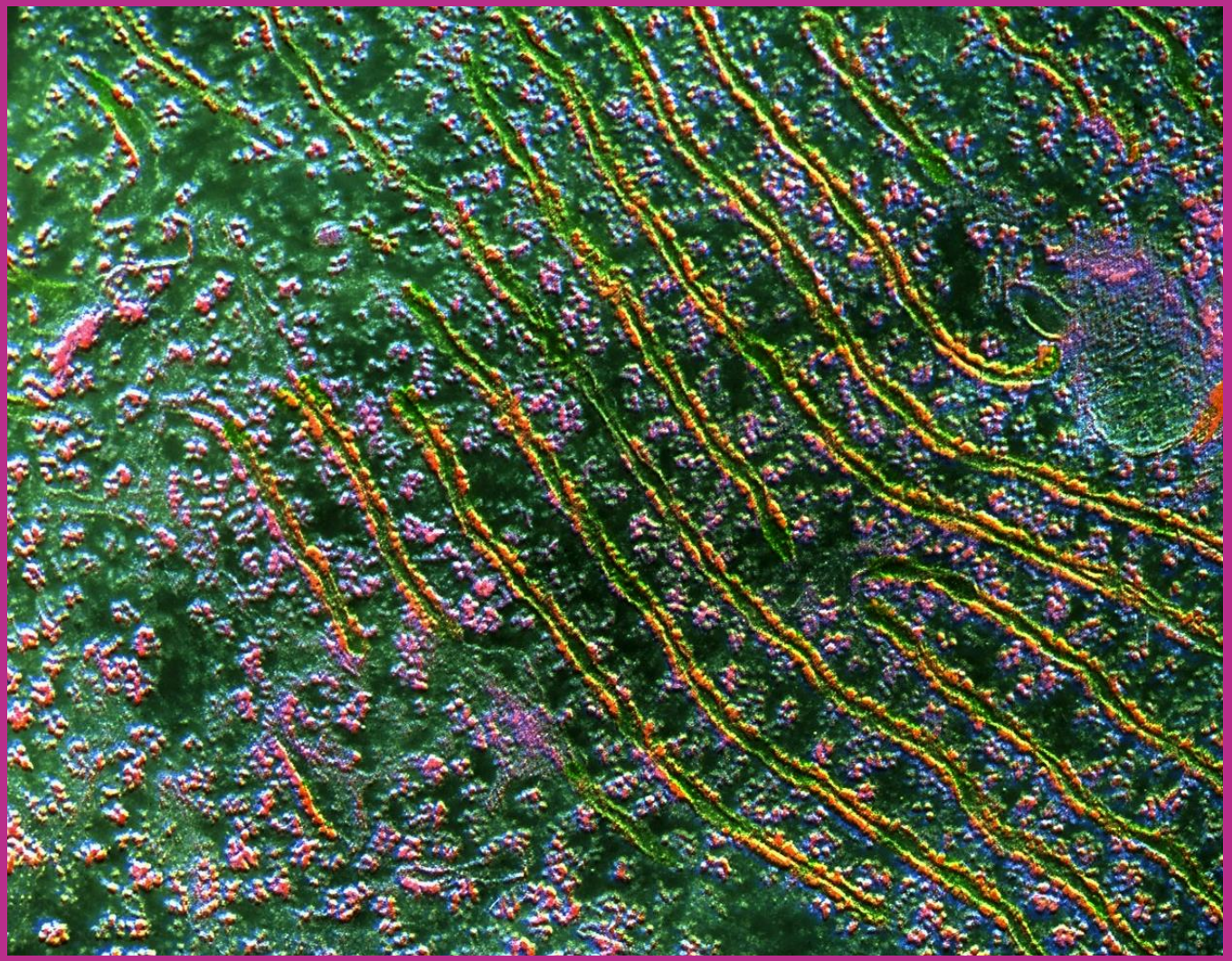
Chapter 3: Cells



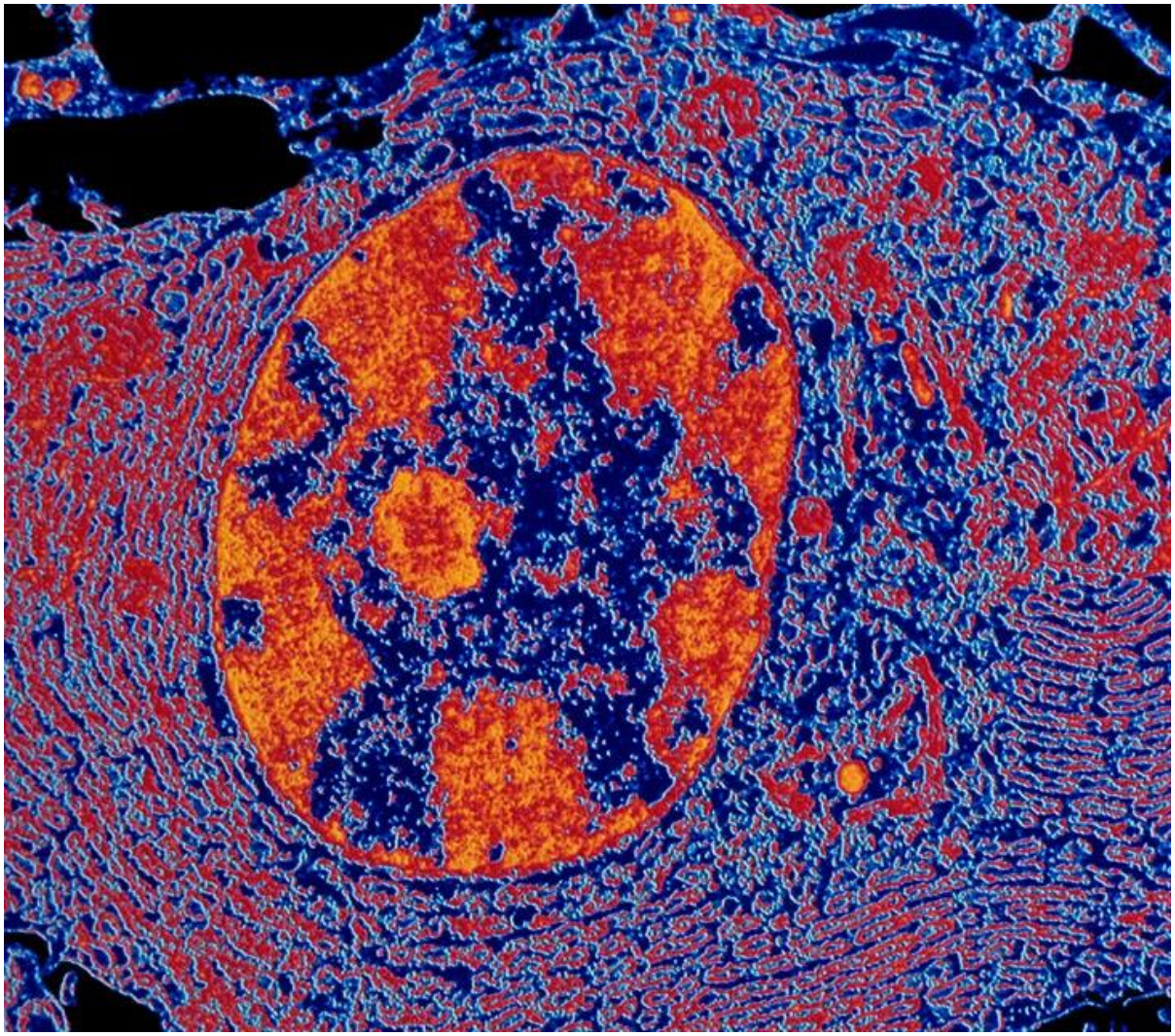
The smallest part of you

Learning Objectives

- Describe what a cell is and the two general types of cells.
- Describe the structure and functions of cell membranes.
- Describe several ways in which molecules move across membranes.
- Describe how cells are connected and how they communicate with each other.

3.1–3.3

What is a cell?



3.1 All organisms are made of cells.

The **cell:** The smallest unit of life that can function independently and perform all the necessary functions of life, including reproducing itself.

Figure 3-1a
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Figure 3-1c
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Figure 3-1b
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Cell Theory

1. All living organisms are made up of one or more cells.

2. All cells arise from other pre-existing cells.

Take-home message 3.1

- The most basic unit of any organism is the cell, the smallest unit of life that can function independently and perform all of the necessary functions of life, including reproducing itself.
- All living organisms are made up of one or more cells and all cells arise from other pre-existing cells.

3.2 Prokaryotic cells are structurally simple, but there are many types of them.

Every cell on earth falls into one of two basic categories:

1. A **eukaryotic cell**
    - has a central control structure called a nucleus, which contains the cell's DNA.
    - **eukaryotes**
2. A **prokaryotic cell**
    - does not have a nucleus; its DNA simply resides in the middle of the cell.
    - **prokaryotes**

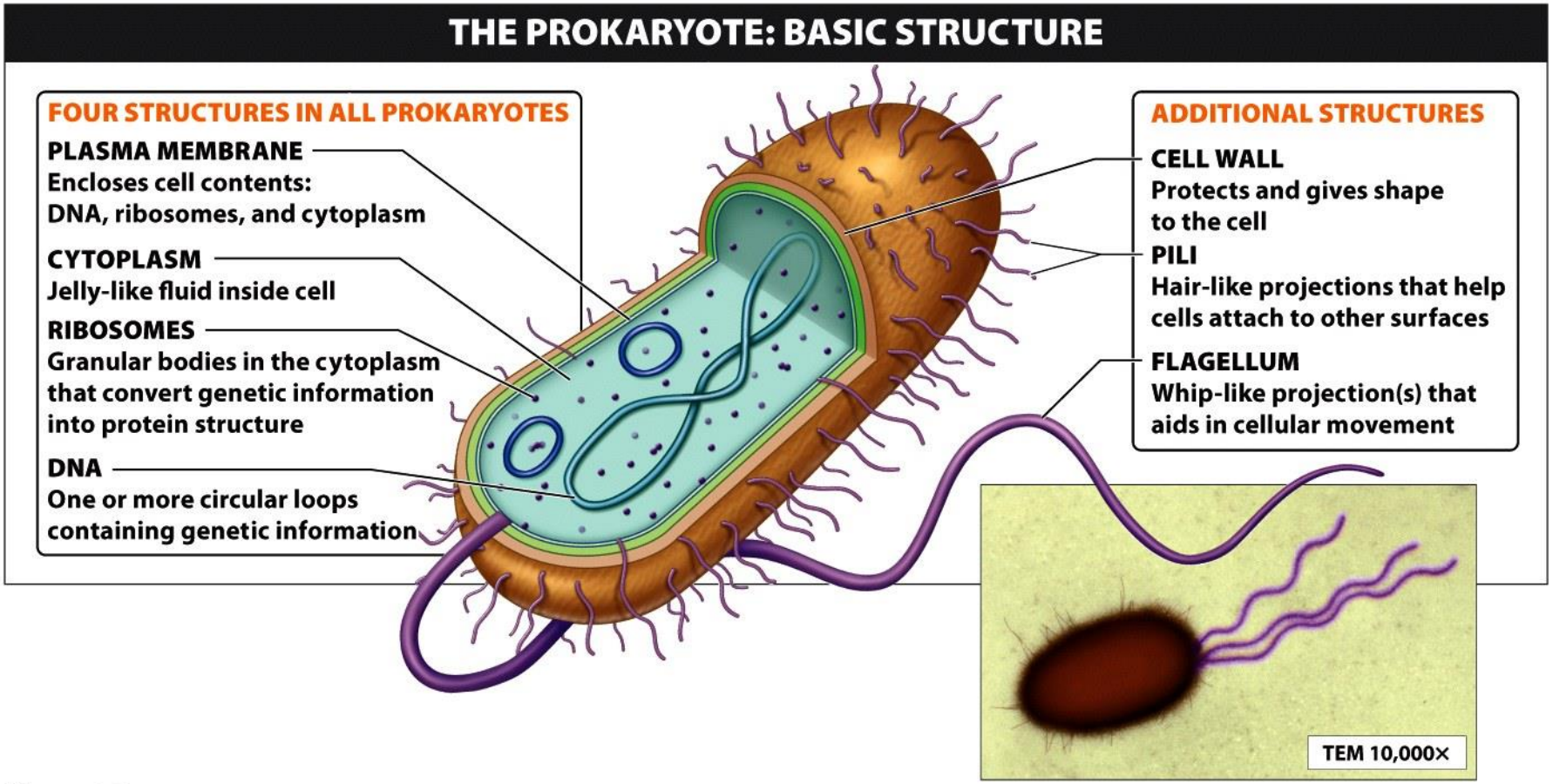

Figure 3-3
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Take-home message 3.2

- Every cell on earth is either a eukaryote or a prokaryote.
- Prokaryotes, which have no nucleus, were the first cells on earth.

Take-home message 3.2

- They are all single-celled organisms.
- Prokaryotes include the bacteria and archaea and, as a group, are characterized by tremendous metabolic diversity.

3.3 Eukaryotic cells have compartments with specialized functions.

Eukaryotic cells have organelles.

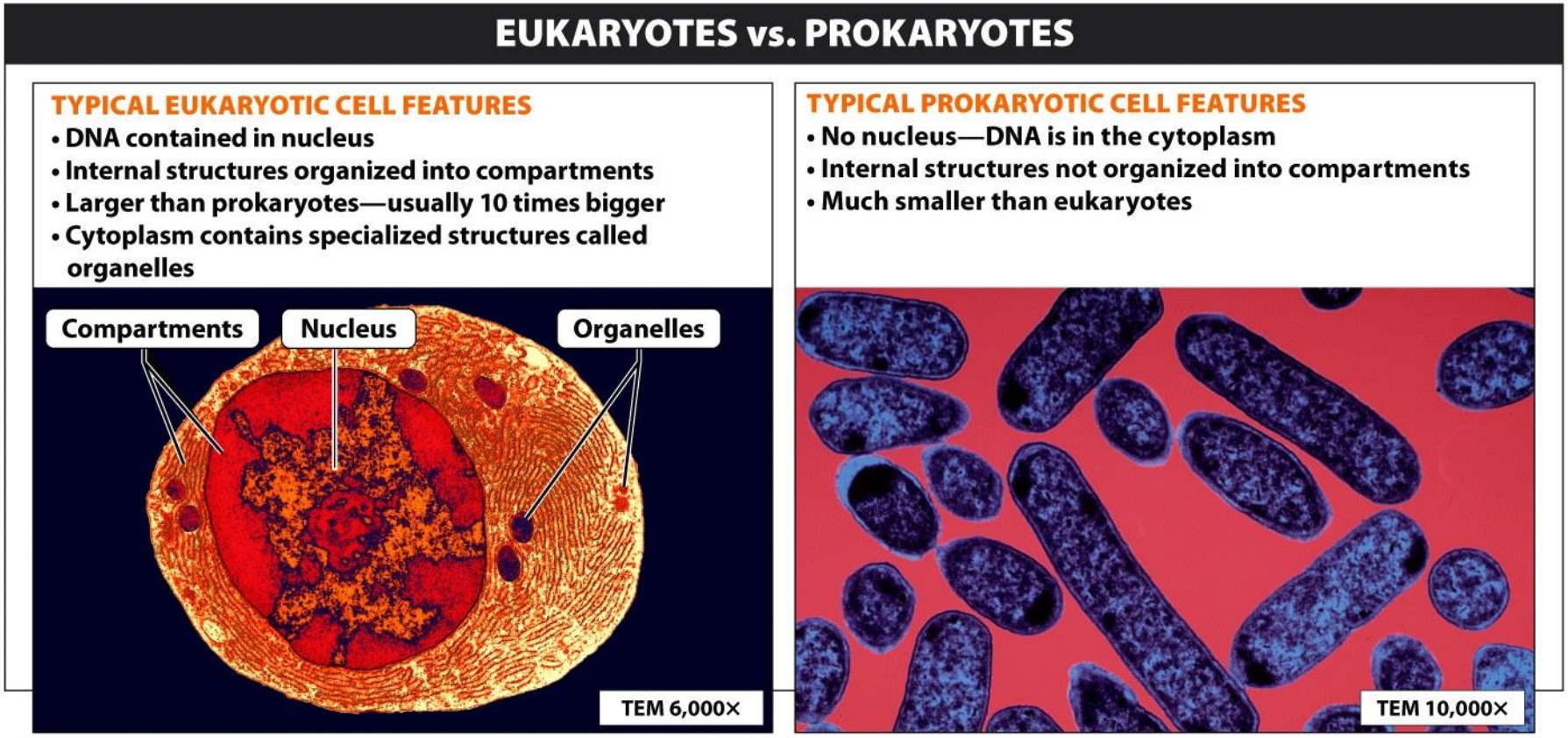

Figure 3-5
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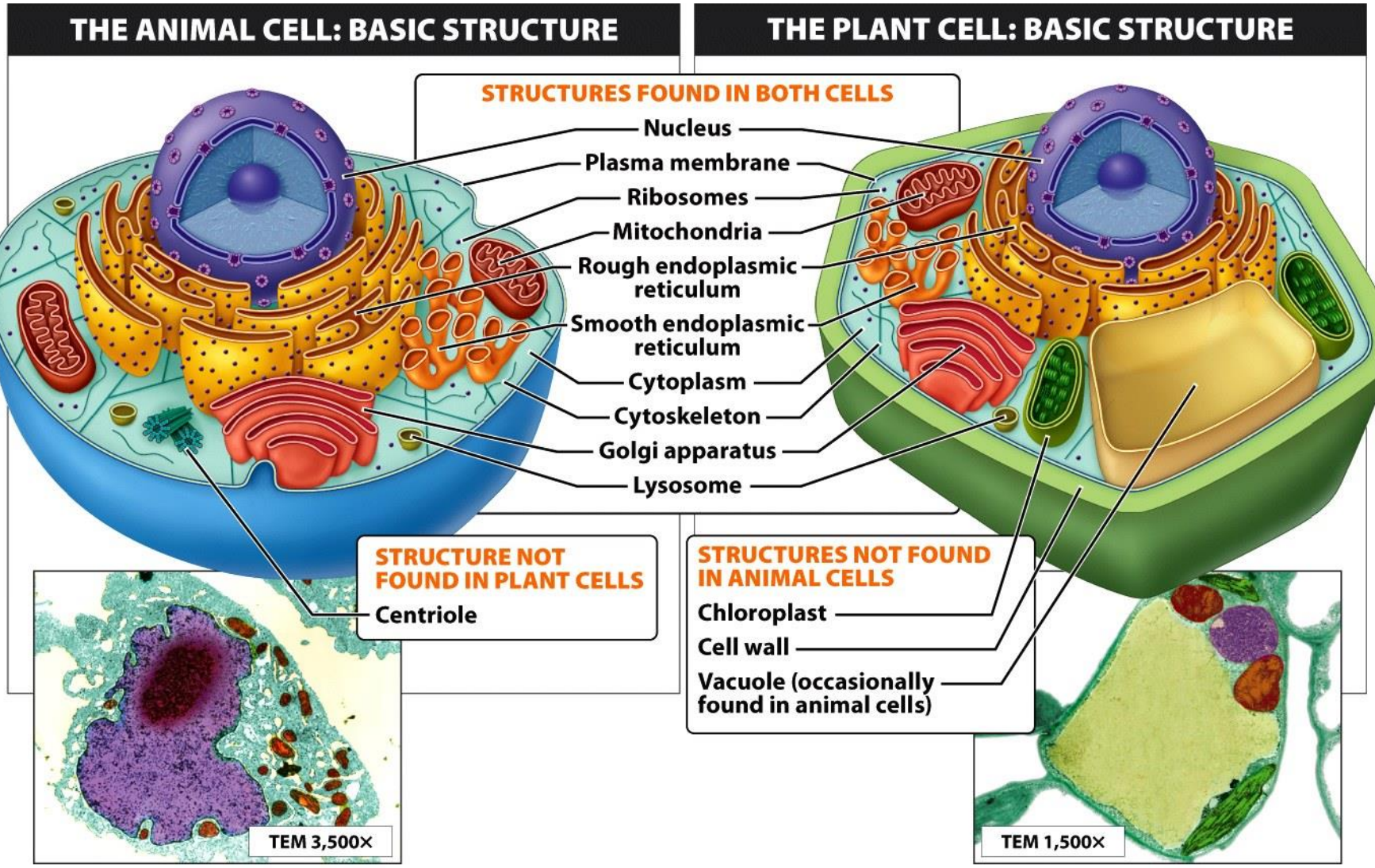

Figure 3-6

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3.4–3.7
Cell membranes

are gatekeepers.

3-4. Every cell is bordered by a plasma membrane.

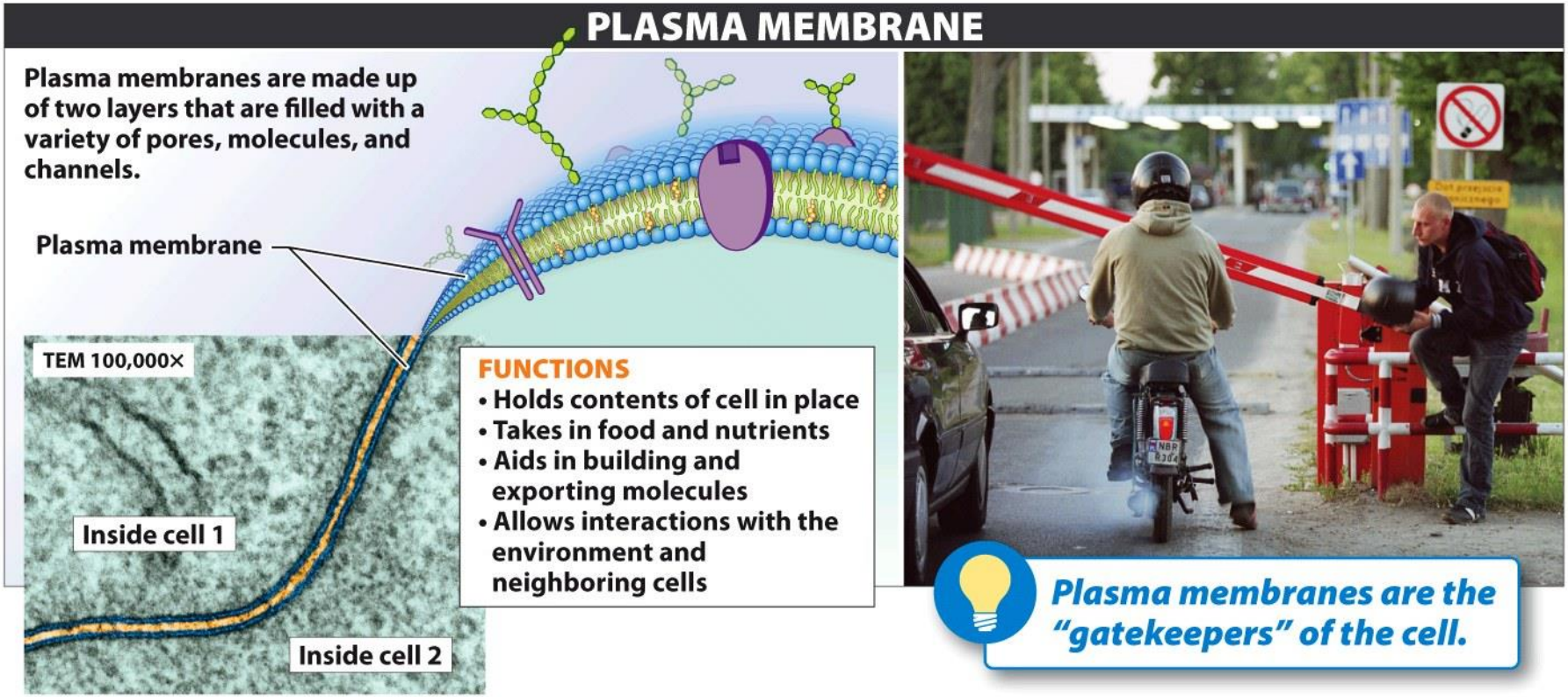

Figure 3-8
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Why are plasma membranes such complex structures?

They perform several critical functions.

- Take in food and nutrients
- Dispose of waste products
- Build and export molecules
- Regulate heat exchange
- Regulate flow of materials in and out of cell

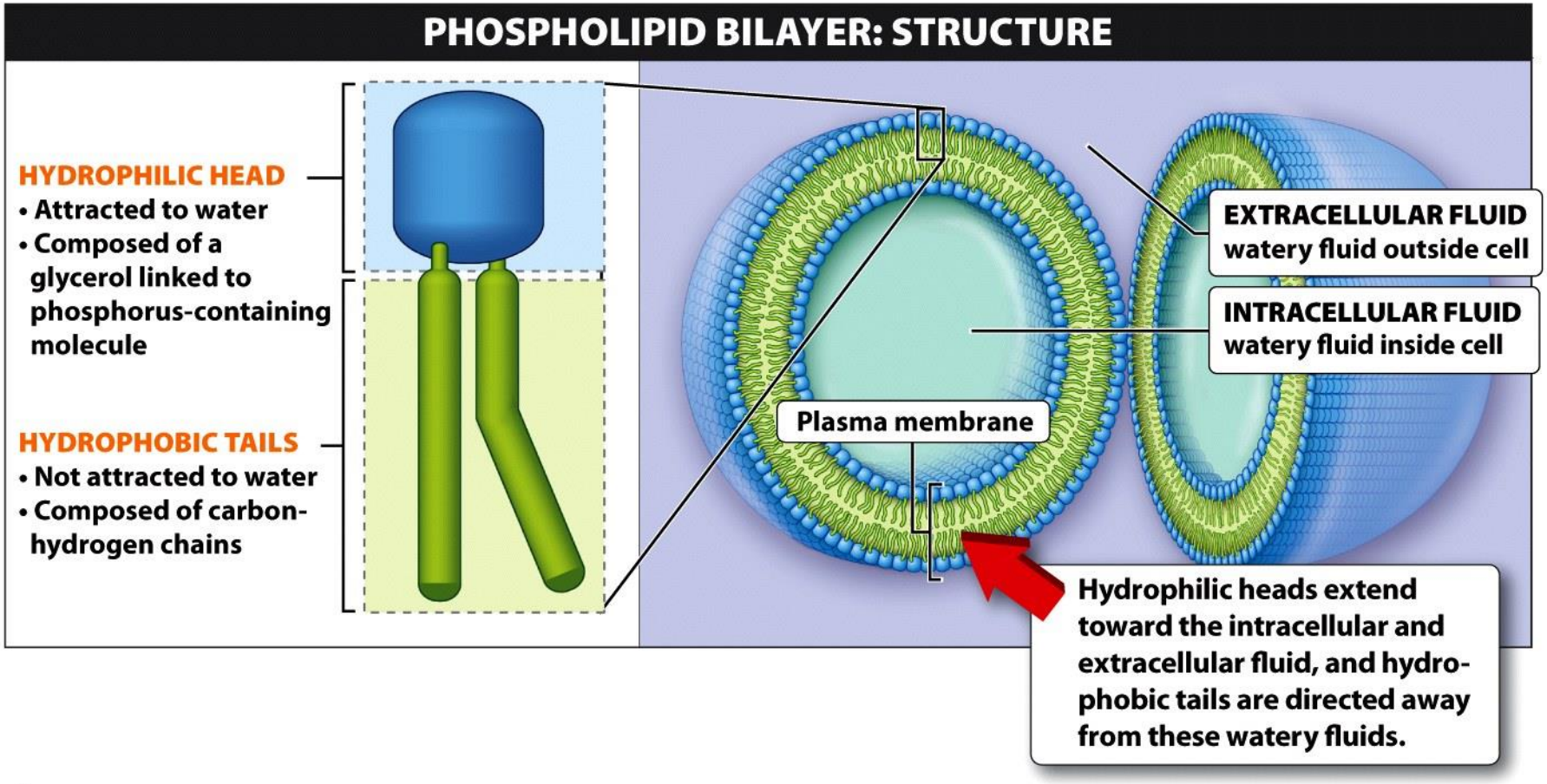

Figure 3-9
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Take-home message 3.4

- Every cell of every living organism is enclosed by a plasma membrane, a two-layered membrane that holds the contents of a cell in place and regulates what enters and leaves the cell.

3.5 Molecules embedded within the plasma membrane help it perform its functions.

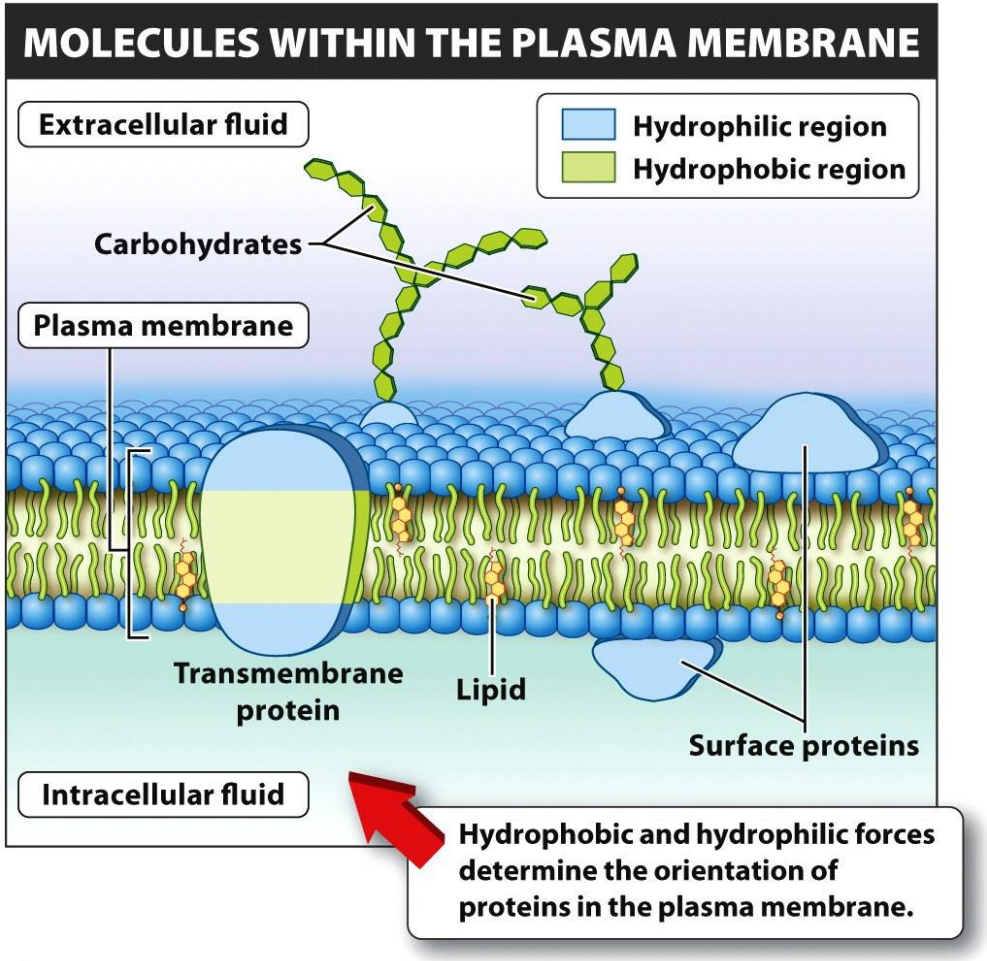

Figure 3-10
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What determines whether a protein resides on the surface or extends through the bilayer?

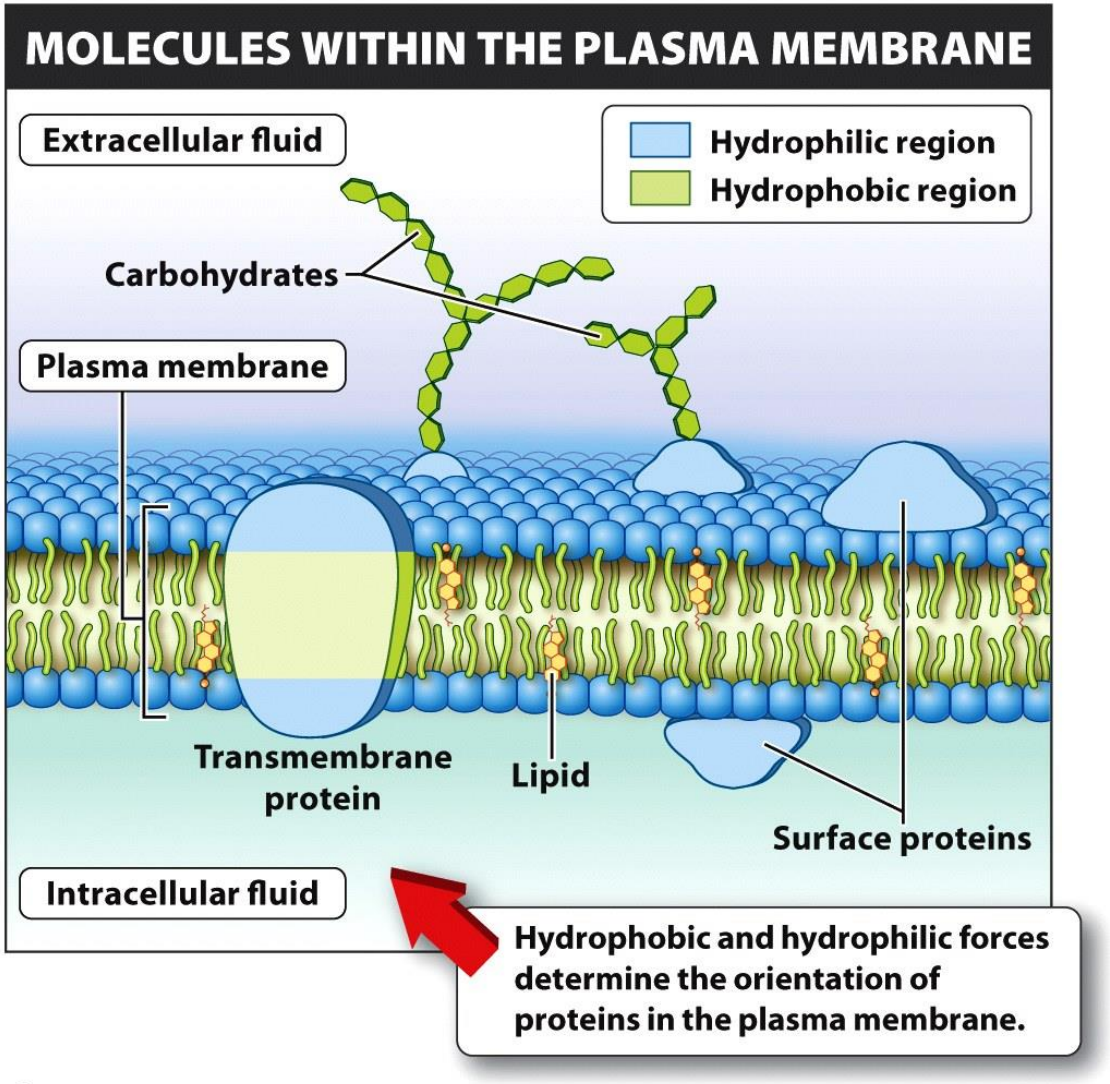

Figure 3-10
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There are four primary types of membrane proteins, each of which performs a different function.

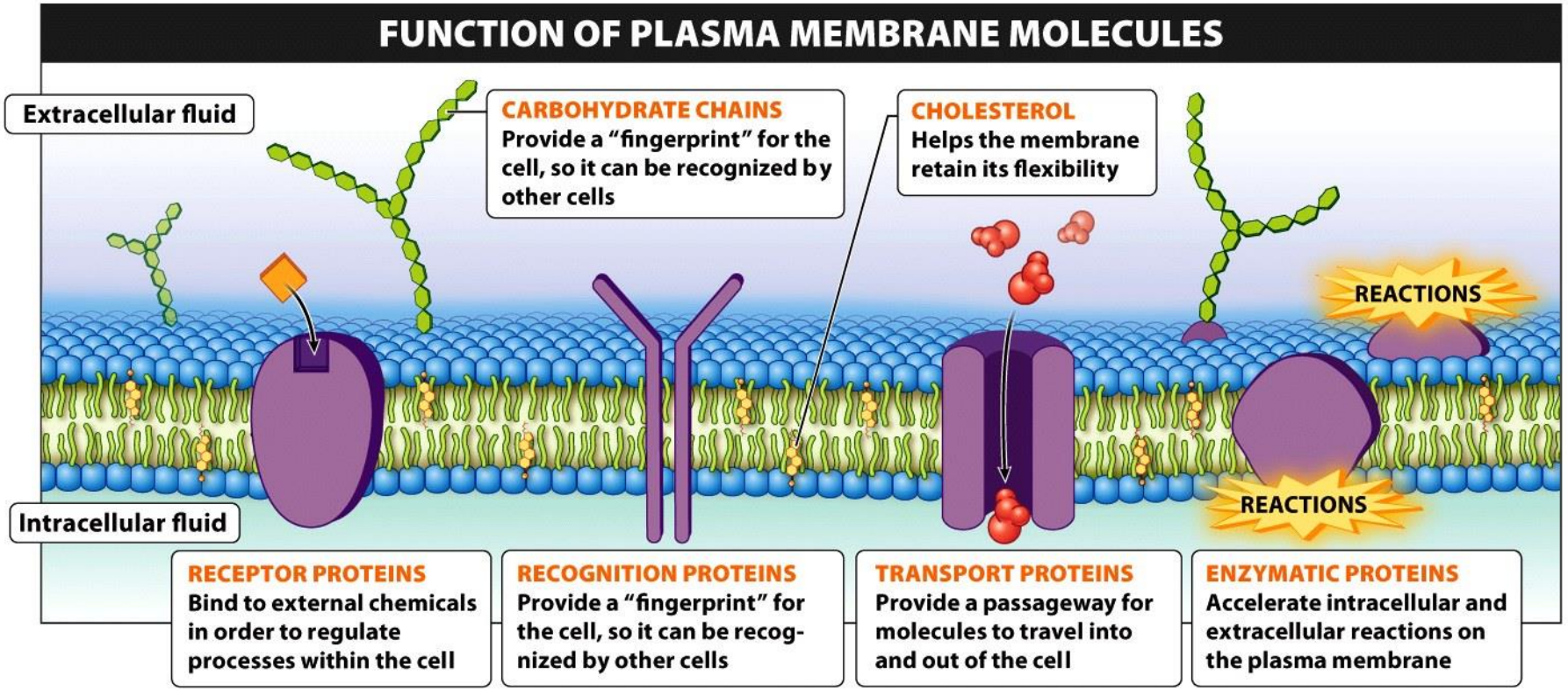

Figure 3-11
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The Plasma Membrane "Fluid Mosaic"

In addition to proteins, two other molecules are found in the plasma membrane:

1. Short, branched carbohydrate chains
2. Cholesterol

Take-home message 3.5

- The plasma membrane is a fluid mosaic of proteins, lipids, and carbohydrates.

Take-home message 3.5

- Proteins found in the plasma membrane enable it to carry out most of its gatekeeping functions.

- The proteins function as receptors, help molecules gain entry into and out of the cell, and catalyze reactions on the inner and outer cell surfaces.

Take-home message 3.5

- Carbohydrates and plasma proteins identify the cell to other cells.

- Phospholipids make up the majority of plasma membranes, while cholesterol influences membrane fluidity.

3.7 Membrane surfaces have a "fingerprint" that identifies the cell.

- Cells with an improper fingerprint are recognized as foreign and are attacked by your body's defenses.

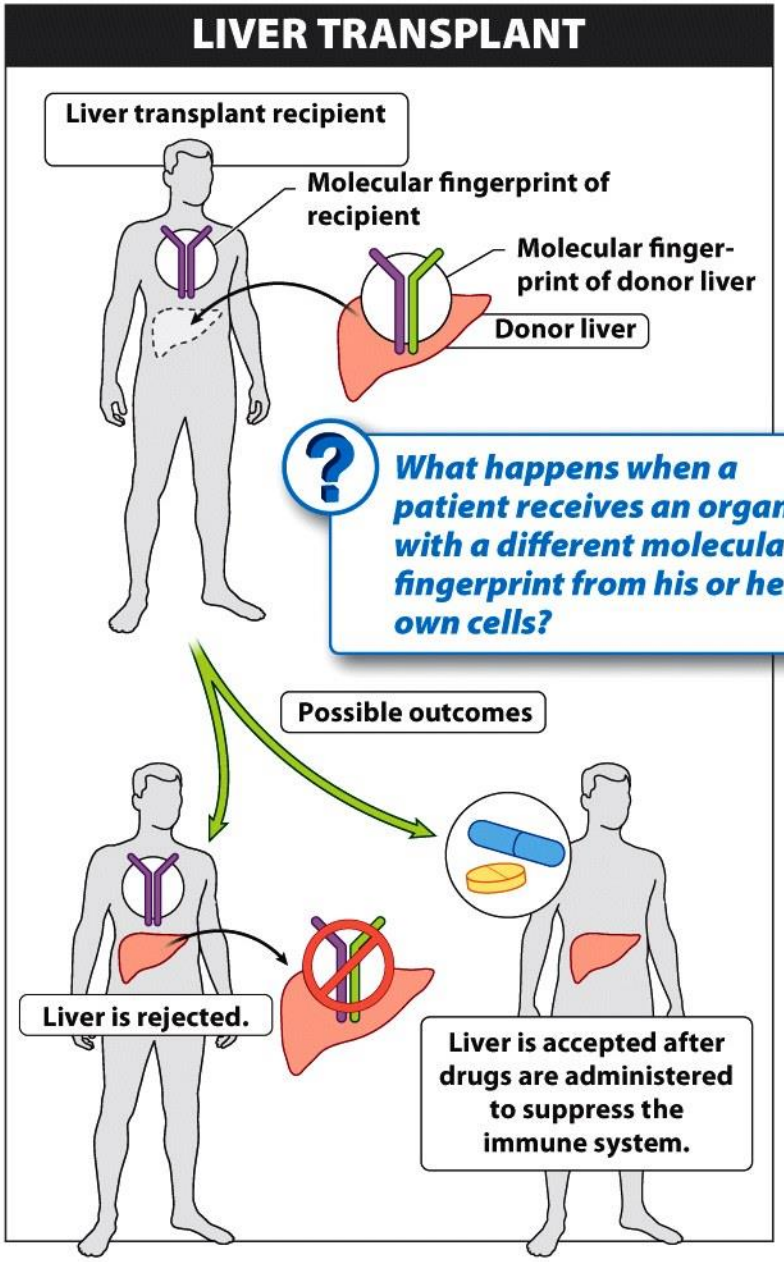

Figure 3-14

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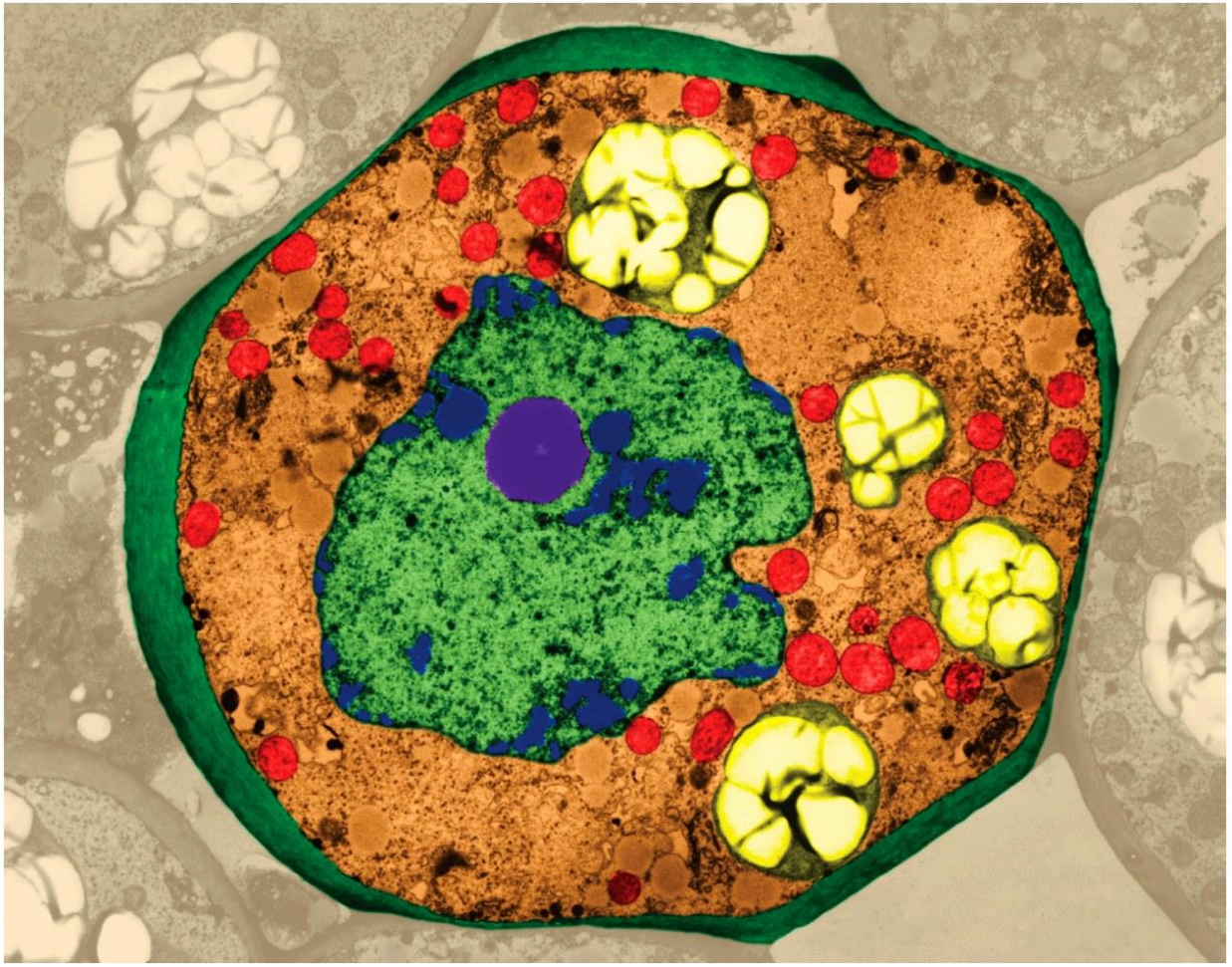
Take-home message 3.7

- Every cell in your body has a “fingerprint” made from a variety of molecules on the outside-facing surface of the cell membrane.
- This molecular fingerprint is key to the function of your immune system.

3.13–3.21
Nine important landmarks distinguish

eukaryotic cells.



3.13 The nucleus is the cell's genetic control center.

- The nucleus—the largest and most prominent organelle in most eukaryotic cells.

- The nucleus has two primary functions:
  - genetic control center
  - storehouse for hereditary information

Figure 3-26
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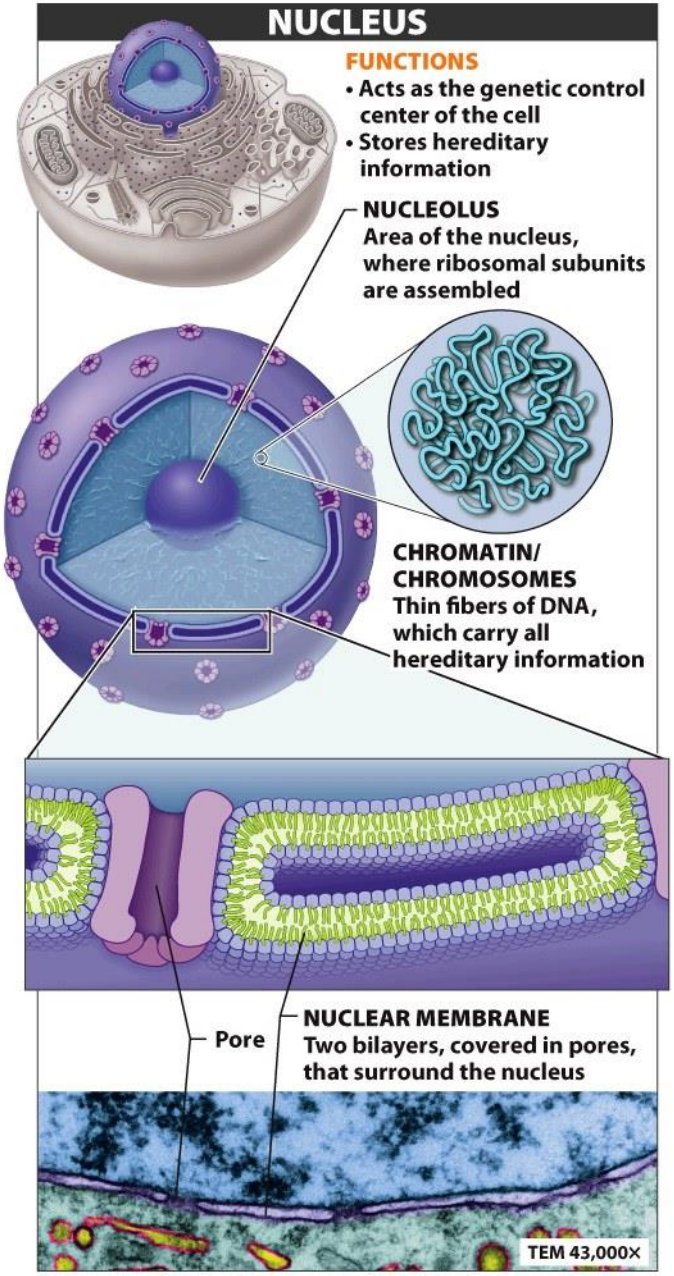

Figure 3-27

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Chromatin

- a mass of long, thin fibers consisting of DNA with some proteins attached

Nucleolus

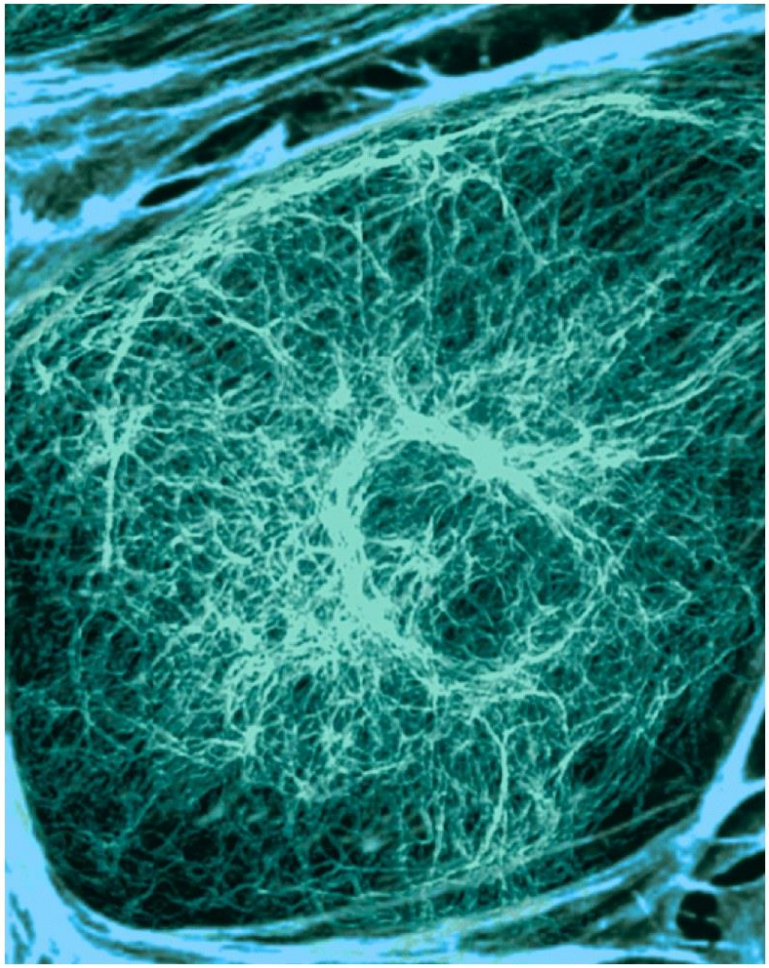
- an area near the center of the nucleus where subunits of the **ribosomes** are assembled

- Ribosomes are like little factories.

Take-home message 3.13

- The nucleus is usually the largest and most prominent organelle in the eukaryotic cell.
- It directs most cellular activities by controlling which molecules are produced and in what quantity they are produced.
- The nucleus is also the storehouse for all hereditary information.

3.14 Cytoplasm and cytoskeleton: the cell's internal environment, physical support, and movement

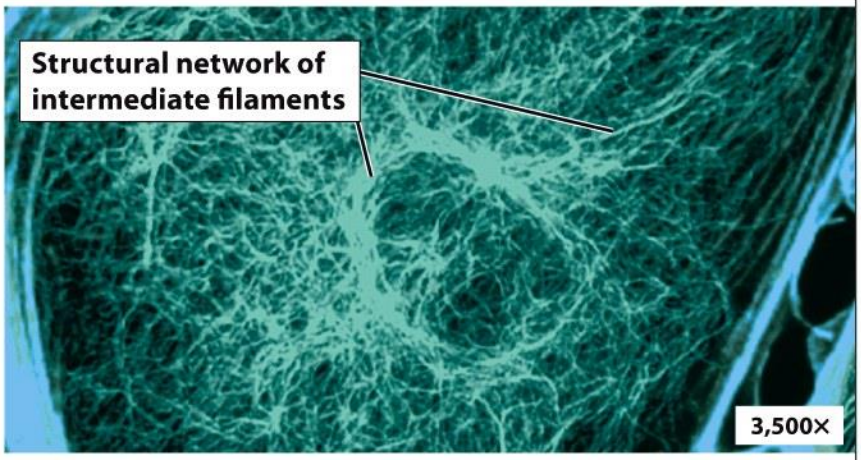


Cytoskeleton: Three Chief Purposes

CYTOSKELETON

FUNCTIONS

- Acts as the inner scaffolding of the cell
- Provides shape and support
- Controls intracellular traffic flow
- Enables movement



Cilia and Flagellum

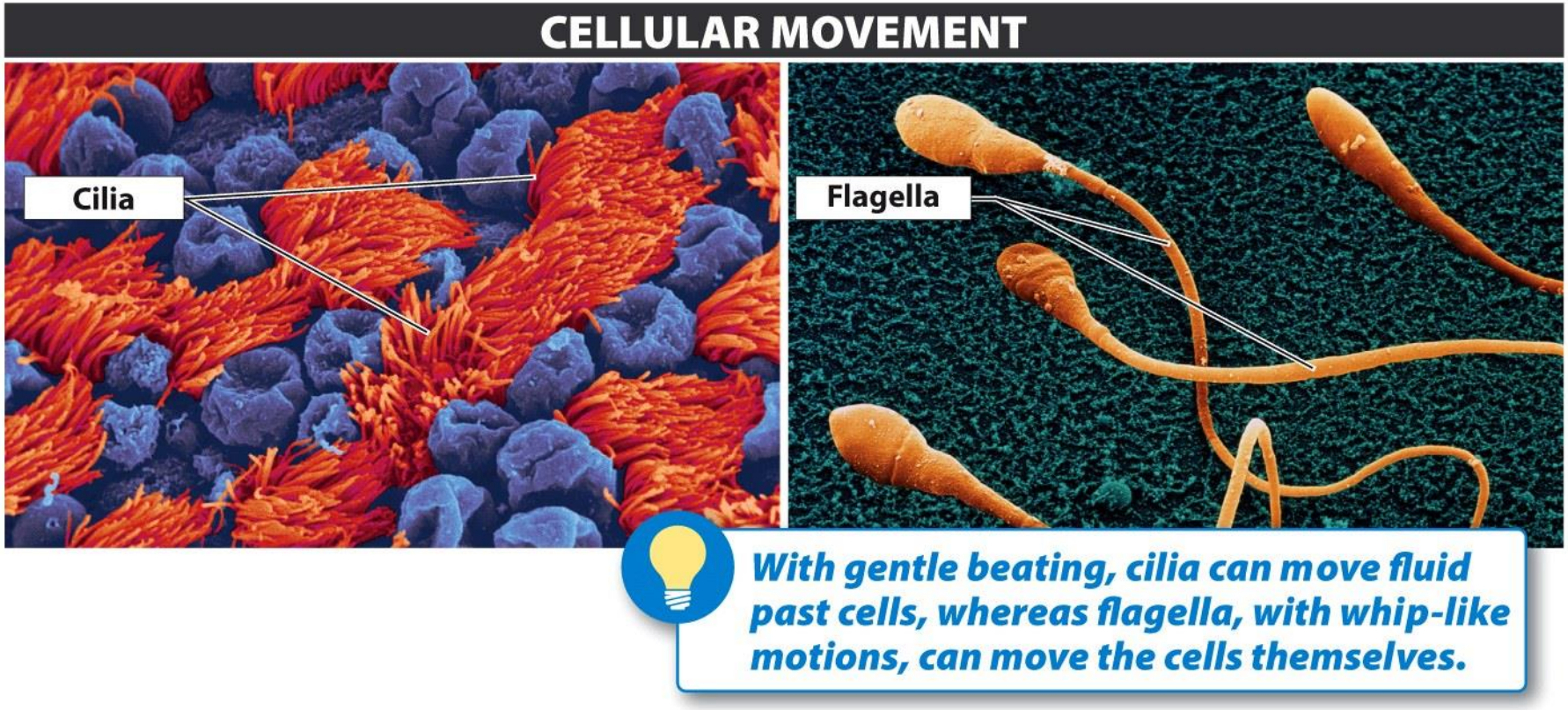


Figure 3-29
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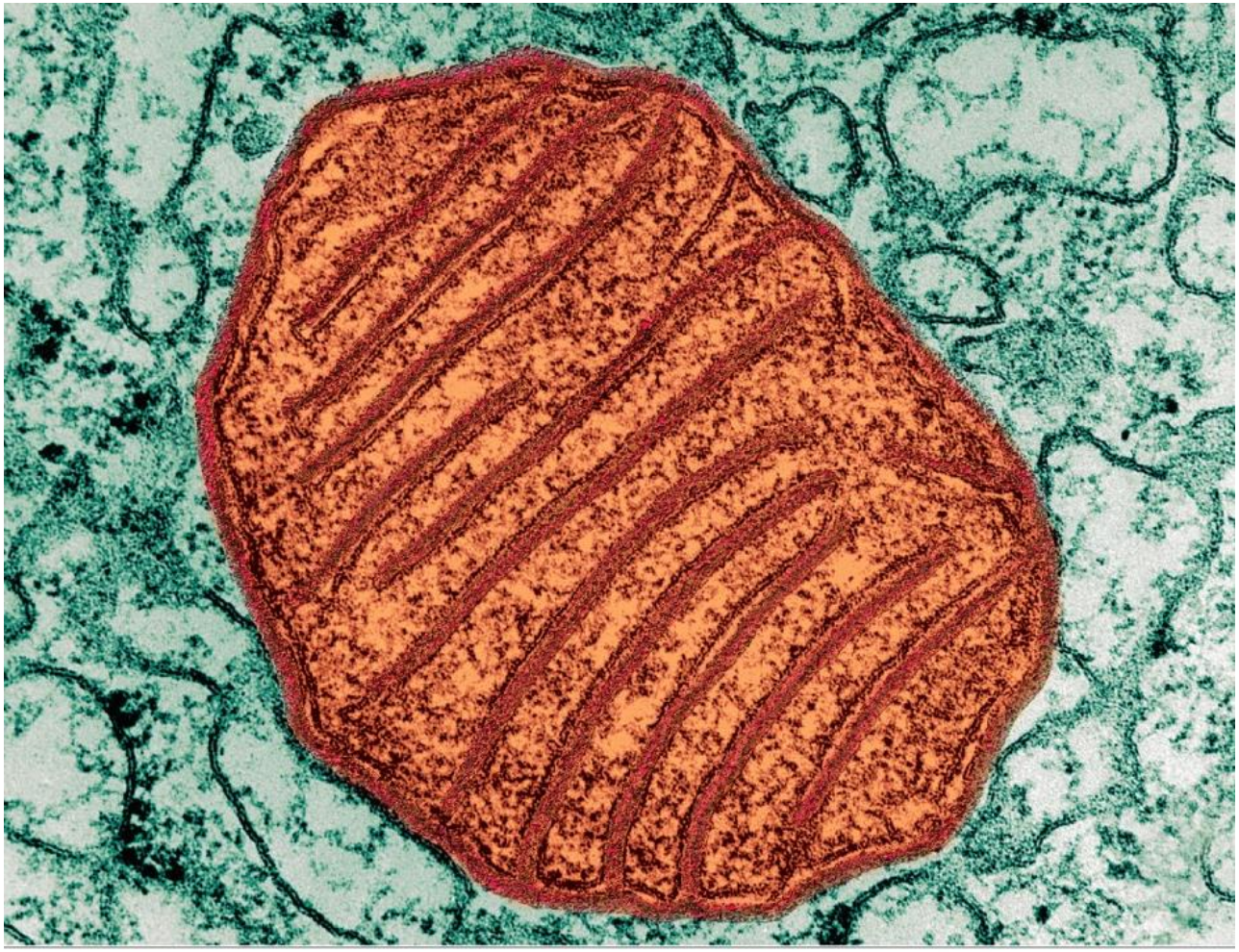
Take-home message 3.14

- The inner scaffolding of the cell, which is made from proteins, is the cytoskeleton.

Take-home message 3.14

- It gives animal cells shape and support.
- It gives cells some ability to control their movement.
- It serves as a series of tracks on which organelles and molecules are guided across and around the inside of the cell.

3.15 Mitochondria: the cell's energy converters



Bag-within-a-Bag Structure:
the intermembrane space and the matrix

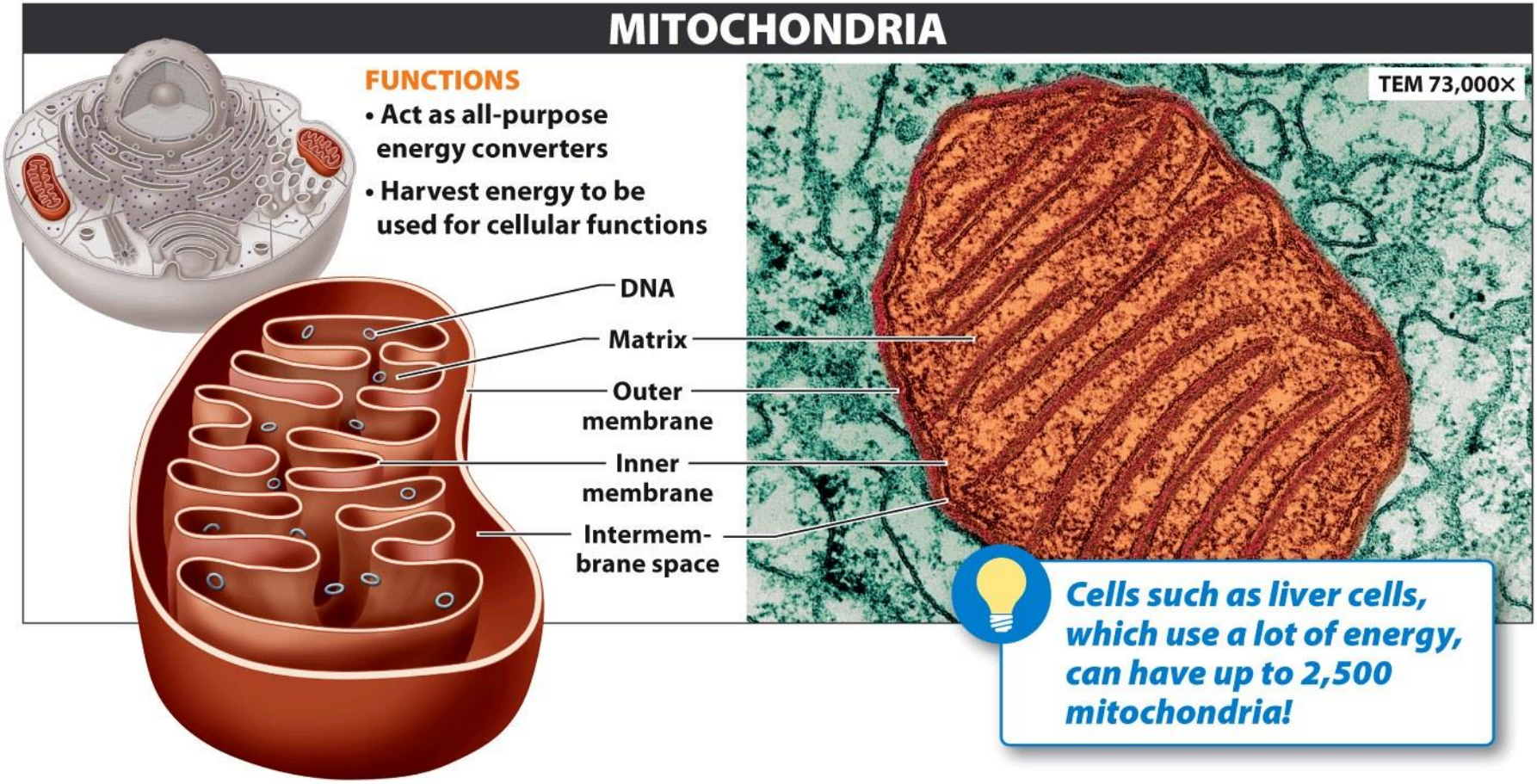


Figure 3-30
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We all have more DNA from one parent than the other.

Who is the bigger contributor: mom or dad?

Why?

Which statement about mitochondria is false?

1. Mitochondria are surrounded by two membranes.
2. Mitochondria make energy of the cell (ATP).
3. You inherited half of your mitochondria from your mother.
4. The characteristics of mitochondria can be explained by endosymbiosis.

Which cell type contains the most mitochondria per cell?

1. Liver
2. Muscle
3. White blood cell
4. Dermal cell
5. White adipose cell
6. Red blood cell

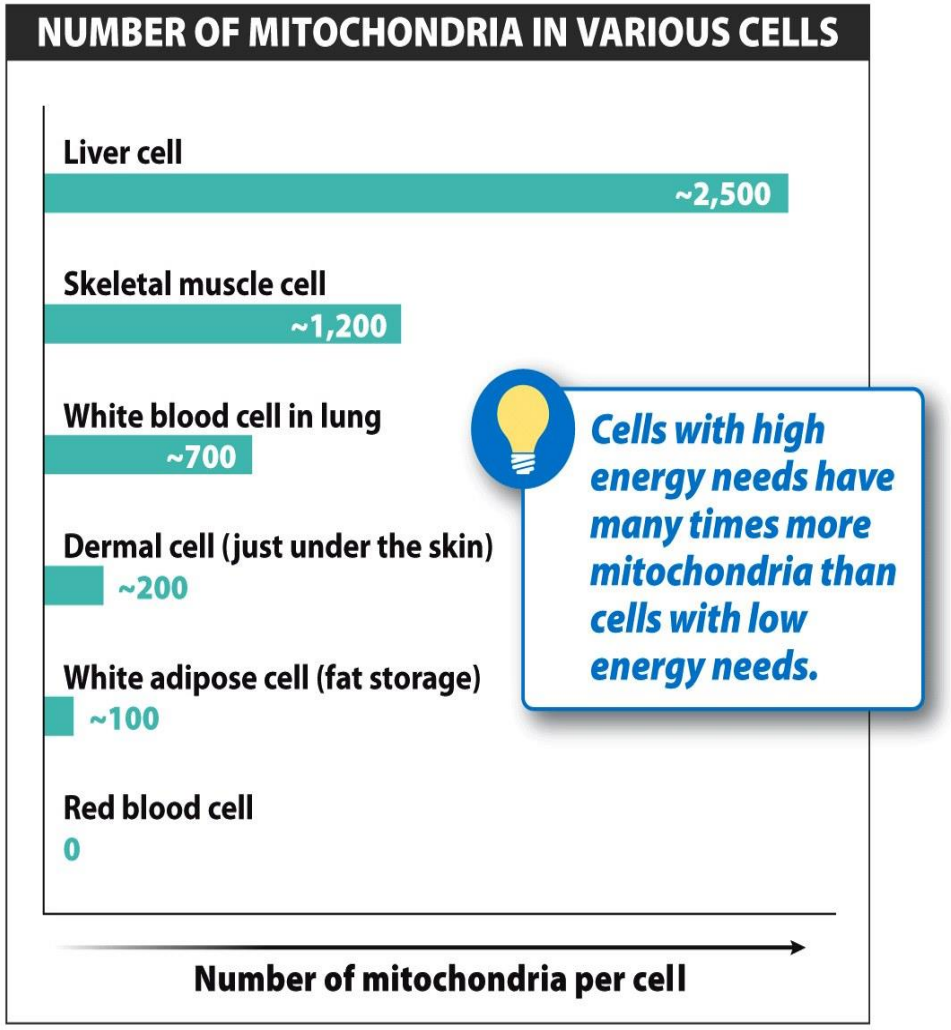

Figure 3-31
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Which cell type in the graph might require the most energy?

1. Liver
2. Muscle
3. White blood cell
4. Dermal cell
5. White adipose cell
6. Red blood cell

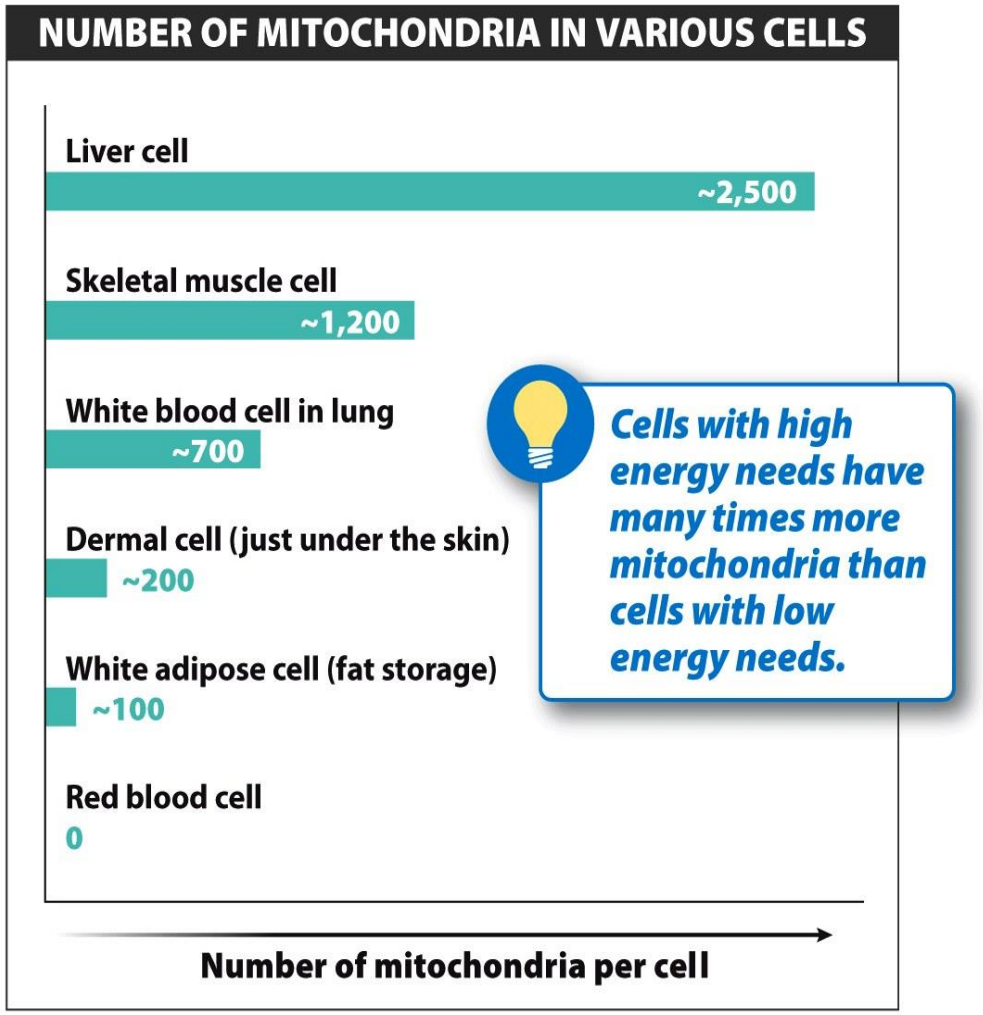

Figure 3-31
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Take-home message 3.15

- In mitochondria, the energy contained within the chemical bonds of carbohydrate, fat, and protein molecules is converted into carbon dioxide, water, and ATP—the energy source for all cellular functions and activities.

- Mitochondria may have their evolutionary origins as symbiotic bacteria living within other cells.

3.16 Lysosomes are the cell's garbage disposals.

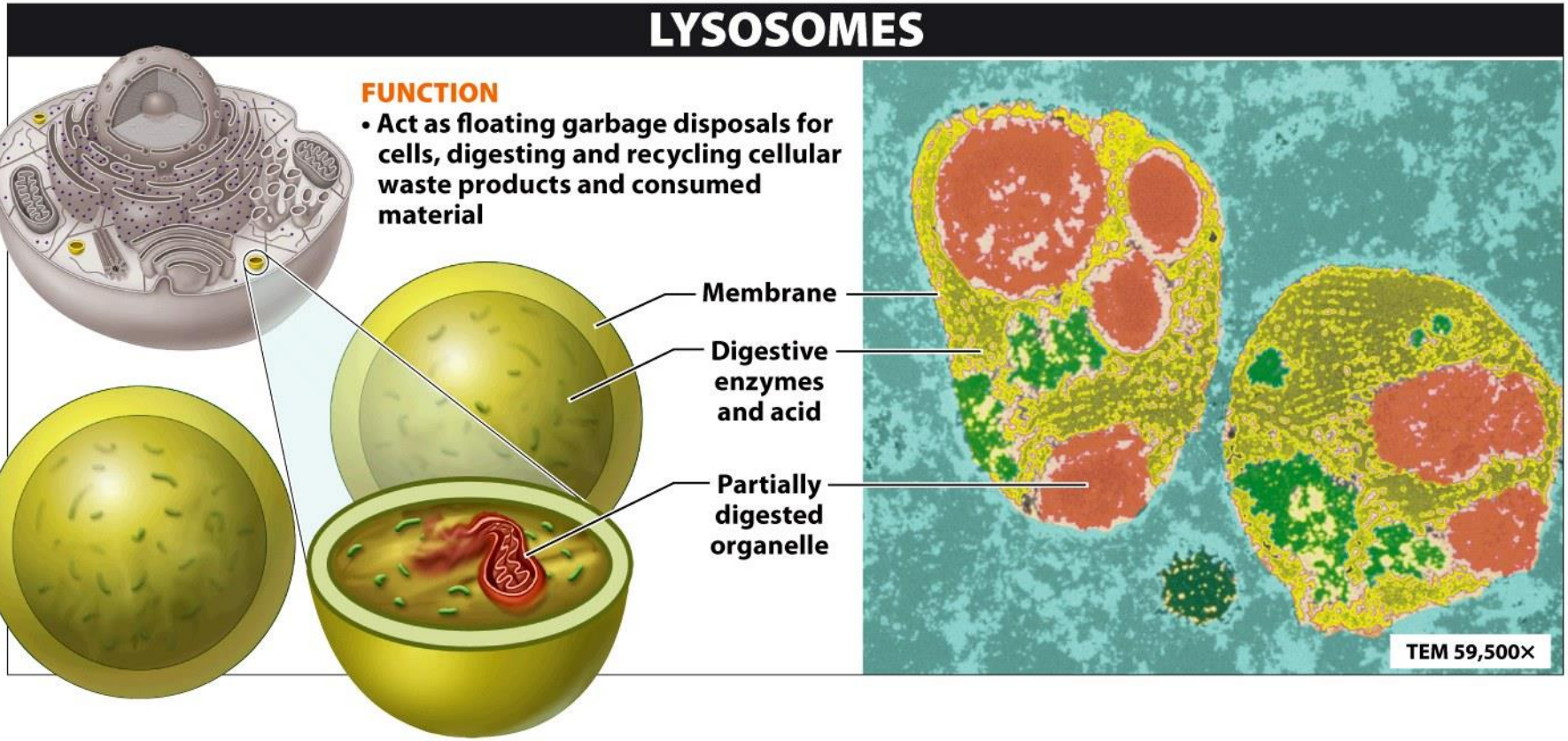

Figure 3-32
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Lysosomes

round, membrane-enclosed, acid-filled vesicles that function as garbage disposals

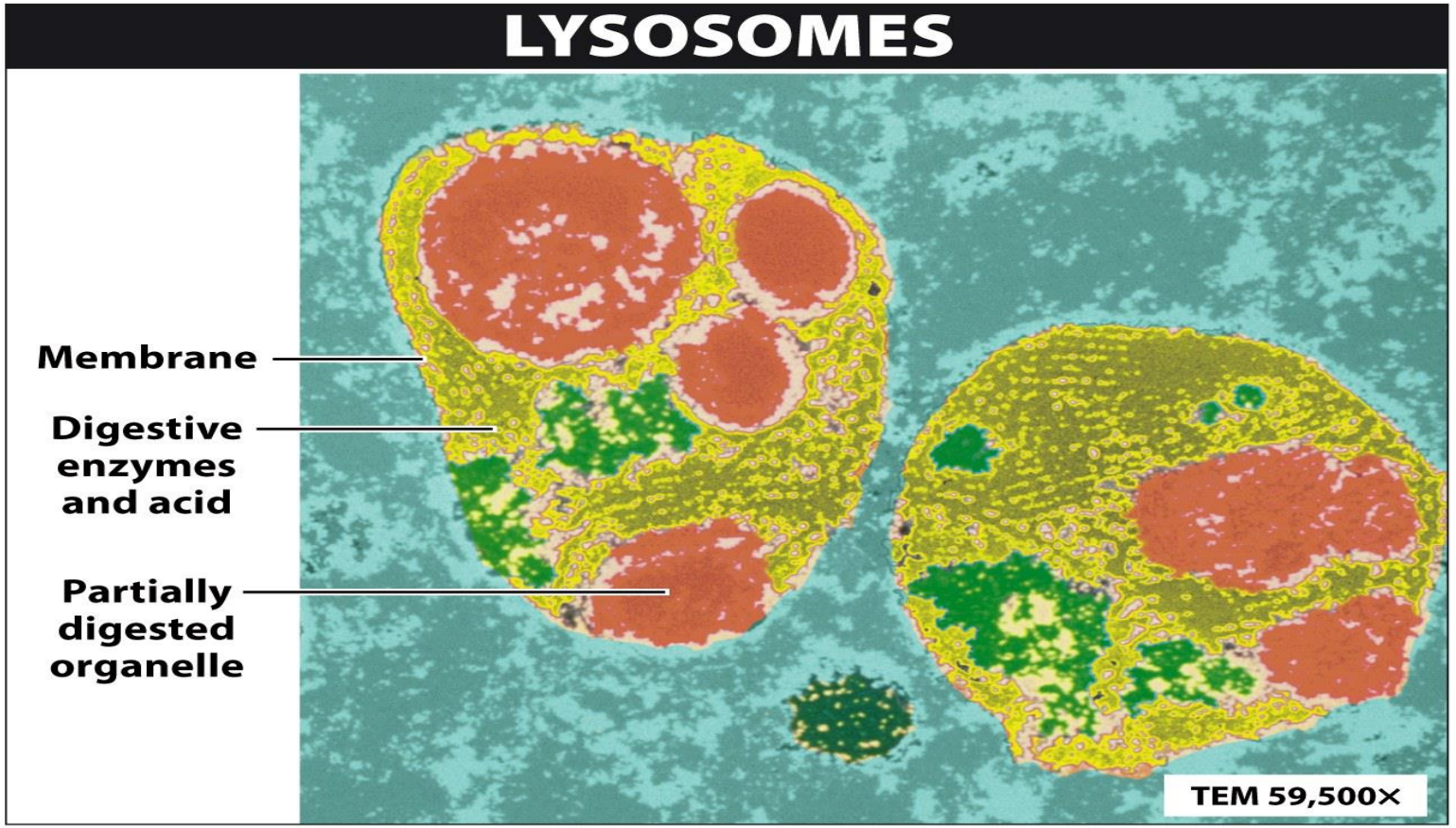

Figure 3-32 part 2
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Take-home message 3.16

- Lysosomes are round, membrane-enclosed, acid-filled vesicles that function as a cell's garbage disposal.
- They are filled with about 50 different digestive enzymes and enable a cell to dismantle macromolecules, including disease-causing bacteria.

The Endomembrane System Rough E.R. Smooth E.R. and Golgi

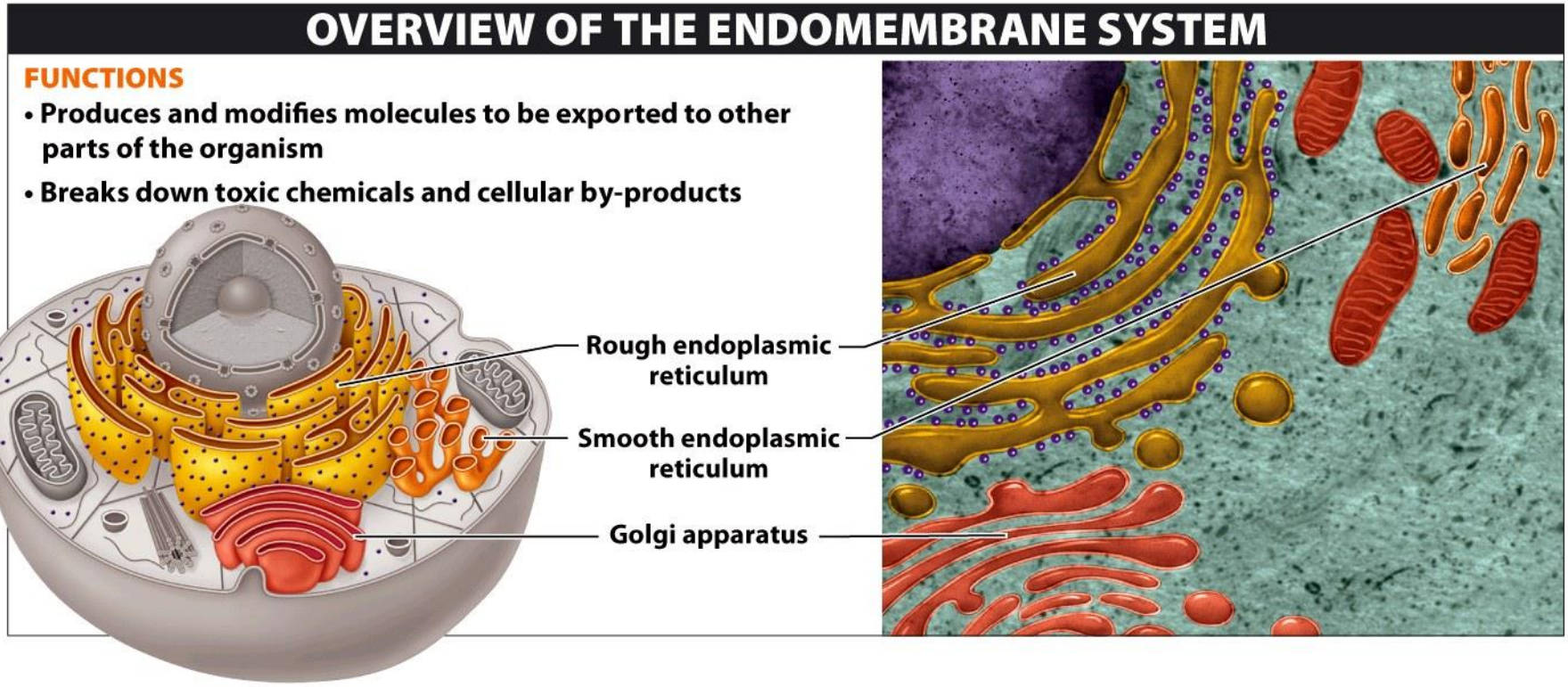

Figure 3-33
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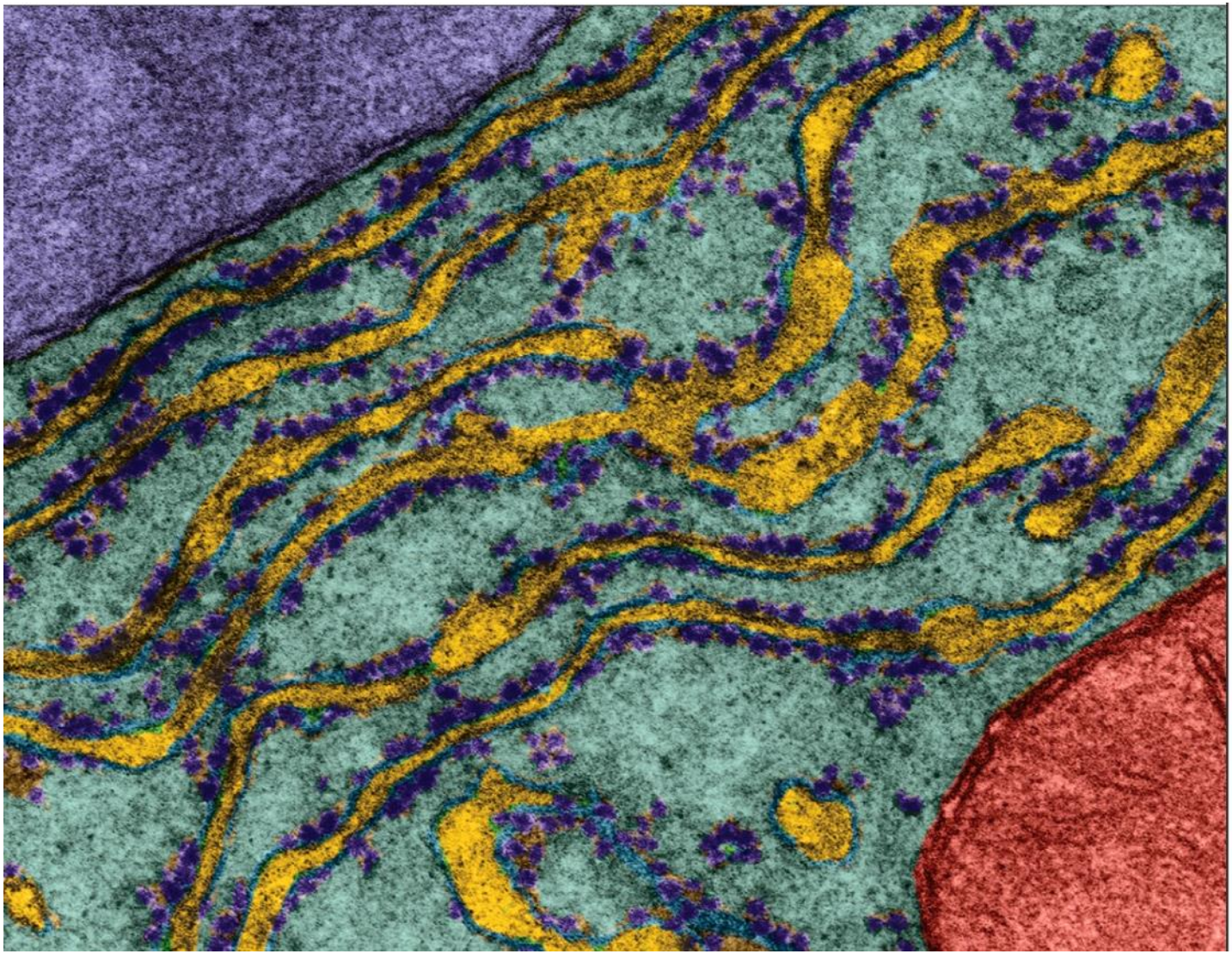
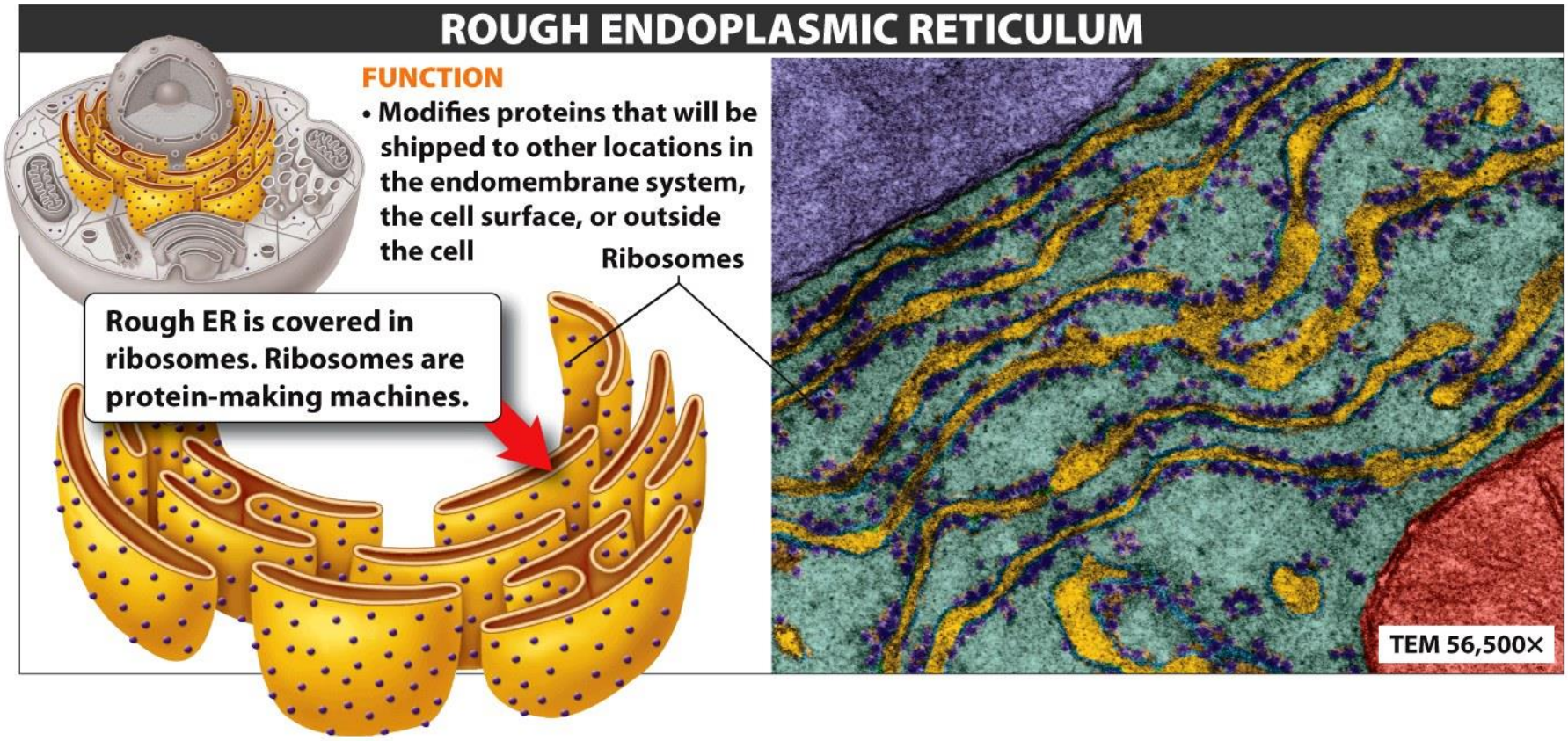
3.17 Endoplasmic reticulum: where cells build proteins and disarm toxins



Rough Endoplasmic Reticulum



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The Smooth Endoplasmic Reticulum

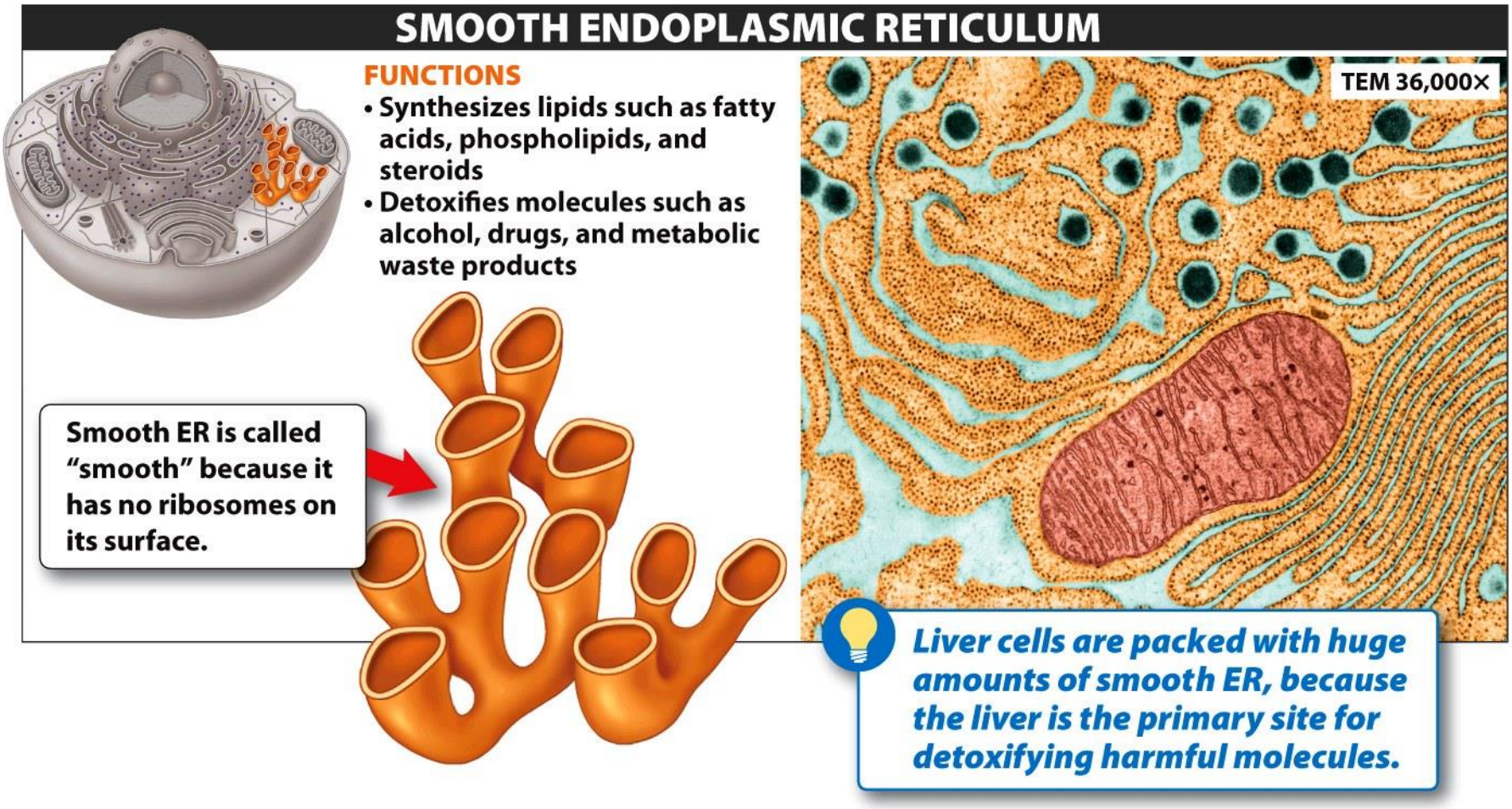

Figure 3-35
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Take-home message 3.17

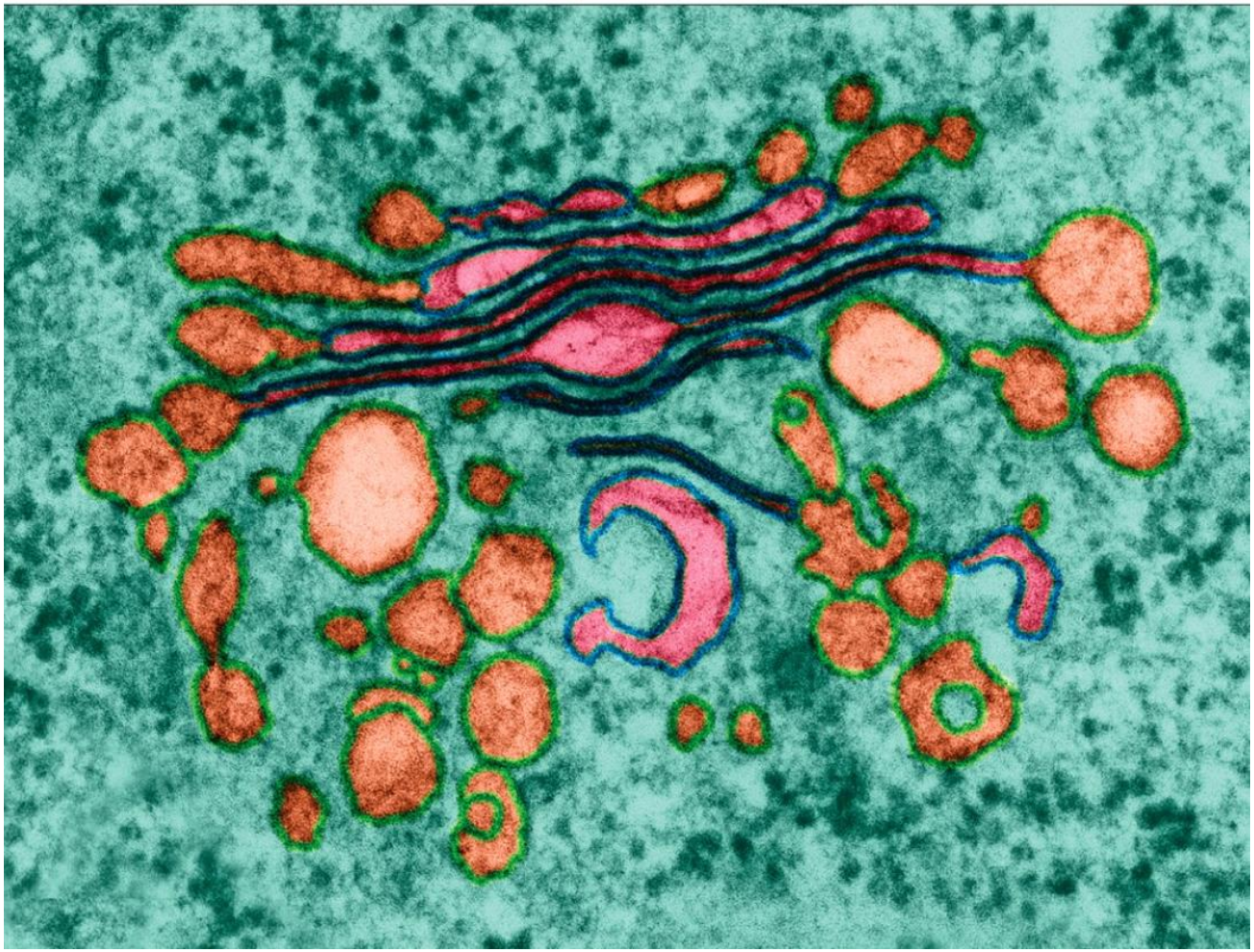
- The production and modification of biological molecules within eukaryotic cells occurs in a system of organelles called the endomembrane system, which includes the rough and smooth endoplasmic reticulum.

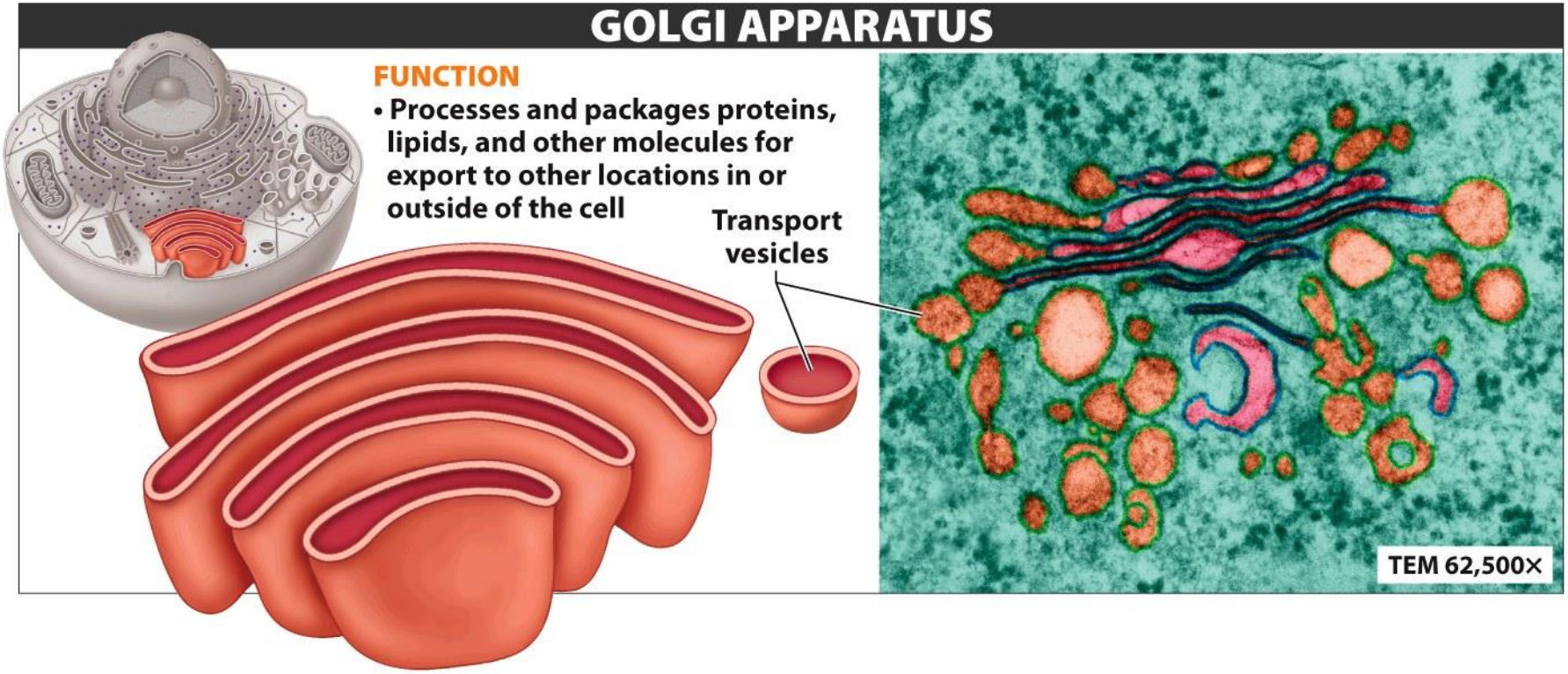
Take-home message 3.17

- In rough ER, proteins that will be shipped elsewhere in the body are folded and packaged.
- In the smooth ER, lipids are synthesized and alcohol, antibiotics, and other drugs are detoxified.

3.18 The Golgi apparatus processes products for delivery throughout the body.

3.18 Golgi apparatus: Where the cell processes products for delivery throughout the body





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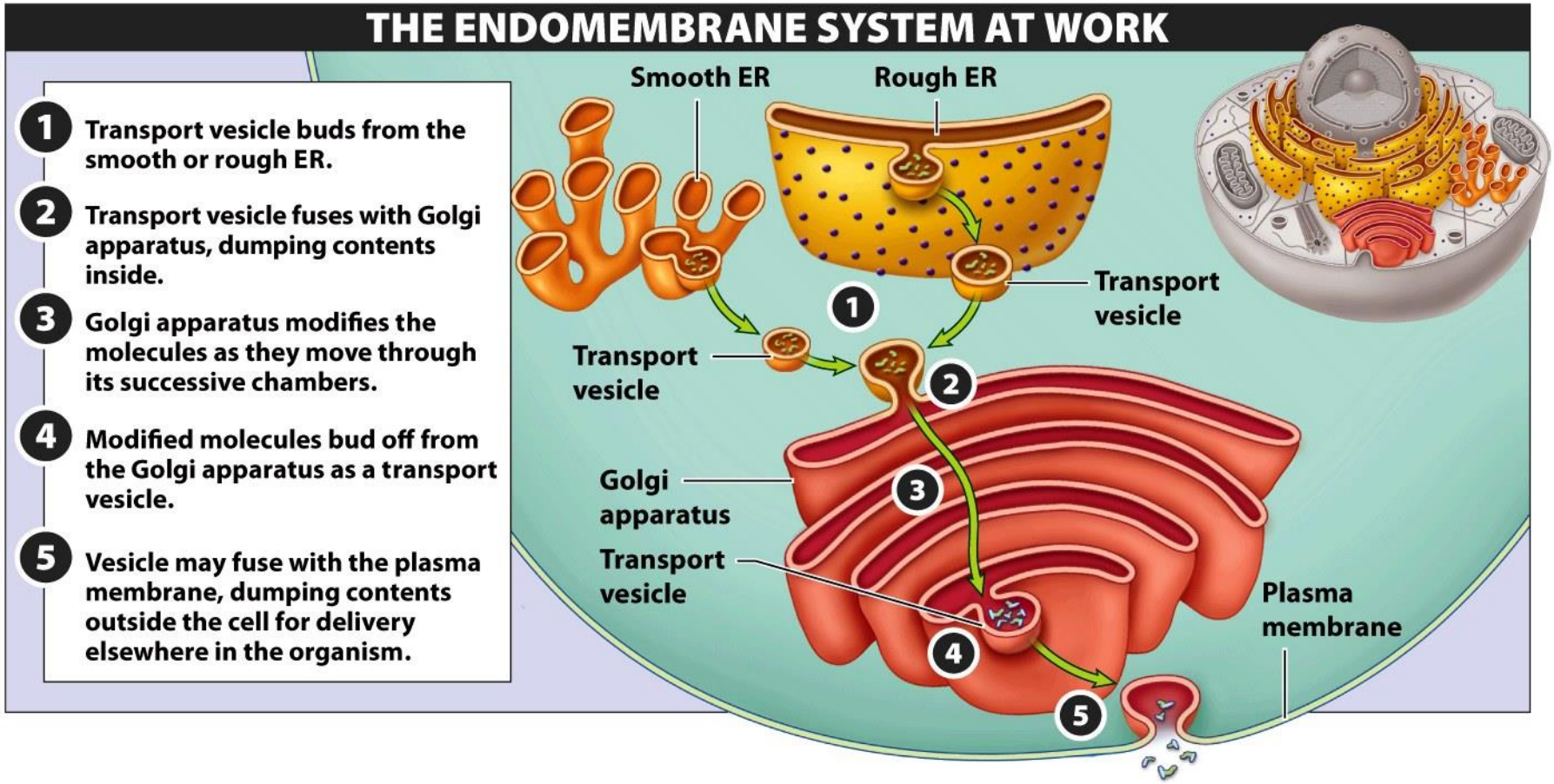

Figure 3-37
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You can think of a cell as a car factory. The control center holds the directions for making the car. There are assembly lines for constructing the engine and frame of the car. After the main structure of the car is built, the finishing touches are added (paint, leather seats, chrome bumpers). Lastly, the car is shipped to different car dealers. Which organelle would be responsible for putting the finishing touches on the car (protein)?

1. Nucleus
2. Ribosome
3. Rough endoplasmic reticulum
4. Smooth endoplasmic reticulum
5. Golgi apparatus

Take-home message 3.18

- The Golgi apparatus—another organelle within the endomembrane system—processes molecules synthesized within a cell and packages those that are destined for use elsewhere in the body.

3.19 The cell wall provides additional protection and support for plant cells.

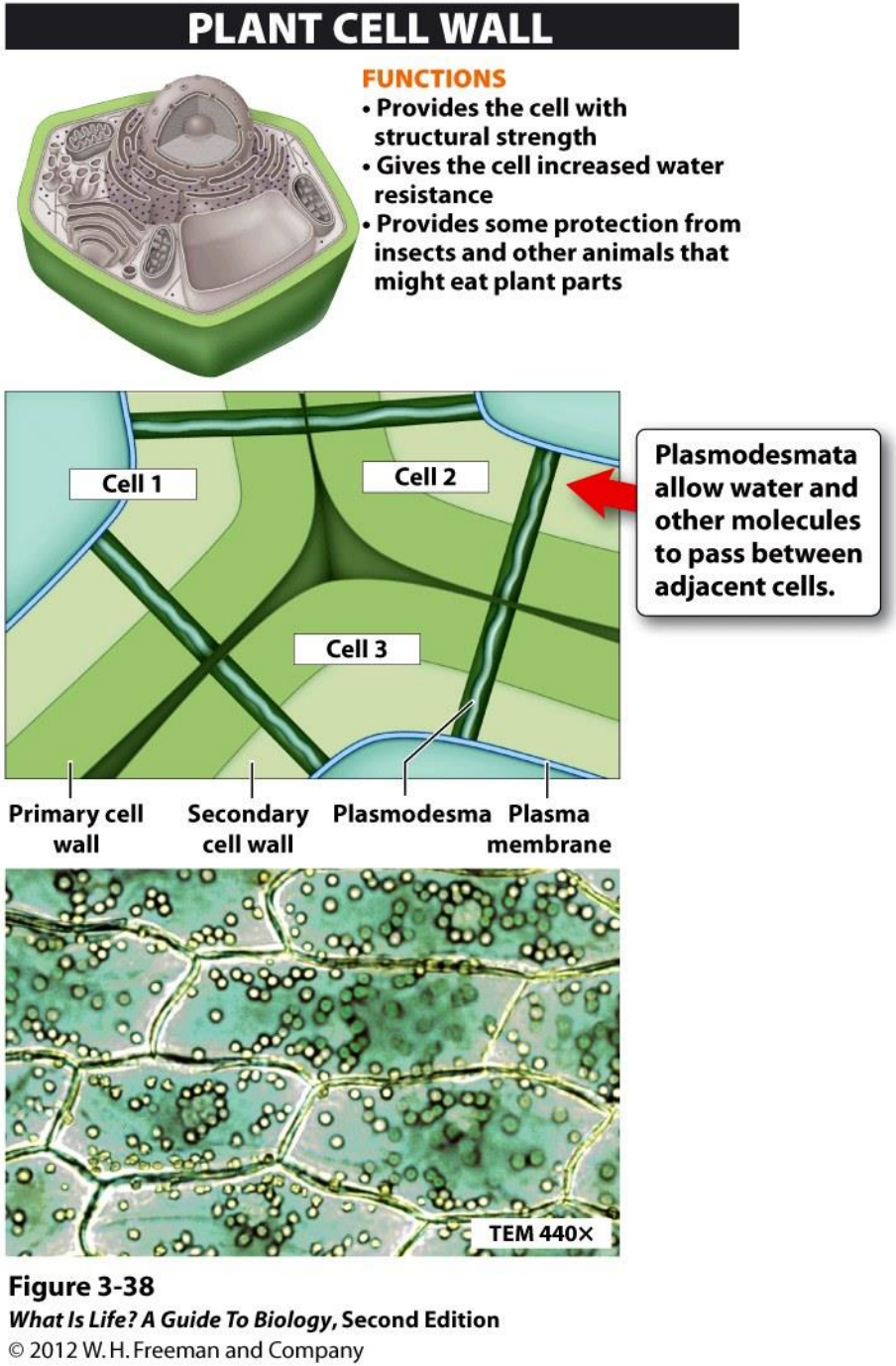

Figure 3-38

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Take-home message 3.19

- The cell wall is an organelle found in plants (and some other non-animal organisms).
- It is made primarily from the carbohydrate cellulose and it surrounds the plasma membrane of a plant cell.

Take-home message 3.19

- The cell wall confers tremendous structural strength on plant cells, gives plants increased water resistance, and provides some protection from insects and other animals that might eat them.

- In plants, plasmodesmata connect cells and enable communication and transport between them.

3.20 Vacuoles: multipurpose storage sacs for cells

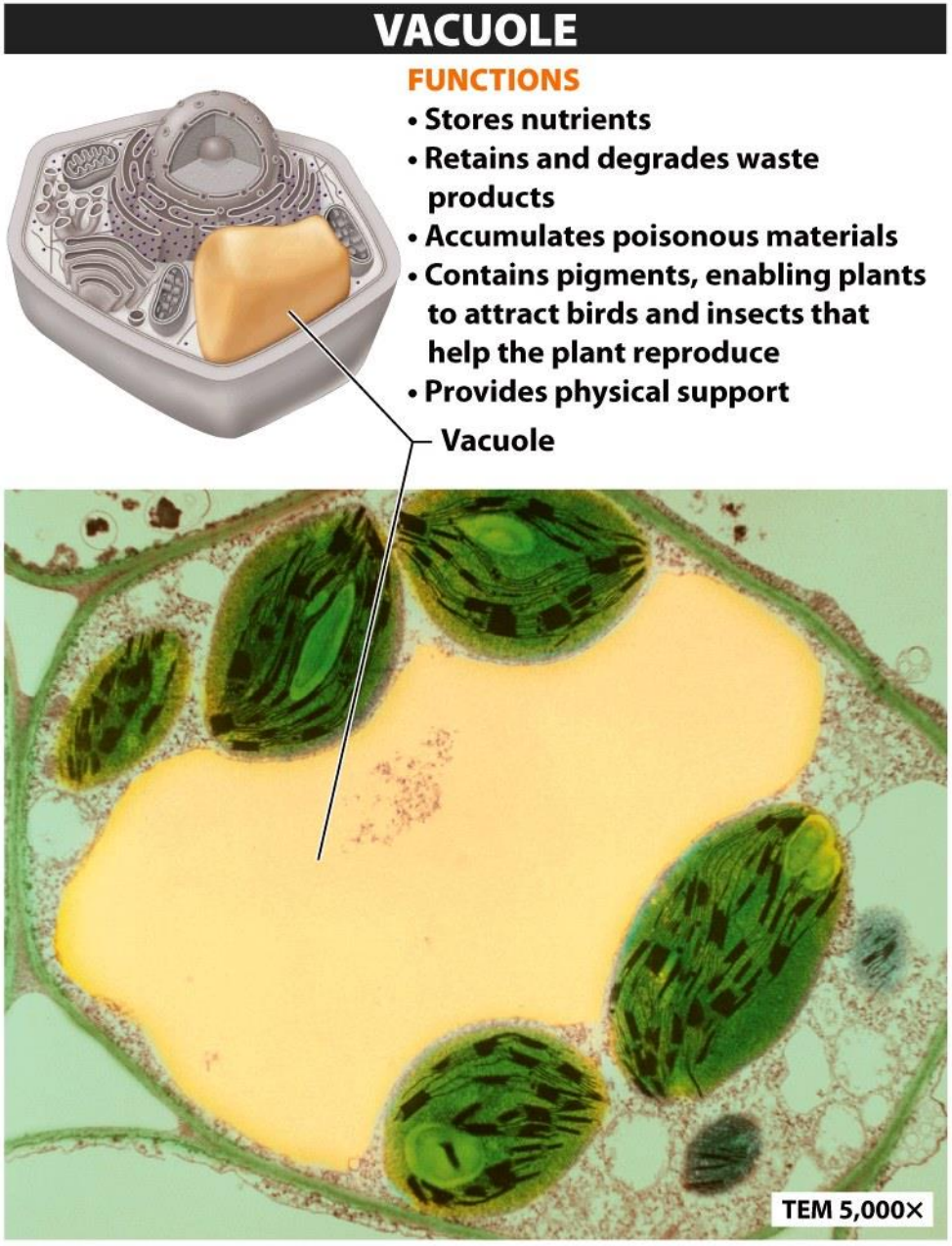

Figure 3-39
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The central vacuole can play an important role in five different areas of plant life:

1. Nutrient storage
2. Waste management
3. Predator deterrence
4. Sexual reproduction
5. Physical support

Take-home message 3.20

- In plants, vacuoles can occupy most of the interior space of the cell.
- Vacuoles also appear in some other eukaryotic species.
- They function as storage space and play a role in nutrition, waste management, predator deterrence, reproduction, and physical support.

3.21 Chloroplasts: the plant cell's power plant

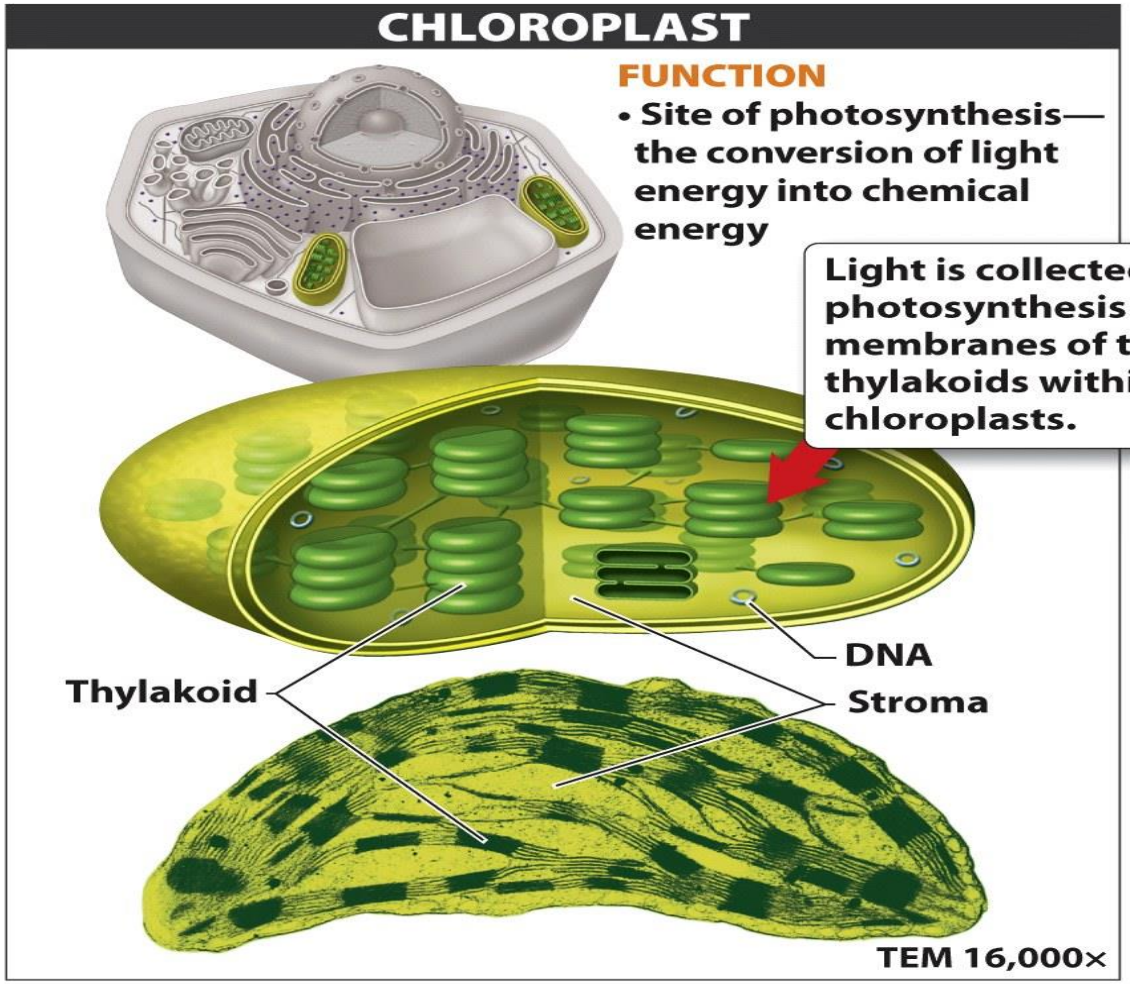

Figure 3-40
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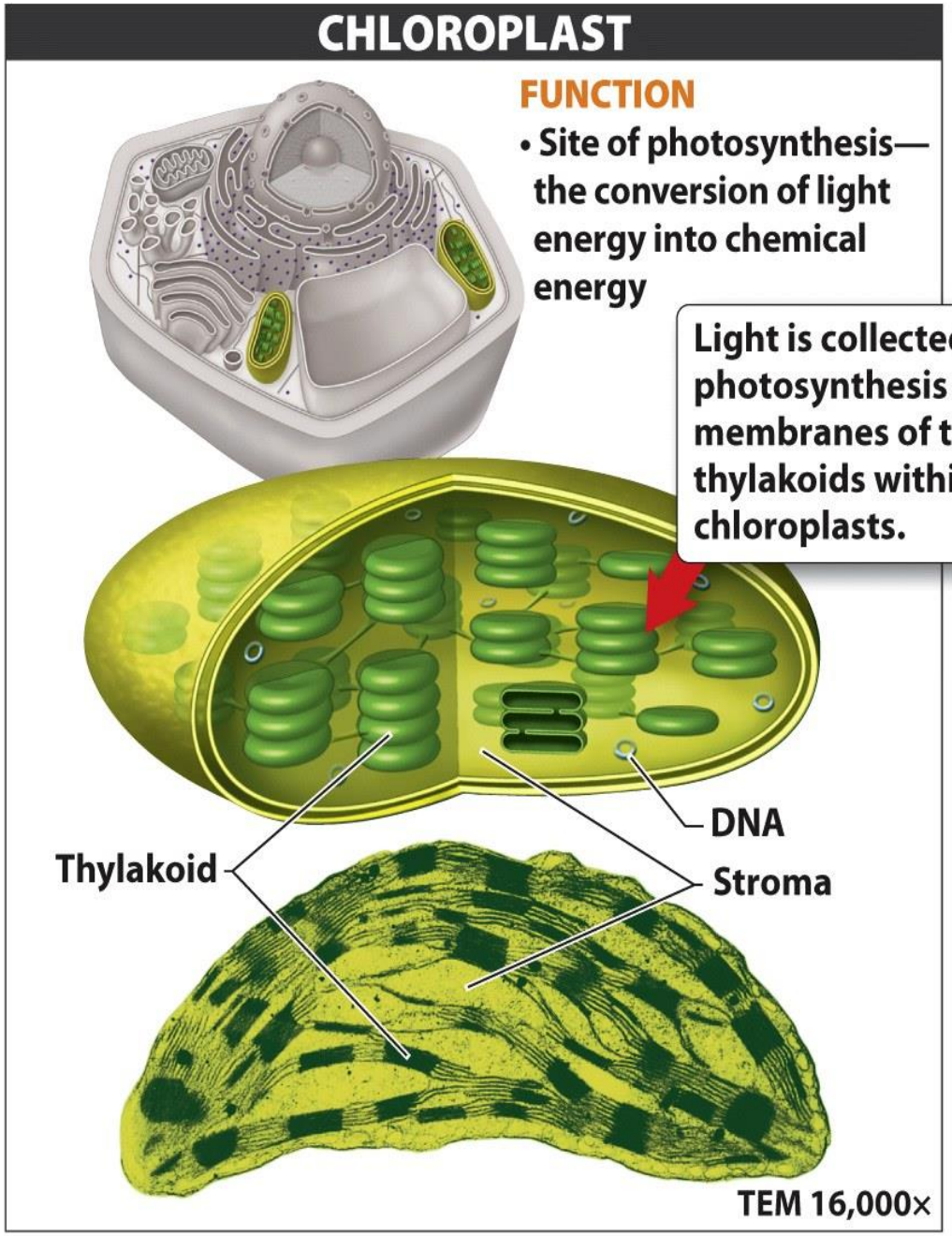

Figure 3-40
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The **stroma** and interconnected little flattened sacs called **thylakoids**

REVIEW OF CELL STRUCTURES

STRUCTURE	ANIMALS	PLANTS	FUNCTION
 Nucleus	✓	✓	Directs cellular activity and stores hereditary information
 Cytoskeleton	✓	✓	Provides structural shape and support and enables cellular movement
 Mitochondrion	✓	✓	Harvests energy for cellular functions
 Lysosome	✓	✓	Digests and recycles cellular waste products and consumed material
 Rough ER	✓	✓	Modifies proteins that will be shipped elsewhere in the organism
 Smooth ER	✓	✓	Synthesizes lipids and detoxifies molecules
 Golgi apparatus	✓	✓	Processes and packages proteins, lipids, and other molecules
 Cell wall	⊘	✓	Provides structural strength, protection, and increased resistance to water loss
 Vacuole	Sometimes	✓	Stores nutrients, degrades waste products, provides pigments and structural support
 Chloroplast	⊘	✓	Performs photosynthesis

Figure 3-41

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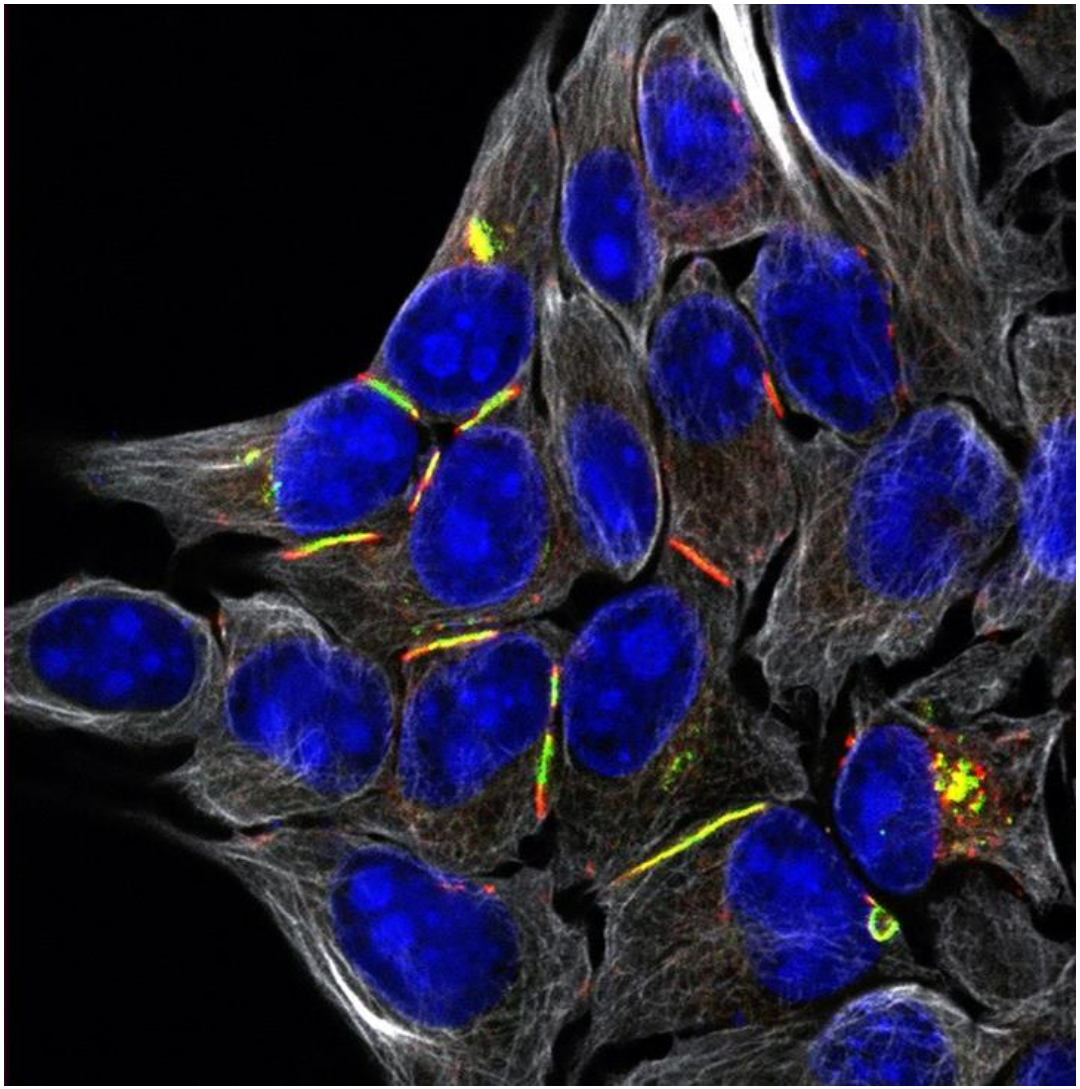
Almost all eukaryotic organisms derive energy directly or indirectly from the sun. Therefore, which organelle is the most important for life as we know it?

1. Nucleus
2. Endoplasmic reticulum
3. Golgi
4. Chloroplast
5. Mitochondria

3.8–3.11
Molecules move across membranes

in several ways.



3.8 Passive transport is the spontaneous diffusion of molecules across a membrane.

There are two types of passive transport:

1. Diffusion
2. Osmosis

Diffusion and Concentration Gradients

- Solutes
- Solvents

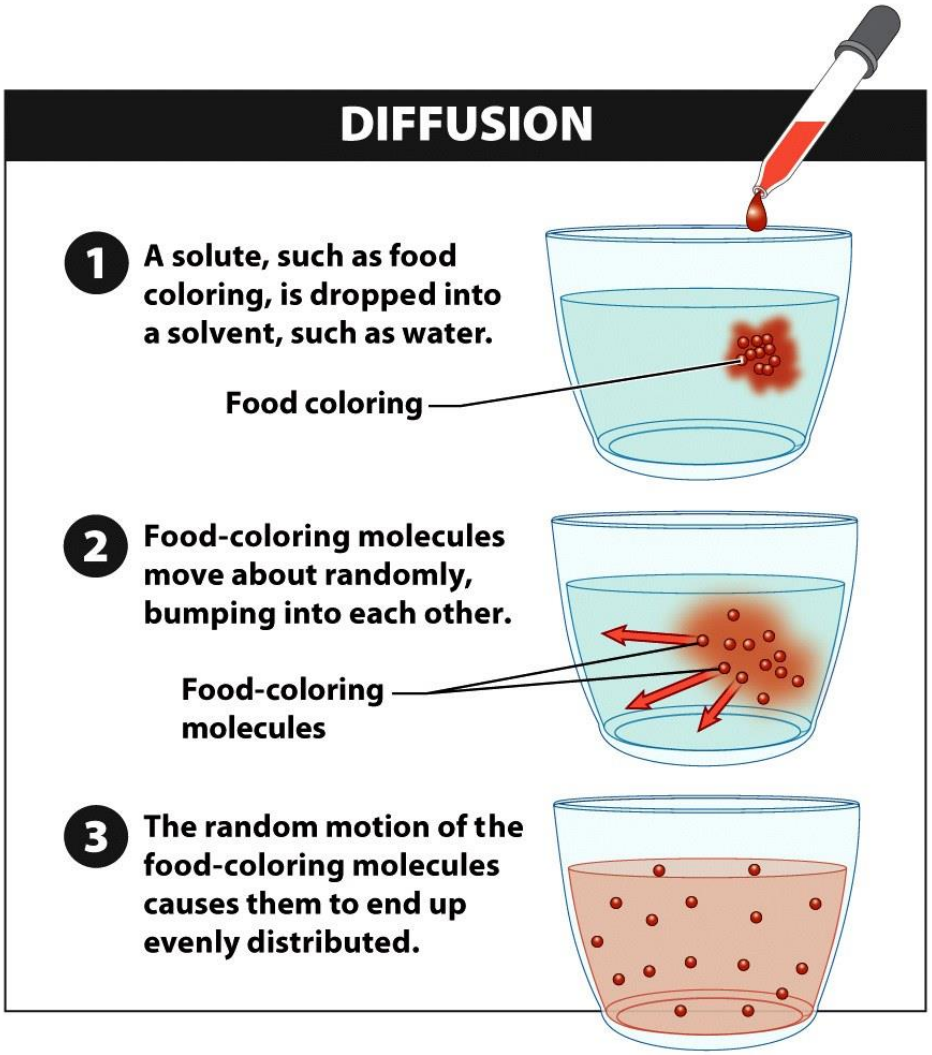


Figure 3-16
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Simple Diffusion

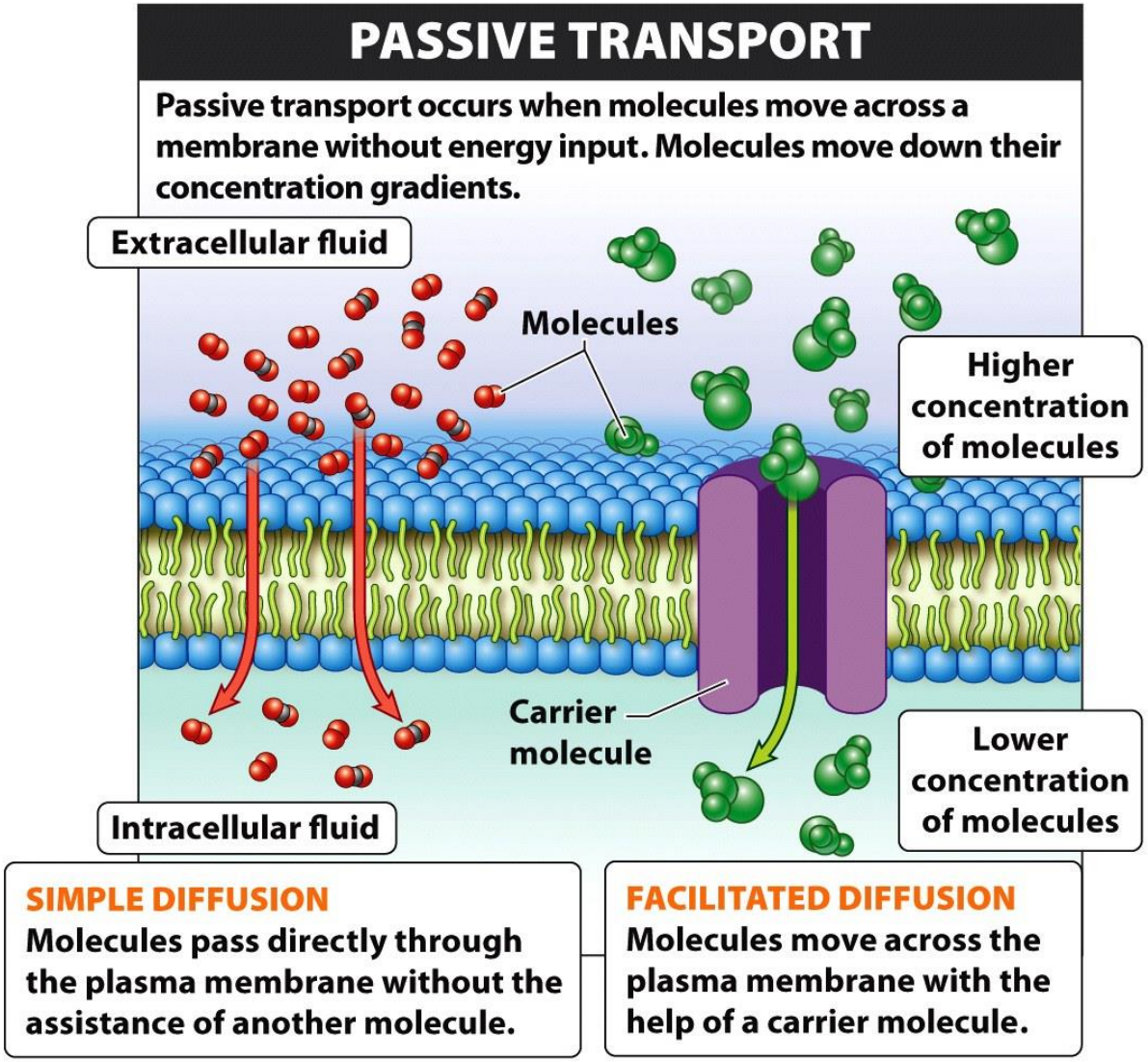

Figure 3-17
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Facilitated Diffusion

- Most molecules can't get through plasma membranes on their own.

- Carrier molecules
  - Transport proteins

Take-home message 3.8

- Cells must acquire necessary materials, such as food molecules, from outside the cell.
- Cells must remove metabolic waste molecules and molecules for use elsewhere in the body.

Take-home message 3.8

- In passive transport—which includes simple and facilitated diffusion and osmosis—the molecular movement occurs spontaneously, without the input of energy.

- This generally occurs as molecules move down their concentration gradient.

3.9 Osmosis is the passive diffusion of water across a membrane.

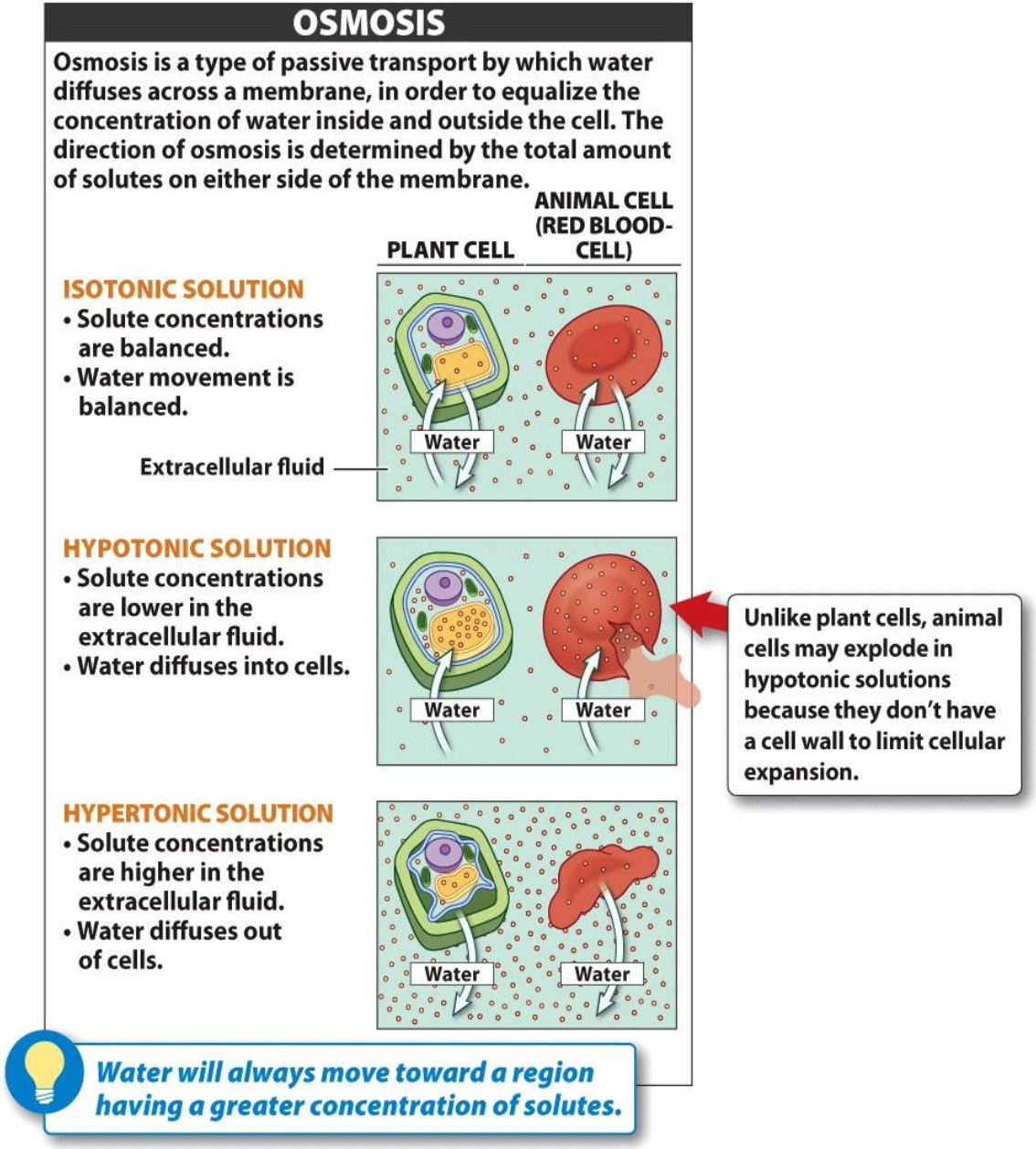

Figure 3-18

What Is Life? A Guide To Biology, Second Edition

Cells in Solution

- **Tonicity**
  - The relative concentration of solutes outside of the cell relative to inside the cell

Hypertonic

Hypotonic

Isotonic

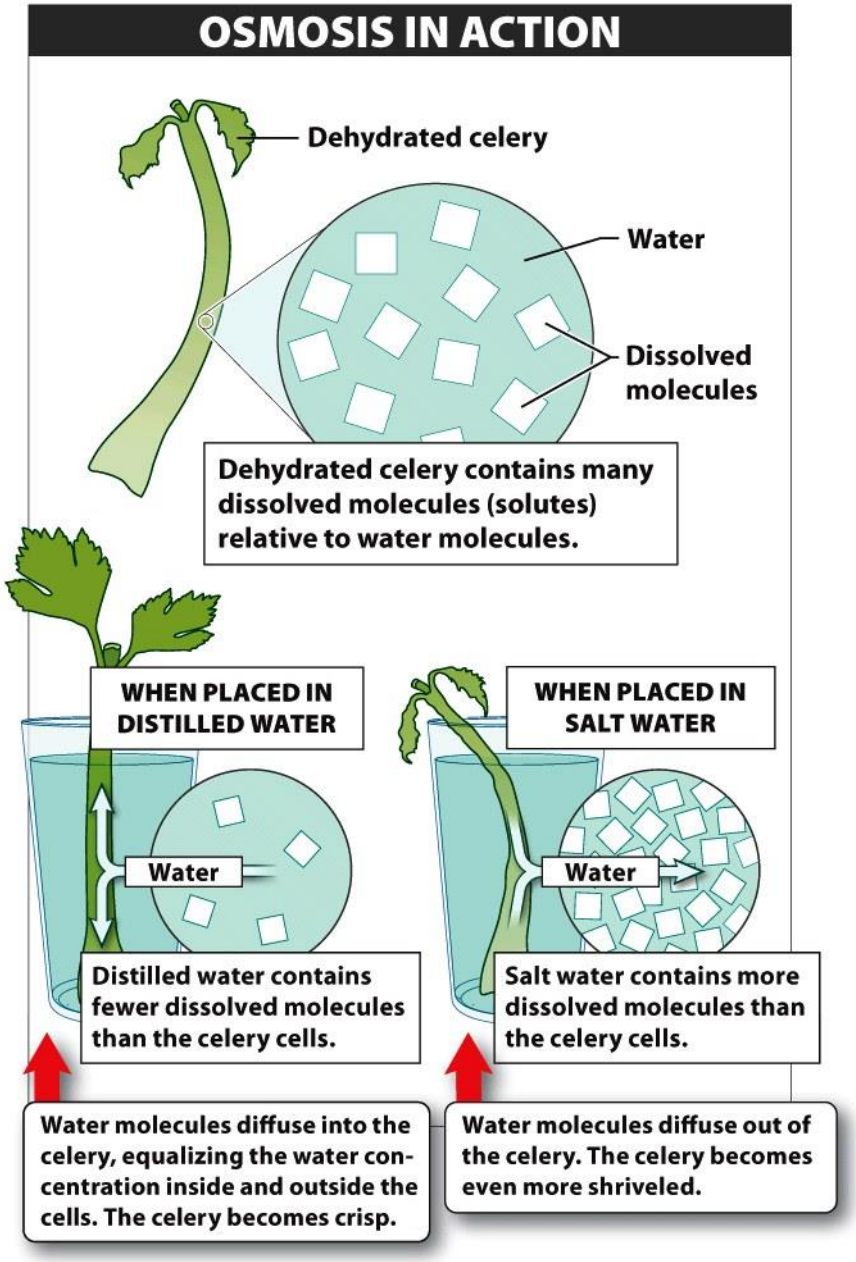

Figure 3-19

***What Is Life? A Guide To Biology*, Second Edition**

How do laxatives relieve constipation?

- Milk of magnesia and magnesium salts
- Water moves via osmosis from the cells into the intestines.

The Direction of Osmosis

- Determined only by a difference in ***total concentration*** of all the molecules dissolved in the water

- It does not matter what solutes they are.

Take-home message 3.9

- The diffusion of water across a membrane is a special type of passive transport called osmosis.
- Water molecules move across the membrane until the concentration of water inside and outside of the cell is equalized.

3.10 In active transport, cells use energy to move small molecules.

Molecules can't always move spontaneously and effortlessly in and out of cells.

Primary Active Transport:
Uses Energy Directly from ATP

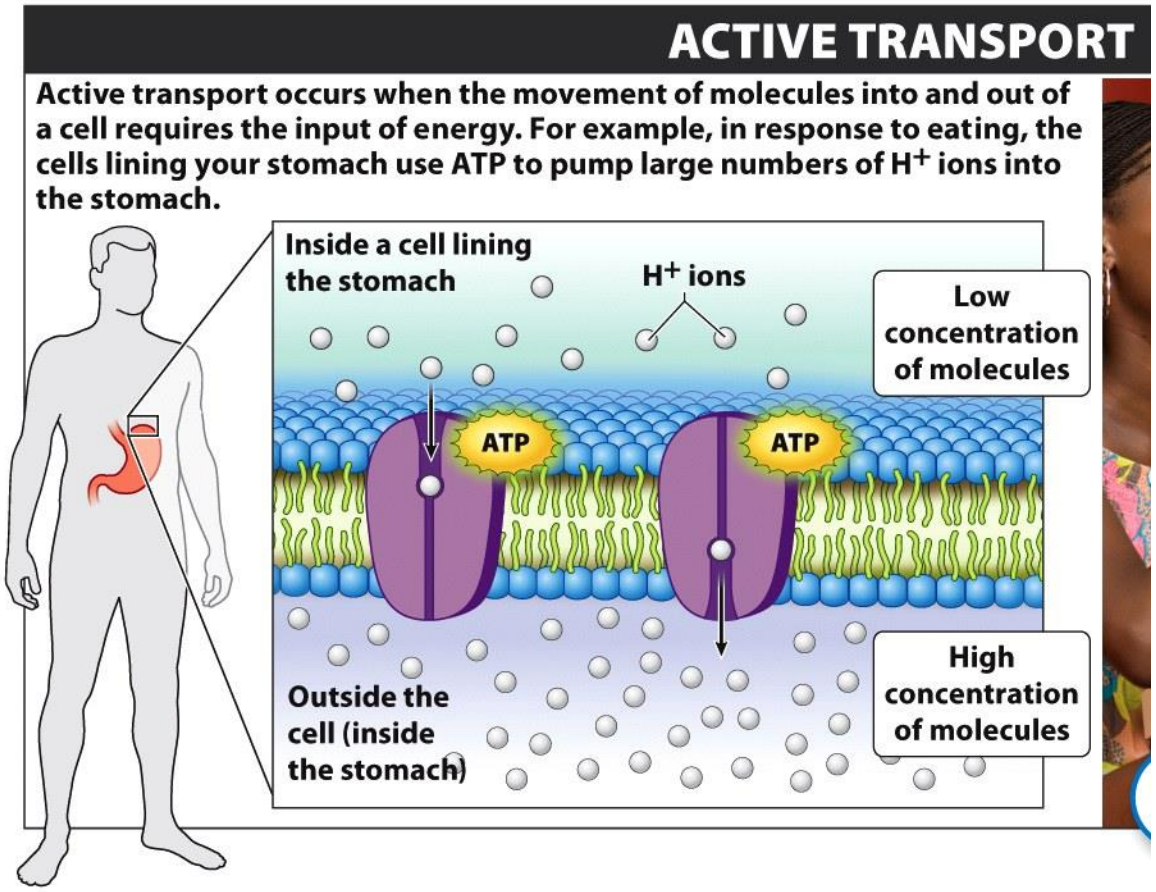

Figure 3-20
What Is Life? A Guide To Biology

Active Transport

- An indirect method many transporter proteins use for fueling their activities

- The transport protein moves one molecule against its concentration gradient

Secondary Active Transport

- No ATP is used ***directly.***

- At some other point and in some other location, energy from ATP was used to pump one of the types of molecules involved against their concentration gradient.

Take-home message 3.10

- In active transport, moving molecules across a membrane requires energy.
- Active transport is necessary if the molecules to be moved are very large or if they are being moved against their concentration gradient.

Take-home message 3.10

- Proteins embedded within the plasma membrane act like motorized revolving doors to actively transport the molecules.

3.11 Endocytosis and exocytosis are used for bulk transport of particles.

Many molecules are just too big to get into a cell by passive or active transport.

Two types of endocytosis:

1. Phagocytosis
2. Pinocytosis

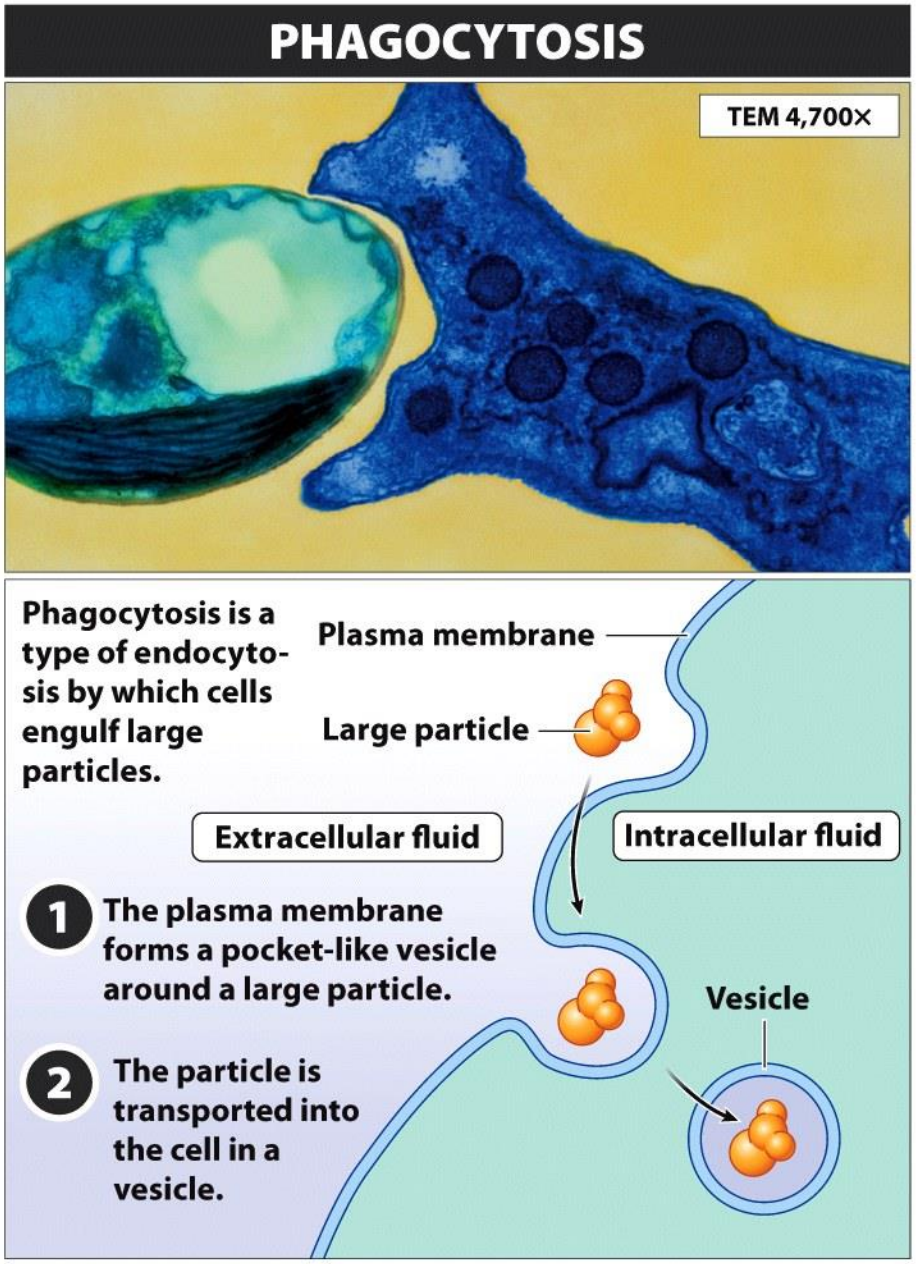

Figure 3-21
What Is Life? A Guide To Biology

Pinocytosis: the process of cells taking in dissolved particles and liquid

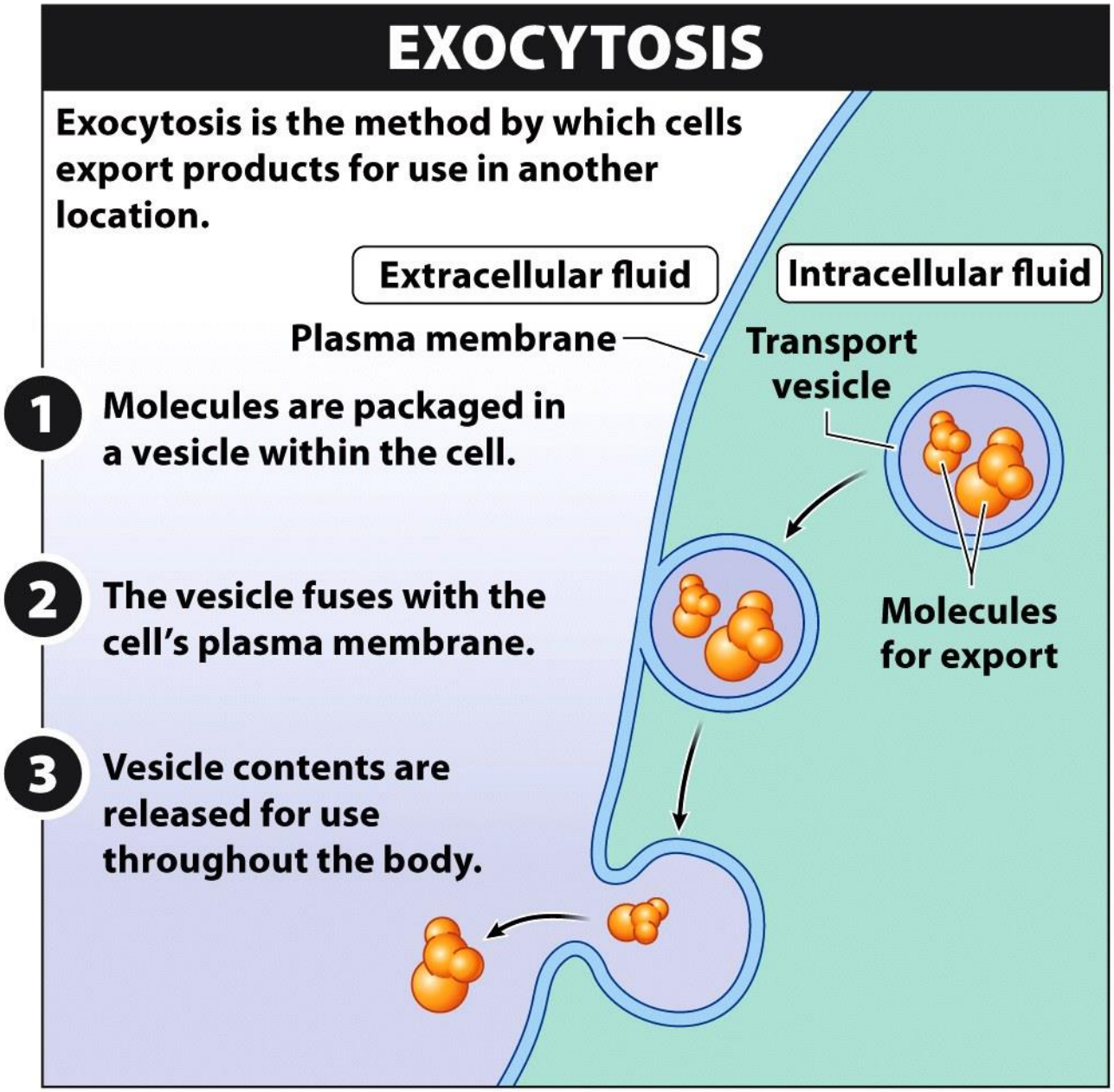

Figure 3-24
What Is Life? A Guide To Biology

When a woman nurses her baby, proteins are released from the mammary cells, accumulate in the ducts of the breast, and flow out of the nipple. Which process listed below is involved?

1. Phagocytosis
2. Pinocytosis
3. Receptor-mediated endocytosis
4. Exocytosis

Take-home message 3.11

- When molecules cannot get into a cell via diffusion or a pump (e.g., when the molecules are too big), cells can engulf the materials with their plasma membrane in a process called **endocytosis.**
- Similarly, molecules can be moved out of a cell via **exocytosis.**

Take-home message 3.11

- In both processes the plasma membrane moves to surround the molecule and forms a little vesicle that can be pinched off inside the cell or fuse with the plasma membrane and dump its contents outside of the cell.

Take-home message 3.21

- The chloroplast is an organelle in plants and algae in which photosynthesis occurs.
- Chloroplasts may have originally been bacteria that were engulfed by a predatory cell by endosymbiosis.