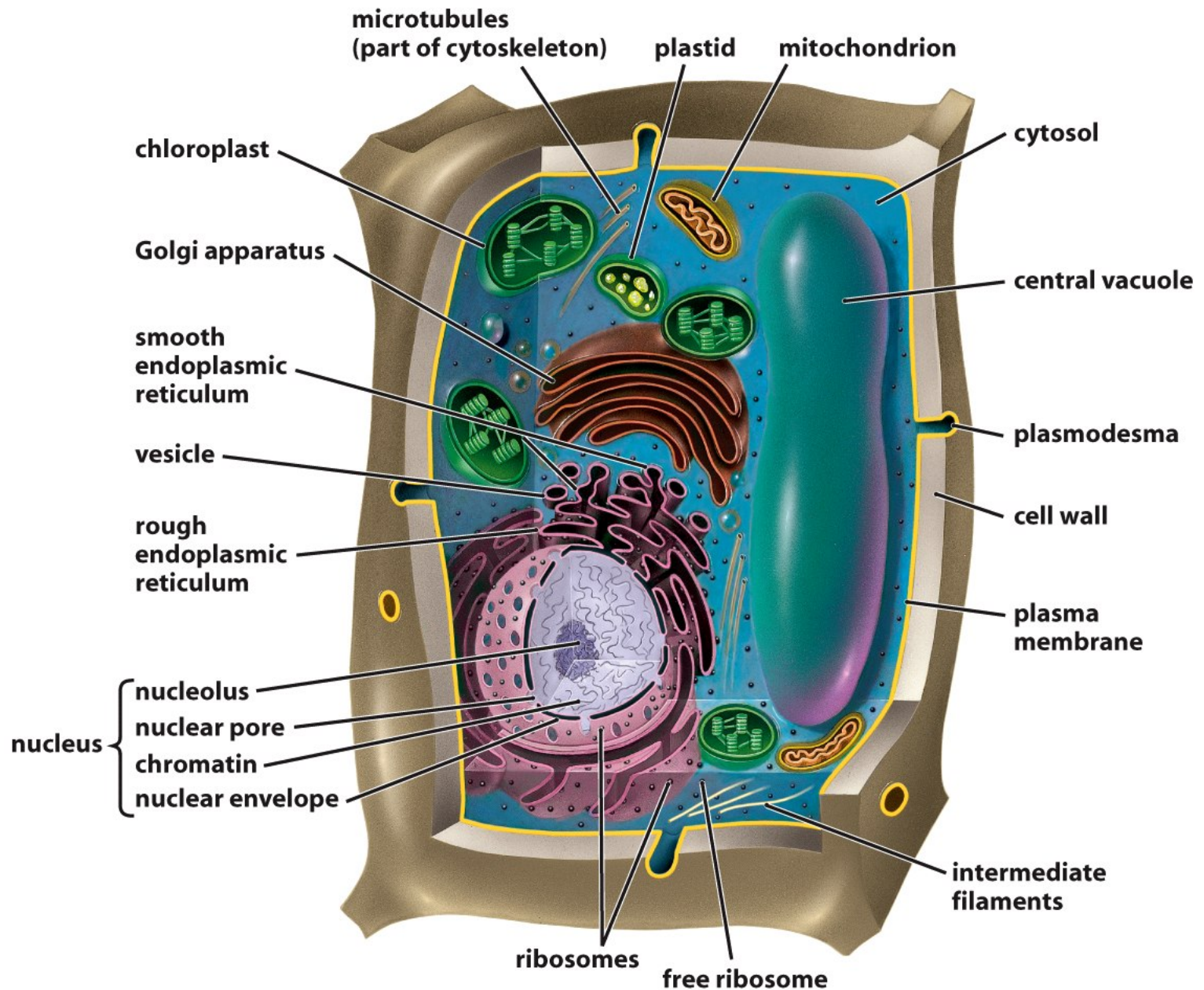


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Section 4.3 Outline

- **4.3 What Are the Major Features of Eukaryotic Cells?**
 - Some Eukaryotic Cells Are Supported by Cell Walls
 - The Cytoskeleton Provides Shape, Support, and Movement
 - Cilia and Flagella Move the Cell Through Fluid or Move Fluid Past the Cell
 - The Nucleus Is the Control Center of the Eukaryotic Cell

Section 4.3 Outline

- **4.3 What Are the Major Features of Eukaryotic Cells? *continued***
 - Eukaryotic Cytoplasm Includes an Elaborate System of Membranes
 - Vacuoles Serve Many Functions
 - Mitochondria Extract Food Energy
 - Chloroplasts Are the Sites of Photosynthesis
 - Plants Use Plastids for Storage

Major Features

- Eukaryotic cells are $> 10\text{ }\mu\text{m}$ long
- A variety of membrane-enclosed **organelles** perform specific functions
- The **cytoskeleton** provides shape and organization

Major Features

- Animal and plant cells differ with regards to cell walls, chloroplasts, plastids, central vacuoles, and centrioles

Cell Walls

- Stiff coatings on outer surfaces of bacteria, plants, fungi, and some protists are cell walls
 - Cells walls support and protect fragile cells and are usually porous
- Cell walls are composed of polysaccharides like cellulose or chitin

The Cytoskeleton

- Cytoskeleton forms a network of protein fibers within the cytoplasm
 - Composed of microfilaments, intermediate filaments, and microtubules

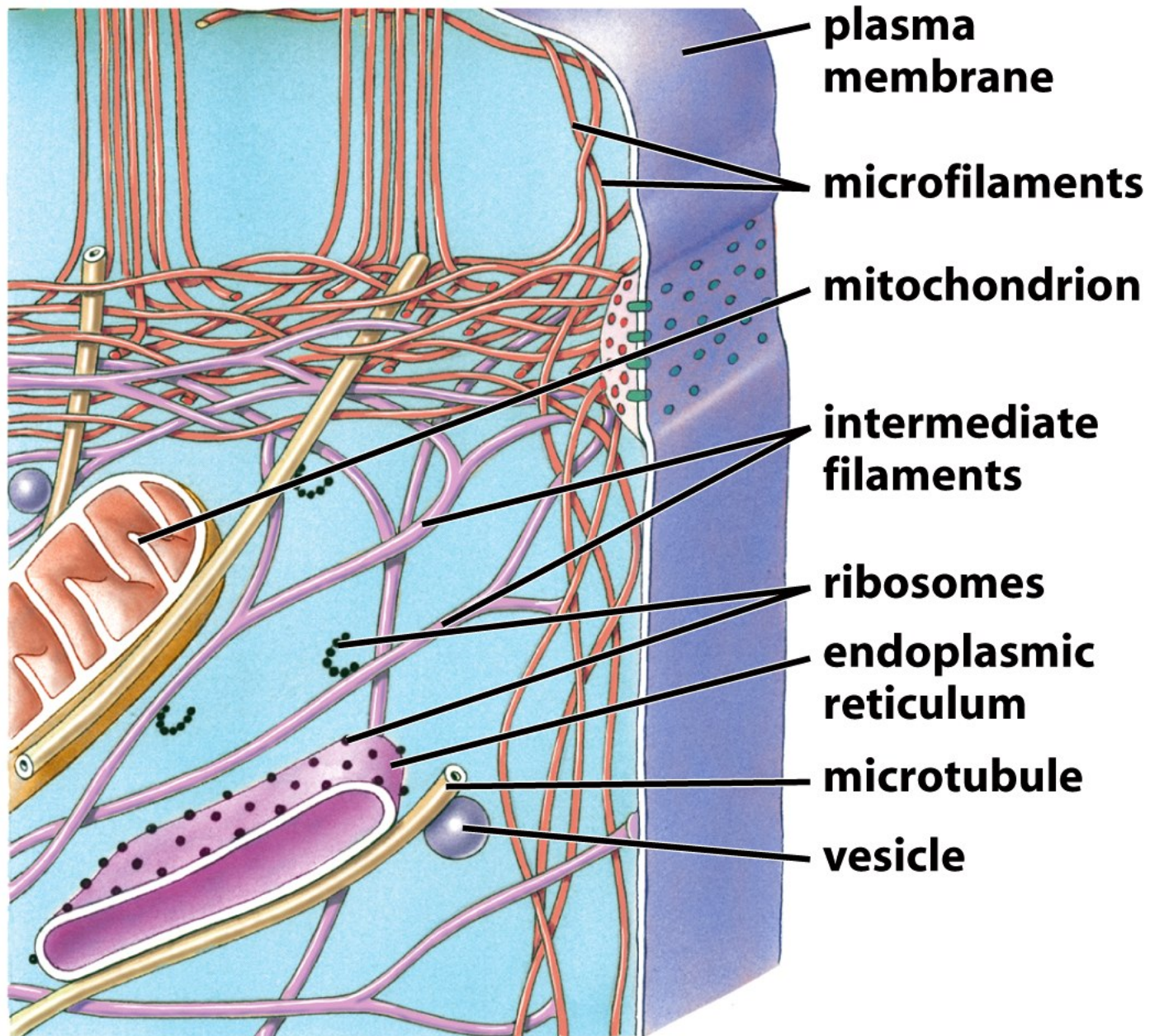


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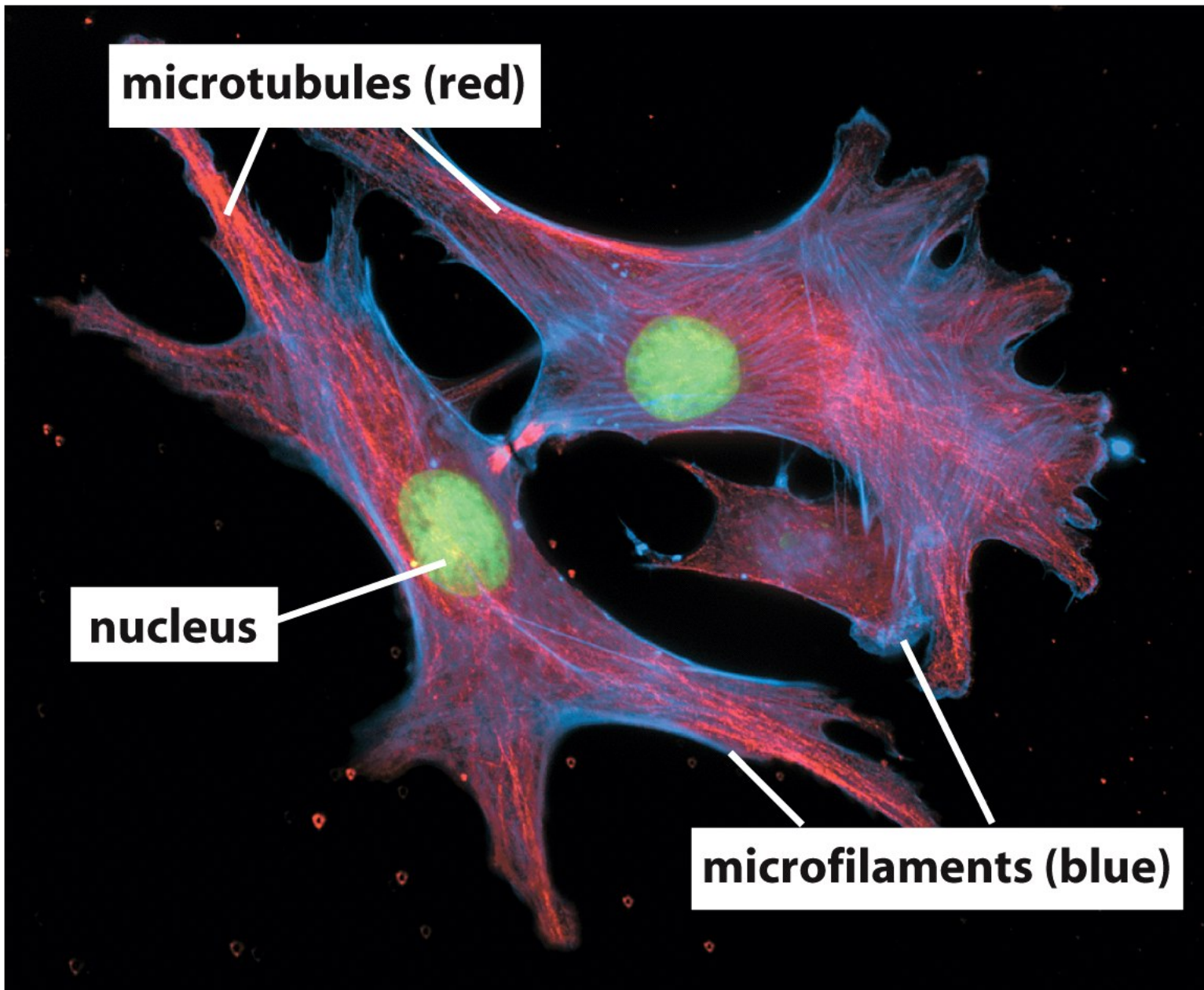


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The Cytoskeleton

- Main functions of cytoskeleton
 - Maintaining and changing cell shape
 - Providing for cell movement
 - Providing for organelle movement, including vesicle endo- and exocytosis
 - Facilitating cell division in chromosome movements and cytokinesis

Cilia and Flagella

- **Cilia** and **flagella** are extensions of the plasma membrane

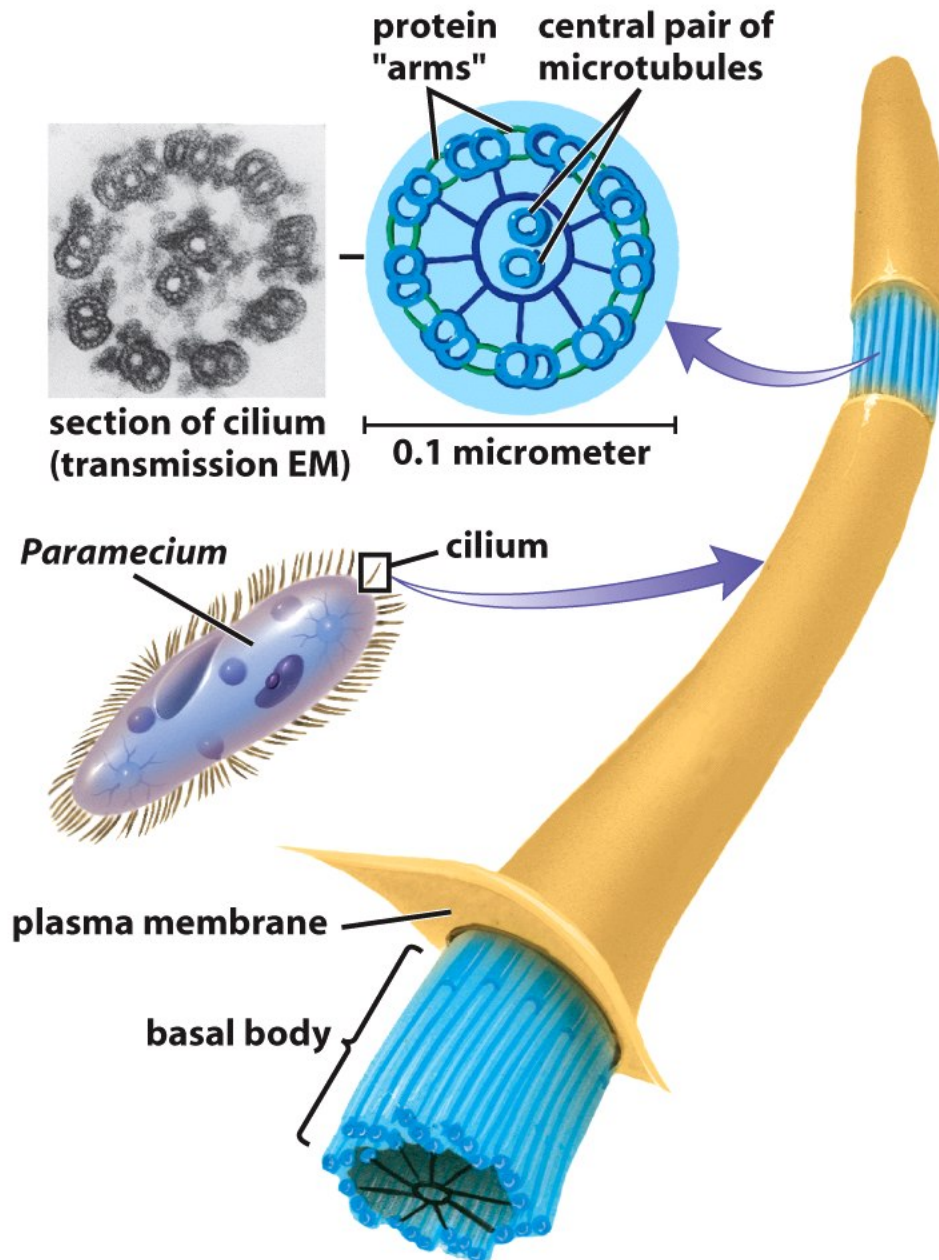


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Cilia and Flagella

- **Cilia and flagella** are composed of **microtubules** in a “9+2” arrangement formed by **centrioles** which become membrane-anchored structures called basal bodies
- Cilia are short (10-25 μm) and numerous while flagella are long (50-75 μm) but few in any cell

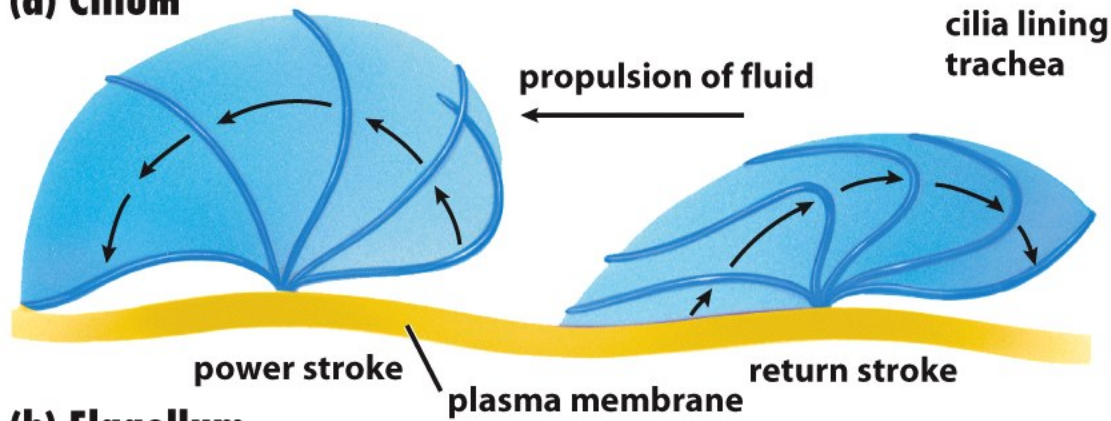
Cilia and Flagella

- Long pairs of microtubules slide along each other (using ATP) causing movement of cilia and flagella

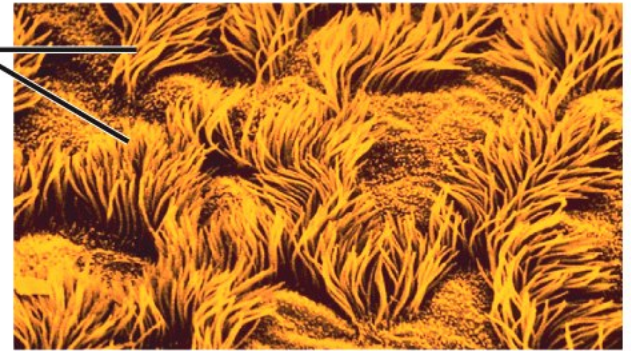
Cilia and Flagella

- Functions
 - Cilia or flagella may be used to move cell about
 - Cilia may be used to create currents of moving fluid in their environment

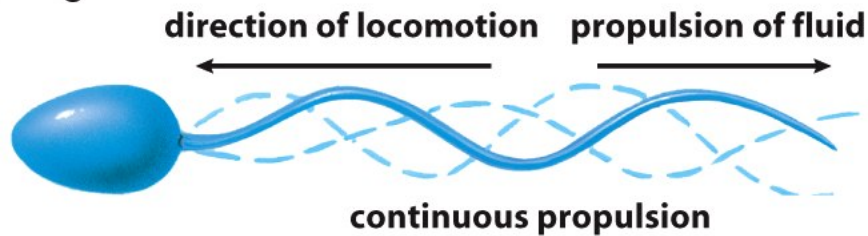
(a) Cilium



cilia lining trachea



(b) Flagellum



flagellum of human sperm

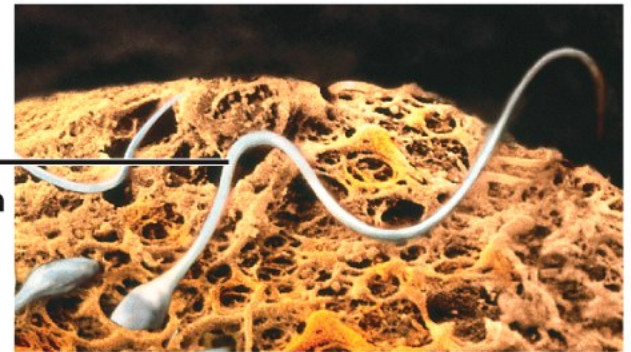
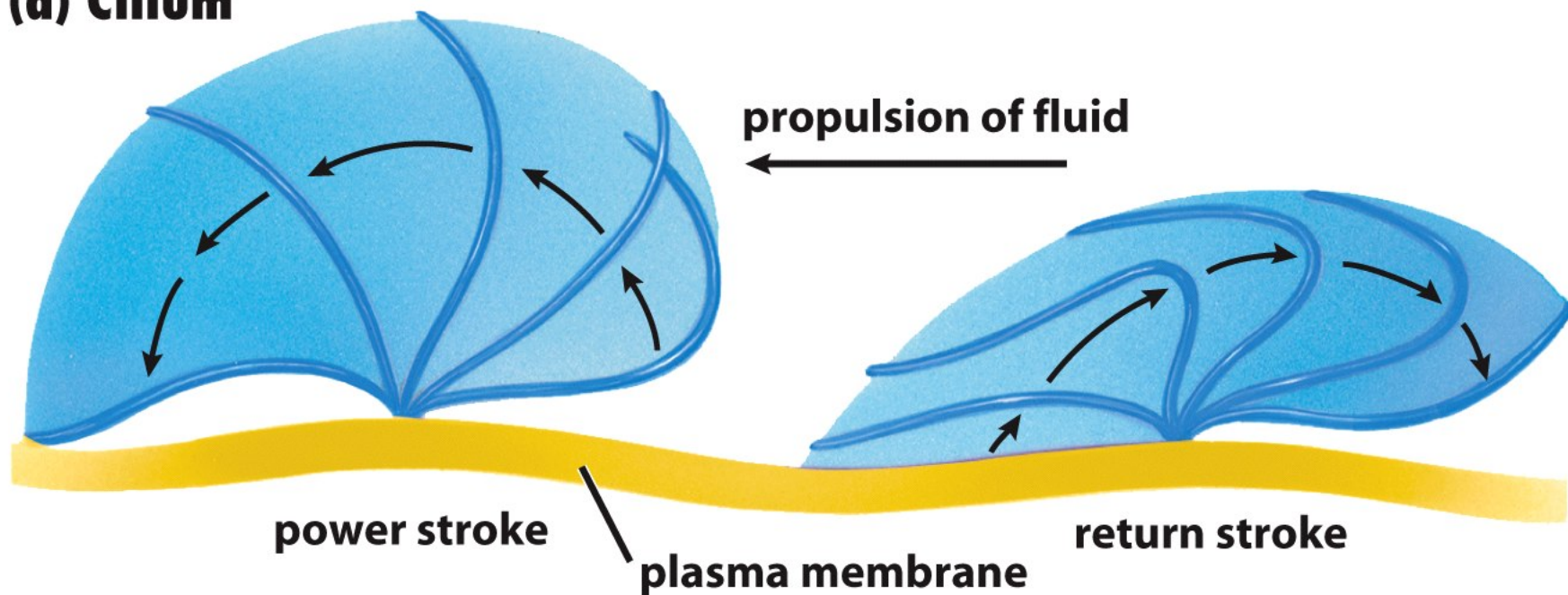
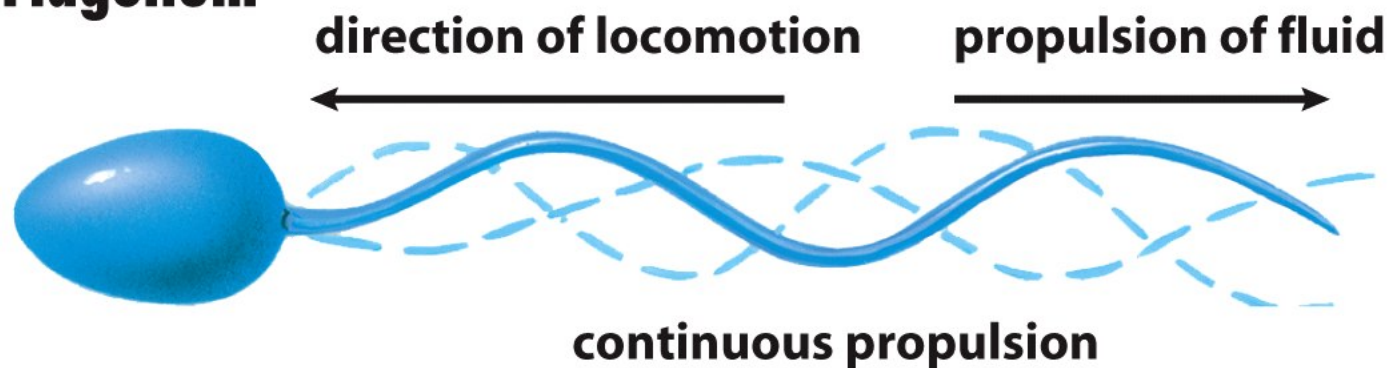


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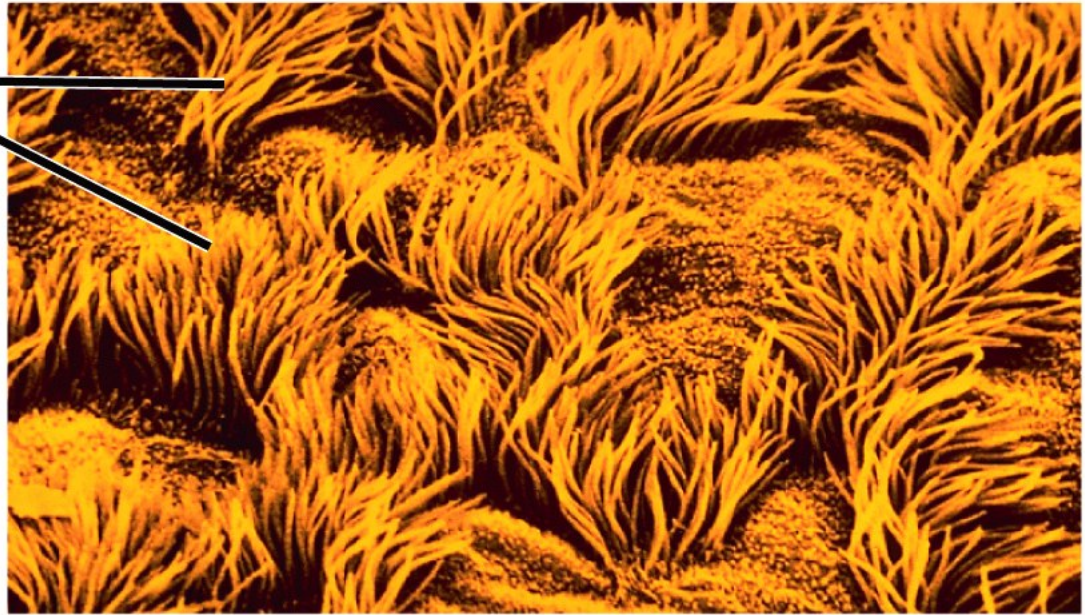
(a) Cilium



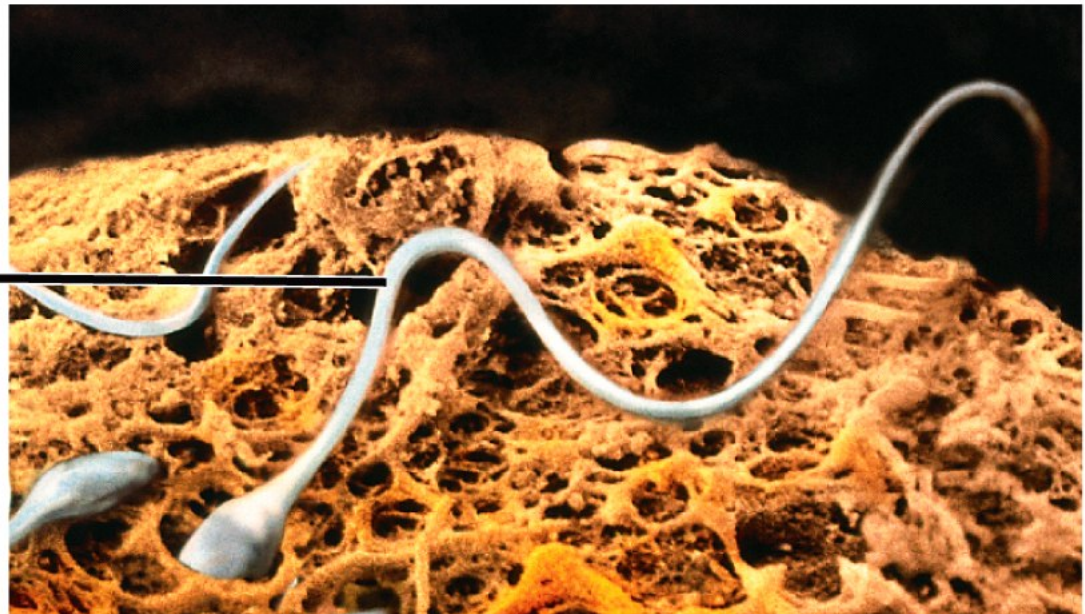
(b) Flagellum



**cilia lining
trachea**



**flagellum of
human sperm**



The Nucleus

- The nucleus is an organelle that contains three major parts
 - Nuclear envelope
 - Chromatin
 - Nucleolus

The Nucleus

- The **nuclear envelope** separates chromosomes from cytoplasm
 - Envelope is a double membrane with **nuclear pores** for transport
 - Outer membrane is studded with ribosomes

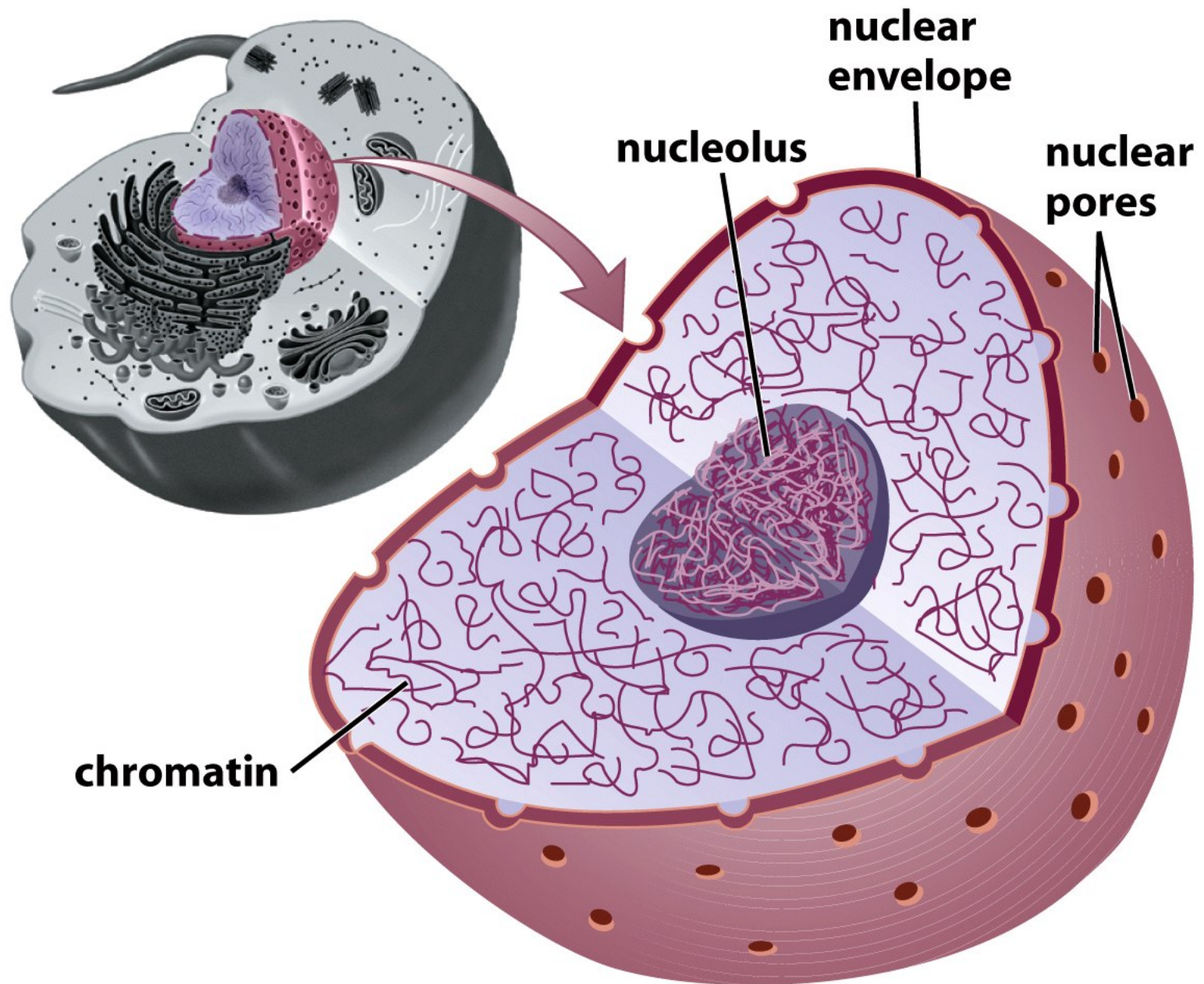


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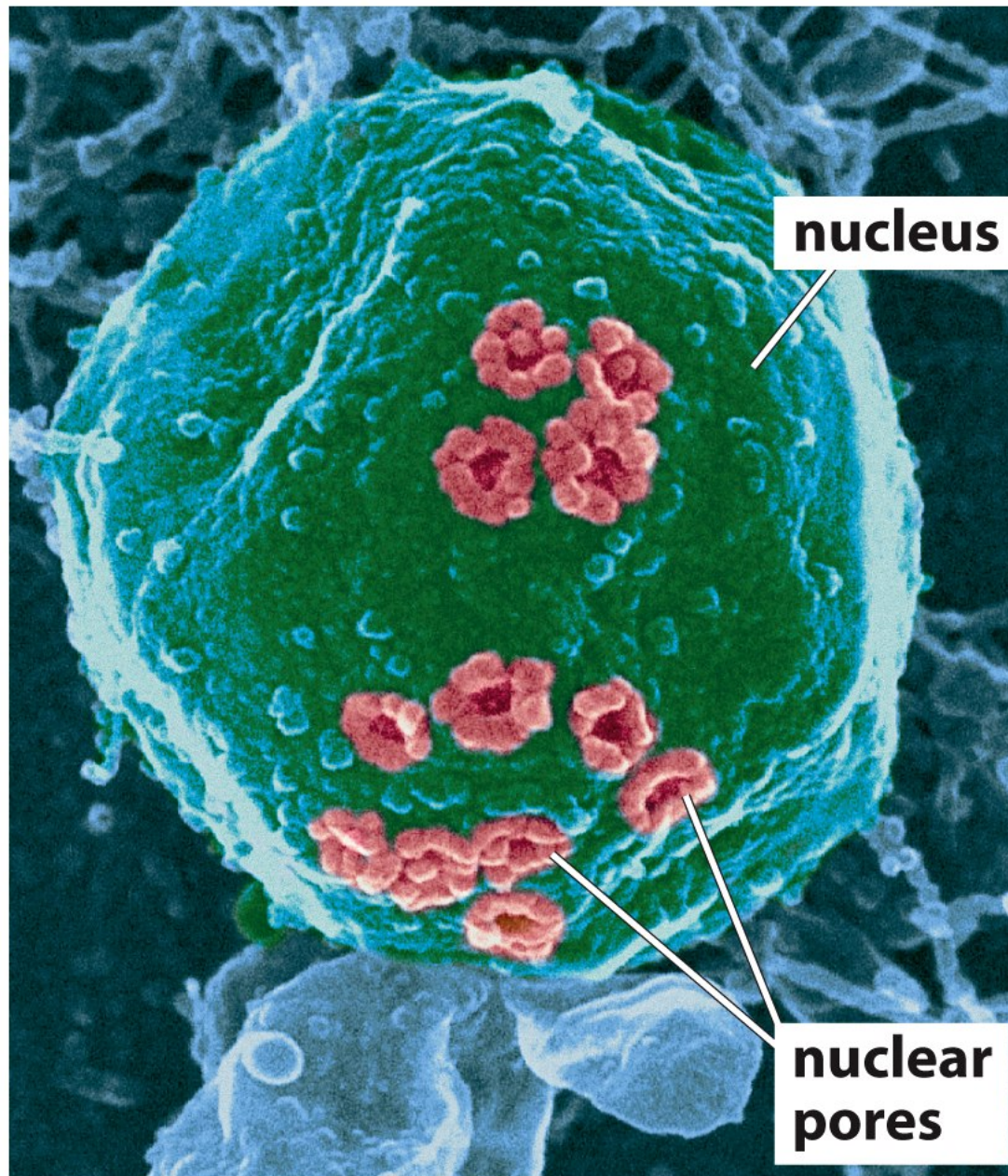


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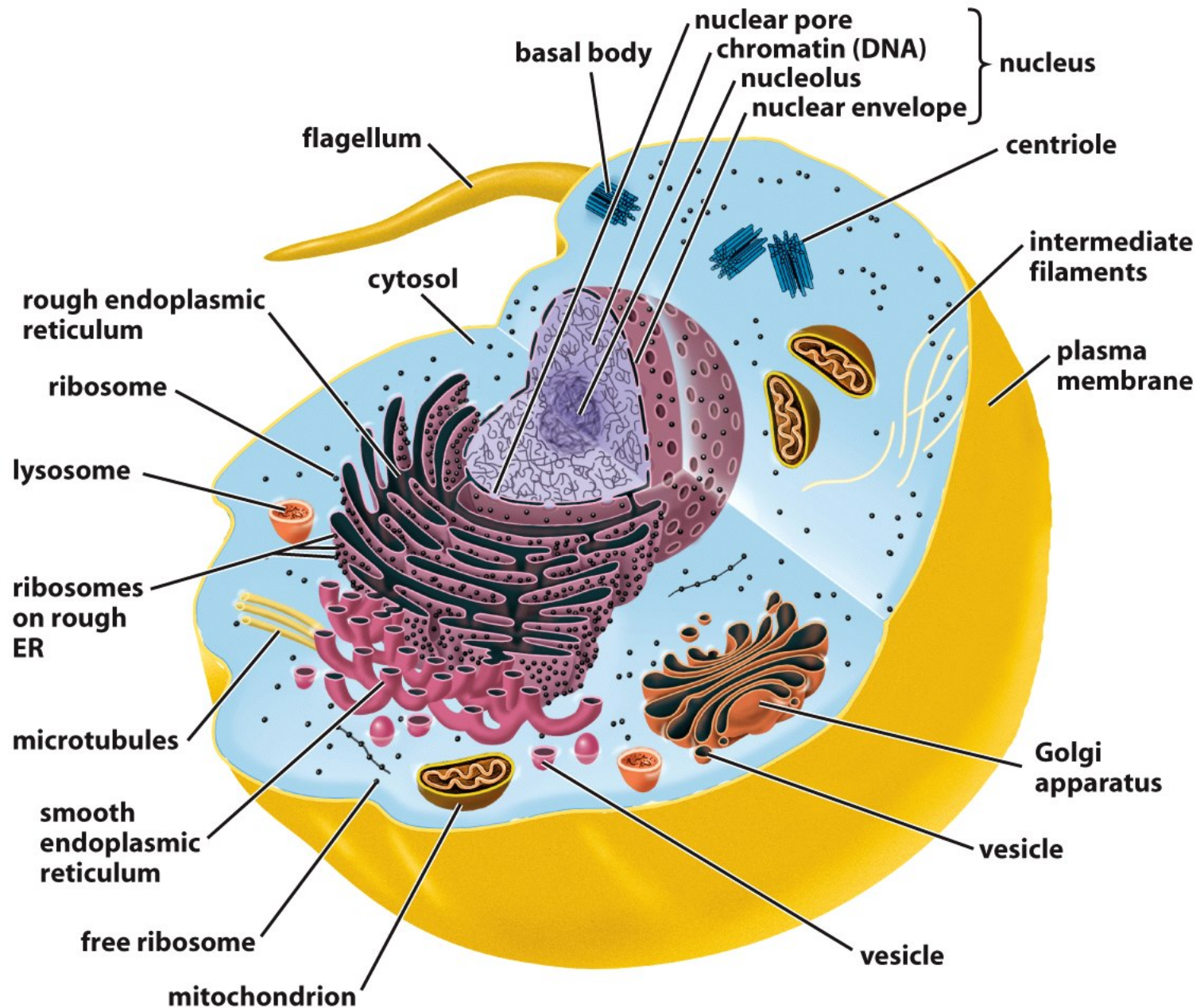


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The Nucleus

- The nucleus contains DNA in various configurations
 - Compacted **chromosomes** (during cell division)
 - Diffuse **chromatin** (as DNA directs reactions through an RNA intermediate by coding for proteins)

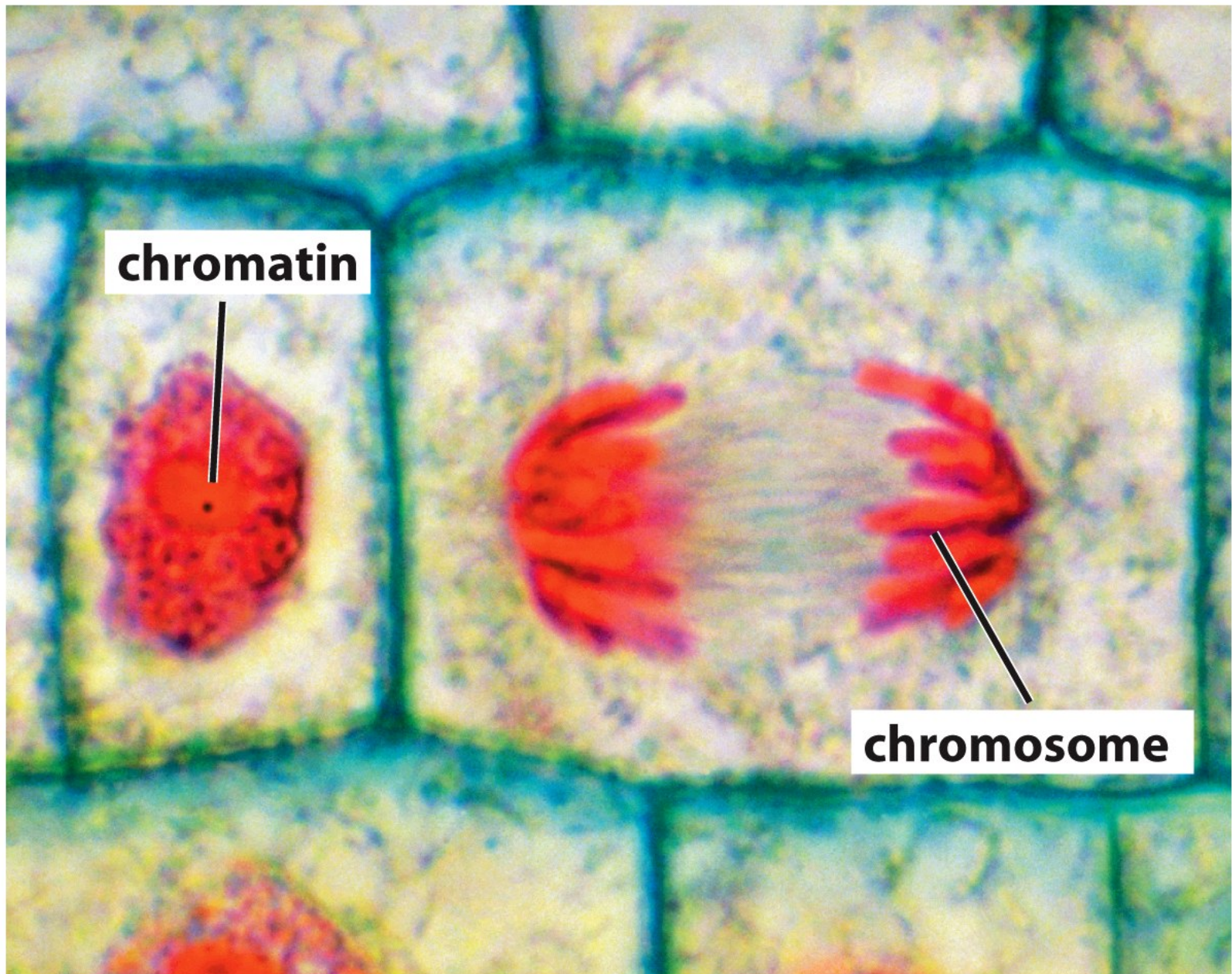


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The Nucleus

- Darker area within the nucleus called the **nucleolus**
 - Functions as the site of **ribosome** synthesis
 - Ribosomes synthesize proteins

System of Membranes

- Membrane system includes the plasma membrane and organelle membranes

System of Membranes

- **Plasma membrane** isolates cell and allows for regulation of transport
 - Plants, fungi, and some protists additionally have a **cell wall** outside the plasma membrane

System of Membranes

- **Vesicles** are membranous sacs that transport substances among the separate regions of the membrane system

System of Membranes

- **Endoplasmic reticulum (ER)** forms a series of enclosed, interconnected channels within cell
- There are two forms of ER
 - **Smooth ER**
 - **Rough ER**

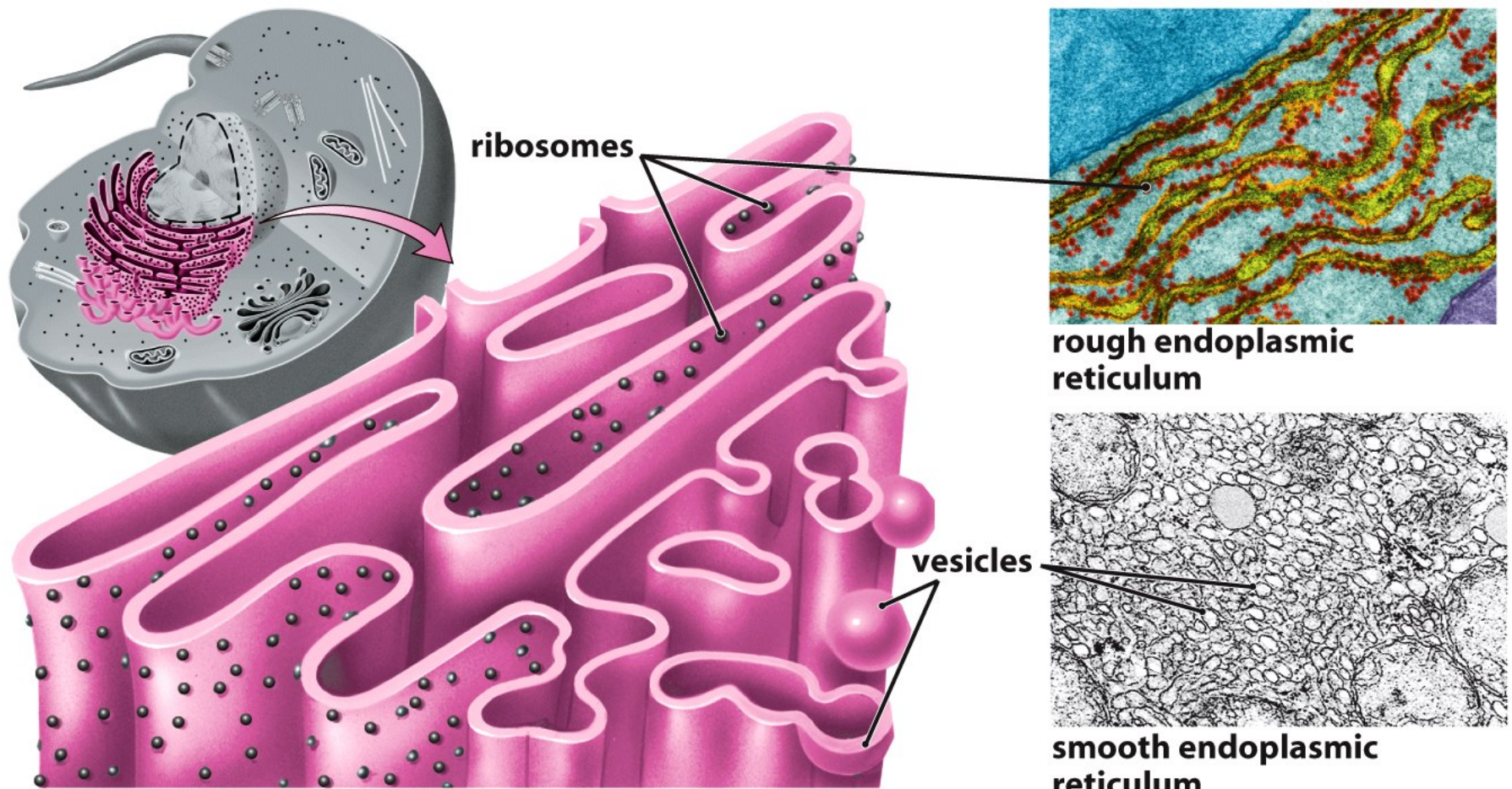


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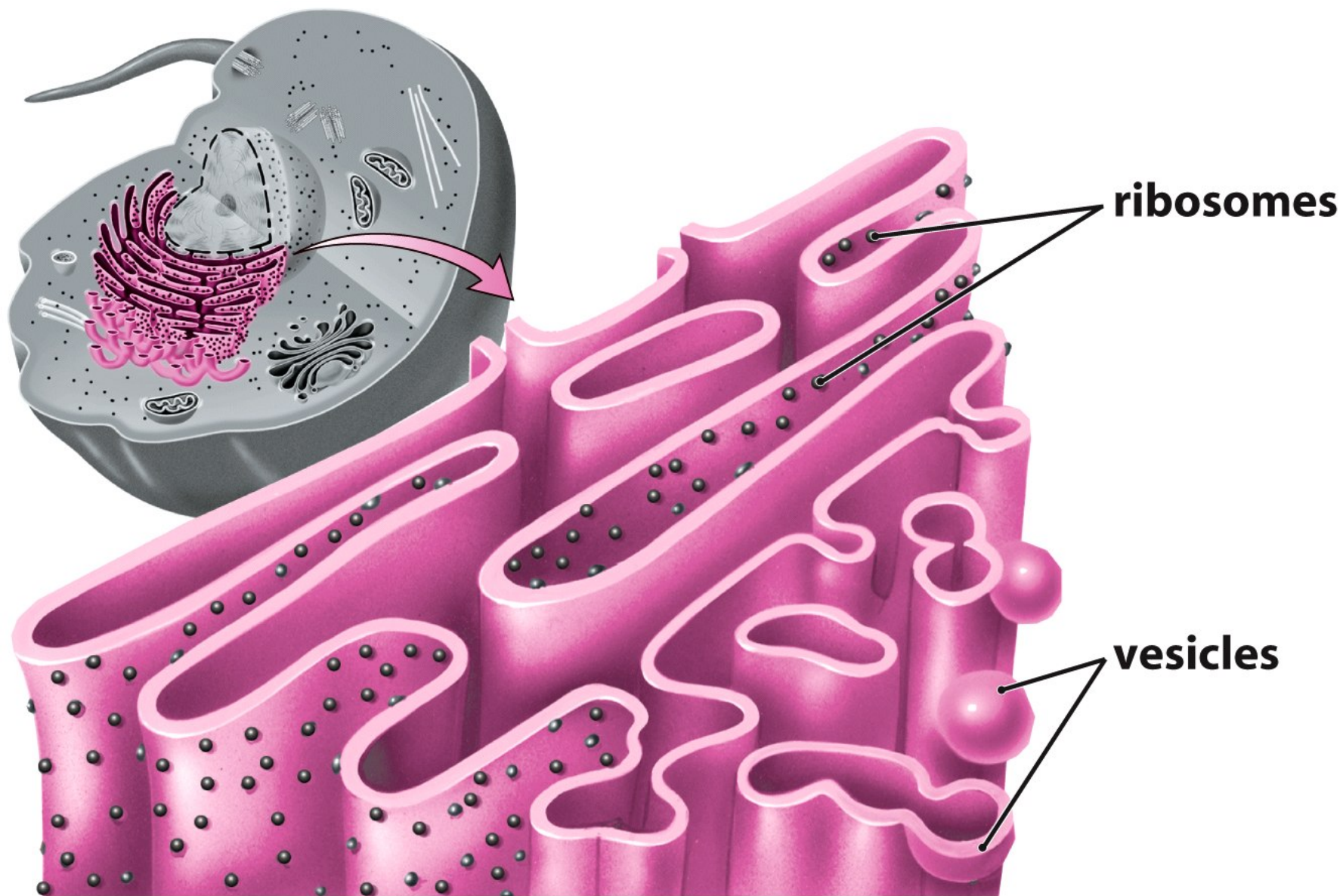
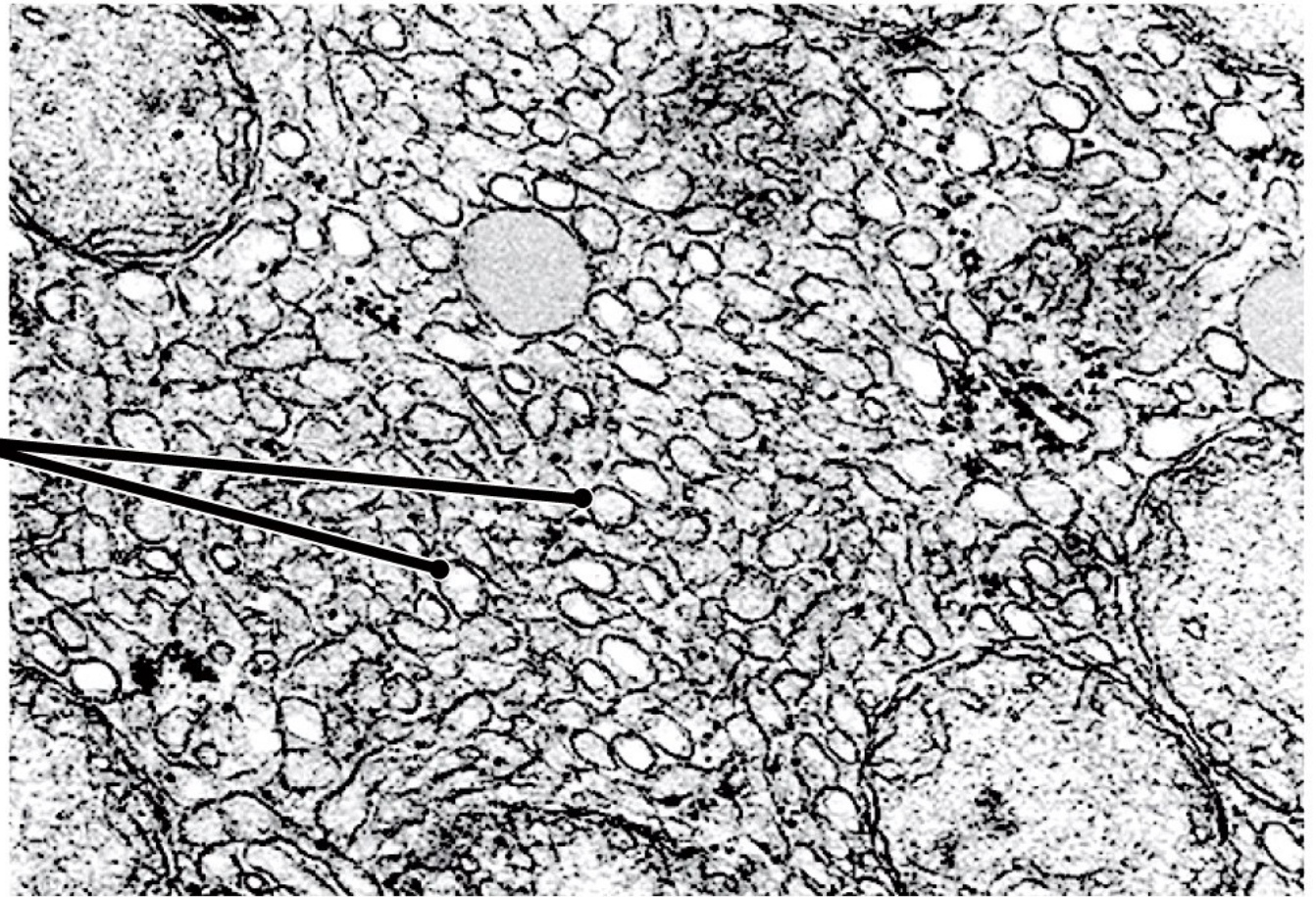


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System of Membranes

- **Smooth ER** has no ribosomes
 - Contains enzymes that detoxify drugs (in liver cells) or synthesizes lipids

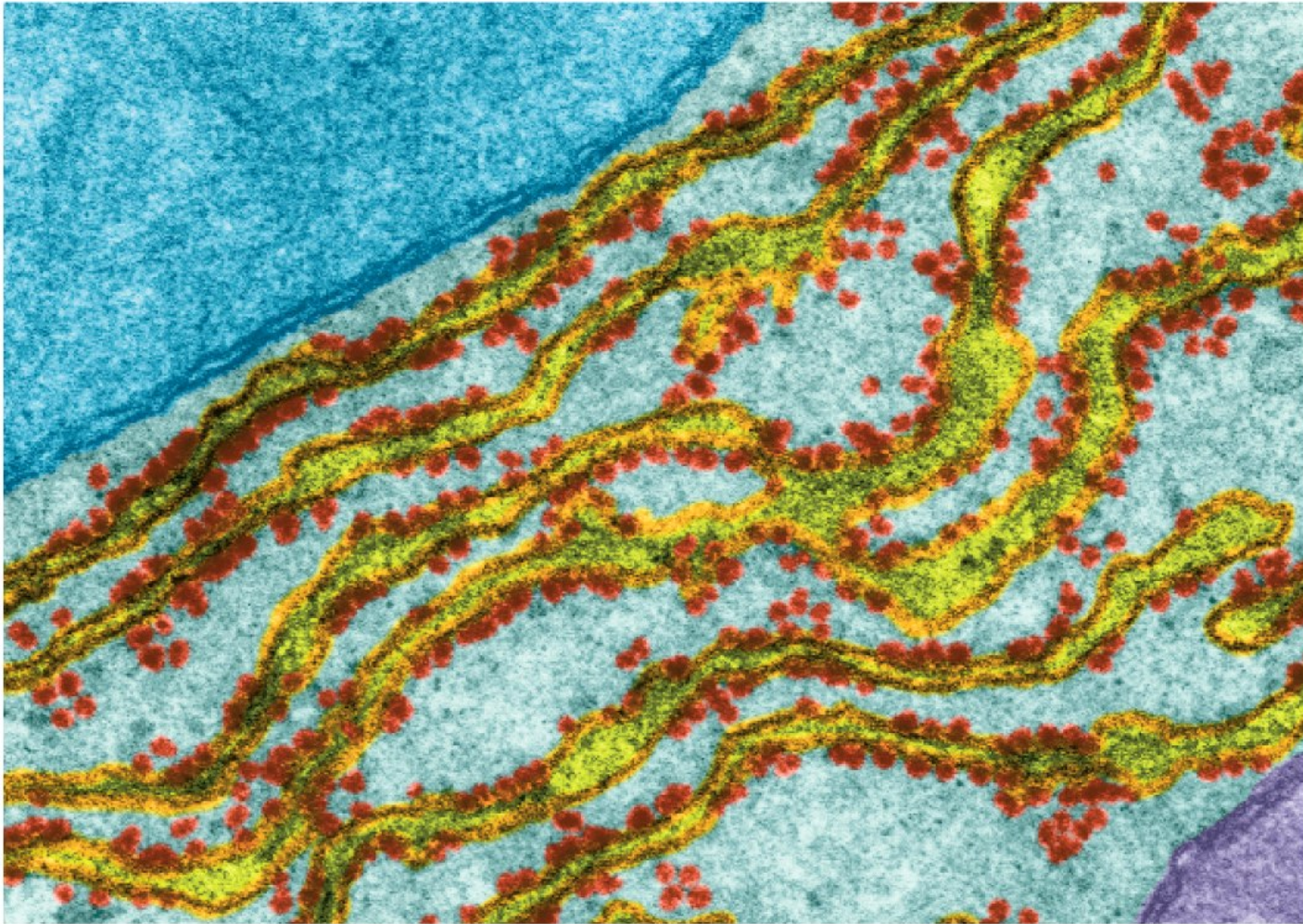
vesicles



**smooth endoplasmic
reticulum**

System of Membranes

- **Rough ER** is studded with ribosomes on outside
 - Produces proteins and phospholipids destined for other membranes or for secretion (export)



rough endoplasmic reticulum

System of Membranes

- **Golgi Apparatus** is a set of stacked flattened sacs
 - Receives proteins from ER (via transport vesicles) and sorts them by destination
 - Modifies some molecules (e.g. proteins to glycoproteins)
 - Packages material into vesicles for transport

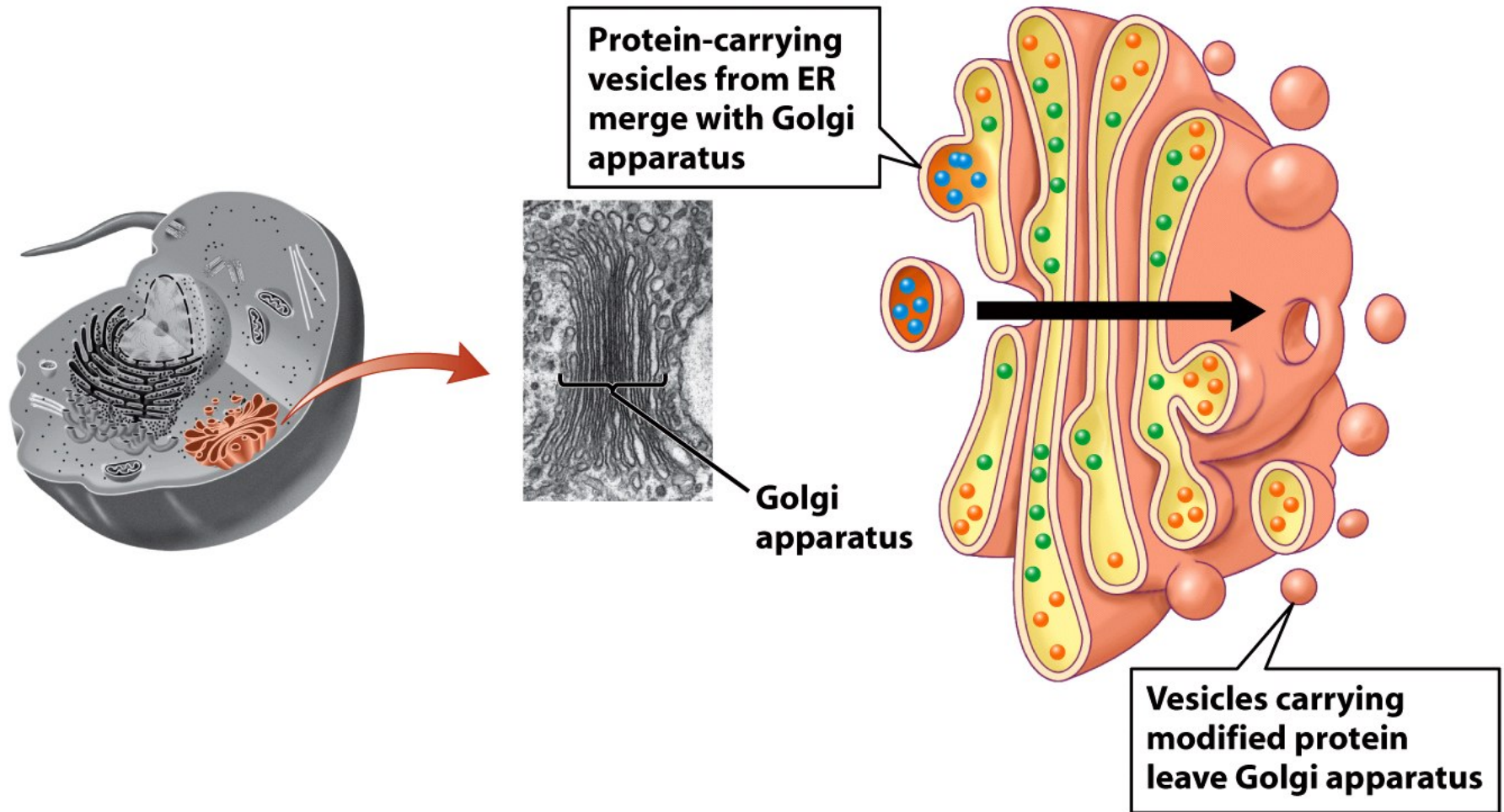
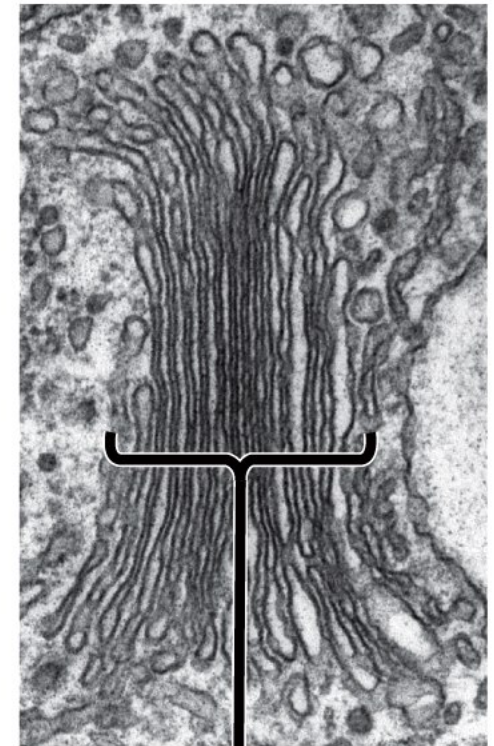
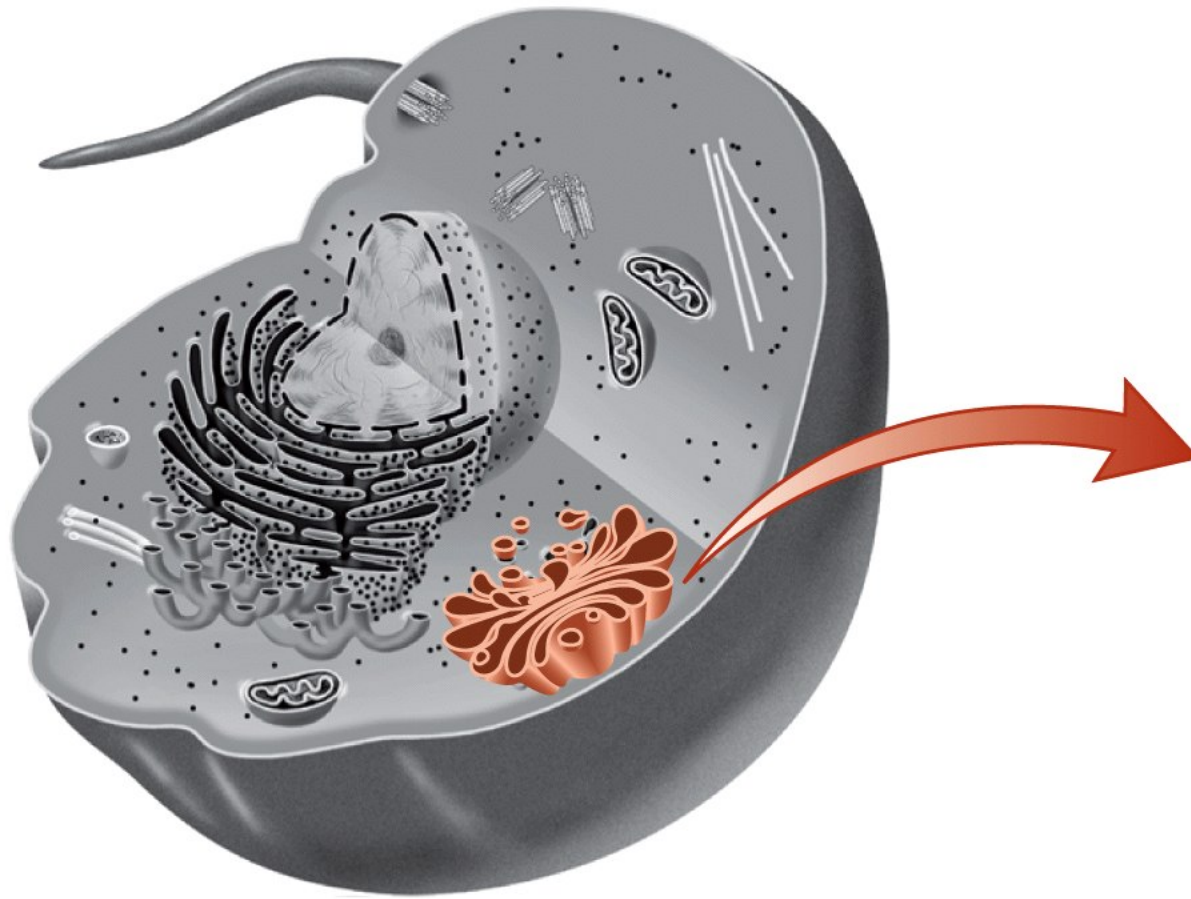


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**Golgi
apparatus**

System of Membranes

- Three fates of substances made in the membrane system:
 1. Secreted proteins made in RER, travel through Golgi, then are exported through plasma membrane
 - **Figure 4-14** illustrates this process for antibodies, proteins produced by white blood cells to inactivate foreign disease-causing agents

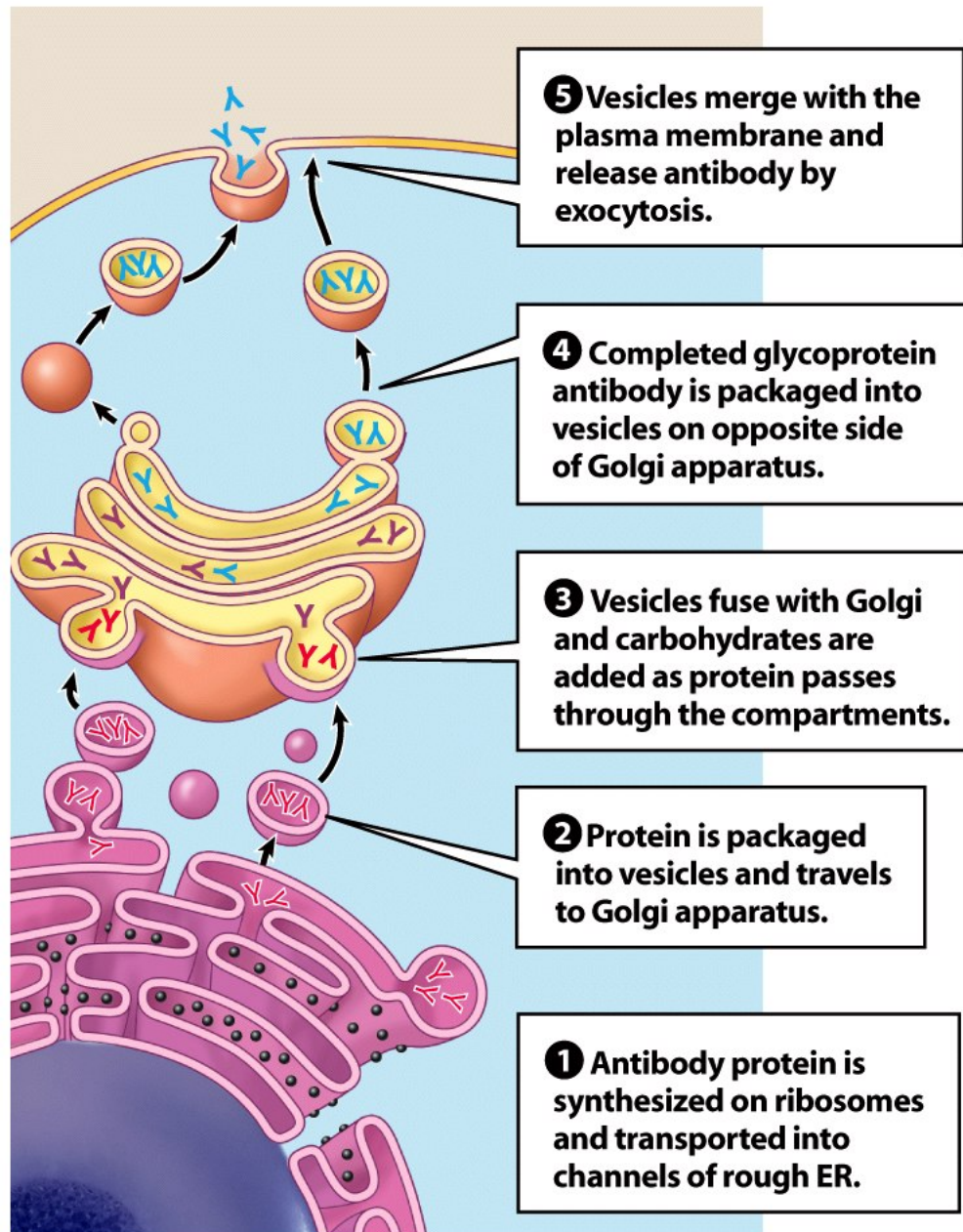


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System of Membranes

2. Digestive proteins made in RER, travel through Golgi, and are packaged as **lysosomes** for use in cell
 - Lysosomes fuse with **food vacuoles** and digest food into basic nutrients

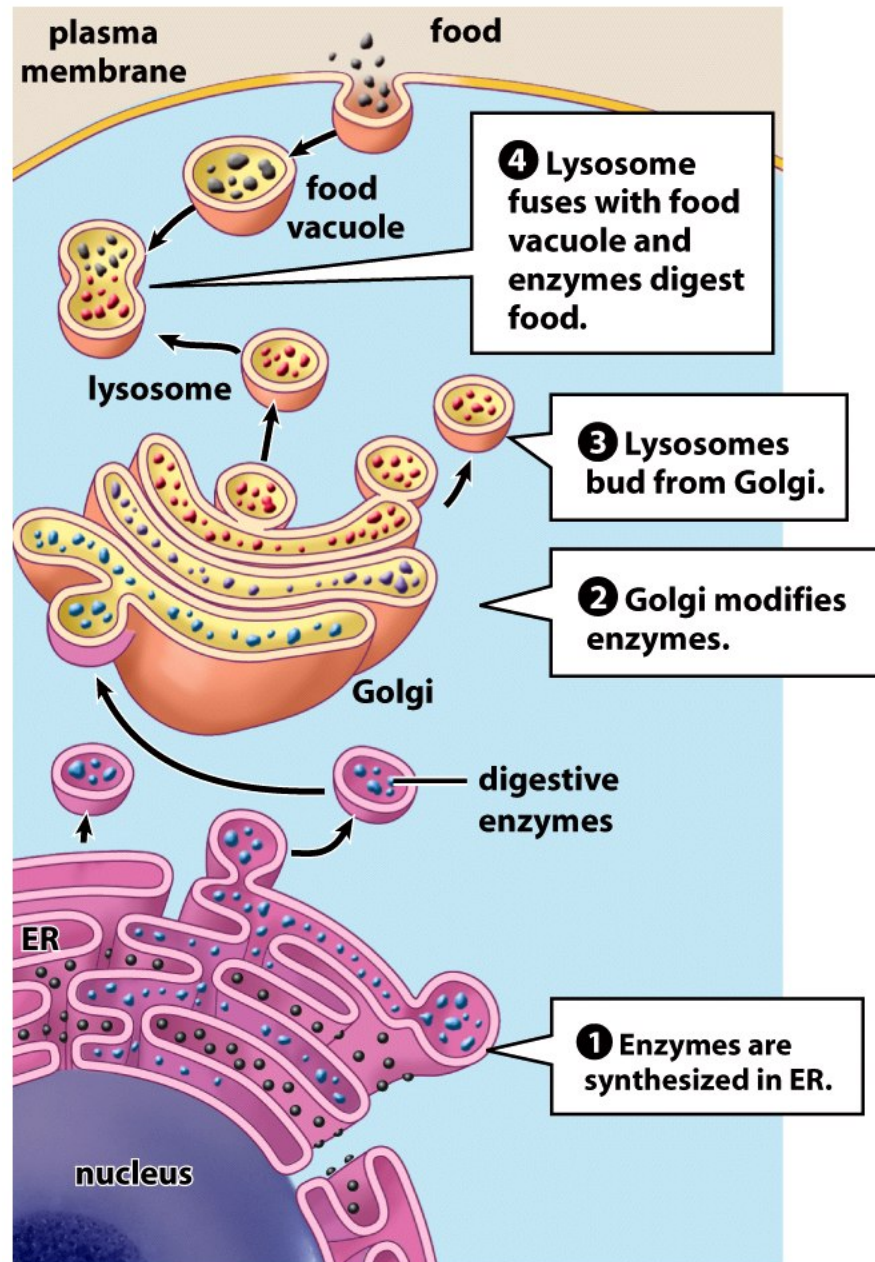


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System of Membranes

3. Membrane proteins and lipids made in ER, travel through Golgi, and replenish or enlarge organelle and plasma membranes

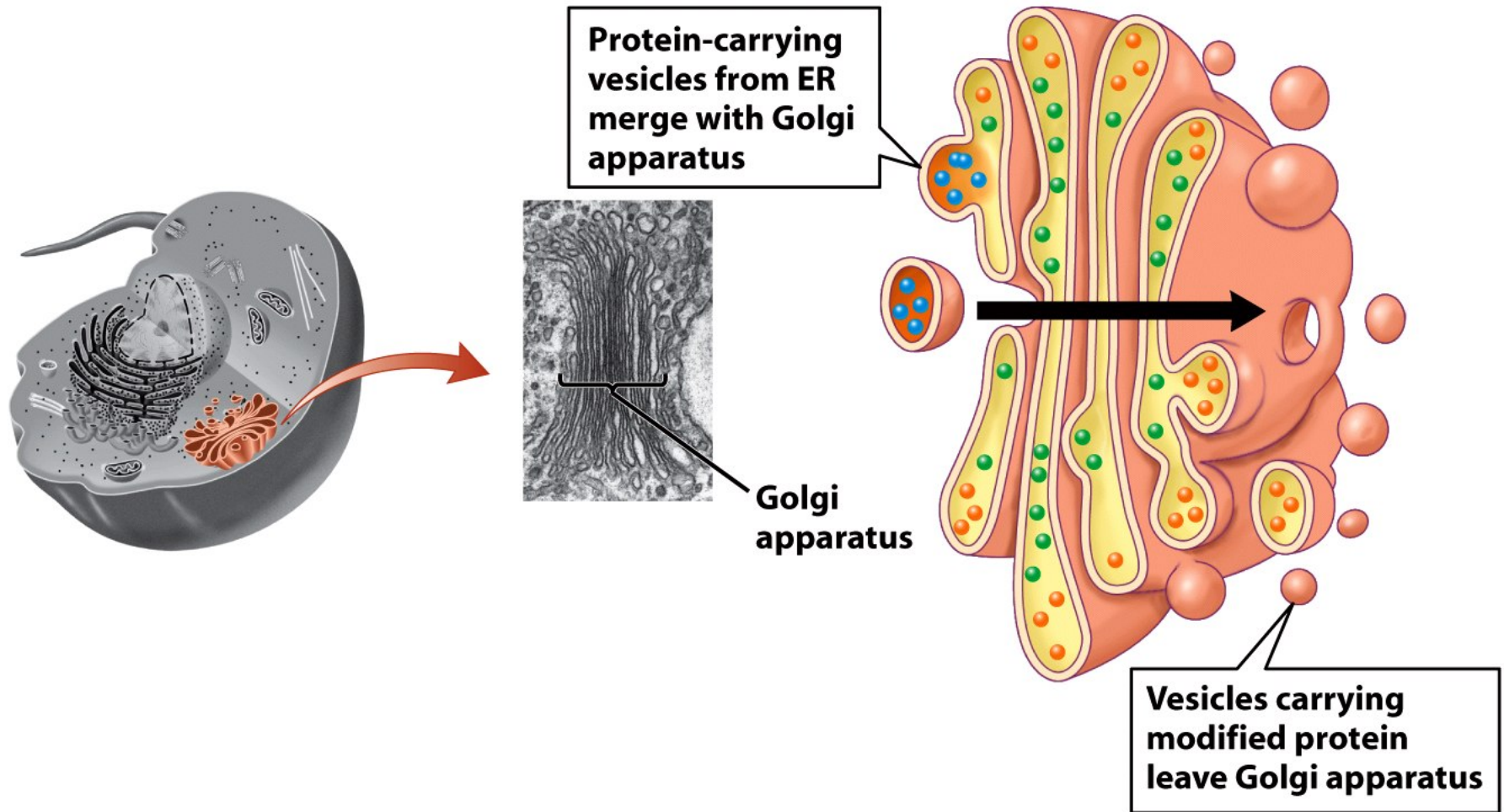


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Vacuoles Serve Many Functions

- Fluid-filled sacs with a single membrane
- Functions of vacuoles
 - **Contractile vacuoles** in freshwater organisms used to collect and pump water out

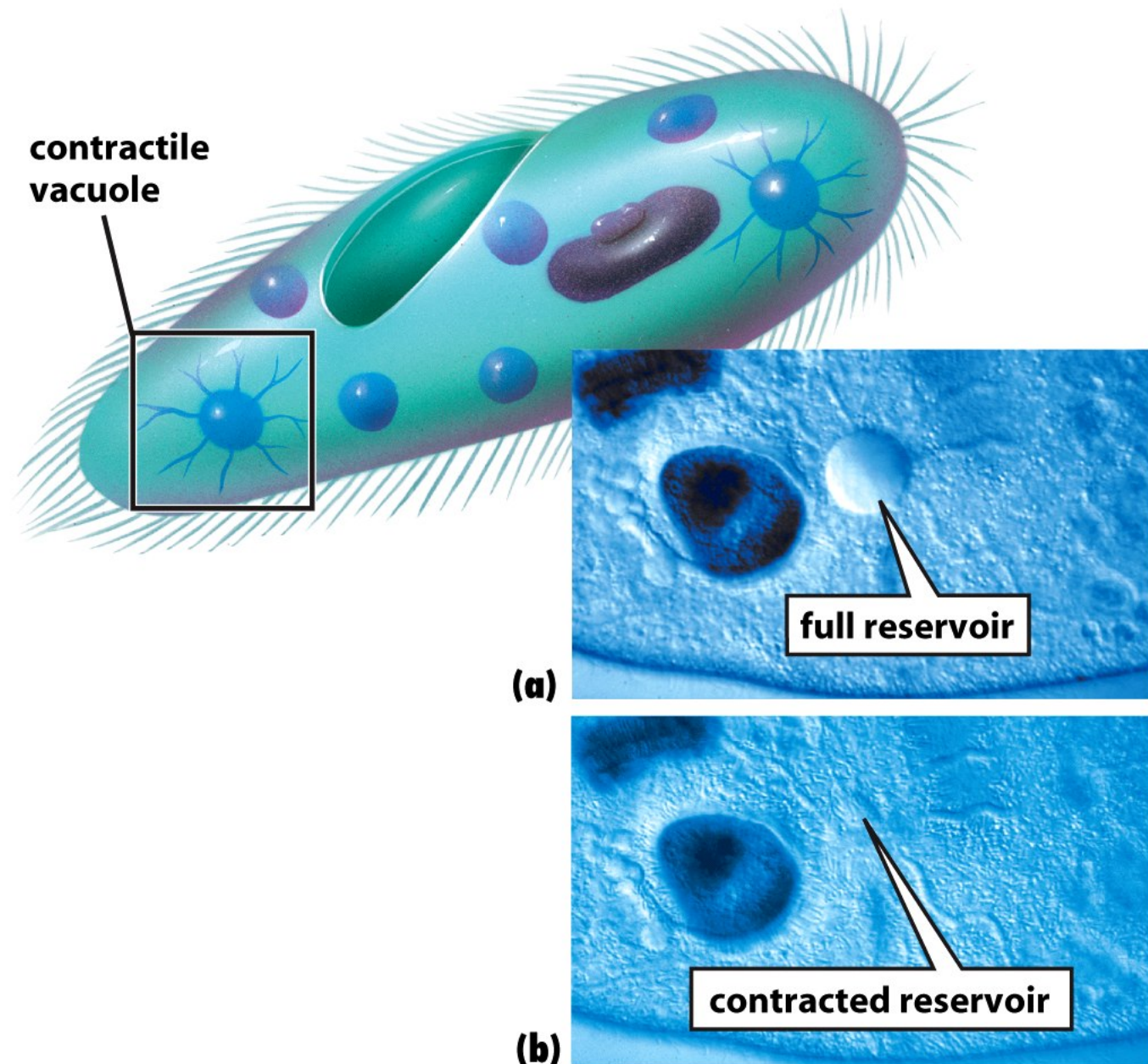


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Vacuoles Serve Many Functions

- Functions of vacuoles (continued)
 - Plant **central vacuoles** used in several ways
 - Maintain water balance
 - Store hazardous wastes, nutrients, or pigments
 - Provide turgor pressure on cytoplasm to keep cells rigid

Mitochondria Extract Food Energy

- Mitochondria are round, oval, or tubular sacs of double-membranes
 - Inner membrane is folded into **cristae**
 - **Intermembrane compartment** lies between inner and outer membranes
 - **Matrix** space within inner membrane

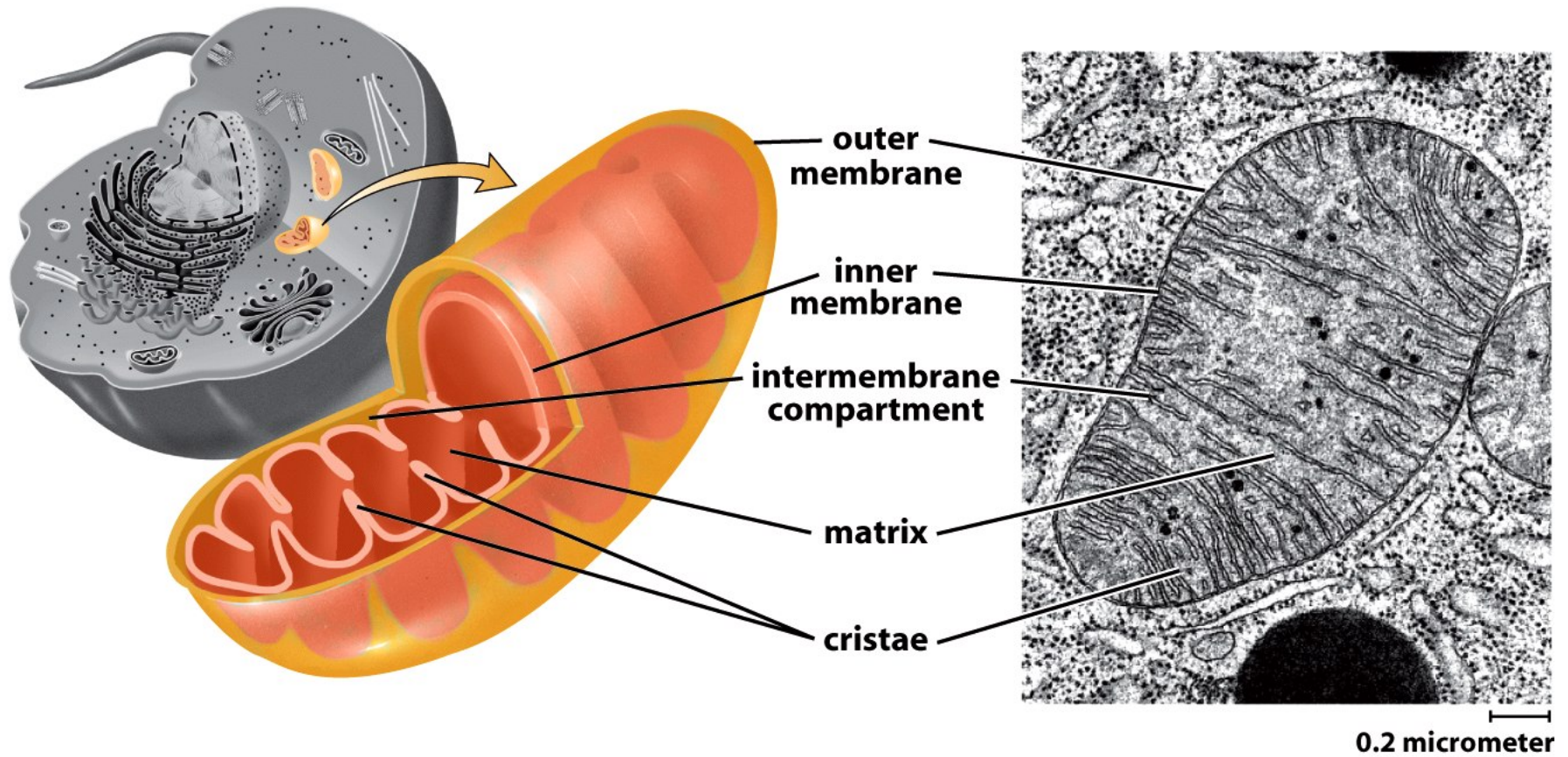


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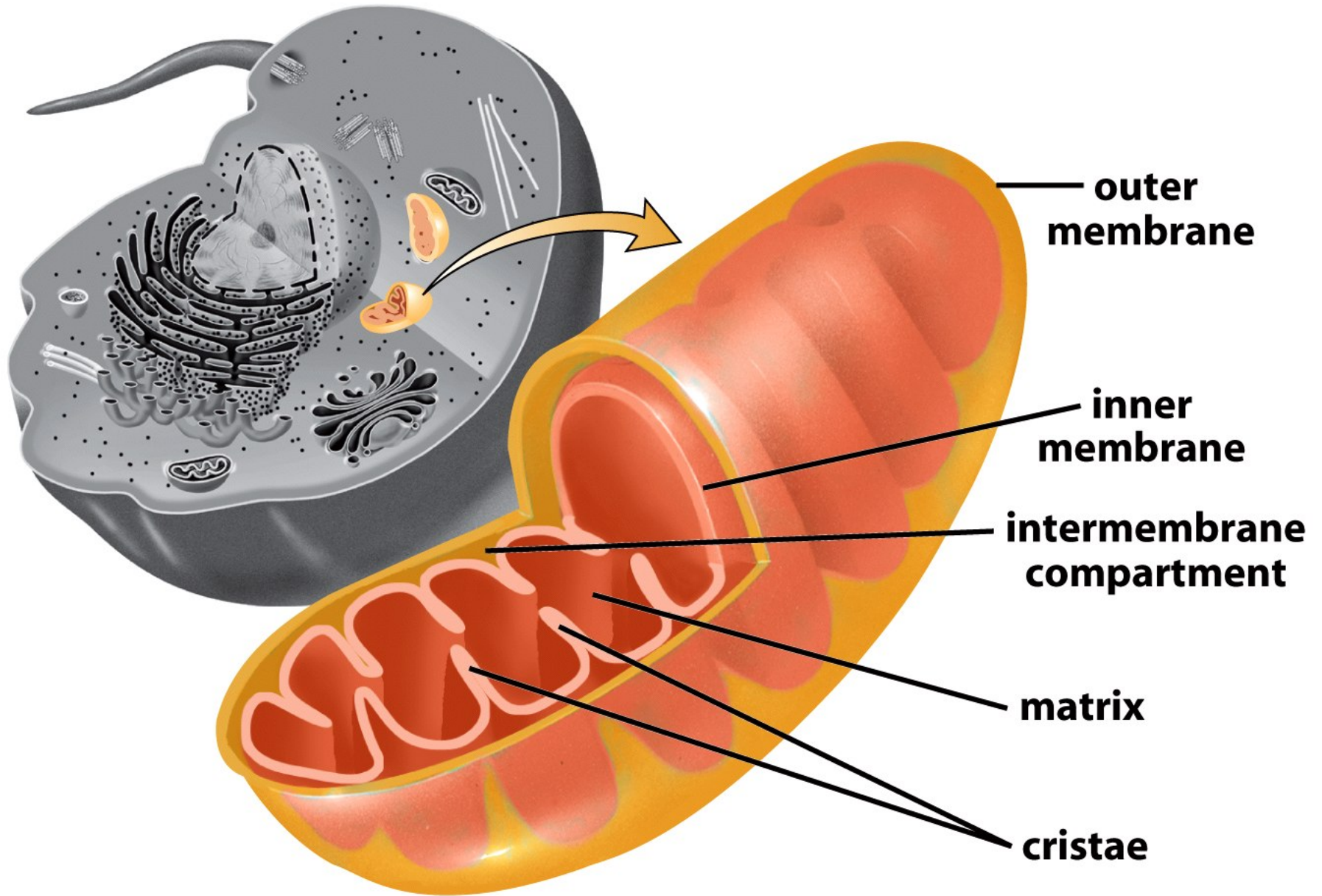


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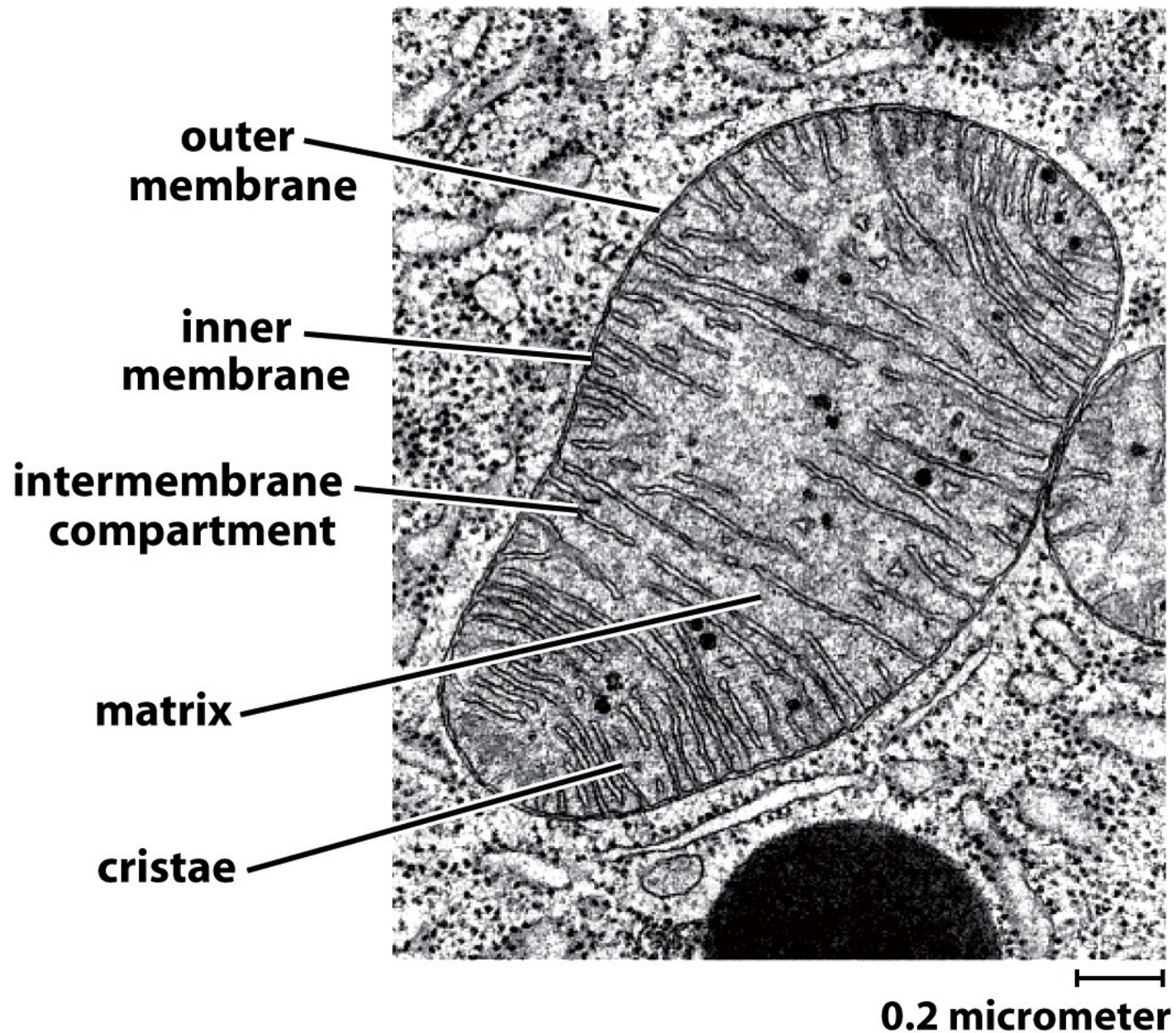


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Mitochondria Extract Food Energy

- Mitochondria may be remnants of free-living prokaryotes (**endosymbiotic hypothesis**)

Mitochondria Extract Food Energy

- Function as the “powerhouses of the cell”
 - Mitochondria extract energy from food molecules
 - Extracted energy is stored in high-energy bonds of ATP
 - Energy extraction process involves **anaerobic** and **aerobic** reactions

Chloroplasts

- Chloroplasts are specialized organelles surrounded by a double membrane
 - Outer membrane
 - Inner membrane encloses the stroma space
 - Stacked hollow membranous sacs (**grana**) within stroma are called **thylakoids**

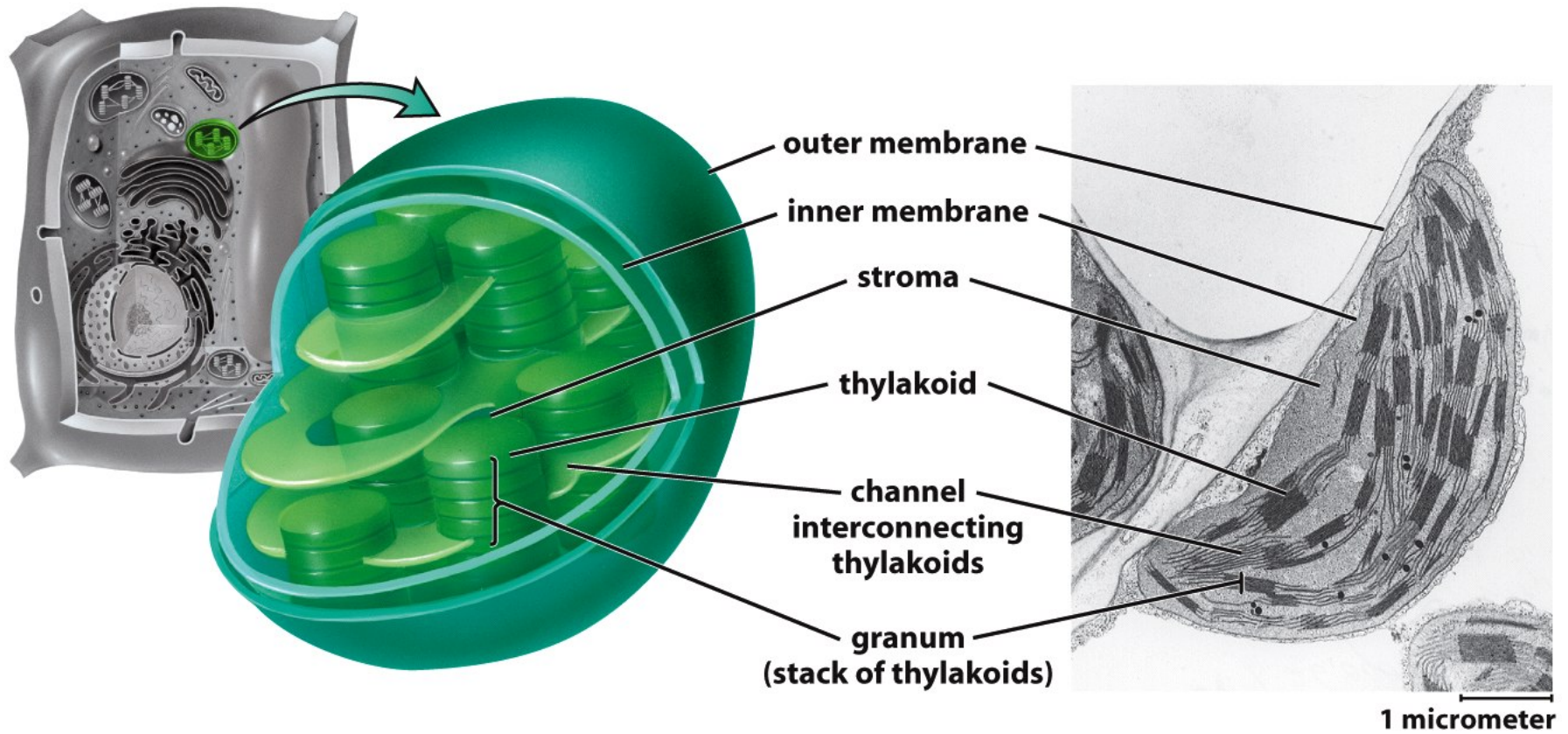


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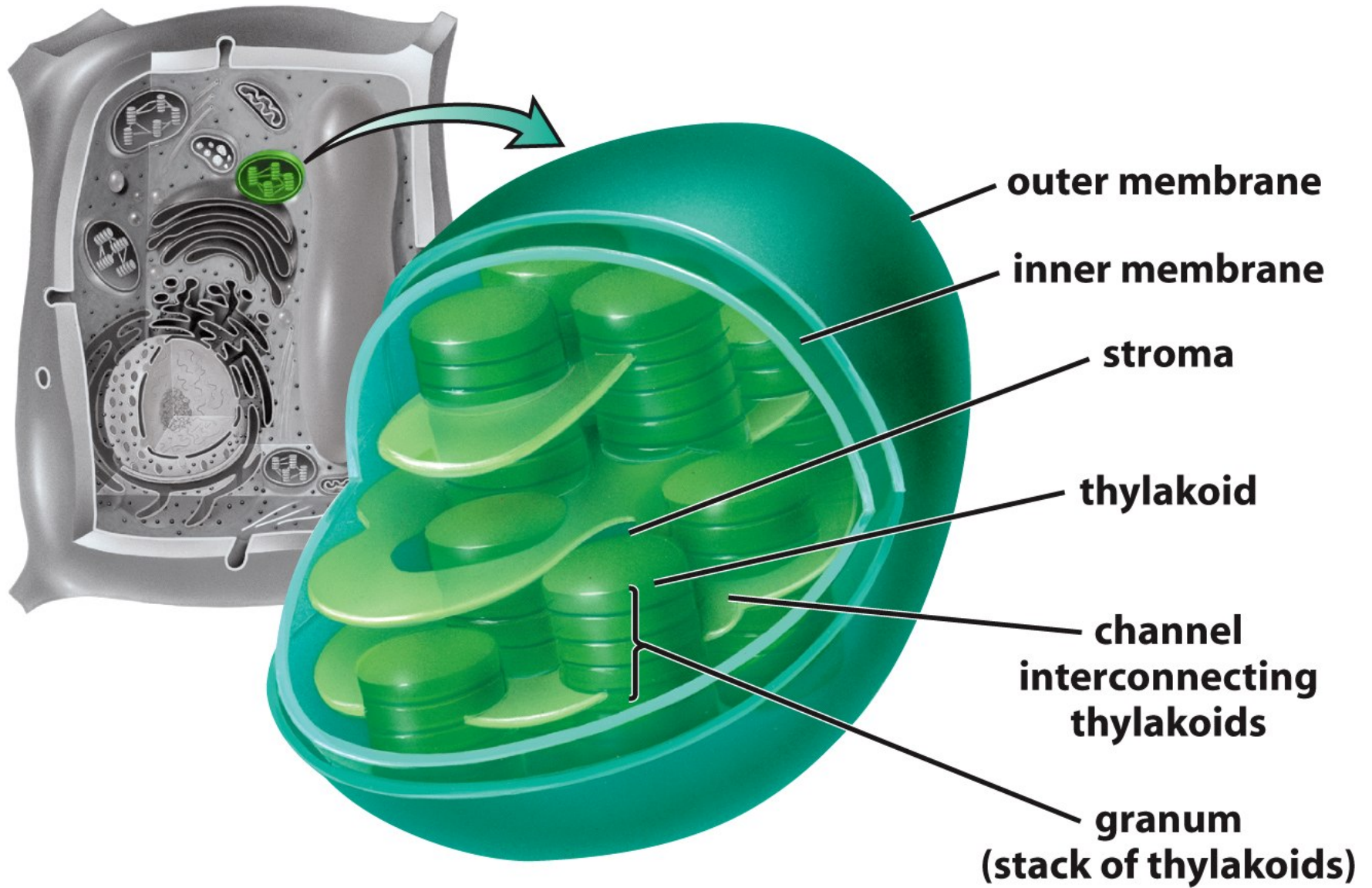


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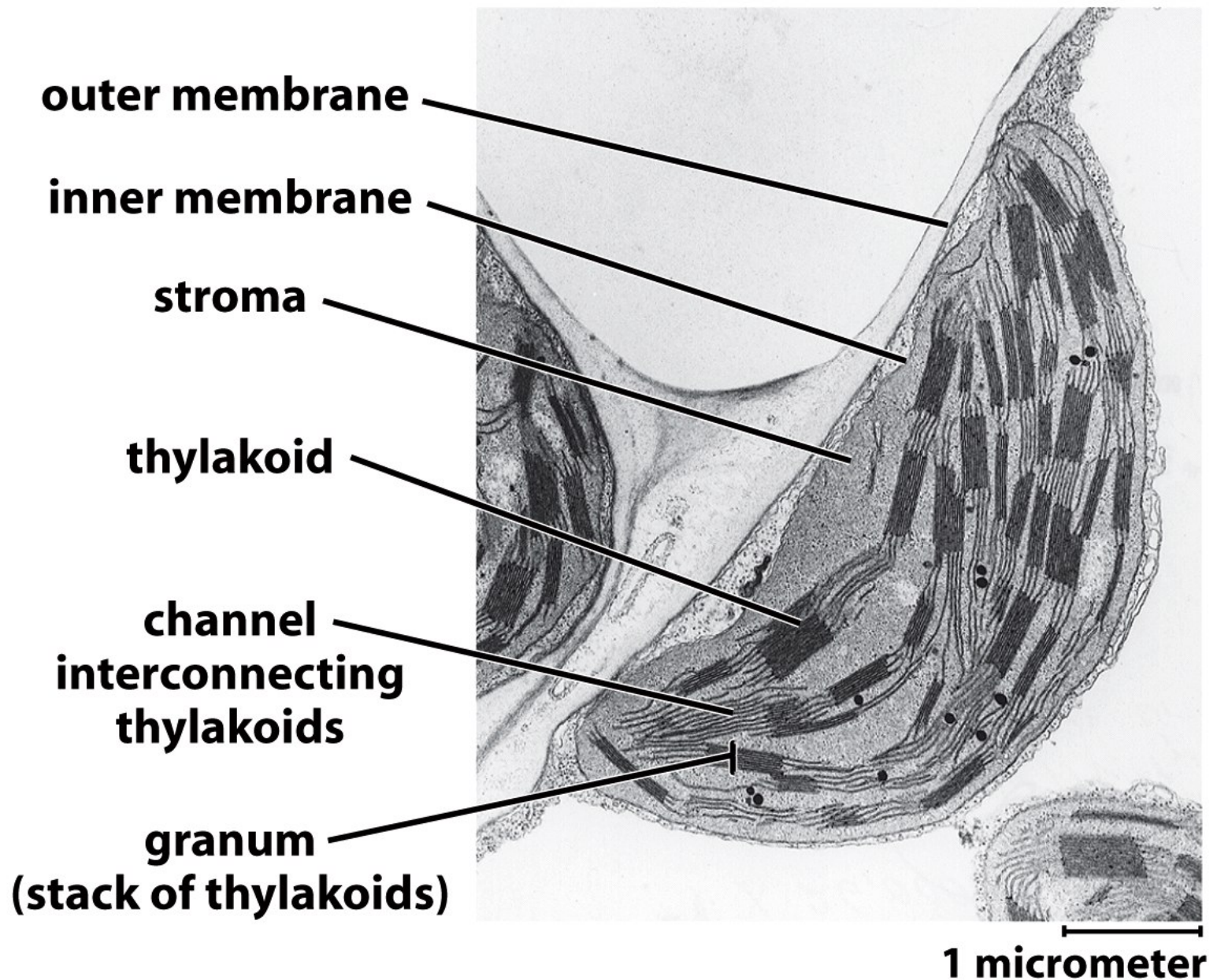


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Chloroplasts

- The thylakoid membranes contain chlorophyll and other pigments that capture sunlight and make sugar, CO_2 , and water (**photosynthesis**)

Plants Use Plastids for Storage

- Plastids found only in plants and photosynthetic protists
- Surrounded by a double membrane

Plants Use Plastids for Storage

- Functions
 - Storage for photosynthetic products like starch
 - Storage of pigment molecules giving color to ripe fruit

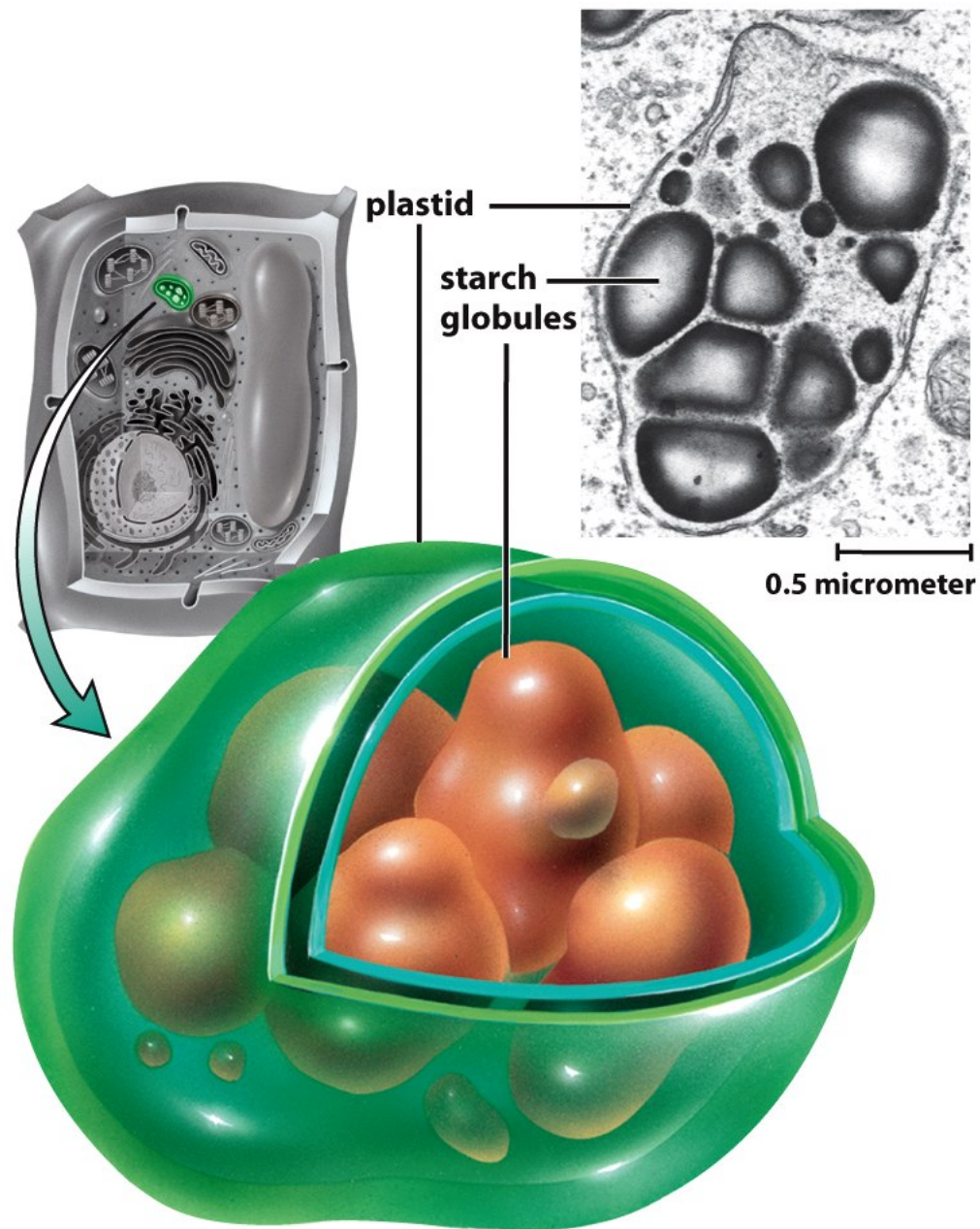


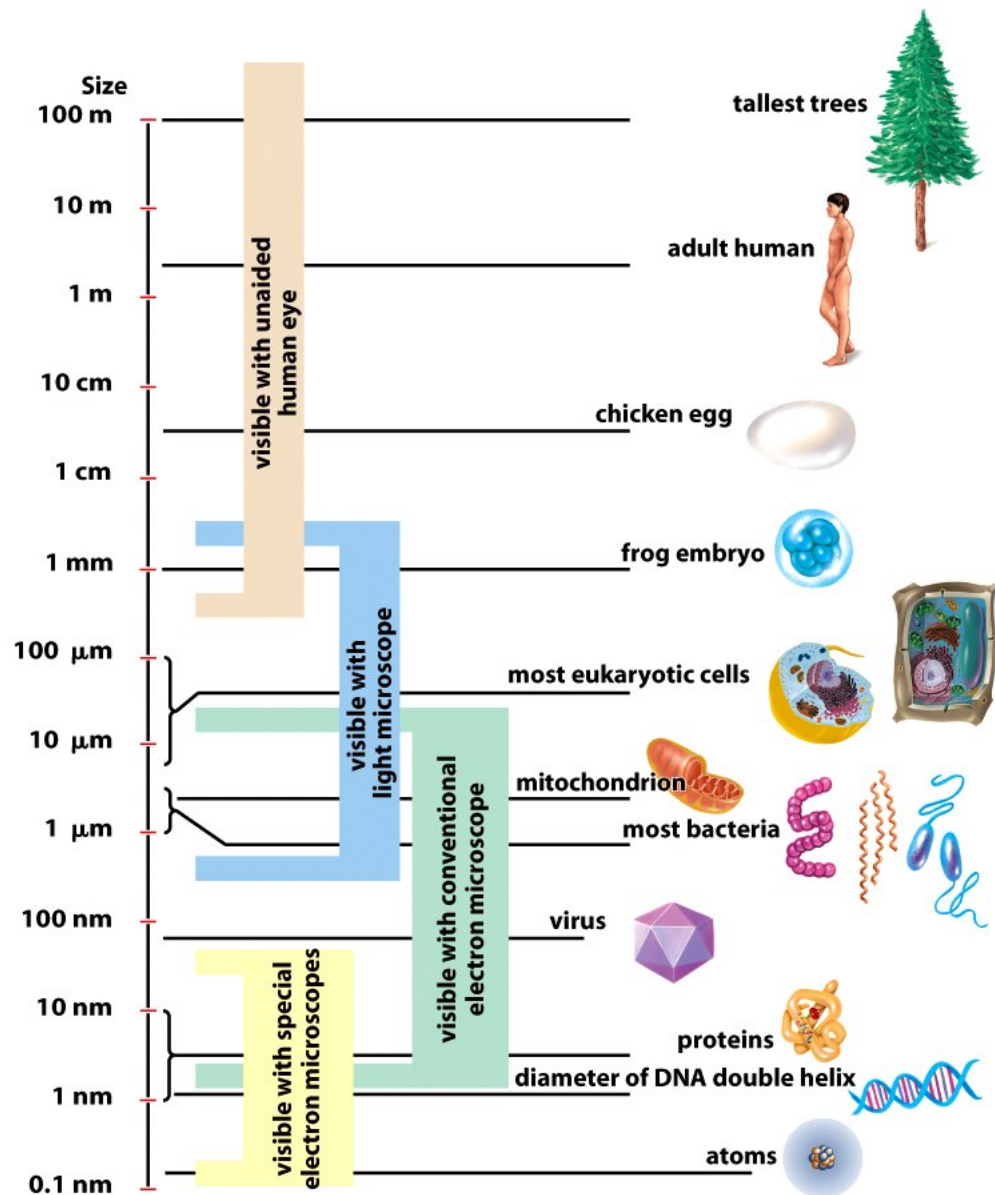
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Section 4.4 Outline

- **4.4 What Are the Major Features of Prokaryotic Cells?**
 - Prokaryotic Cells Are Small and Possess Specialized Surface Features
 - Prokaryotic Cell Have Fewer Specialized Structures Within Their Cytoplasm

Prokaryotic Cells

- Most prokaryotic cells (bacteria) are < 5 μm long



Units of measurement:

1 centimeter (cm) = 1/100 m

1 micrometer (μm) = 1/1,000,000 m

1 meter (m) = 39.37 inches

1 millimeter (mm) = 1/1000 m

1 nanometer (nm) = 1/1,000,000,000 m

Figure 4-1 Biology: Life on Earth, 8/e

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Prokaryotic Cells

- A stiff **cell wall** is usually present

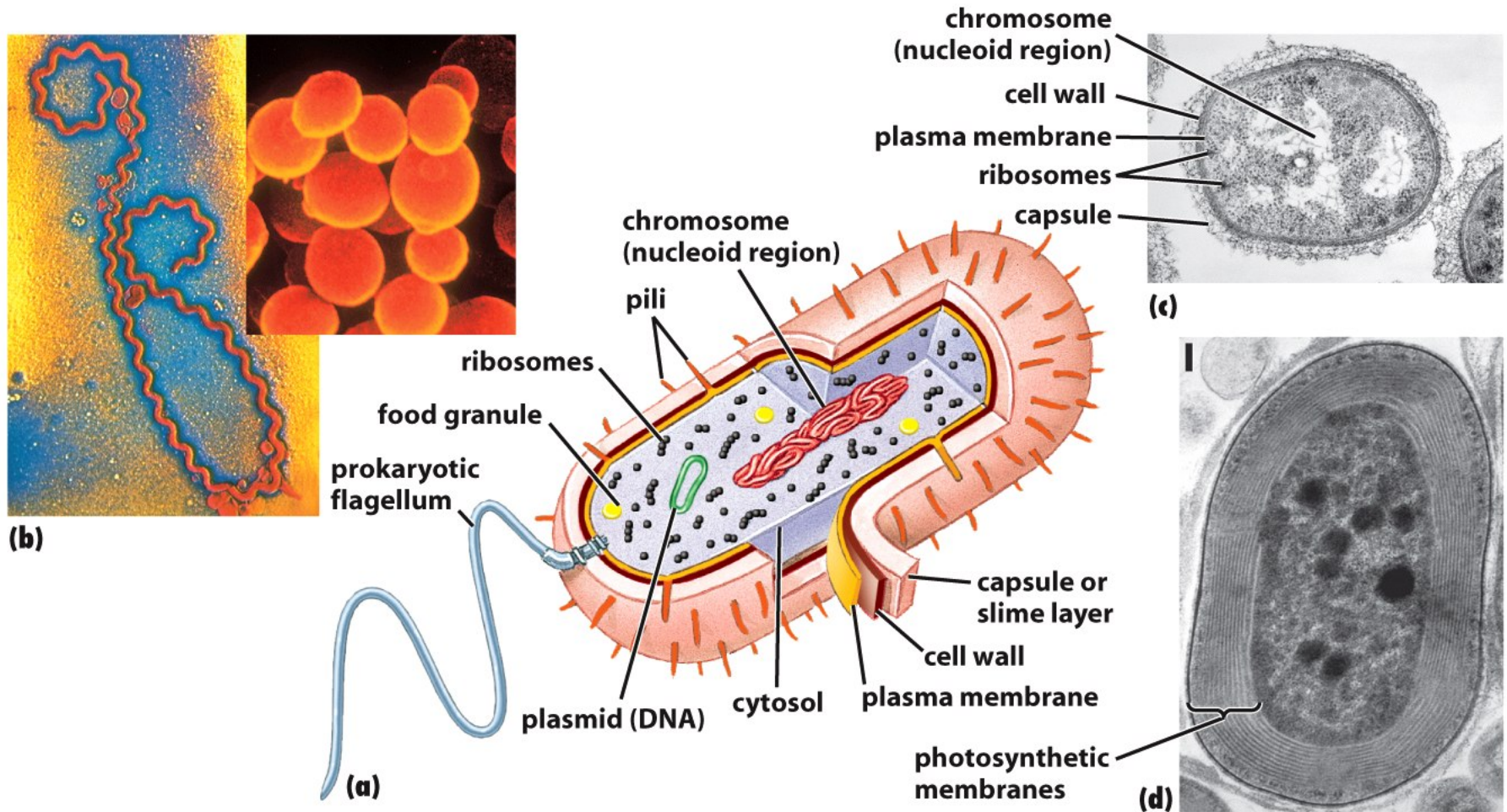


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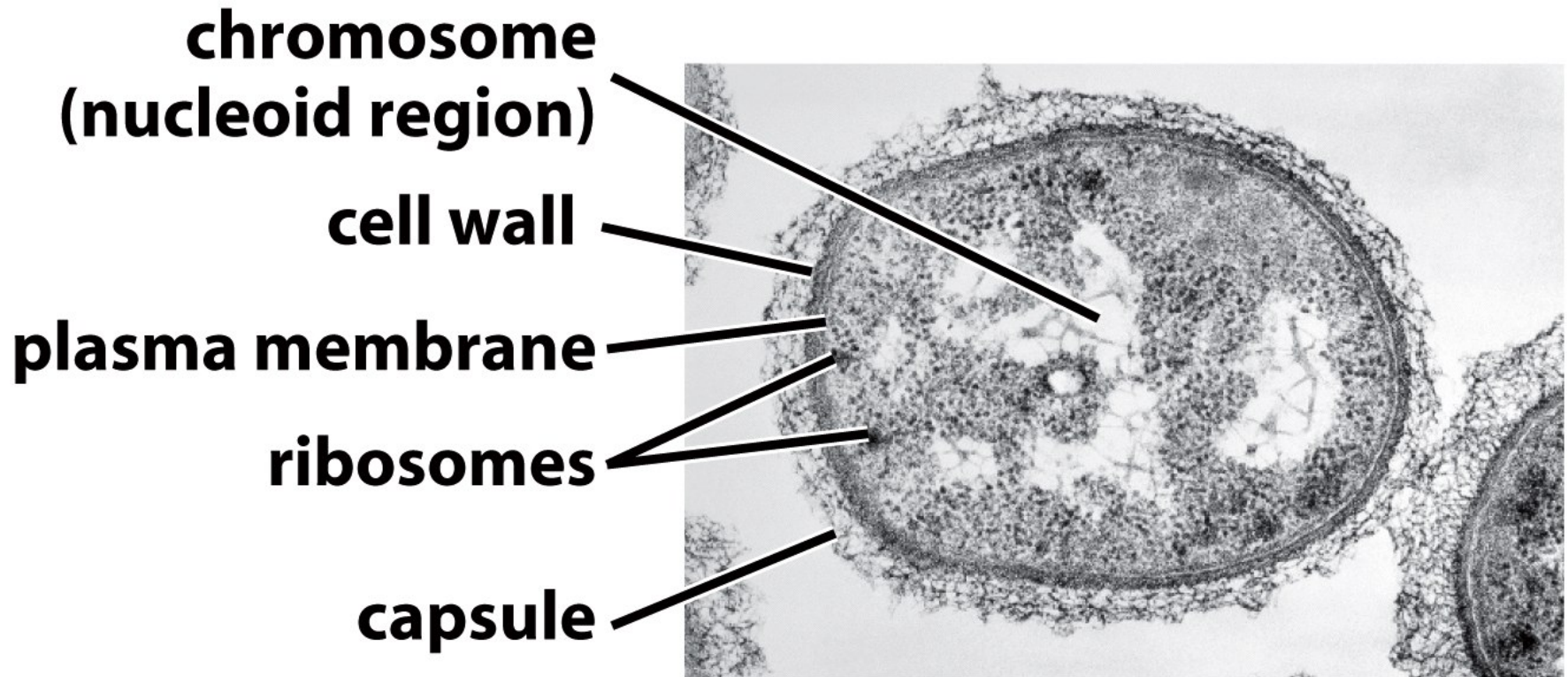


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Prokaryotic Cells

- Some bacteria are propelled by **flagella**
- Infectious bacteria may have polysaccharide adhesive **capsules** and **slime layers** on their surfaces
- **Pili** and **fimbriae** are protein projections in some bacteria that further enhance adhesion

Prokaryotic Cells

- Can take the shape of rods, spheres, or helices

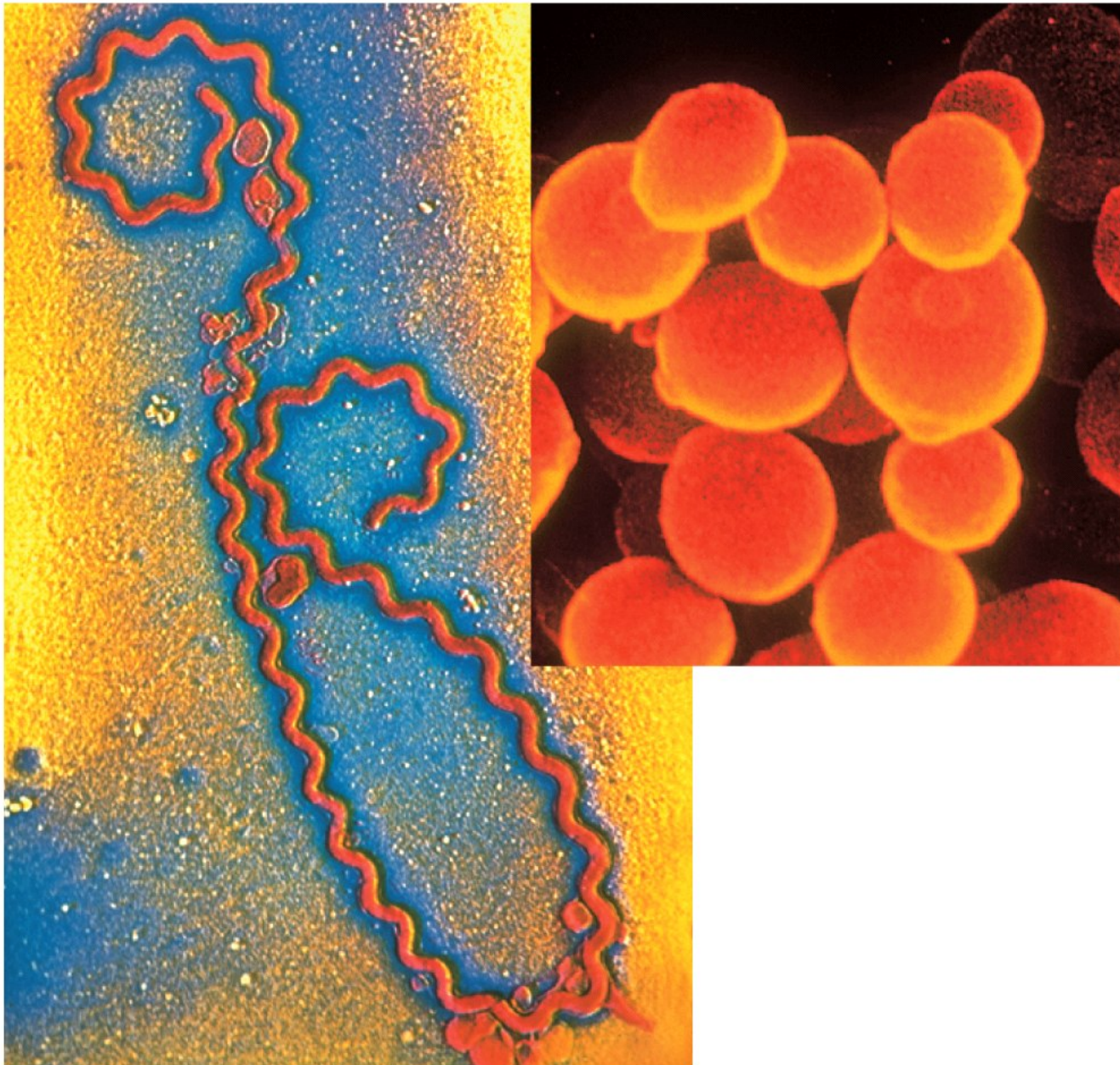


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Prokaryotic Cells

- Single, circular chromosome of DNA
 - Chromosome found coiled in an area called the **nucleoid**
- Small rings of DNA (**plasmids**) located in the cytoplasm

Prokaryotic Cells

- No nuclear membrane or membrane-bound organelles present
- Some have internal membranes used to capture light
- Cytoplasm may contain **food granules**

**photosynthetic
membranes**

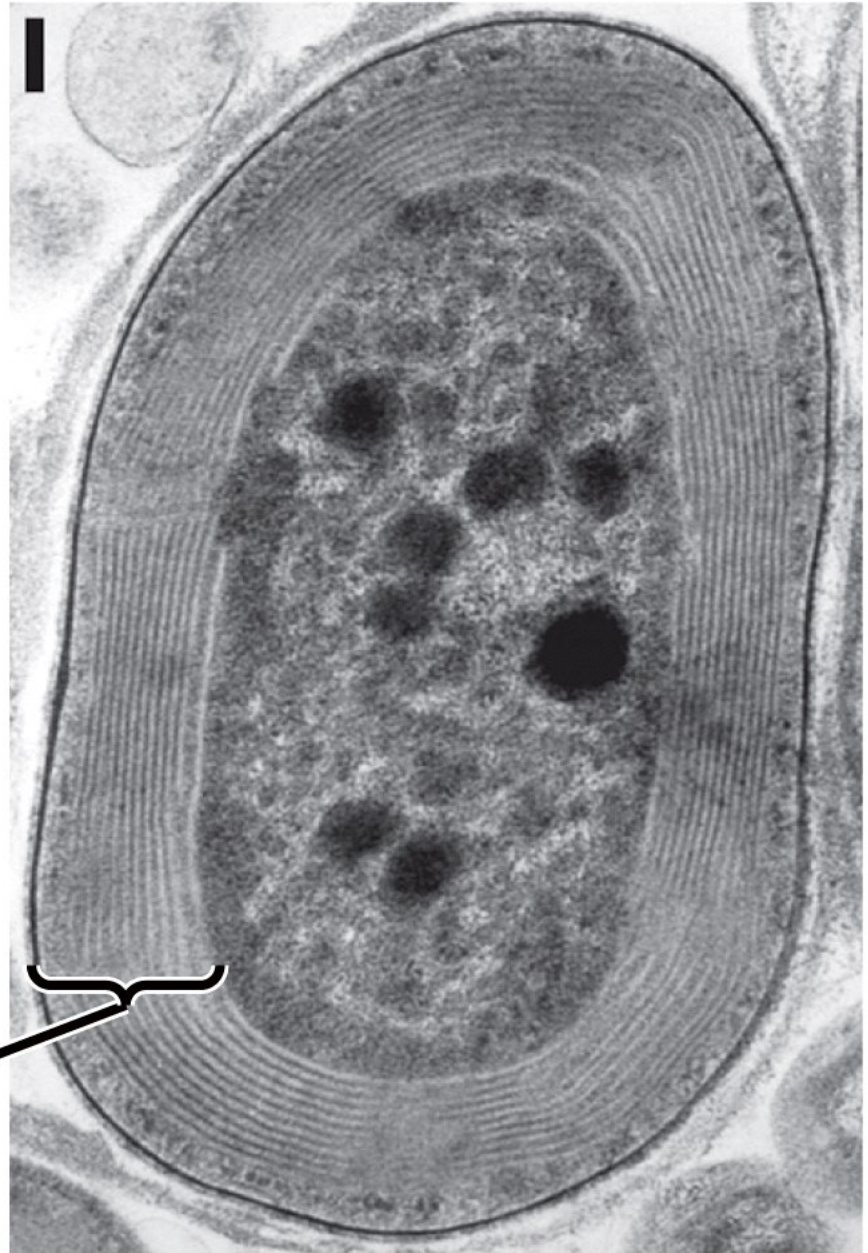


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