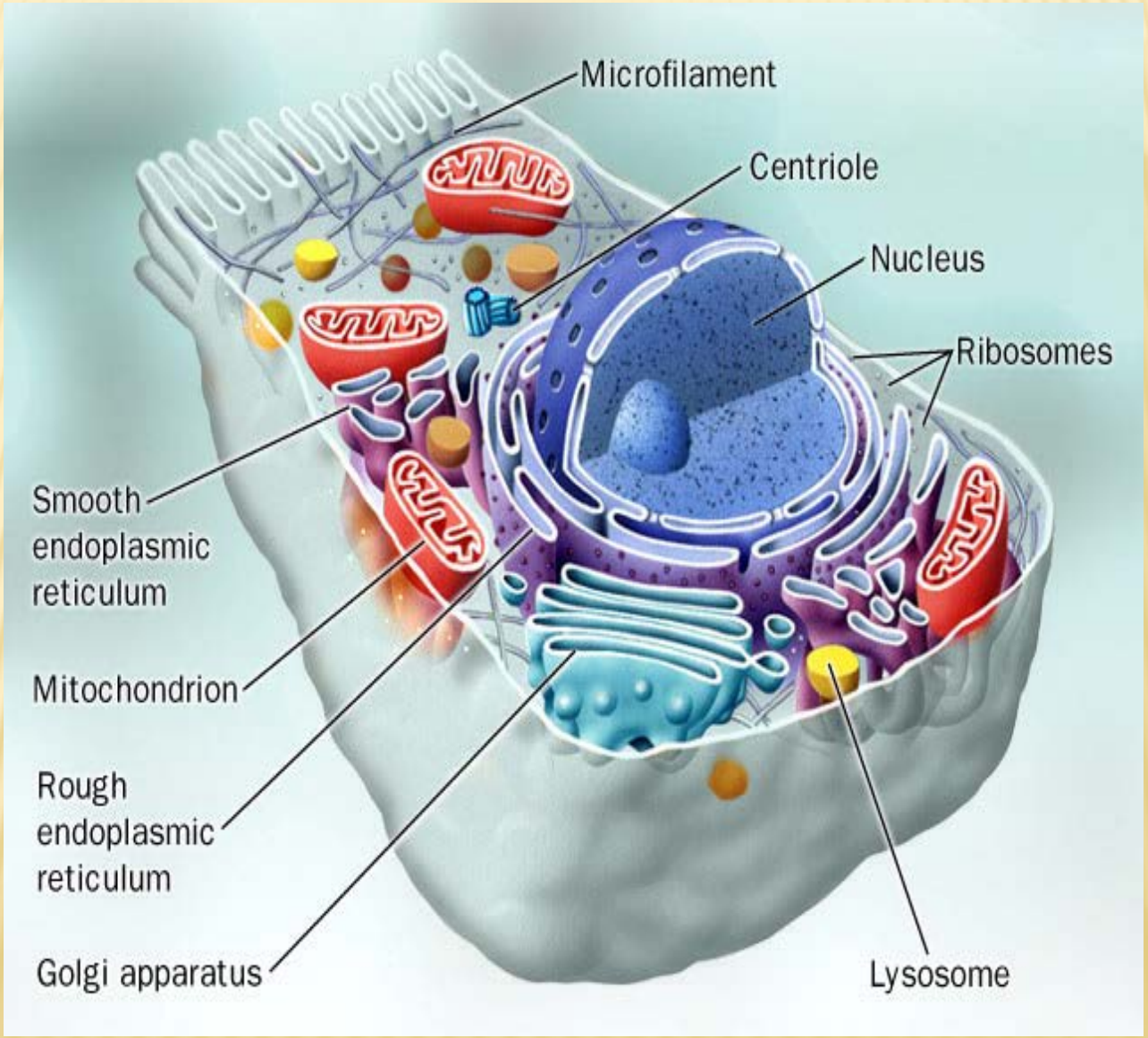
Chapter 4 The Cell



1) Cell Theory

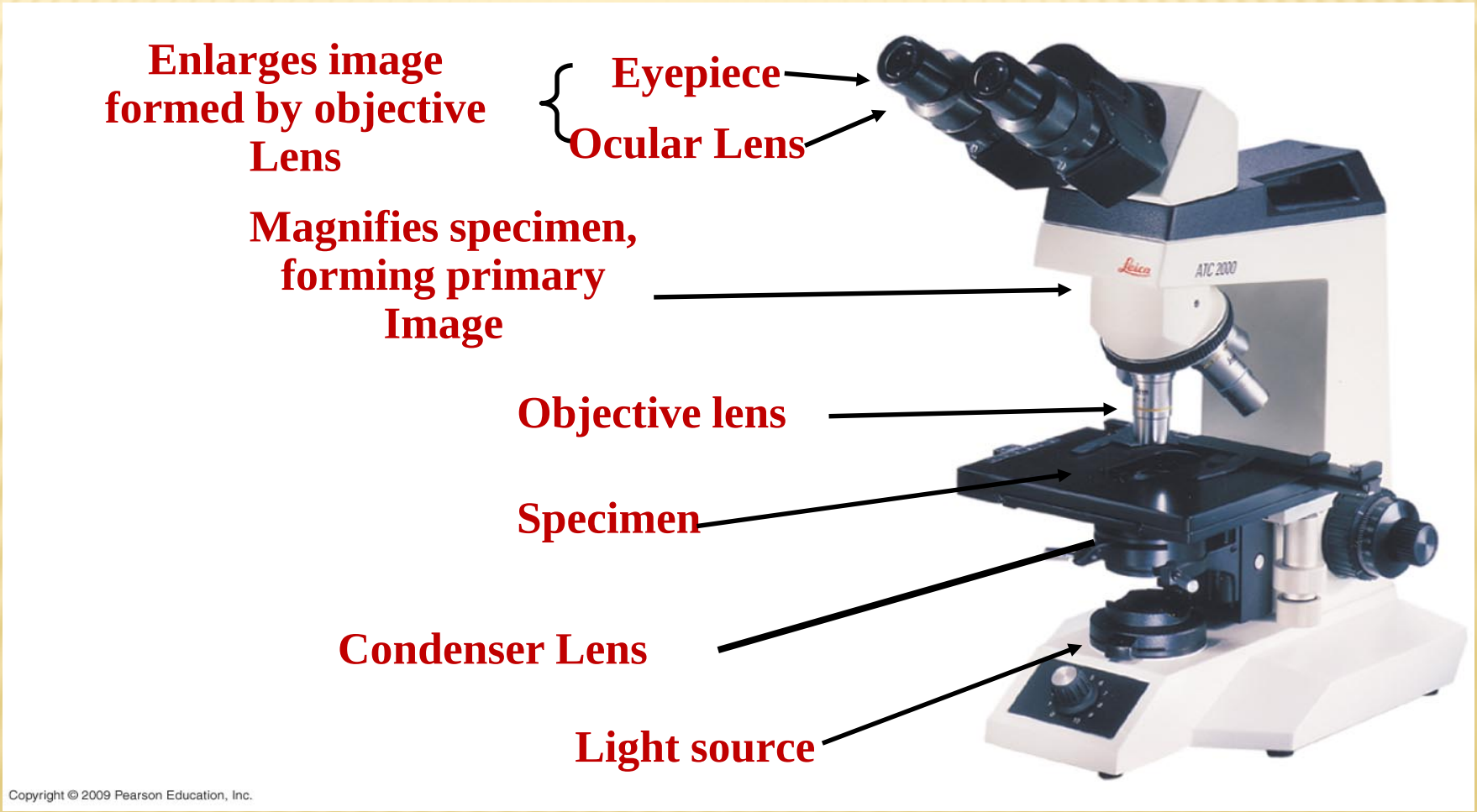
1) All organisms are composed of one or more cells
2) The cell is the simplest structure that can perform all activities required for life
3) All cells come from other pre-existing cells by cell division

Microscopes

- A variety of microscopes have been developed for a clearer view of cells and cellular structure
- The most frequently used microscope is the light microscope (LM) — like the one used in biology laboratories
- Light passes through a specimen then through glass lenses into the viewer's eye
- Specimens can be magnified up to 1,000 times the actual size of the specimen

Microscopes

Light microscope (LM)



Microscopes

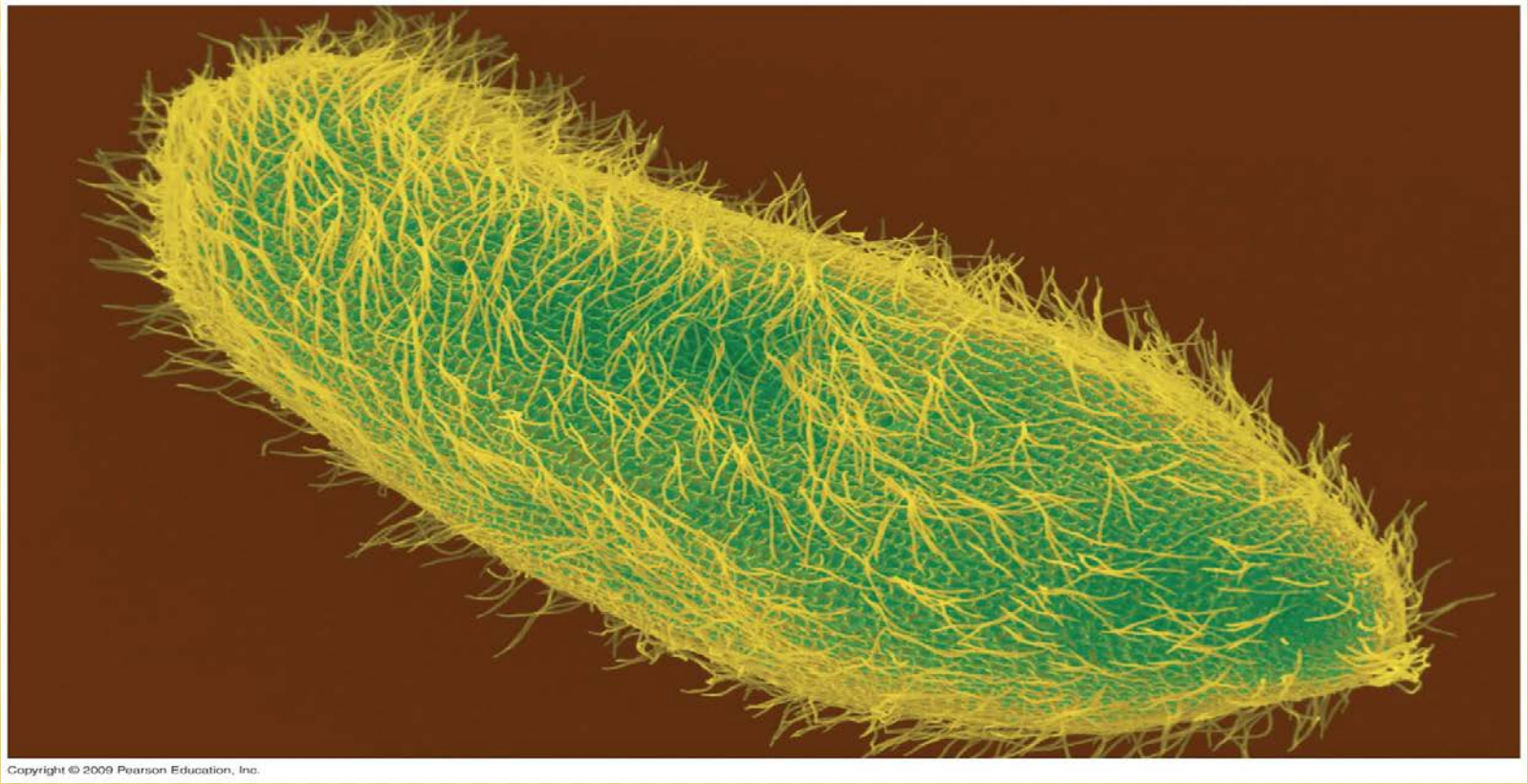
Light Micrograph (LM) of a protist, *Paramecium*.

Microscopes reveal the world of the cell

- Biologists often use a very powerful microscope called the electron microscope (EM) to view the ultrastructure of cells
  - It can resolve biological structures as small as 2 nanometers (nm) and can magnify up to 100,000 times
  - Instead of light, the EM uses a beam of electrons

Microscopes

Scanning Electron Micrograph (SEM) of *Paramecium*.



Microscopes

Transmission Electron Micrograph (TEM) of *Paramecium*

Most cells are microscopic

- The surface area of a cell is important for carrying out the cell's functions, such as acquiring adequate nutrients and oxygen
  - A small cell has more surface area relative to its cell volume and is more efficient

Number of Cells

Organisms may be:

1) *Unicellular* – **composed of one cell like bacteria**

2) *Multicellular*- **composed of *many cells* that may organize**

Type of Cells

There are two major types of cells

1. **Prokaryotic cells** include bacteria & lack a nucleus or membrane-bound structures called organelles

2. **Eukaryotic cells** include most other cells & have a nucleus and membrane-bound organelles (plants, fungi, & animals)

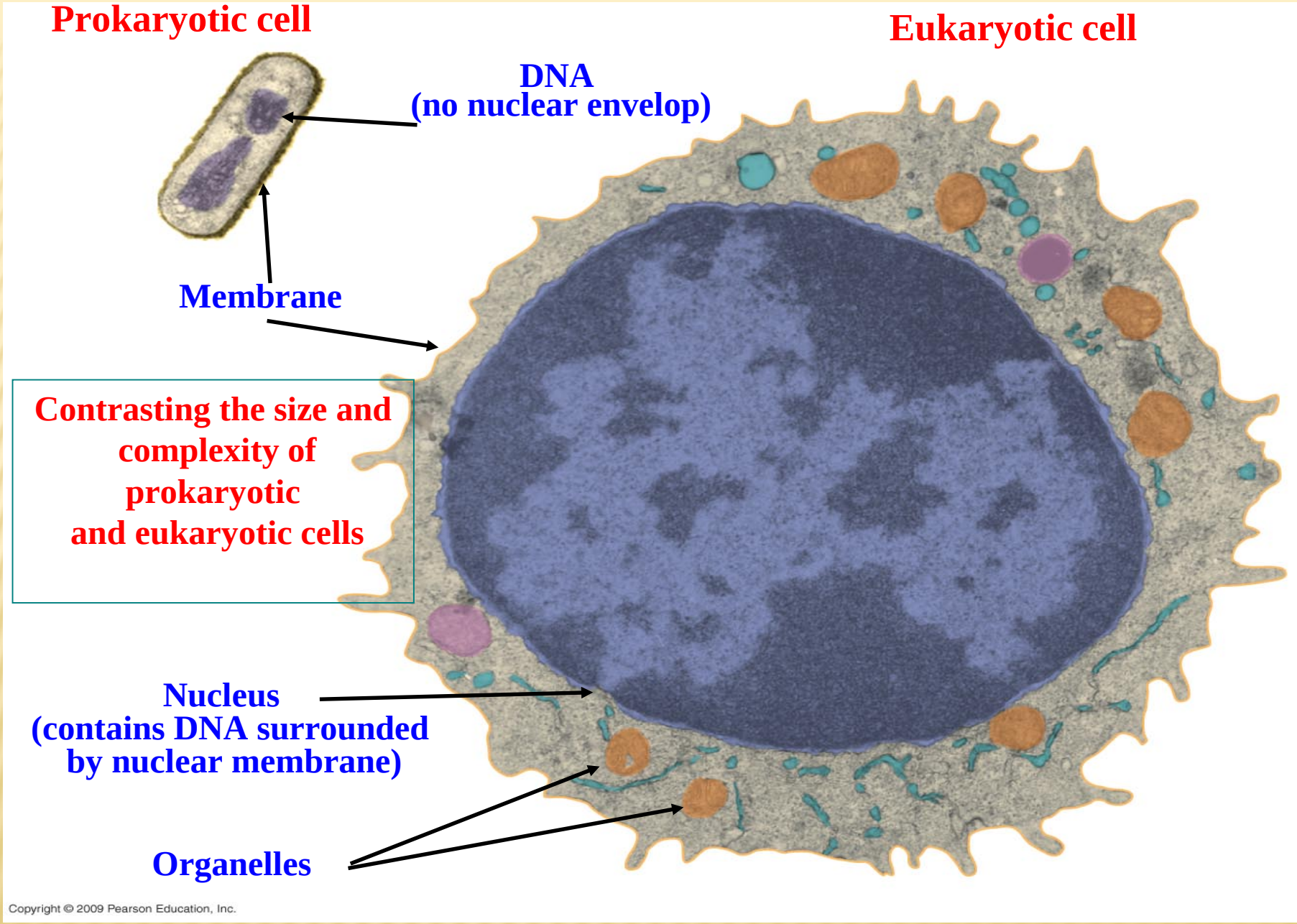
Cells are the structural and functional units of life

Prokaryotic cells

1) Genetic material is not surrounded by a nuclear membrane
2) Simple and small
3) No membrane-bound organelles
4) Single celled organisms.
5) Bacteria and Archaea

Eukaryotic cells

1) Genetic material is surrounded by a nuclear membrane
2) Possess organelles surrounded by membranes
3) Plants, animals, and fungi are eukaryotic



Prokaryotic cells are structurally simpler than eukaryotic cells

Bacteria and Archaea have prokaryotic cells

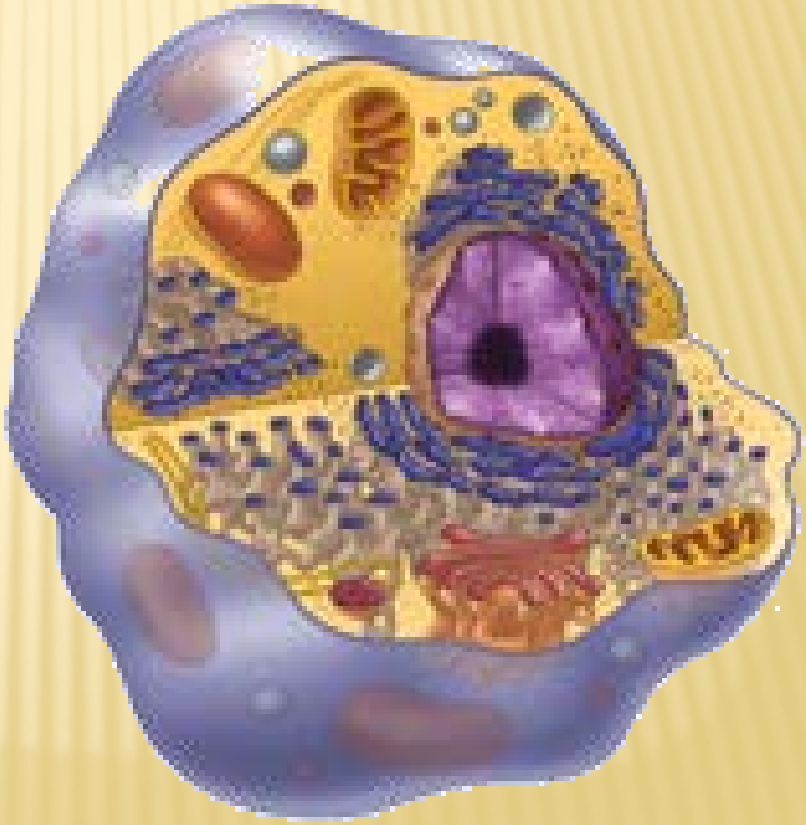
All other forms of life have eukaryotic cells

- **Both prokaryotic and eukaryotic cells have a plasma membrane and one or more chromosomes and ribosomes**
- **Eukaryotic cells have a membrane-bound nucleus and a number of other organelles, whereas prokaryotes have a nucleoid and no true organelles**

Eukaryotic Cell

Contains 3 basic cell structures:

1) **Nucleus**
2) **Cell Membrane**
3) **Cytoplasm with organelles**



Organelles

1) Very small (Microscopic)
2) Perform various functions for a cell
3) Found in the cytoplasm
4) May or may not be membrane-bound

Organelles Found in Cells

Examples of Organelles include:

1) **Endoplasmic reticulum (rough & smooth) Function in Synthesis of cell products & Transport**
2) **Golgi Bodies: wrap & export proteins**
3) **Nucleolus: makes ribosomes**
4) **Lysosomes: digest & get rid of wastes**
5) **Ribosomes: make proteins**

Eukaryotic cells

There are four life processes in eukaryotic cells that depend upon structures and organelles

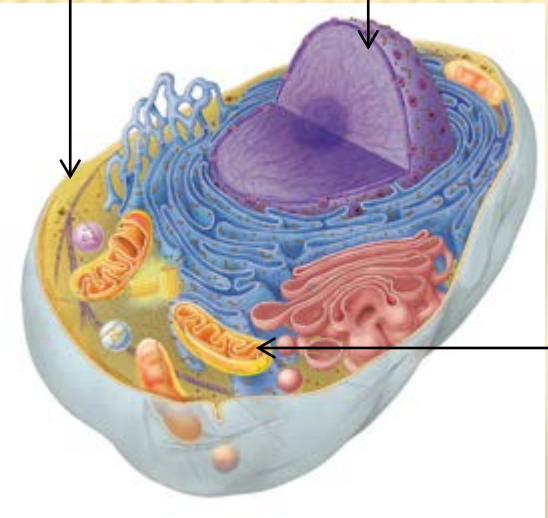
1) **Manufacturing**
2) **Breakdown of molecules**
3) **Energy processing**
4) **Structural support, movement, and communication**

Similarities between plant cells and animal cells

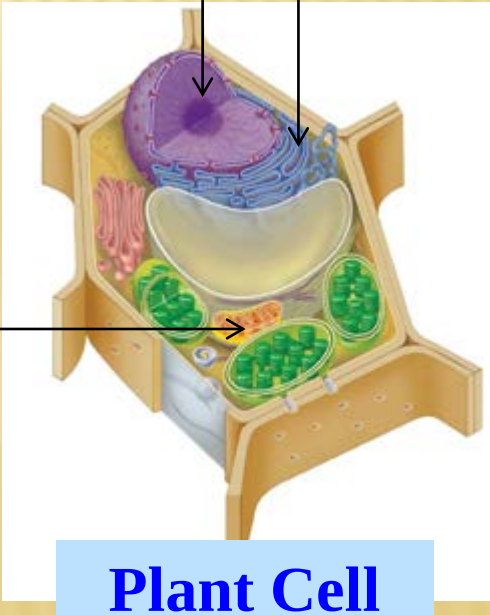
1) Both have a cell membrane surrounding the cytoplasm

2) Both have a nucleus

3) Both contain mitochndria



Animal Cell



Plant Cell

Differences between plant cells and animal cells

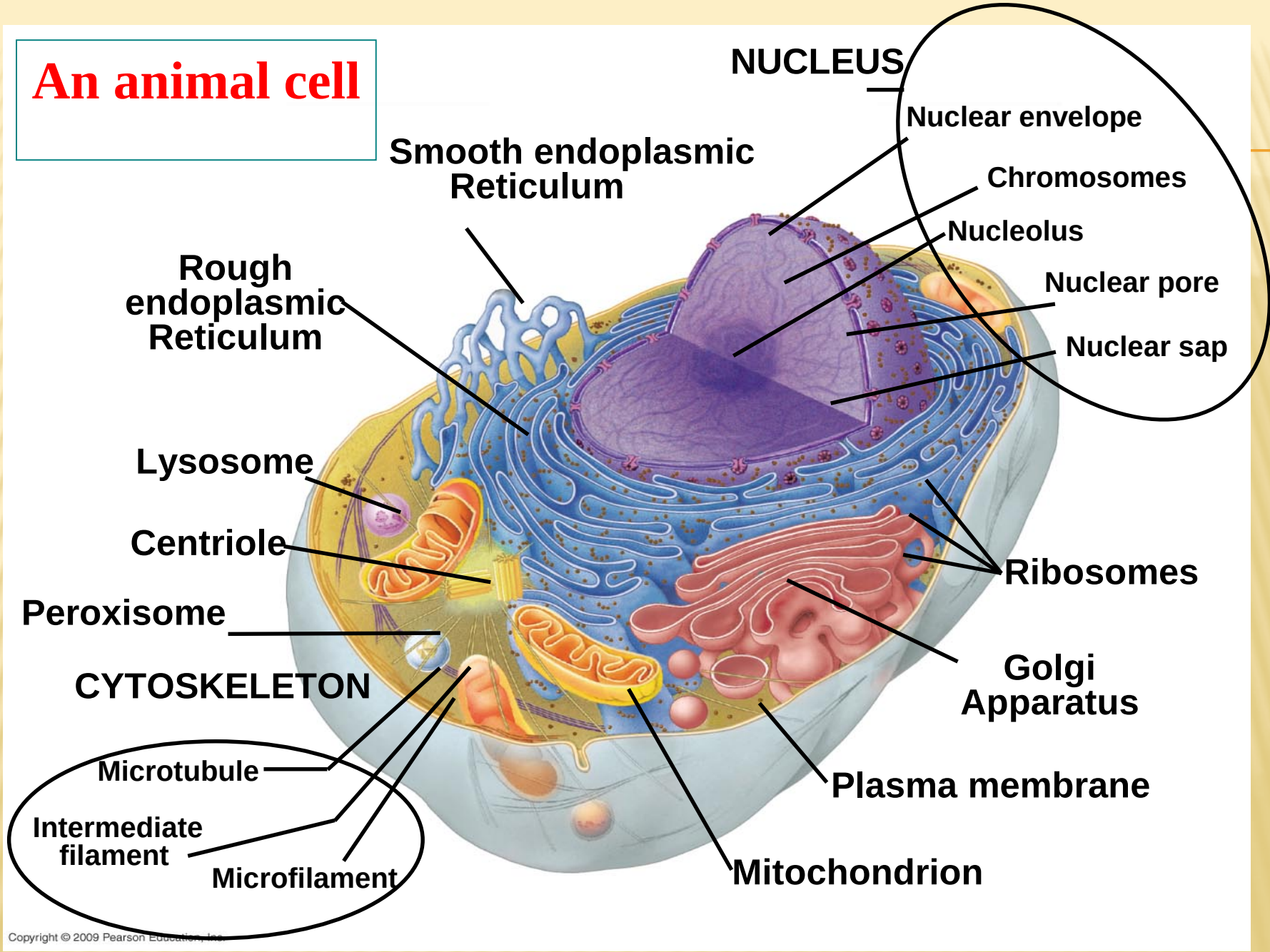
Although there are many similarities between animal and plant cells, differences exist

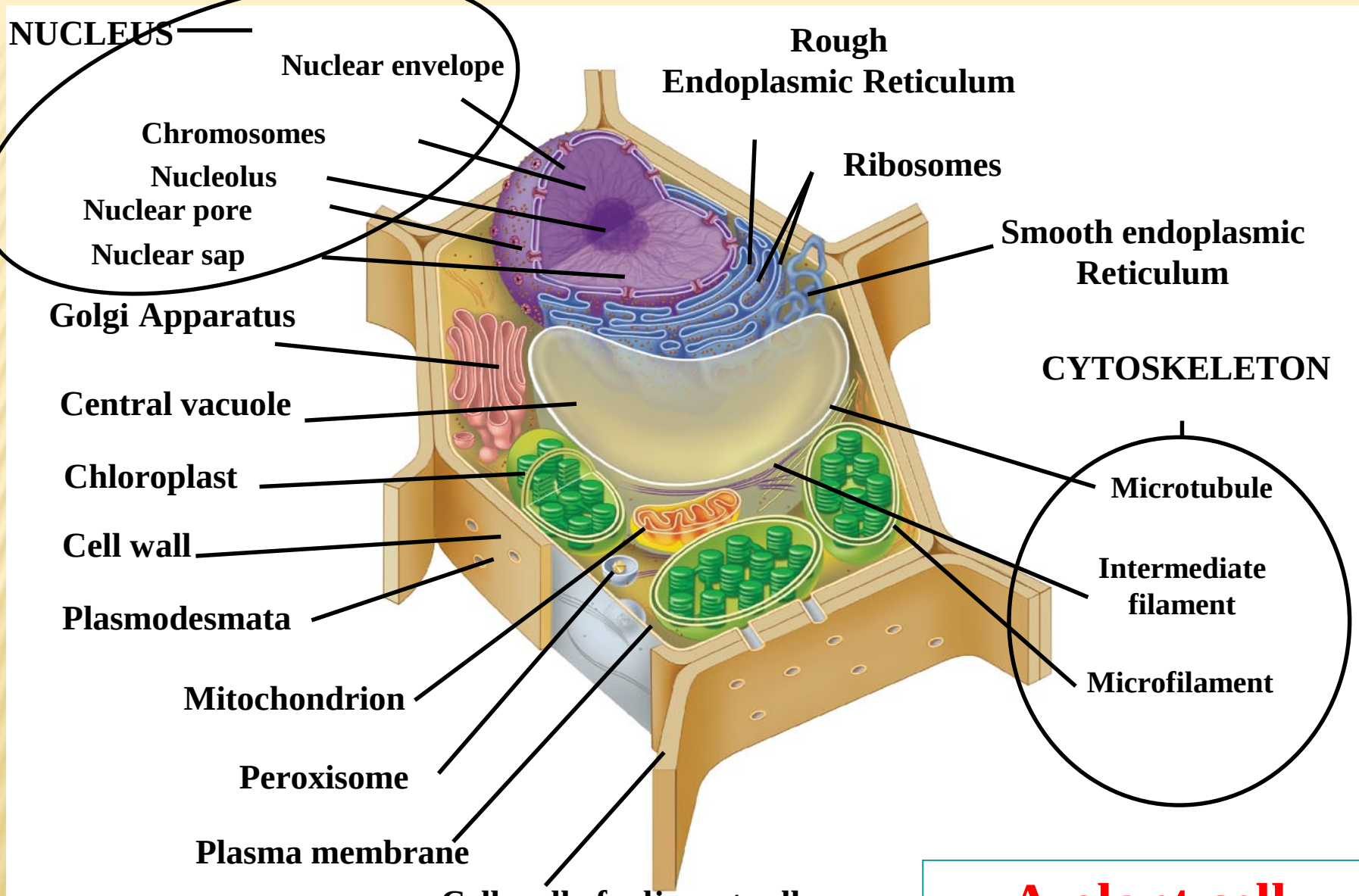
Animal cells	Plant cells
Relatively smaller in size	Relatively larger in size
Lysosomes and centrioles are found in animal cells	Lysosomes and centrioles are not found in plant cells
No cell wall, No chloroplasts	Cell wall and chloroplasts present

Differences between Plant Cells and Animal Cells

Animal cells	Plant cells
Vacuole small or absent	Large central vacuole
Glycogen as food storage	Starch as food storage
Nucleus at the center of the cell	Nucleus near cell wall

An animal cell





A plant cell

Cell Structures

1. Plasma membrane
2. Cytoplasm
3. Nucleus
4. Ribosomes
5. Endoplasmic Reticulum – ER
6. Golgi apparatus
7. Lysosomes
8. Vacuoles
9. Endomembrane System
10. Mitochondria
11. Chloroplasts
12. Cytoskeleton
13. Cilia and flagella
14. Extracellular matrix (ECM)
15. Cell junctions

The structure of plasma membranes

The plasma membrane controls the movement of molecules into and out of the cell, a trait called

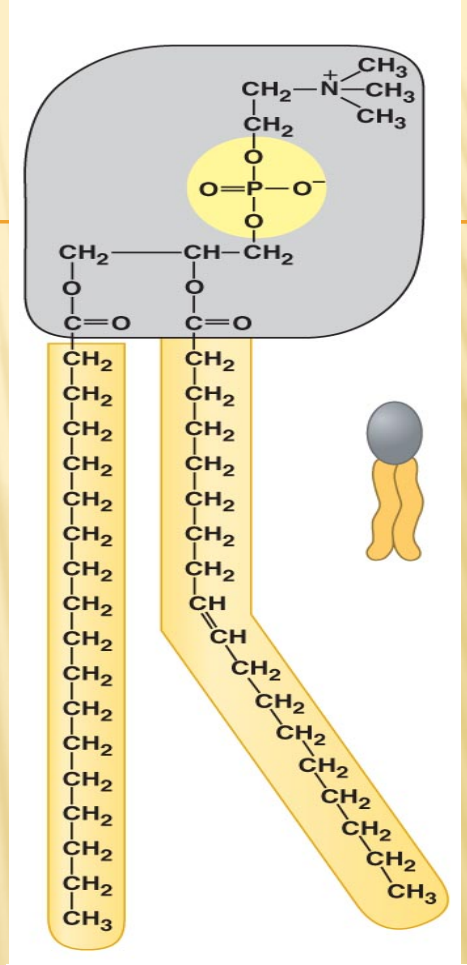
Selective Permeability

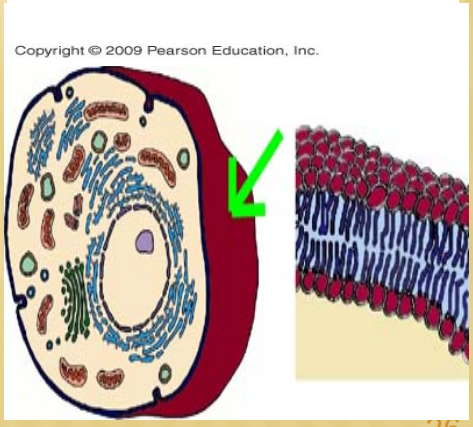
The structure of the membrane with its component molecules is responsible for this characteristic

Membranes are made of lipids, proteins, and some carbohydrates, but the most abundant lipids are phospholipids

Phospholipids

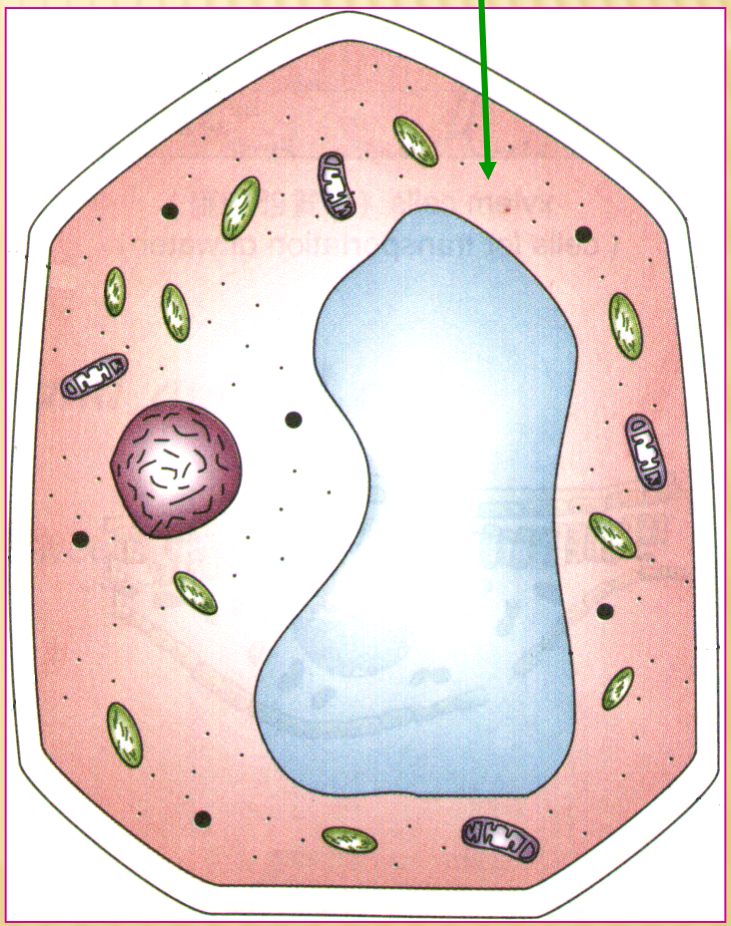
- Heads contain glycerol & phosphate and are hydrophilic (attract water)
- Tails are made of fatty acids and are hydrophobic (repel water)
- Make up a bilayer where tails point inward toward each other
- Can move laterally to allow small molecules (O_2, CO_2, & H_2O to enter)





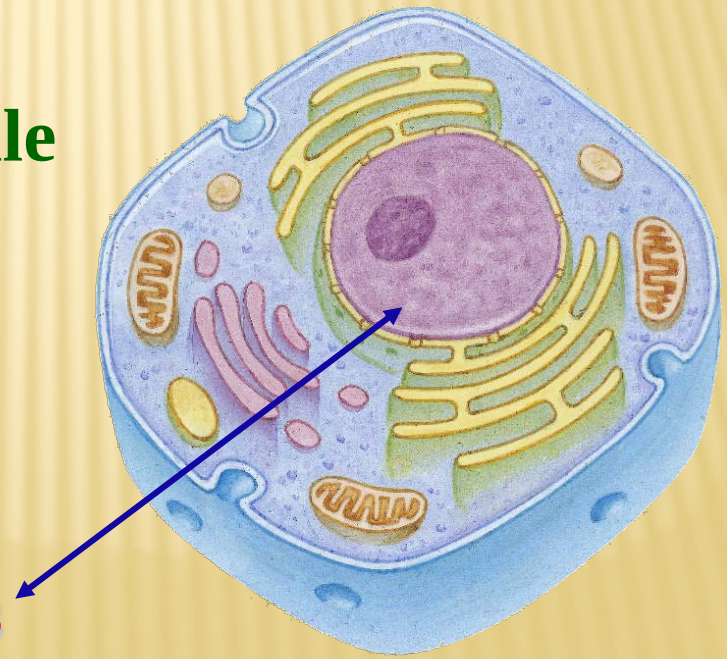
Cytoplasm of a Cell

- Jelly-like substance enclosed by cell membrane
- Provides a medium for chemical reactions to take place
- Contains organelles to carry out specific jobs
- Found in ALL cells



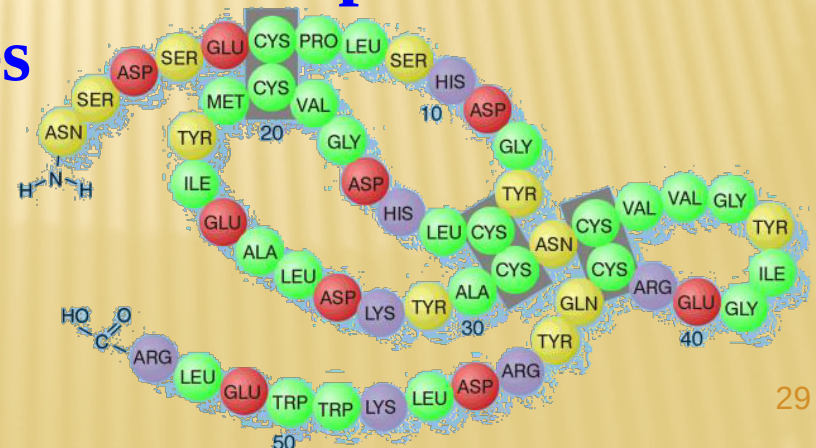
The Control Organelle (The Nucleus)

- Controls the normal activities of the cell
- Contains the DNA in chromosomes
- Bounded by a nuclear envelope (membrane) with pores
- Usually the largest organelle



Ribosomes

- Made of Proteins and rRNA
- Ribosomes are synthesized in the nucleolus, which is found in the nucleus
- "Protein factories" for cell
- Join amino acids to make proteins, Process called protein synthesis
- Cells that synthesize large amounts of protein have a large number of ribosomes



Ribosomes

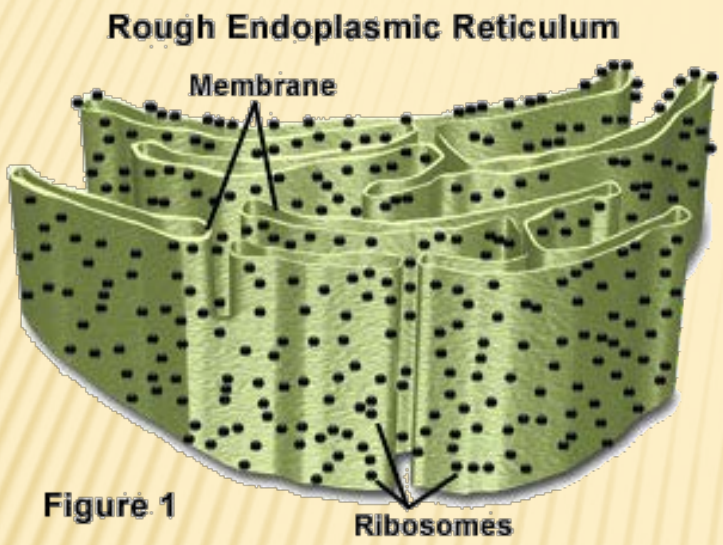
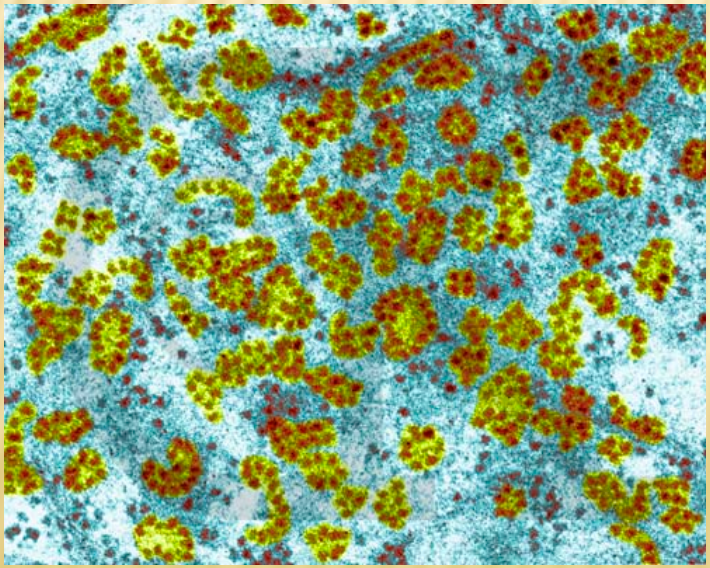


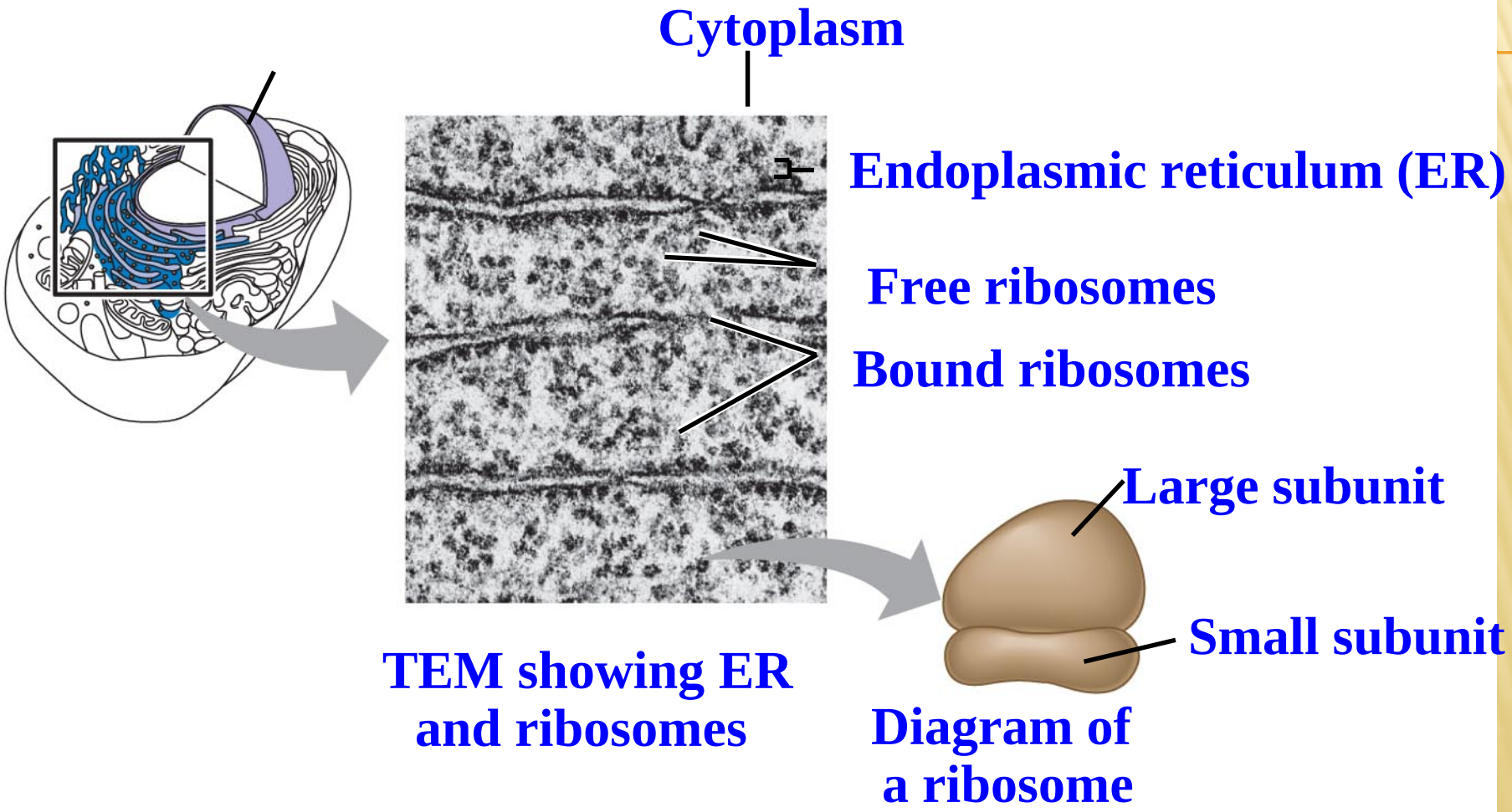
Figure 1

Can be attached to endoplasmic reticulum ER & makes proteins to export

OR



Be free (unattached) in the cytoplasm & makes proteins USED In the cell



Ribosomes

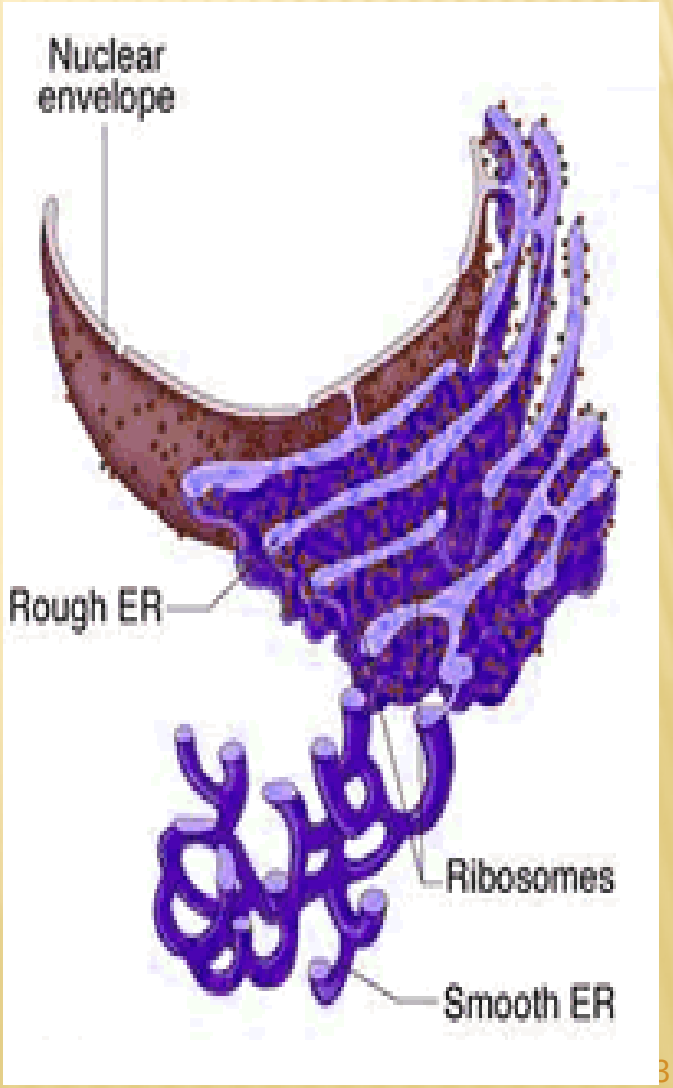
Endoplasmic Reticulum - ER

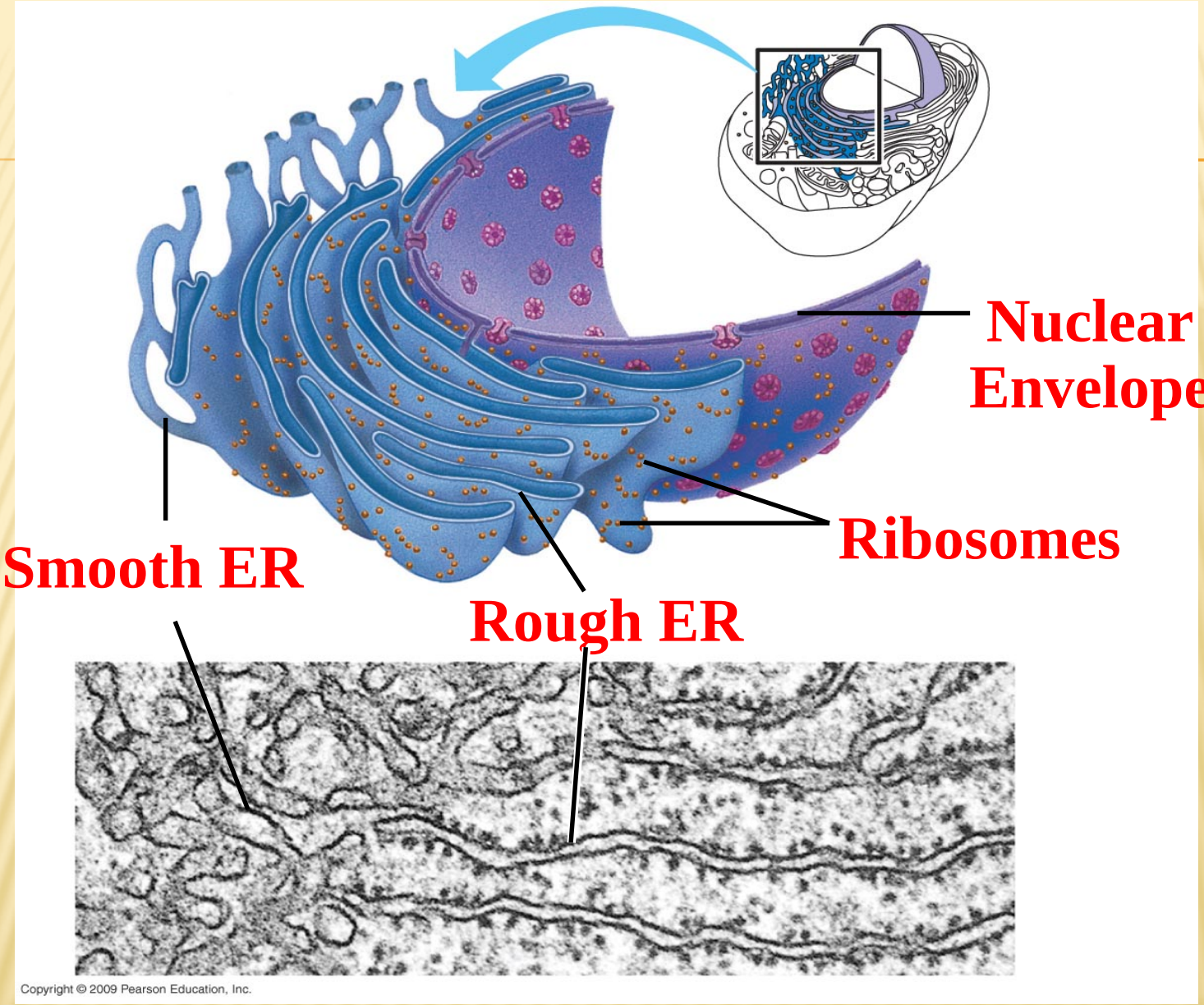
- Network of hollow membrane tubules
- Connect to nuclear envelope & cell membrane
- Function in Synthesis of cell products & Transport

The endoplasmic reticulum

Smooth & Rough Endoplasmic Reticulum

- There are two kinds of endoplasmic reticulum - smooth and rough
- *Smooth ER* lacks ribosomes
- *Rough ER* has ribosomes on its surface





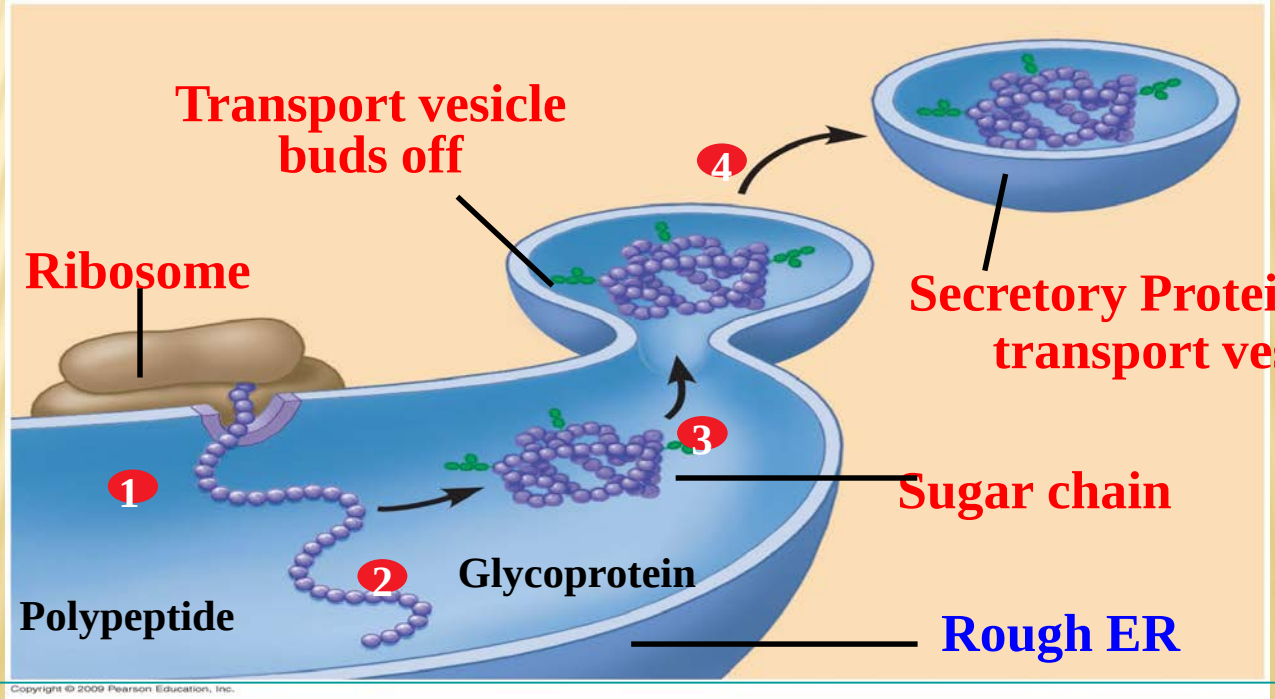
Smooth and rough endoplasmic reticulum

The Smooth Endoplasmic Reticulum SER

- **Smooth ER is involved in a variety of diverse metabolic processes**
  - **For example, enzymes of the smooth ER are involved in the synthesis of**
    - **Lipids**
    - **Oils**
    - **Phospholipids**
    - **Steroids and destroys toxic substances (liver)**

The Rough Endoplasmic Reticulum RER

- **Rough ER makes additional membrane for itself and proteins destined for secretion**
- **Once proteins are synthesized by ribosomes attached to ER, they are modified in the ER lumen then transported in vesicles to other parts of the endomembrane system**

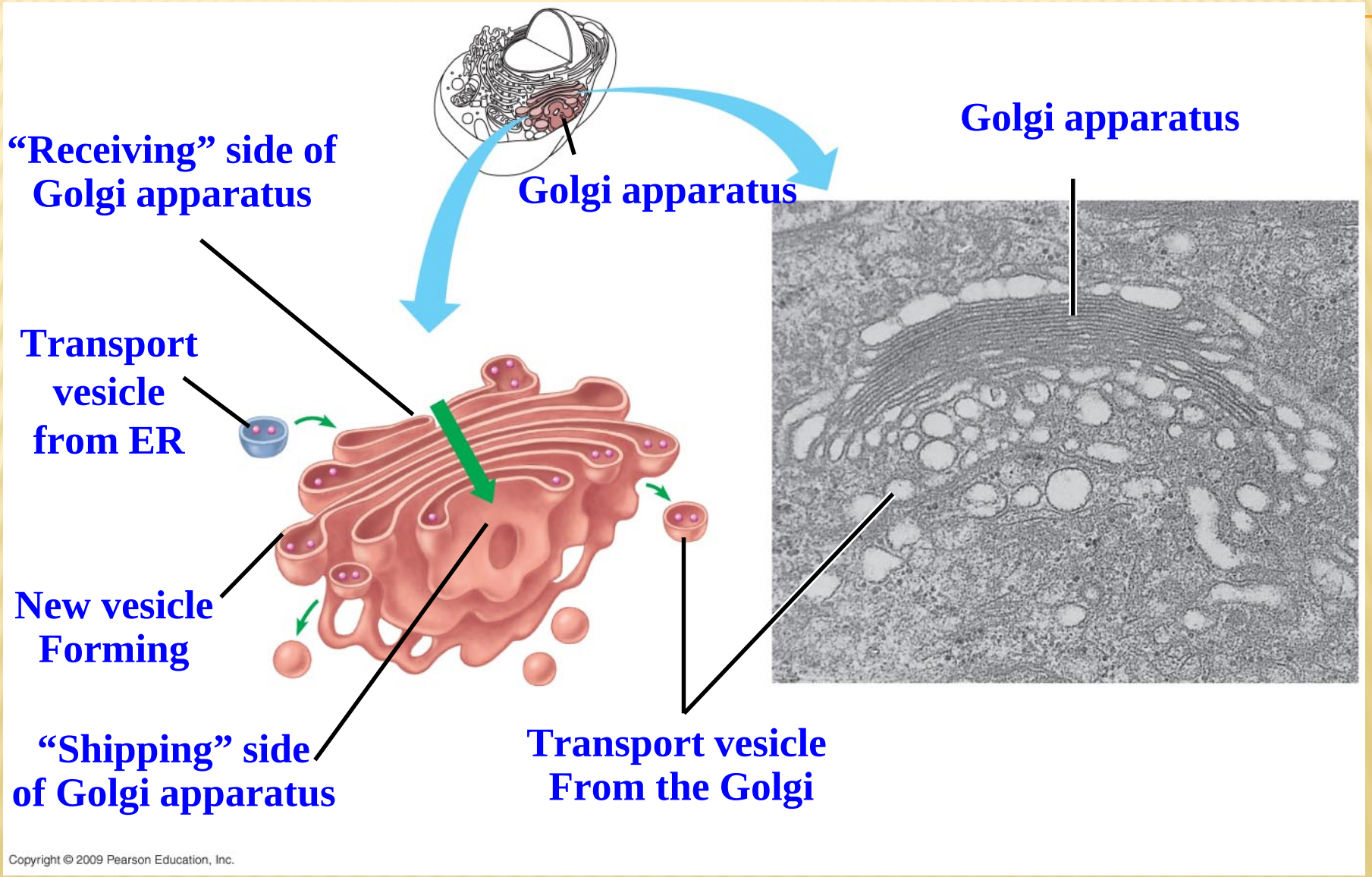


Synthesis and packaging of a secretory protein by the rough ER

The Golgi apparatus

- The Golgi apparatus is Stacks of flattened sacs
- Functions in conjunction with the ER
- Receive & modify proteins made by ER
  - Products travel in transport vesicles from the ER to the Golgi apparatus
  - Products are modified as they go from one side of the Golgi apparatus to the other and travel in vesicles to other sites

The Golgi apparatus

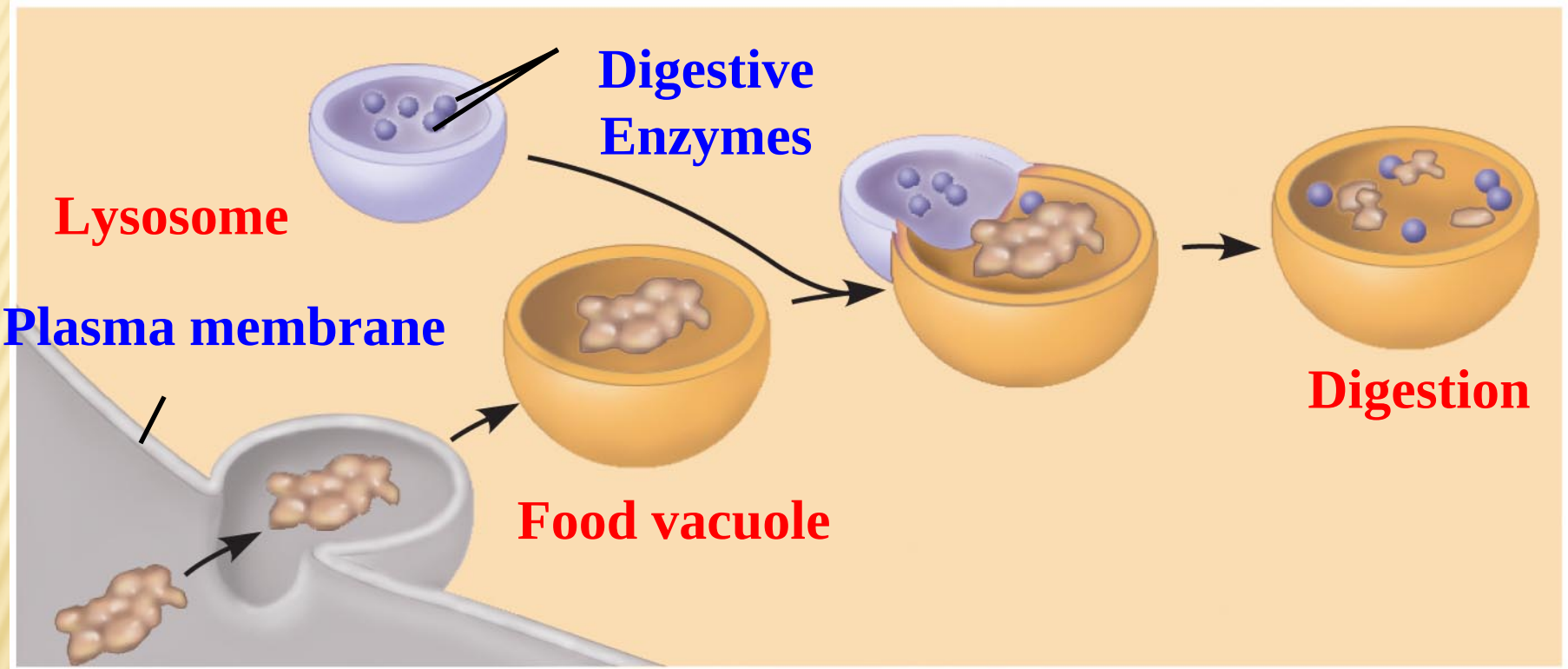


Lysosomes

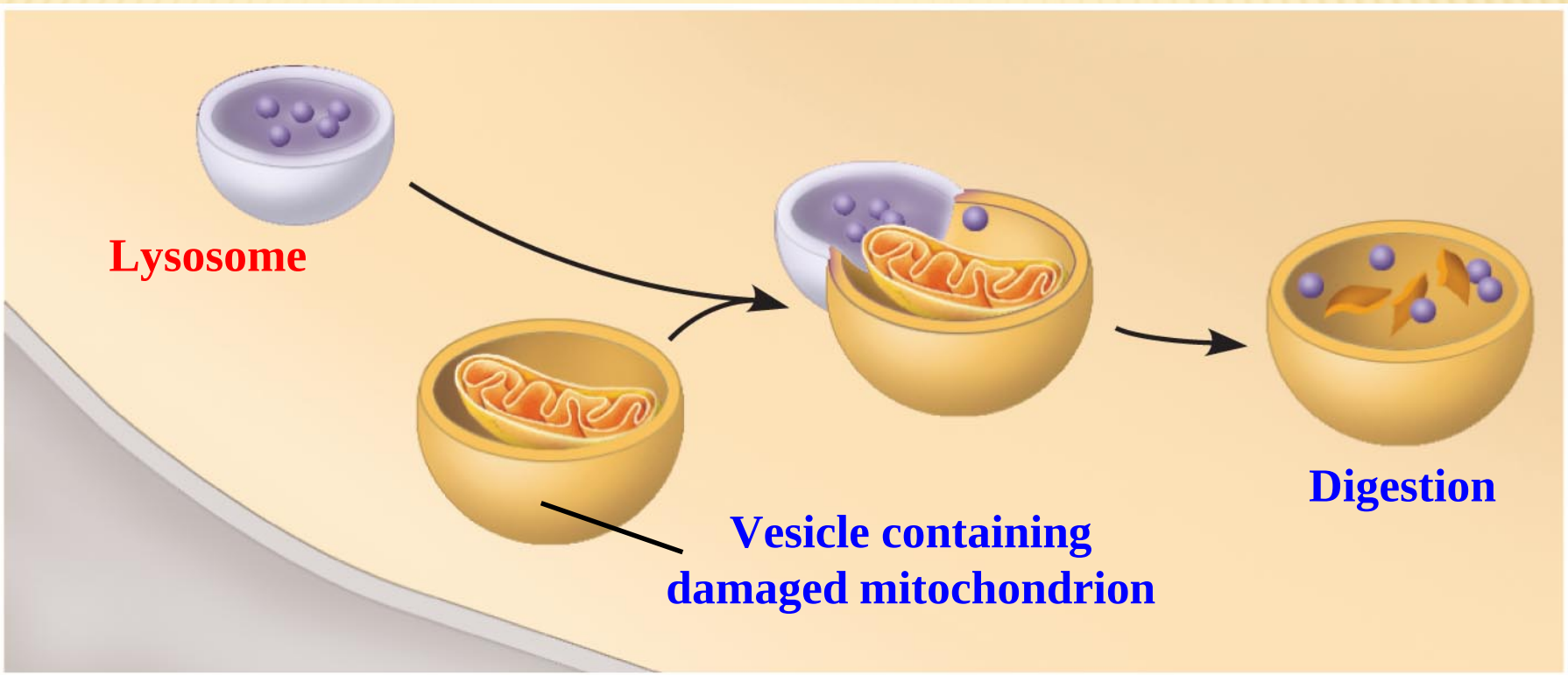
- A lysosome is a membranous sac;
- Contains digestive enzymes
- Breaks down food, bacteria, and worn out cell parts
- Breaks down and recycles cell parts

Lysosomes are digestive compartments

- The enzymes and membrane are produced by the ER and transferred to the Golgi apparatus for processing
- The membrane serves to safely isolate these potent enzymes from the rest of the cell
- One of the several functions of lysosomes is to remove or recycle damaged parts of a cell
  - The damaged organelle is first enclosed in a membrane vesicle
  - Then a lysosome fuses with the vesicle, dismantling its contents and breaking down the damaged organelle



Lysosome fusing with a food vacuole and digesting food

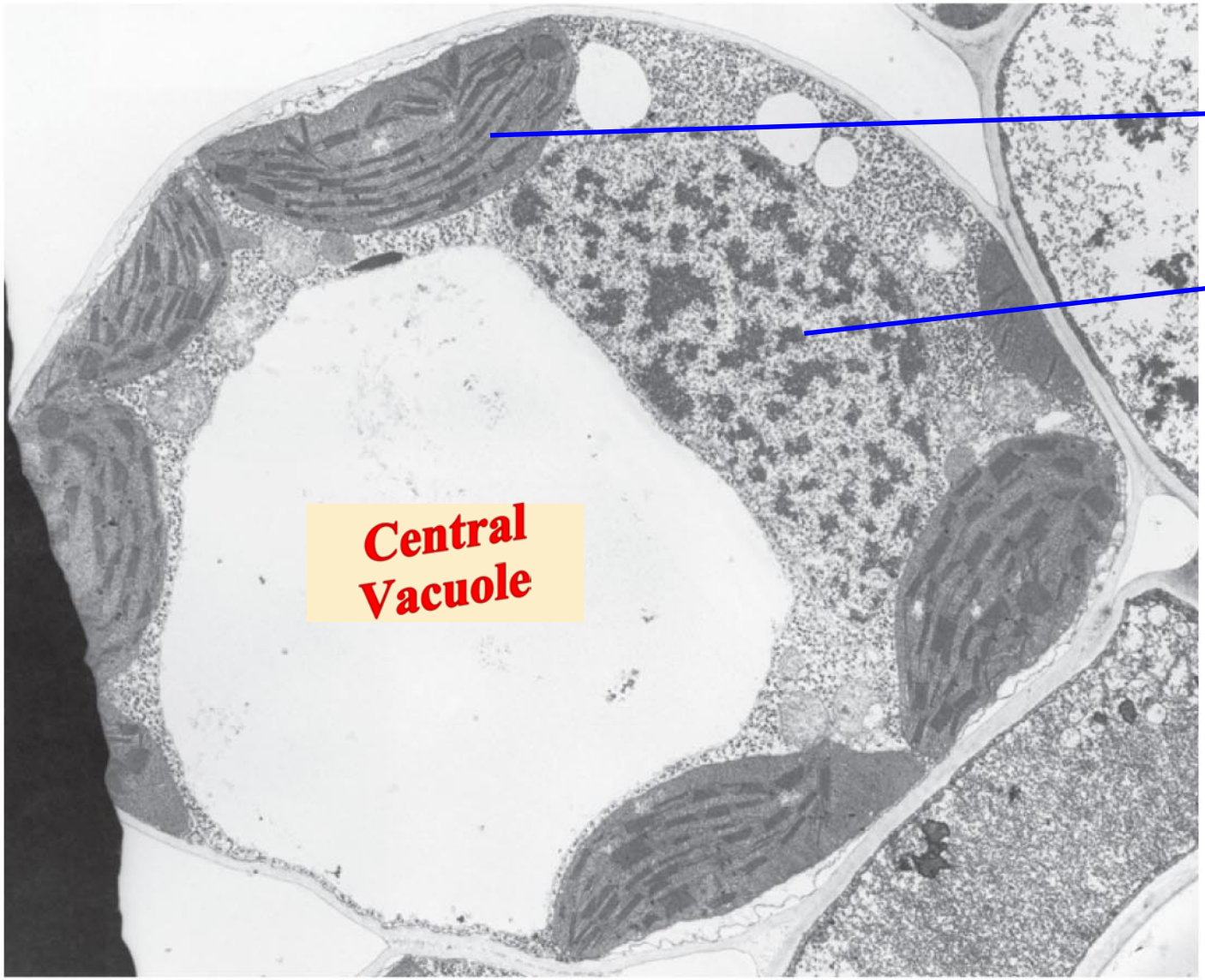


Lysosome fusing with vesicle containing damaged organelle and digesting and recycling its contents

Vacuoles

- **Vacuoles are membranous sacs that are found in a variety of cells and possess an assortment of functions**
  - **Examples are the central vacuole in plants with hydrolytic functions**
  - **Pigment vacuoles in plants to provide color to flowers**
  - **Contractile vacuoles in some protists to expel water from the cell**

Central vacuole in a plant cell

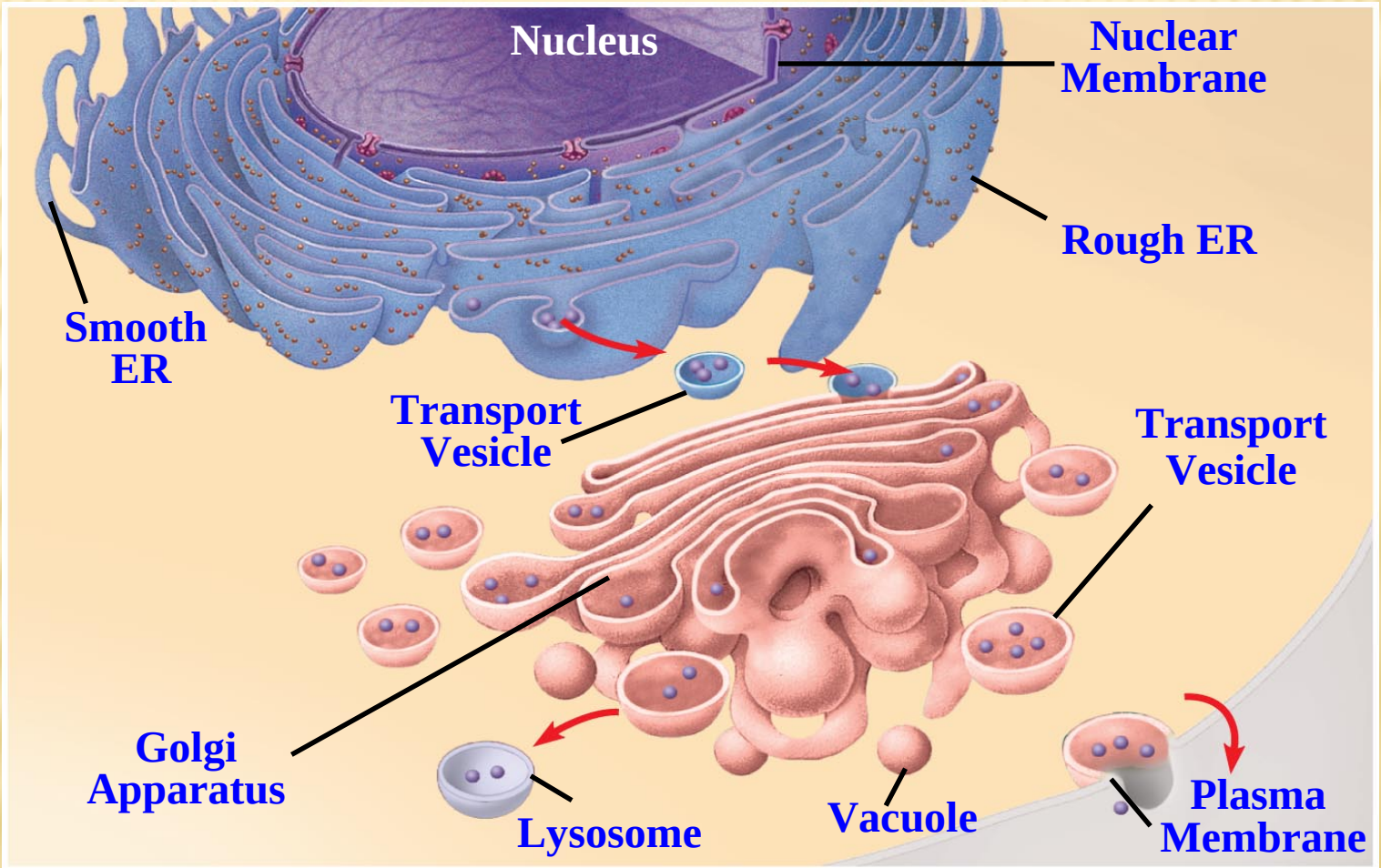


Endomembrane System

- The membranes within an Eukaryotic cell are physically connected directly or indirectly and compose the endomembrane system
- The endomembrane system includes
  1. The nuclear membrane (envelope),
  2. Endoplasmic reticulum (ER),
  3. Golgi apparatus,
  4. Lysosomes
  5. Vacuoles, and
  6. The plasma membrane

Endomembrane System

The following figure summarizes the relationships among the major organelles of the endomembrane system

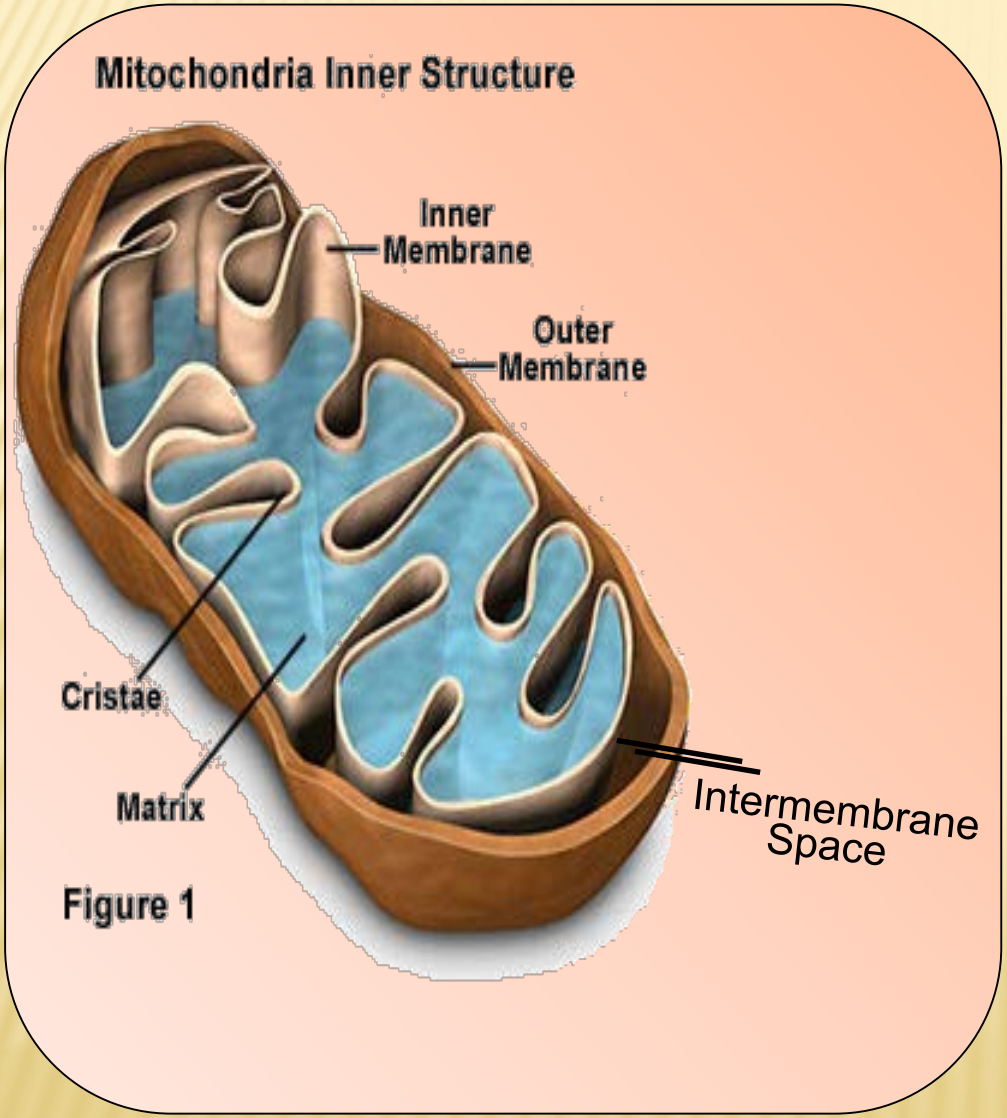


Connections among the organelles of the endomembrane system

Mitochondria

- **"Powerhouse" of the cell**
- **Generate cellular energy** (adenosine triphosphate) **(ATP)**
- **More active cells like muscle cells have more mitochondria**
- **Both plants & animal cells have mitochondria**
- **Site of cellular respiration (burning glucose)**

Mitochondria



Surrounded by a DOUBLE membrane

Has its own DNA

Folded inner membrane called cristae (increases surface area for more chemical Reactions)

Interior called matrix

Mitochondria harvest chemical energy from food

- **Cellular respiration is accomplished in the mitochondria of eukaryotic cells**
  - **Cellular respiration involves conversion of chemical energy in foods to chemical energy stored in ATP (adenosine triphosphate)**
  - **Mitochondria have two internal compartments**
  - **The intermembrane space, which encloses the mitochondrial matrix where materials necessary for ATP generation are found**

Chloroplasts

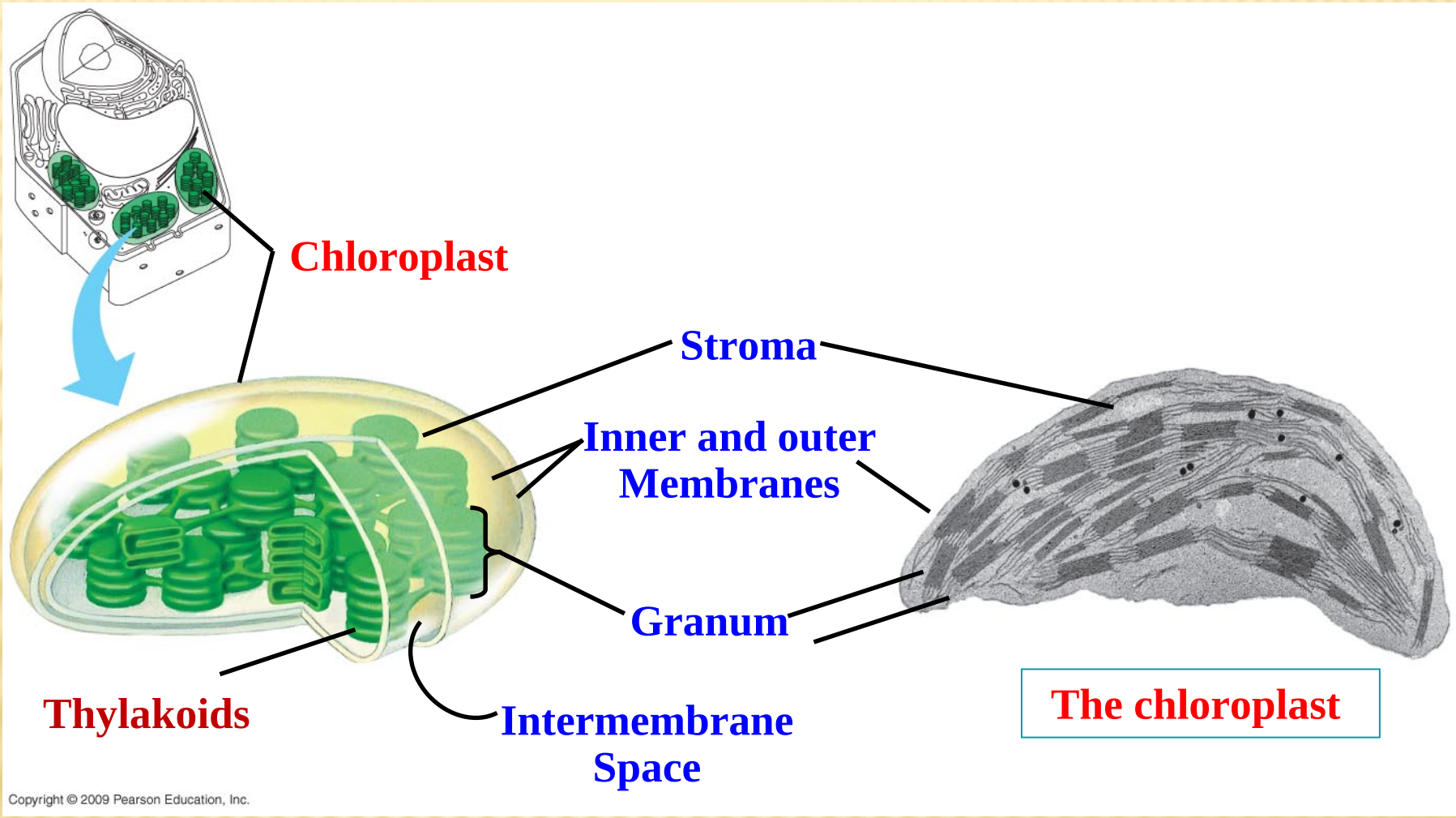
- Found only in producers (organisms containing chlorophyll) like plants
- Producers use energy from sunlight to make their own food (Glucose)
- Energy from sun stored in the Chemical Bonds of Sugars

Chloroplasts

- Surrounded by DOUBLE membrane
- OUTER & INNER membrane
- Thylakoids in Stacks Called GRANA & interconnected
- STROMA – are gel-like material surrounding thylakoids

Chloroplasts

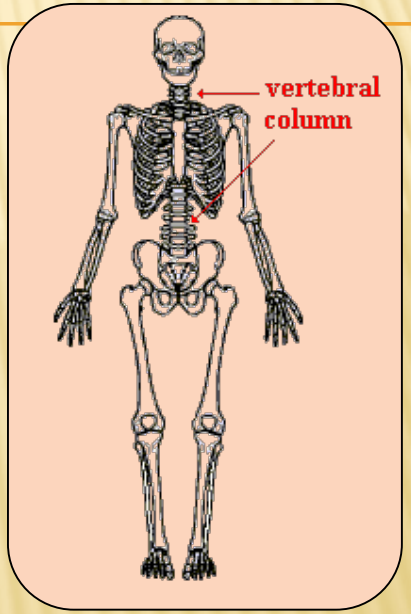
- Contains its own DNA
- Contains enzymes & pigments for Photosynthesis
- Never found in animal or bacterial cells
- Photosynthesis – food making process



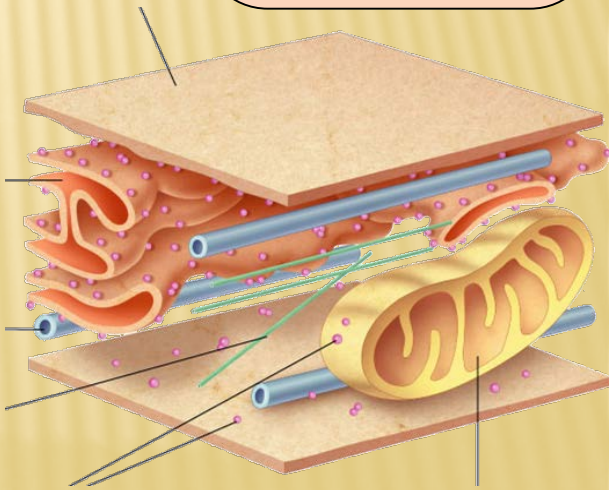
INTERNAL AND EXTERNAL SUPPORT:

THE CYTOSKELETON AND CELL SURFACES

Cytoskeleton



- Cells contain a network of protein fibers, called the cytoskeleton, that functions in
  - Helps cell maintain cell shape
  - Also, helps move organelles around



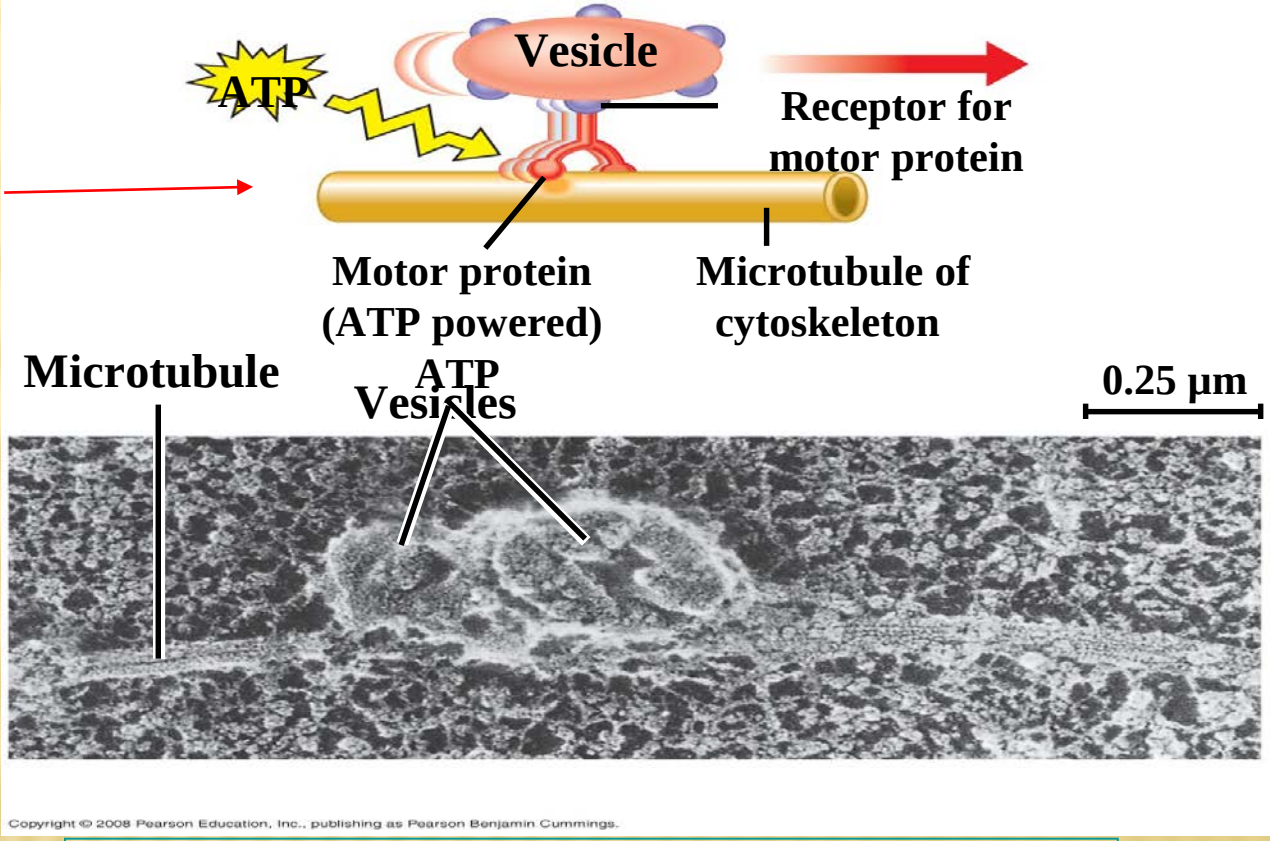
The cell's internal skeleton

- **The cytoskeleton is composed of three kinds of fibers**
  - **Microfilaments (*actin filaments*) support the cell's shape and are involved in motility made of *ACTIN***
  - **Intermediate filaments reinforce cell shape and anchor organelles**
  - **Microtubules (made of *TUBULIN*) shape the cell and act as tracks for motor protein**

The cell's internal skeleton

Motility and cellular regulation result when the cytoskeleton interacts with proteins called motor proteins

Diagram



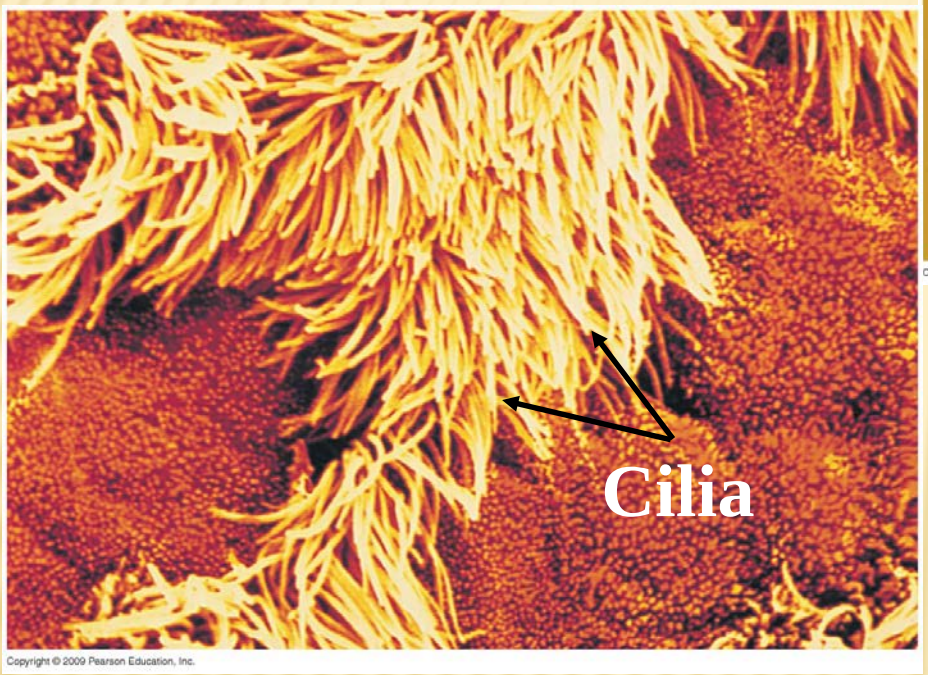
EM micrograph

Motor proteins and the cytoskeleton

Cilia and flagella

- Cilia and flagella are important in locomotion,
- Some cells of multicellular organisms have them for different reasons
- Cells that sweep mucus out of our trachea have cilia
- Animal sperm are flagellated
- Flagella and cilia are composed of microtubules
- They move when microtubules bend

Undulating flagellum on a sperm cell



Cilia on cells lining the respiratory tract

Cilia and flagella move when microtubules bend

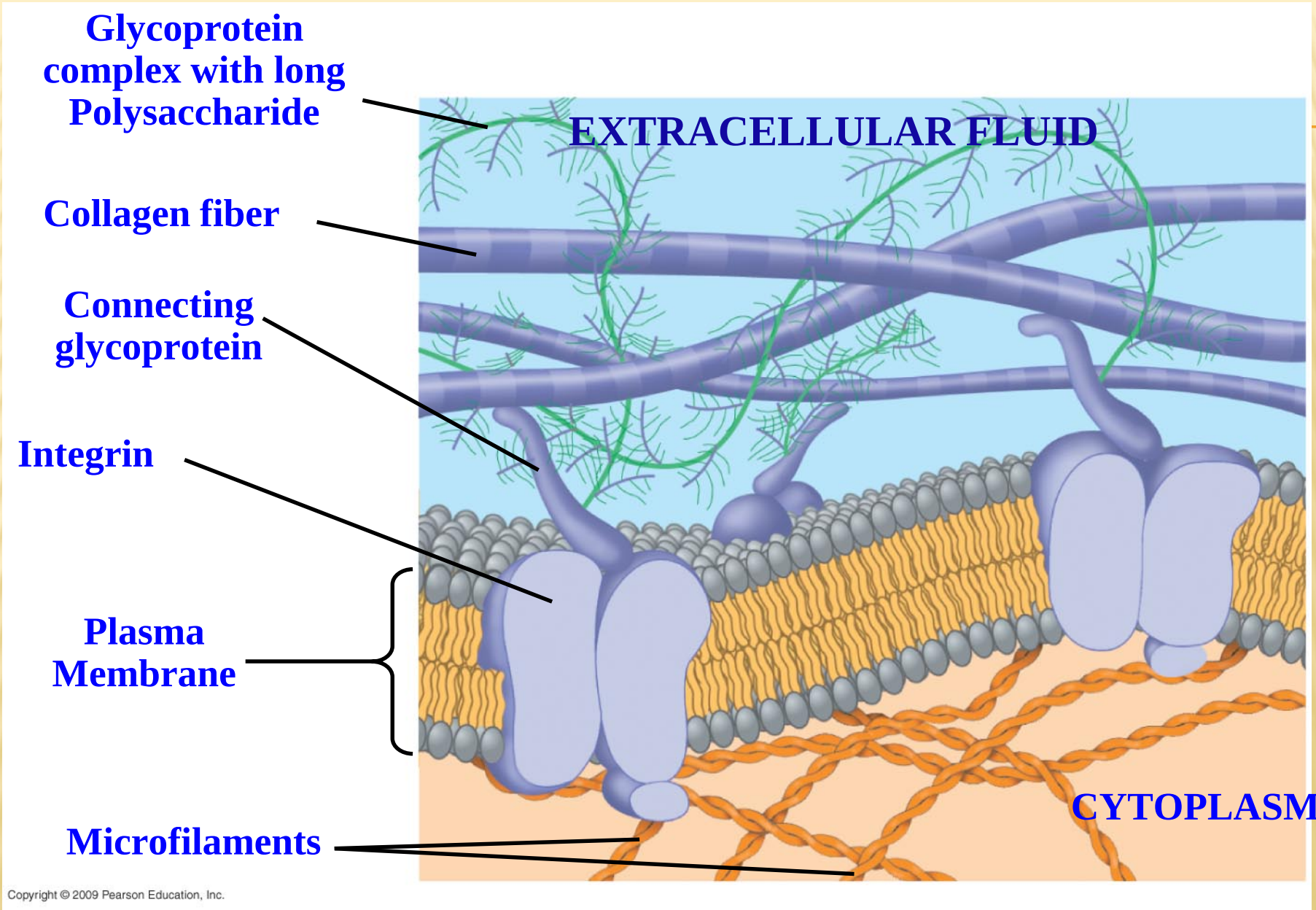
- Although differences exist, flagella and cilia have a common structure and mechanism of movement, except that Cilia are short and flagella are longer and fewer

The extracellular matrix of animal cells functions in support, movement, and regulation

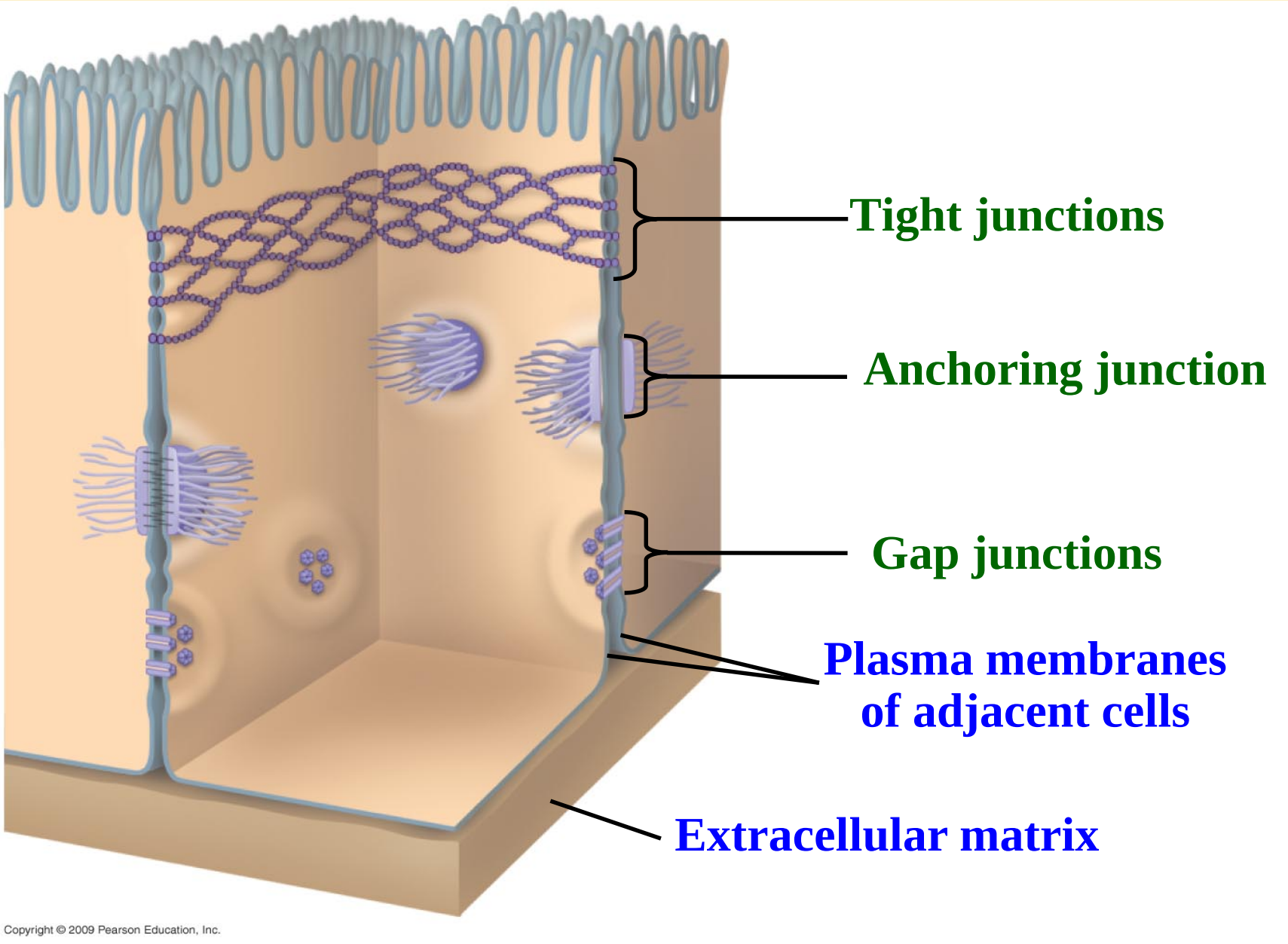
- Cells synthesize and secrete the extracellular matrix (ECM) that is essential to cell function
  - The ECM is composed of strong fibers of collagen, which holds cells together and protects the plasma membrane
  - ECM attaches through connecting proteins that bind to membrane proteins called integrins
  - Integrins span the plasma membrane and connect to microfilaments of the cytoskeleton

Cell junctions of animal tissues

- **Adjacent cells communicate, interact, and adhere through specialized junctions between them**
  - **Tight junctions prevent leakage of extracellular fluid across a layer of epithelial cells**
  - **Anchoring junctions fasten cells together into sheets**
  - **Gap junctions are channels that allow molecules to flow between cells**



The extracellular matrix (ECM) of an animal cell



Three types of cell junctions in animal tissues