Biology High School

For Standardized Scholastic Tests

EST2-ACT2- Biology

Coursework

2024-2025

Dr. Mohamed Kabbany

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.1

History of Cellular Theory
and size of Cells

Lesson 1.4- Topics:

	1.4- Cell Structure and Function
1	History of Cell Theory and Size of the cells
2	Prokaryotes and Eukaryotes
3	Endosymbiosis
4	Neucleus and Nucleolus
5	Cytoplasm and Cytosole
6	Ribosomes
7	Endoplamic Reticulum
8	Golgi Apparatus
9	Lysosomes
10	Mitochoncdria
11	Vacuoles and vesicles
12	Plastids
13	Cytoskeleton
14	Cell Wall
15	Animal and Plant Cell
16	Cell Structure ad Function Mix

* History of the cell theory:

Anton van Leeuwenhoek,
using lenses he crafted, was the first person to observe and document living cells.

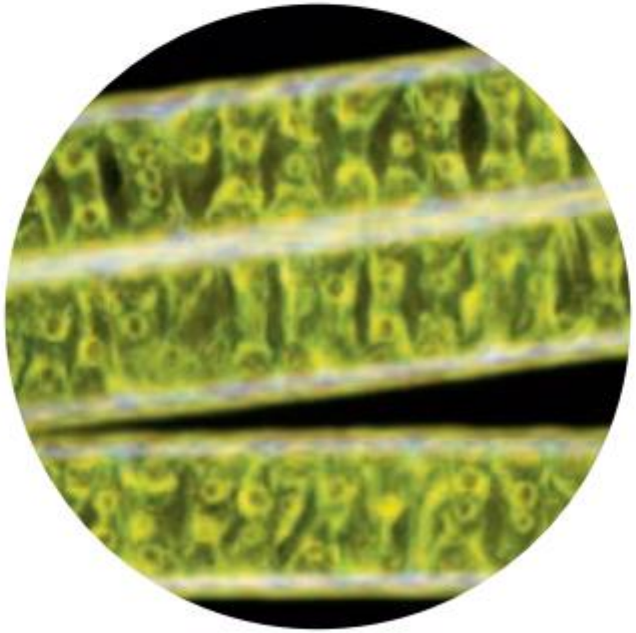
Robert Hooke
developed a microscope that enabled him to study cork tissue.
He named the “cell.”

Matthias Schleiden (a botanist)
concluded that all plants are made of cells.

Theodor Schwann (a zoologist)
all animals are made of cells.

Rudolf Virchow (a pathologist)
Every cell comes from a pre-existing cell.

(a)



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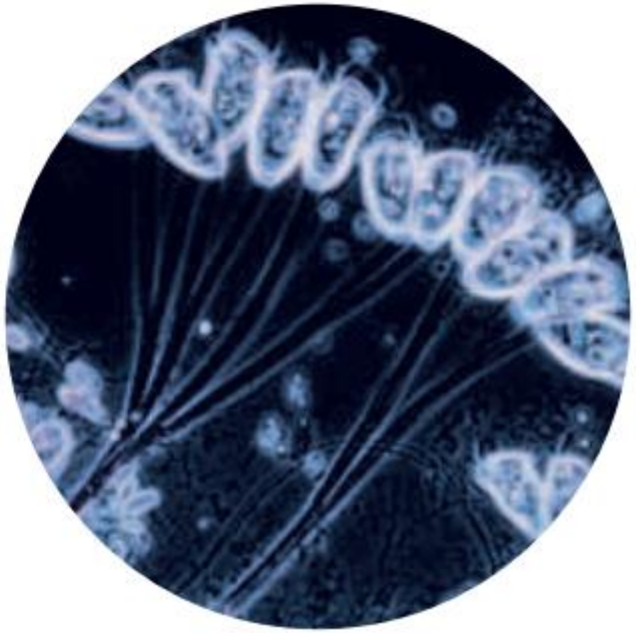
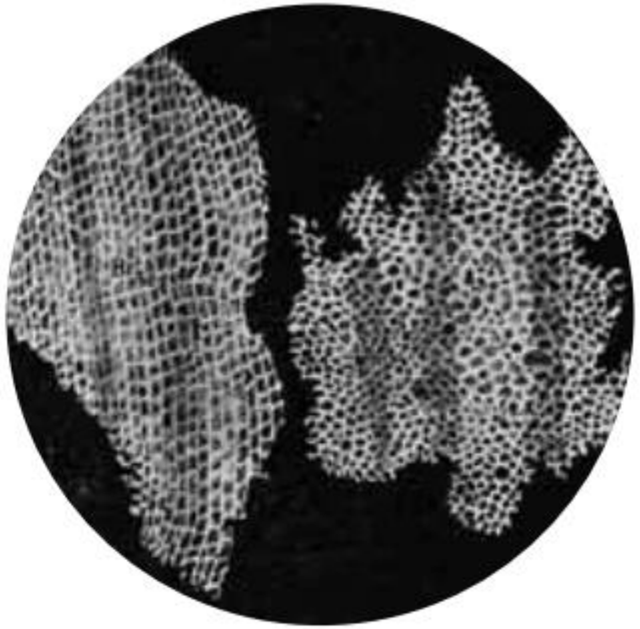


(c)

Anton van Leeuwenhoek (1632–1723) is shown here with one of his hand-held lenses (a).
Leeuwenhoek observed an alga of the genus Spirogyra (b) and a protist of the genus Vorticella (c).

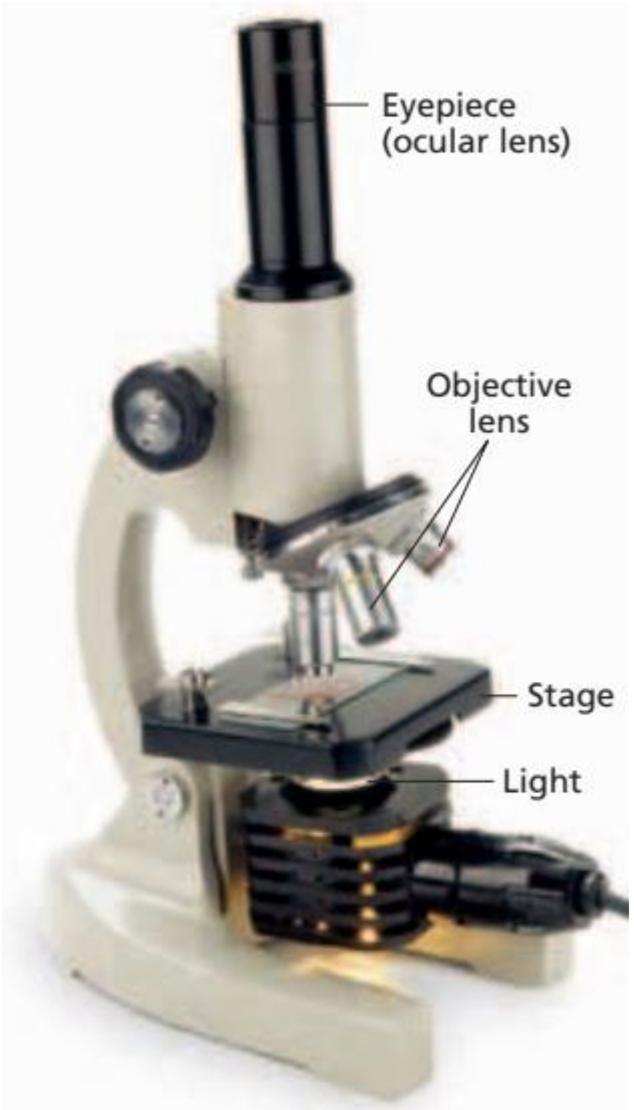
(a)

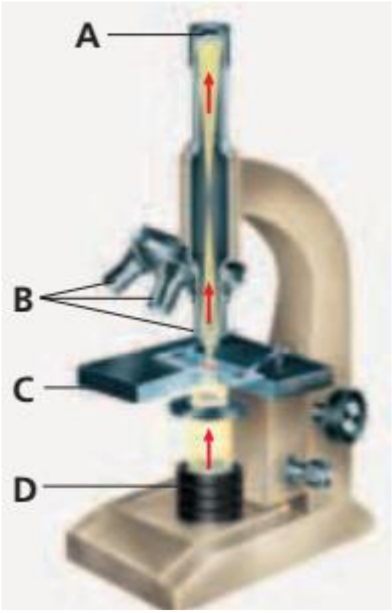


(b)

(c)

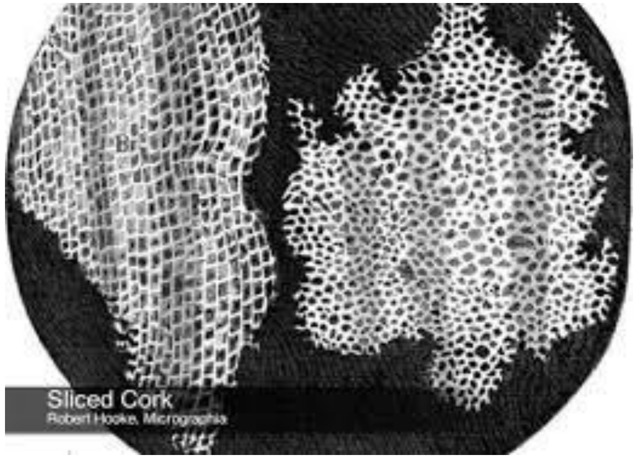
Robert Hooke used an early microscope
a) to see cells in thin slices of cork. His drawings of what he saw
(b) indicate that he had clearly observed the remains
of cork cells (300) (c).





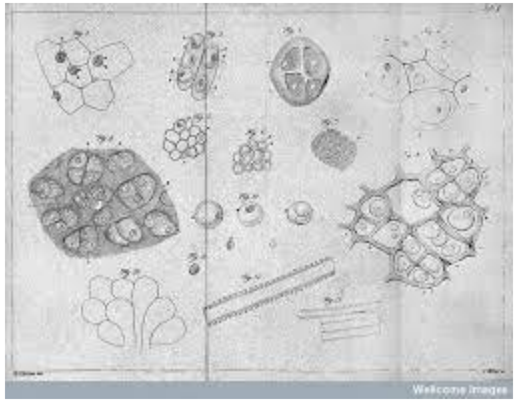
Compound light microscopes open the human eye to an interesting world including tiny pond organisms, healthy and diseased cells, and the functioning of cell parts.

Robert Hook.

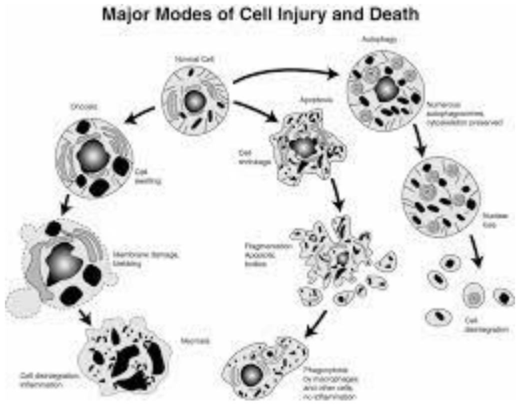


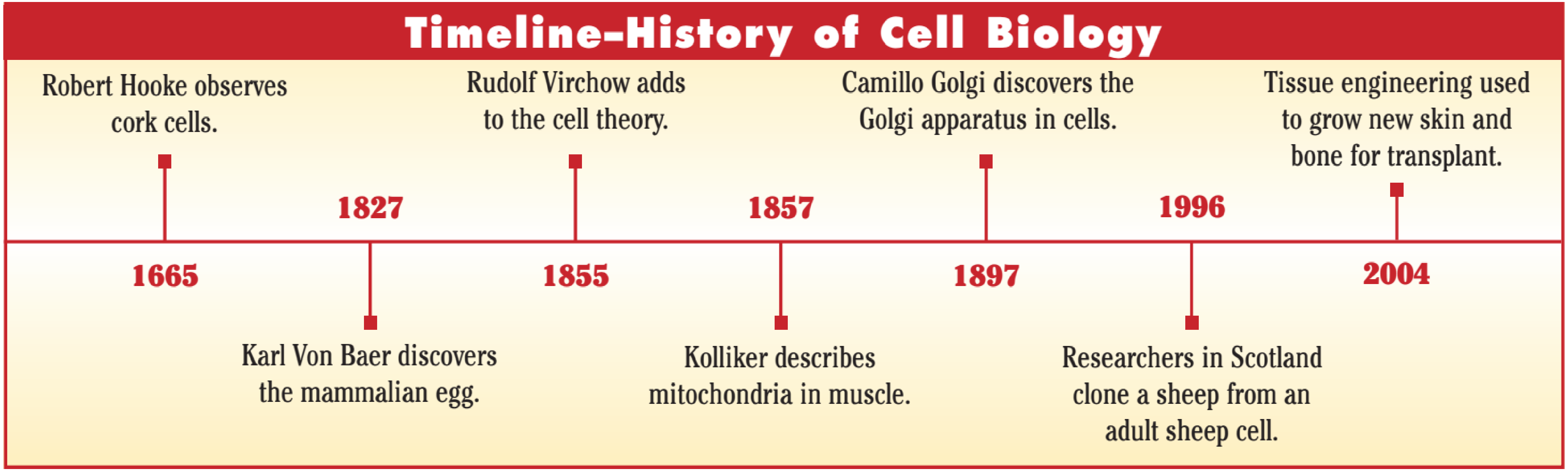
Matthias Schleiden, a Botanist.

Theodor Schwann, a zoologist



Rudolf Virchow, a pathologist





The study of cell biology began with the discovery of the cell by Robert Hooke in 1665. Since then, constantly improving technology has allowed scientists to unlock the secrets of the cell.

CELL THEORY

Modern cell theory states:

- All living things are composed of cells
- Cells are the basic unit of all organisms
- All cells arise from preexisting cells

Animal cells are generally small in size when compared to the plant cell, on average they are 10 - 20 µm (micrometers) in diameter. A red blood cell is about 8 µm.

Plant cells are large. 10-100 µm.

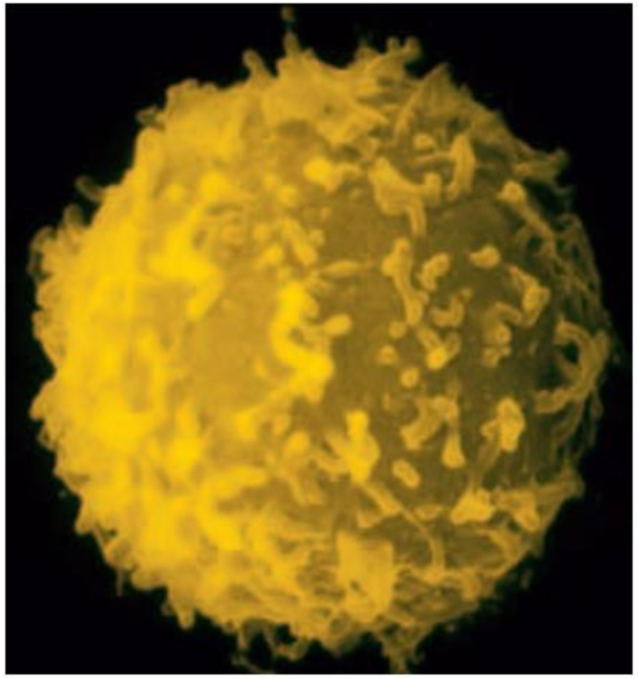
The bacterial cell is very small. It is about 0.5 - 5.0 µm in diameter almost about one-tenth the size of a eukaryotic cell.

However, the largest single cell on earth is an animal cell.

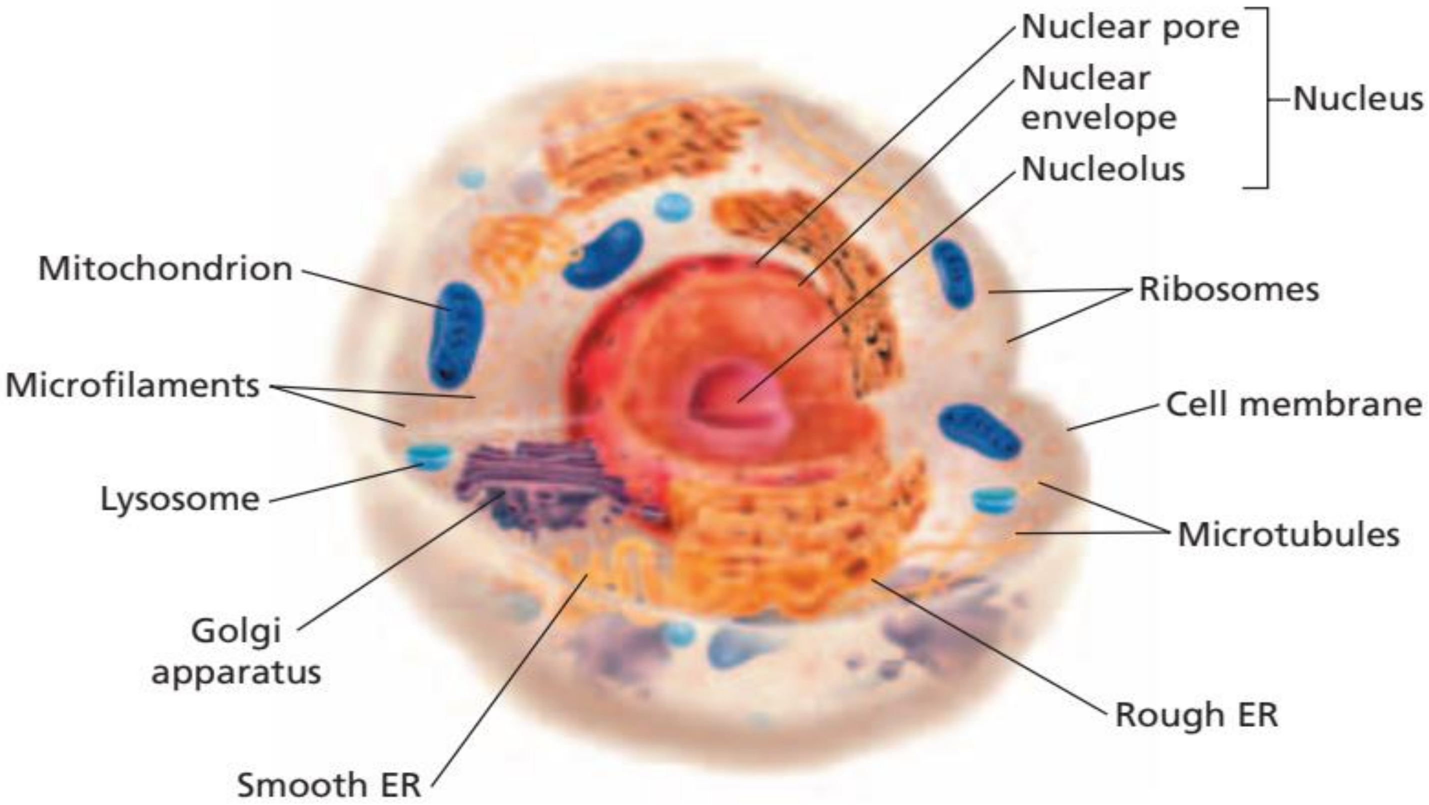
It is the ostrich egg. It is considered one cell

TABLE 1-2 ***Some SI prefixes***

Prefix	Abbreviation	Factor of base unit
giga	G	1,000,000,000 (10^9)
mega	M	1,000,000 (10^6)
kilo	k	1,000 (10^3)
hecto	h	100 (10^2)
deka	da	10 (10^1)
base unit		1
deci	d	0.1 (10^{-1})
centi	c	0.01 (10^{-2})
milli	m	0.001 (10^{-3})
micro	µ	0.000001 (10^{-6})
nano	n	0.000000001 (10^{-9})
pico	p	0.000000000001 (10^{-12})

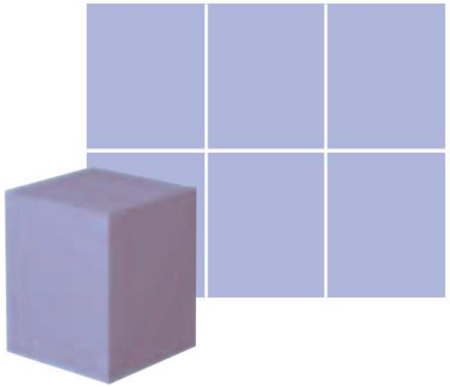


(a)

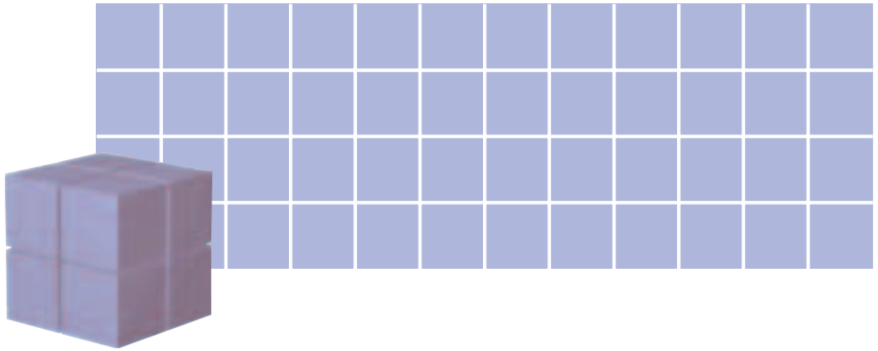


(b)

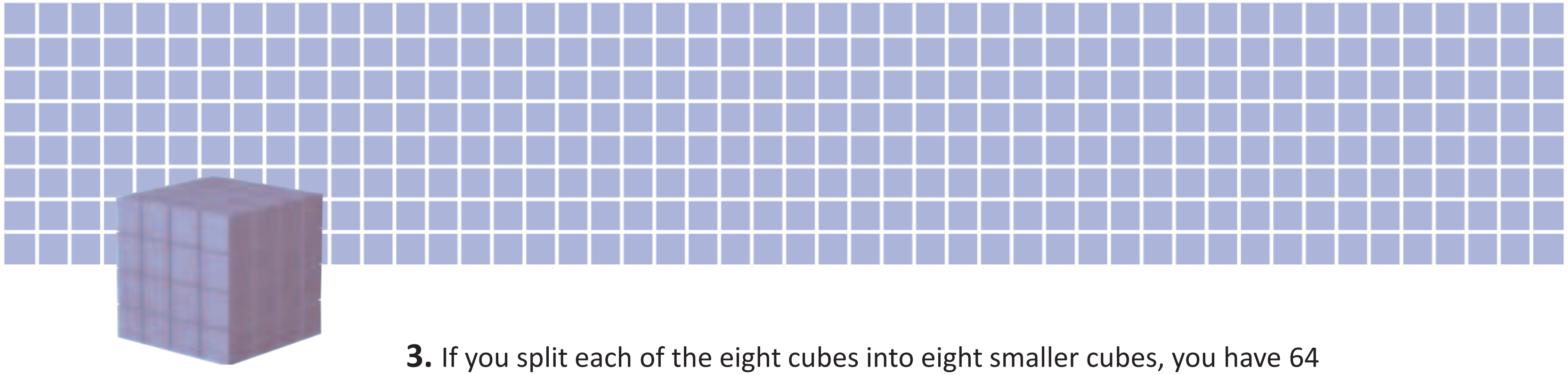
Most animal cells have a cell membrane, a nucleus, and a variety of other organelles embedded in a watery substance.
The surface of the cell membrane can be seen in (a).
The organelles inside the cell are labeled in the diagram (b).



1. All cubes have volume and surface area. The total surface area is equal to the sum of the areas of each of the six sides (area = length X width).



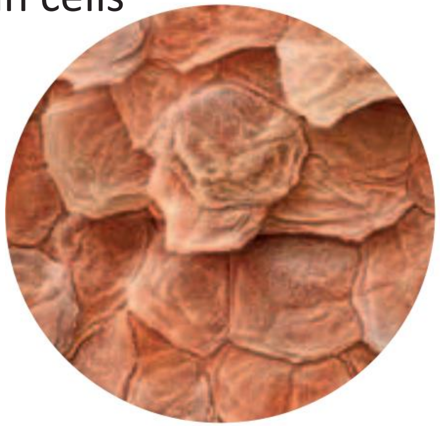
2. If you split the first cube into eight smaller cubes, you get 48 sides. The volume remains constant, but the total surface area doubles.



3. If you split each of the eight cubes into eight smaller cubes, you have 64 cubes that together contain the same volume as the first cube. The total surface area, however, has doubled again.

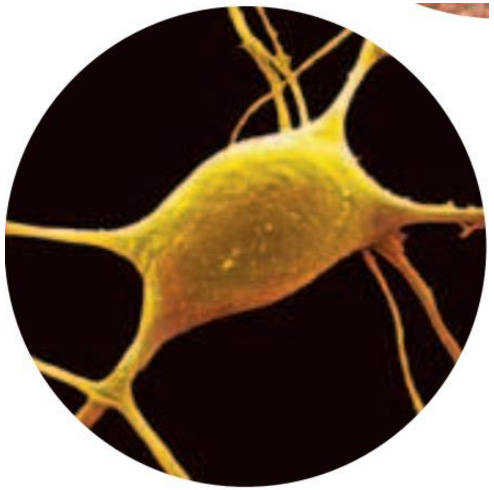
Small cells can exchange substances more readily than large cells because small objects have a higher surface area–to-volume ratio.

(b) Skin cells

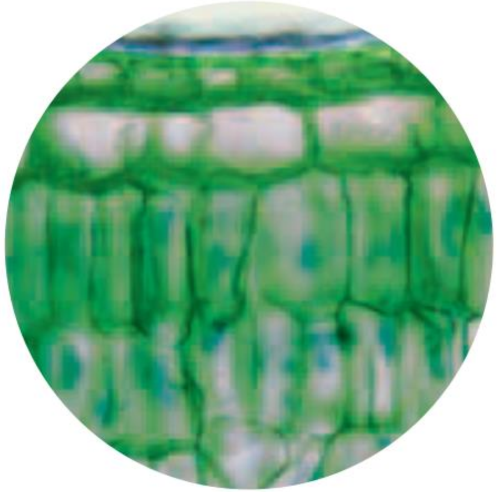


(d) Bacterial cells

(a) Nerve cell



(e) Plant cells



(c) Egg cell

Cells have various shapes.

(a) Nerve cells have long extensions.

(b) Skin cells are flat and platelike.

(c) Egg cells are spherical.

(d) Some bacteria are rod shaped.

(e) Some plant cells are rectangular

Thank you

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Chapter 1

Cellular and Molecular Biology

Lesson 1.4.2

Prokaryotes, Eukaryotes and Endosymbiosis.

Cells are divided into two varieties: <u>prokaryotes and eukaryotes</u>.

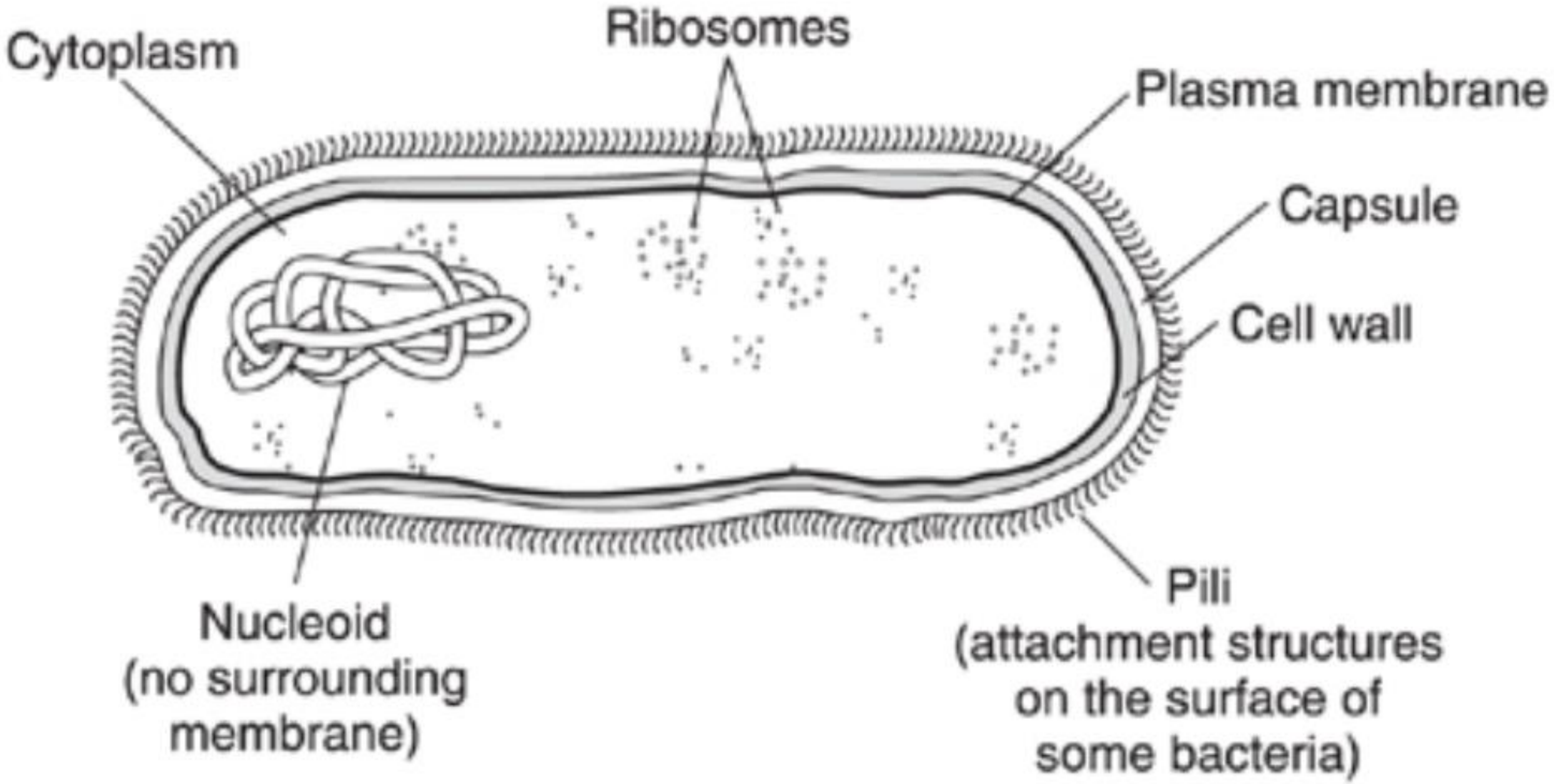
Prokaryotes have no true nucleus or other internal membranous orgamelles.
All bacteria are prokaryotes and all prokaryotes are bacteria.

Eukaryotes have a nucleus and are membranous organelles.
They make up every form of life other than bacteria (animal cells, plant cells and fungi)

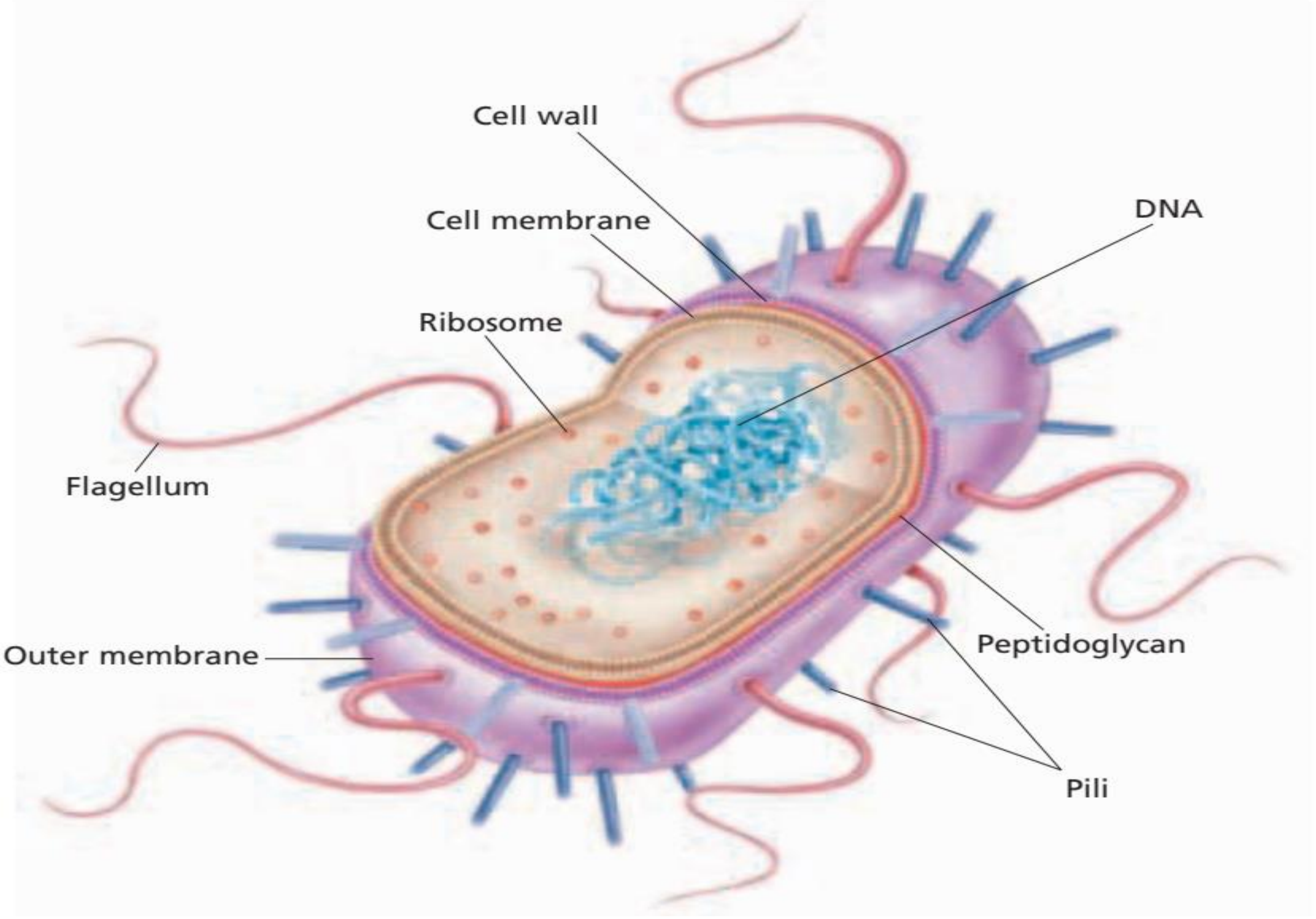
Human cells are eukaryotic cells.

A virus is not considered a cell.

All cells have cell membrane, cytoplasm, ribosomes, DNA and RNA.



A typical prokaryotic cell



A prokaryotic cell lacks a membranebound nucleus and membrane-bound organelles.
Most prokaryotic cells are much smaller than eukaryotic cells are.

Prokaryotes Vs. Eukaryotes

Prokaryotes	Eukaryotes
No membrane-bound organelles such as a nucleus	Contain distinct organelles surrounded by membranes, such as nucleus and mitochondria
Contains a single, circular chromosome	Chromosomes are linear; human body cells contain 46 chromosomes in each nucleus
Can contain plasmids (Extra chromosomal DNA)	Does not contain plasmids
Ribosomes are small	Ribosomes are larger
Respiration can be either aerobic or anaerobic	Respiration is mostly aerobic

Prokaryotes	Eukaryotes
Cytoskeletal elements, such as microfilaments, are absent	Cytoskeletal elements, like microfilaments and microtubules, are present
Most are unicellular.	Some, like euglena and paramecium, are single celled; many are multicellular with specialized cell types, such as muscle, blood, and skin cells
Very small: 1–10 µm .	Larger: 10–100 µm
Most have tough external cell walls .	Most (except plant cells and protists) are surrounded by only a cell membrane.

Endosymbiosis

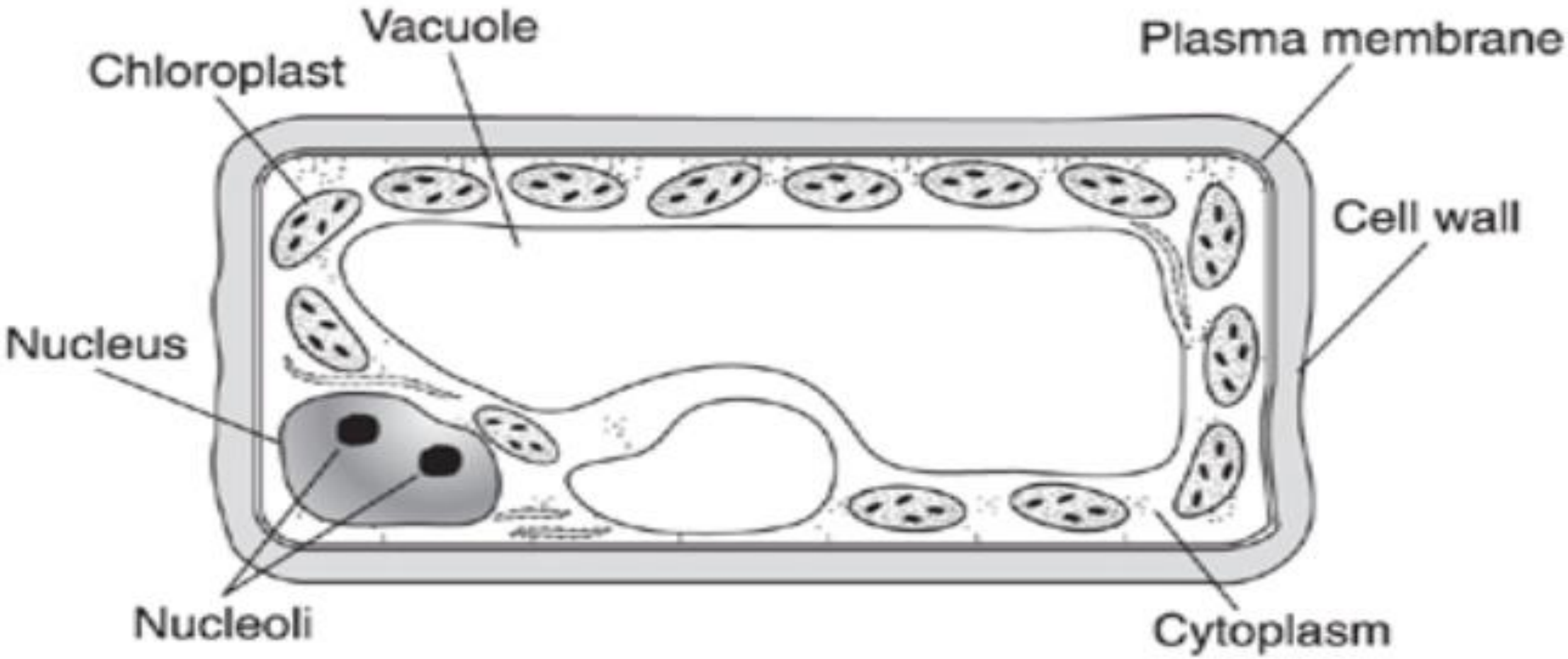
The Earth is about 4.6 billion years old.

All organisms on Earth are believed to have descended from a common ancestral prokaryotic cell about 3.5 billion years ago.

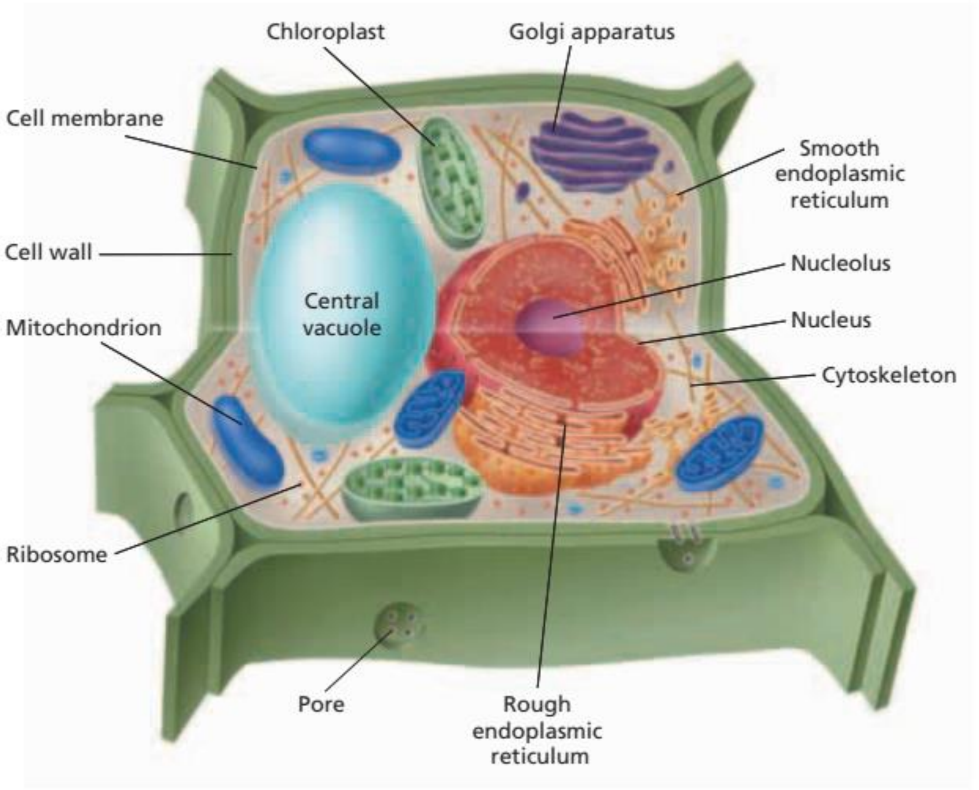
According to the theory of endosymbiosis, eukaryotic cells containing organelles like mitochondria and chloroplasts evolved when free-living prokaryotes took up permanent residence inside other larger prokaryotic cells, about 2 billion years ago.

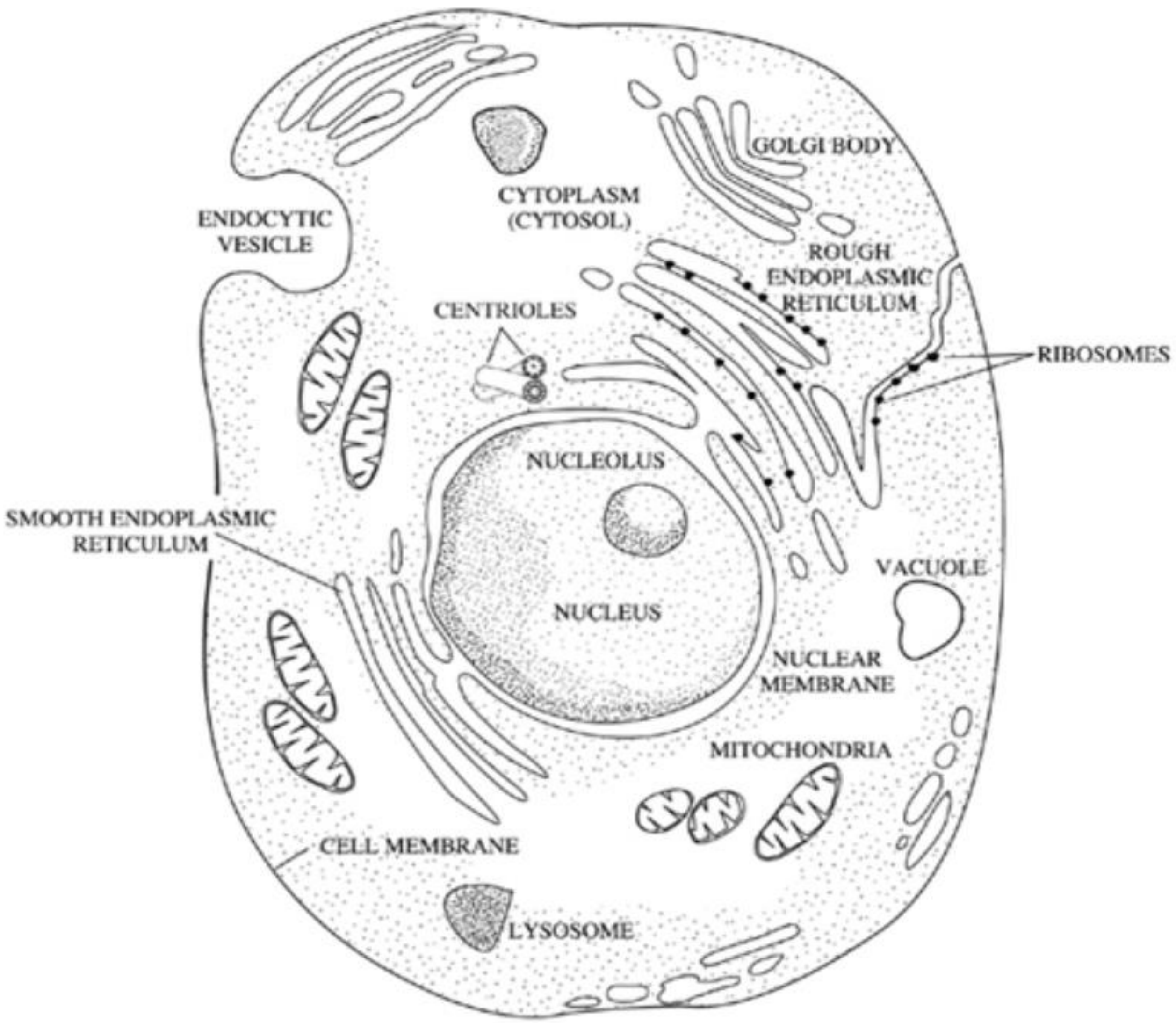
This was the origin of a complex eukaryotic cell with internal membranes that compartmentalized the cell, making it very efficient and leading to the evolution of all multicelled organisms.

A PLANT CELLS



AN ANIMAL CELL



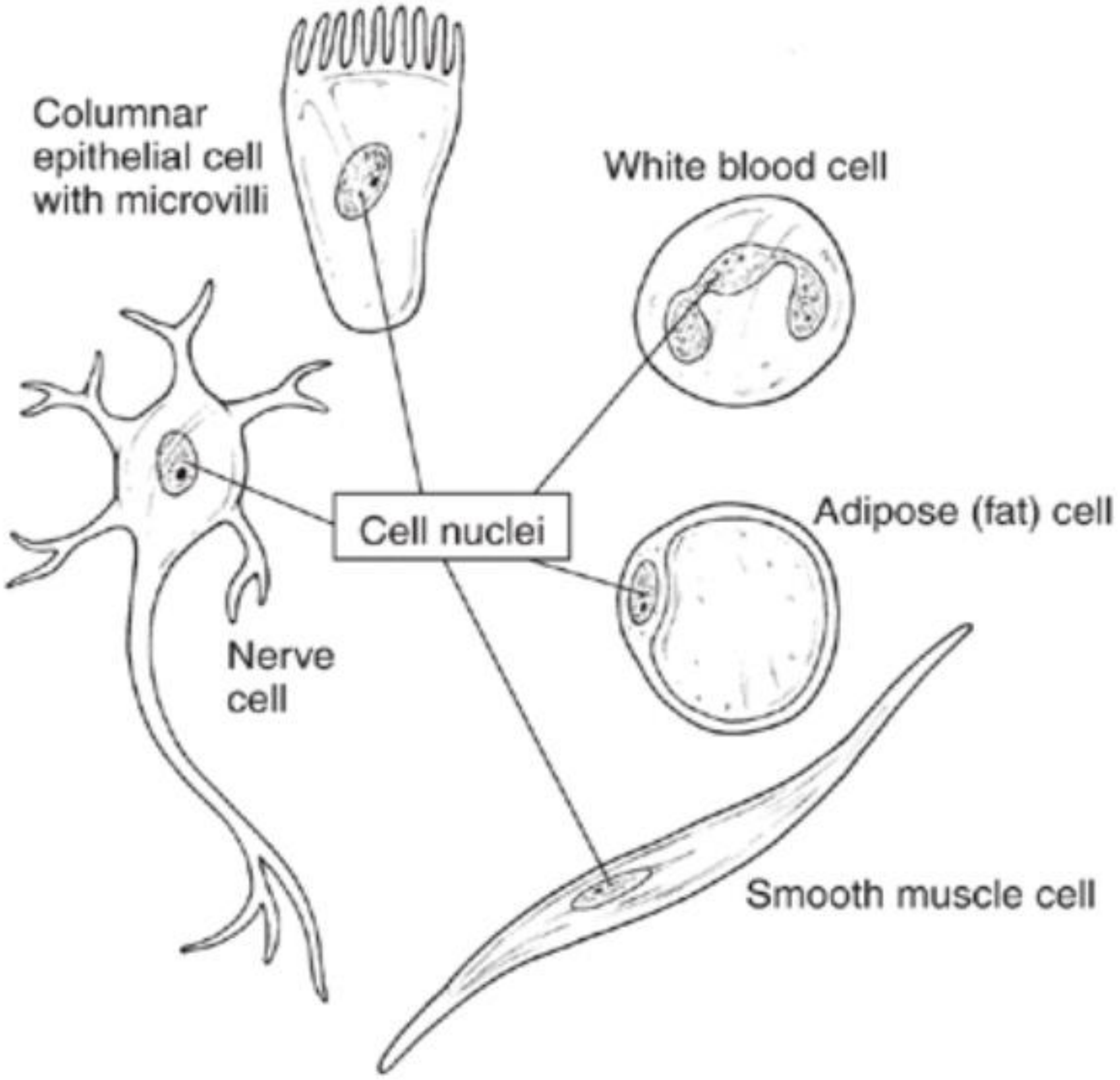


In addition to containing almost all of the types of organelles that animal cells contain, plant cells contain three unique features. Those features are the cell wall, the central vacuole, and plastids, such as chloroplasts.

Although all cells have many structures in common, they do not look alike.

Many, in fact, are quite unique.
A cell's form is dictated by its function.

Although different cell types have different functions and appearances, they all contain the same organelles;



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Chapter 1

Cellular and Molecular Biology

Lesson 1.4.3

Nucleus and Nucleolus

1.4-Topics

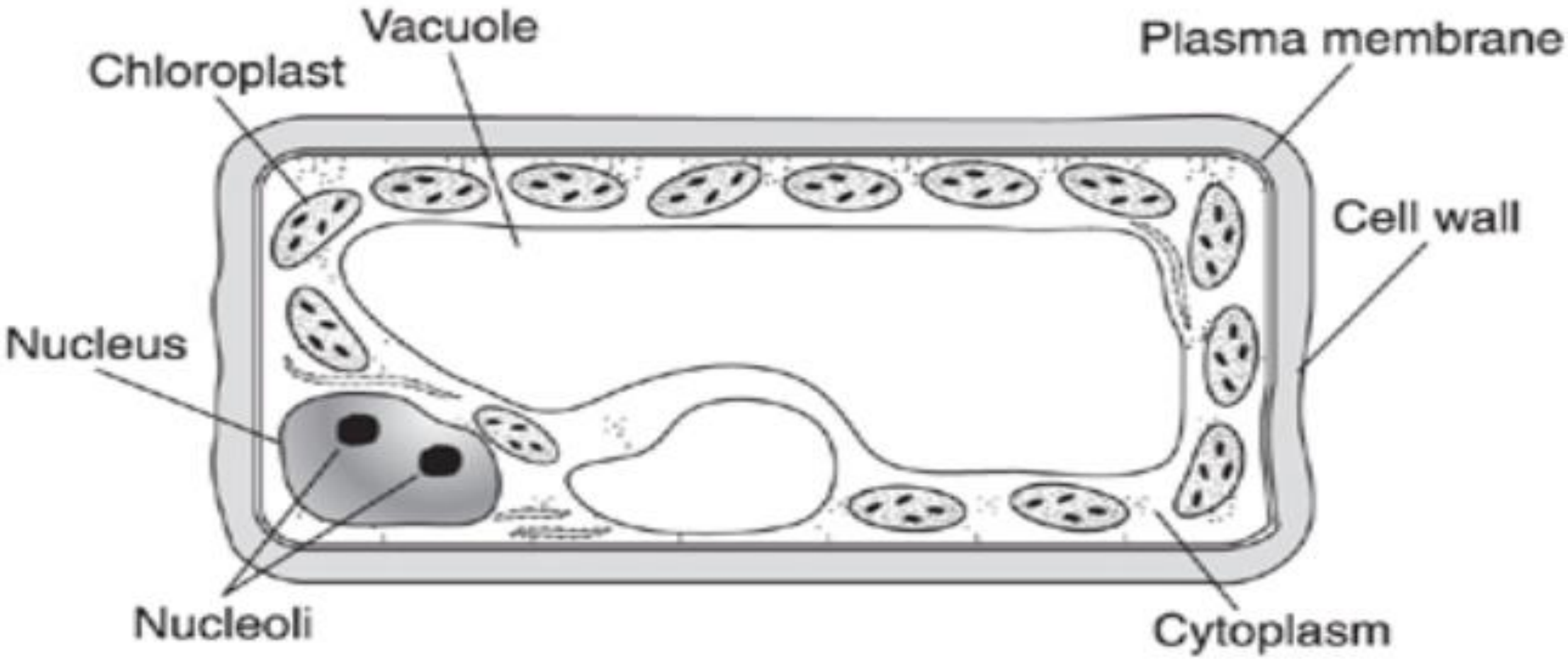
	1.4- Cell Structure and Function
~~1~~	~~History of Cell Theory and Size of the cells~~
~~2~~	~~Prokaryotes, Eukaryotes and Endosymbiosis.~~
3	Neucleus and Nucleolus
4	Cytoplasm and Cytosole
5	Ribosomes
6	Endoplamic Reticulum
7	Golgi Apparatus
8	Lysosomes
9	Mitochoncdria
10	Vacuoles and vesicles
11	Plastids
12	Cytoskeleton
13	Cell Wall
14	Animal and Plant Cell
15	Cell Structure ad Function Mix

STRUCTURES OF PLANT AND ANIMAL CELLS

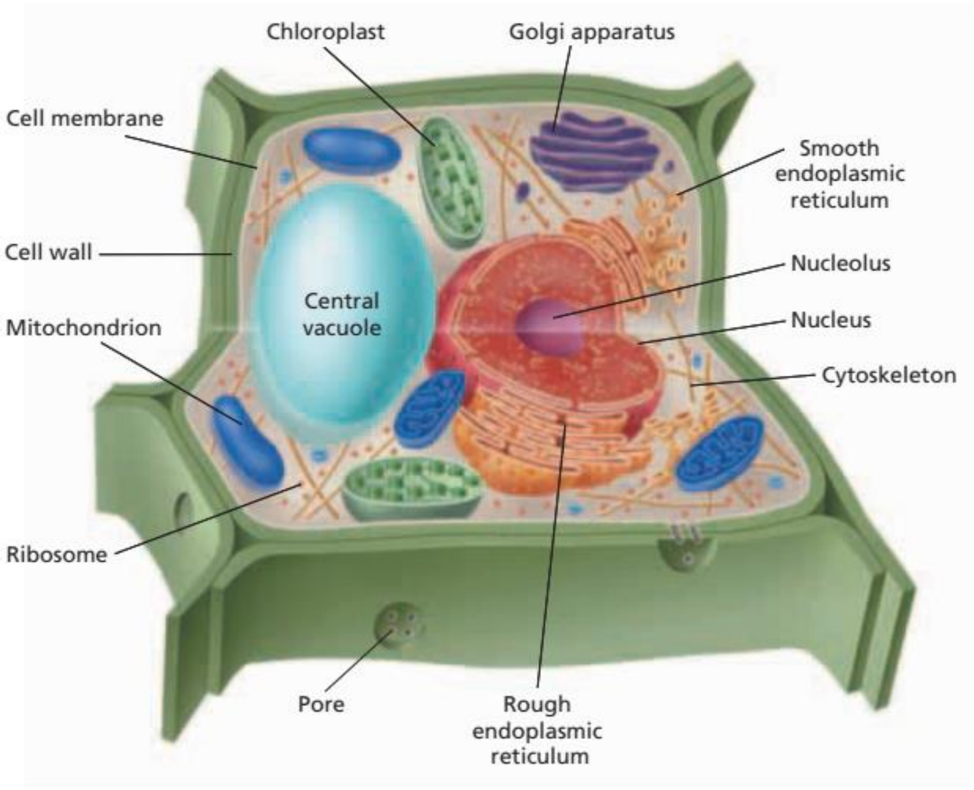
Plant and animal cells have many cellular organelles in common, including ribosomes and mitochondria.

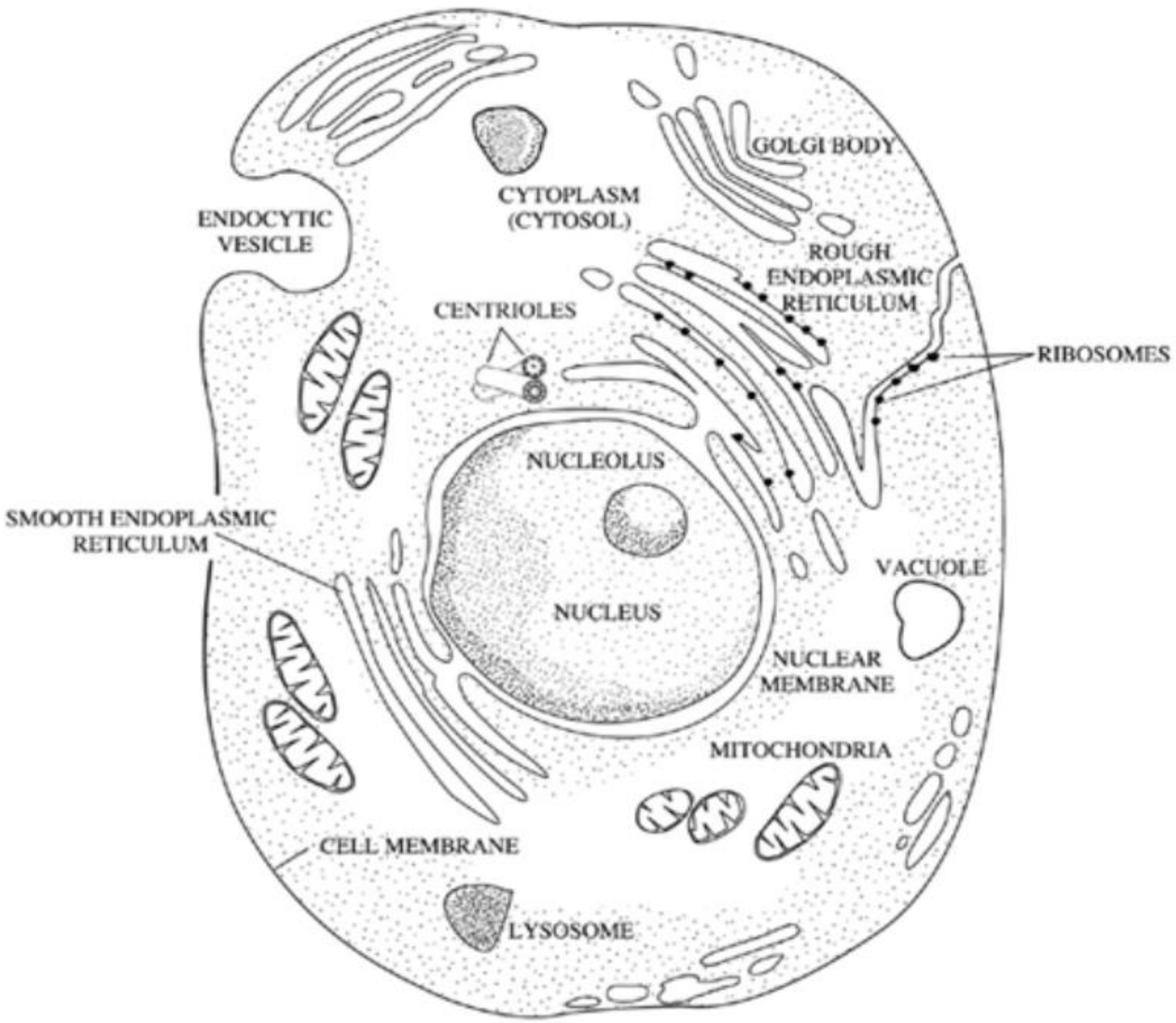
However, they also have organelles unique to the cell type, such as cell walls in plant cells and centrioles in animal cells.

A PLANT CELLS



AN ANIMAL CELL





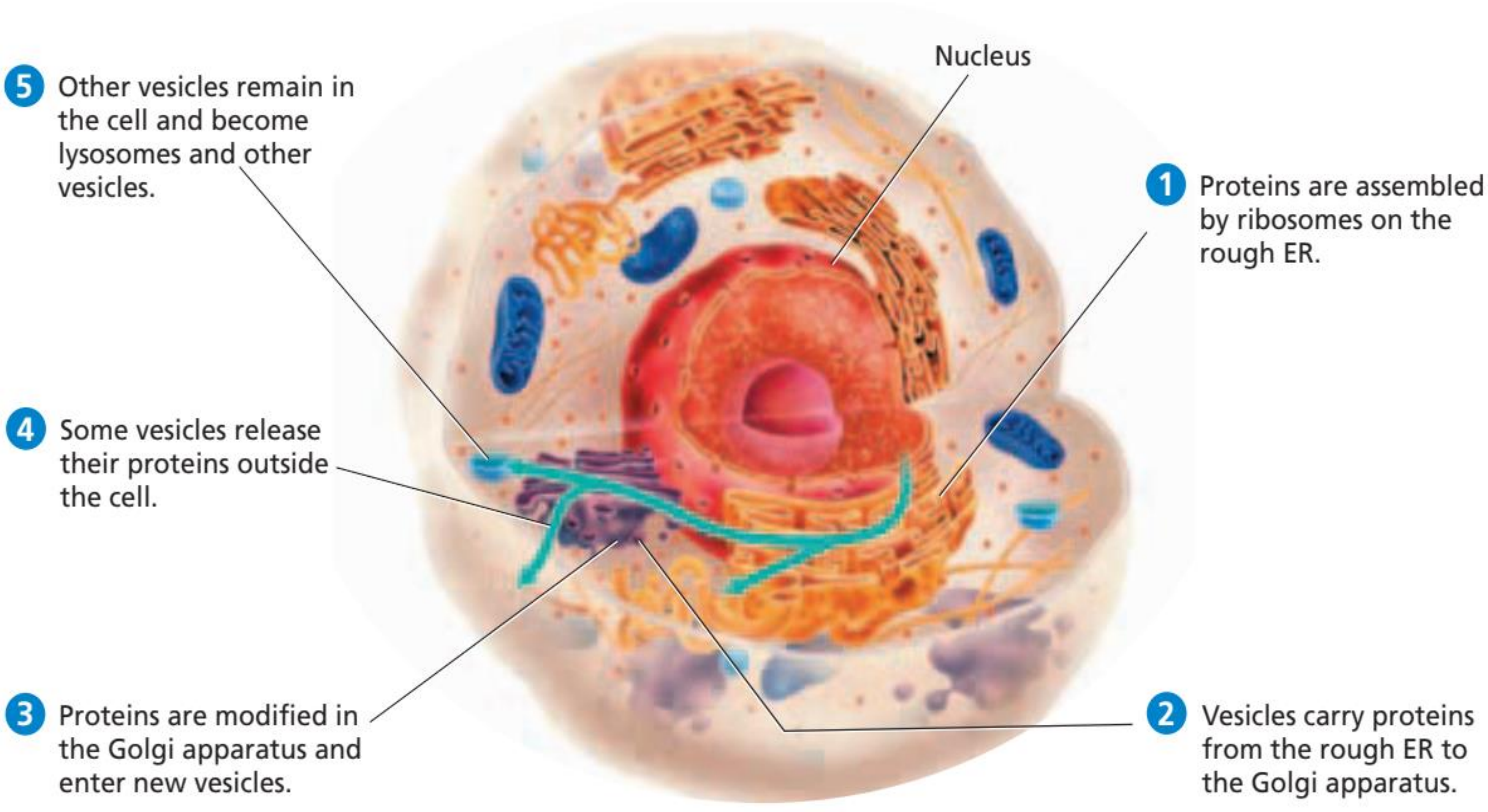
In addition to containing almost all of the types of organelles that animal cells contain, plant cells contain three unique features. Those features are the cell wall, the central vacuole, and plastids, such as chloroplasts.

The Nucleus

The nucleus contains chromosomes made of DNA that is wrapped with special proteins called histones into a chromatin network.

Chromosomes contain genes, bits of DNA that code for polypeptides.

The nucleus is surrounded by a selectively permeable double membrane or nuclear envelope that contains pores and allows for the transport of large molecules such as RNA out of the nucleus and into the cytoplasm.



The rough ER, Golgi apparatus, and vesicles work together to transport proteins to their destinations inside and outside the cell.

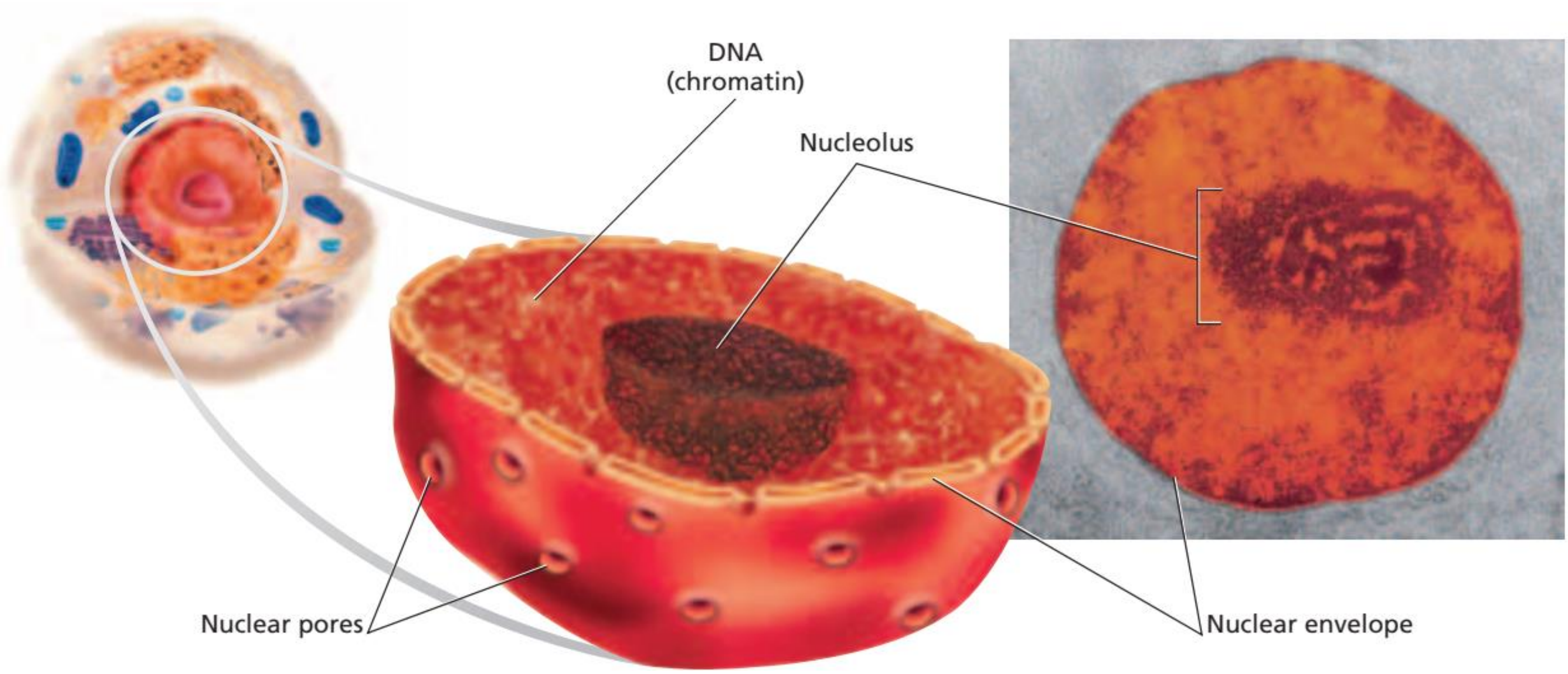
The Nucleolus

The nucleolus is a prominent region inside the nucleus of a cell that is not dividing.

Components of ribosomes are synthesized here.

Nucleoli are not membrane-bound structures but are tangles of chromatin and unfinished bits of ribosomes.

One or two nucleoli are commonly visible in a nondividing cell.



The nucleus of a cell is surrounded by a double membrane called the nuclear envelope. The nucleus stores the cell’s DNA.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.4

Cytoplasm and Cytosole

Cytoplasm and Cytosol

The entire region between the nucleus and plasma membrane is called cytoplasm.

The cytoplasm is formed of cytosol and organelles.

Cytosol refers to the semiliquid portion of the cytoplasm.

In eukaryotic cells, organelles are suspended in the cytosol and get carried around the cell as the cytoplasm cycles around the cell, a process called cyclosis.

The cytosol is the site of chemical reactions in the cell.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.5

Ribosomes

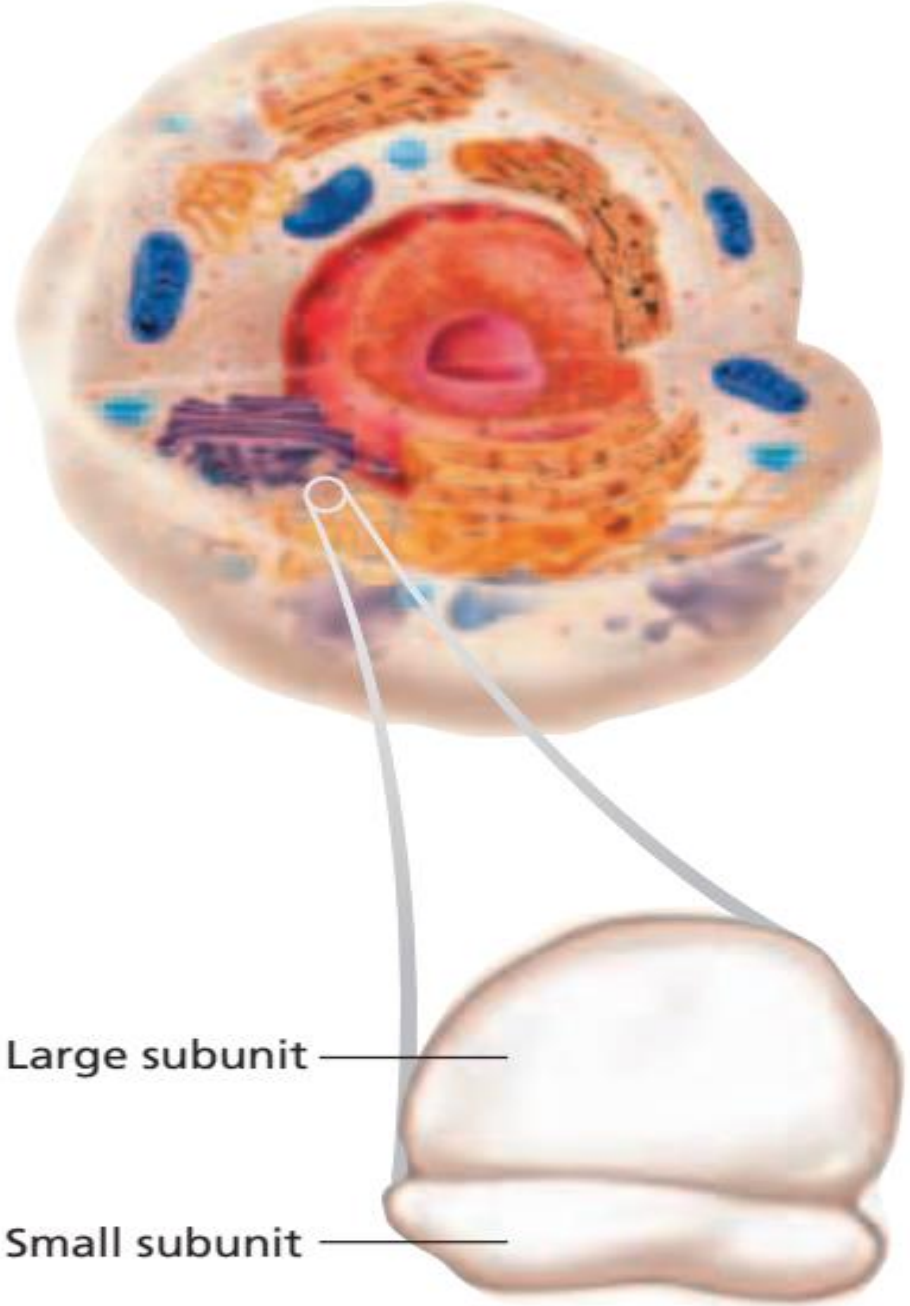
Ribosome

This is the site of protein synthesis.

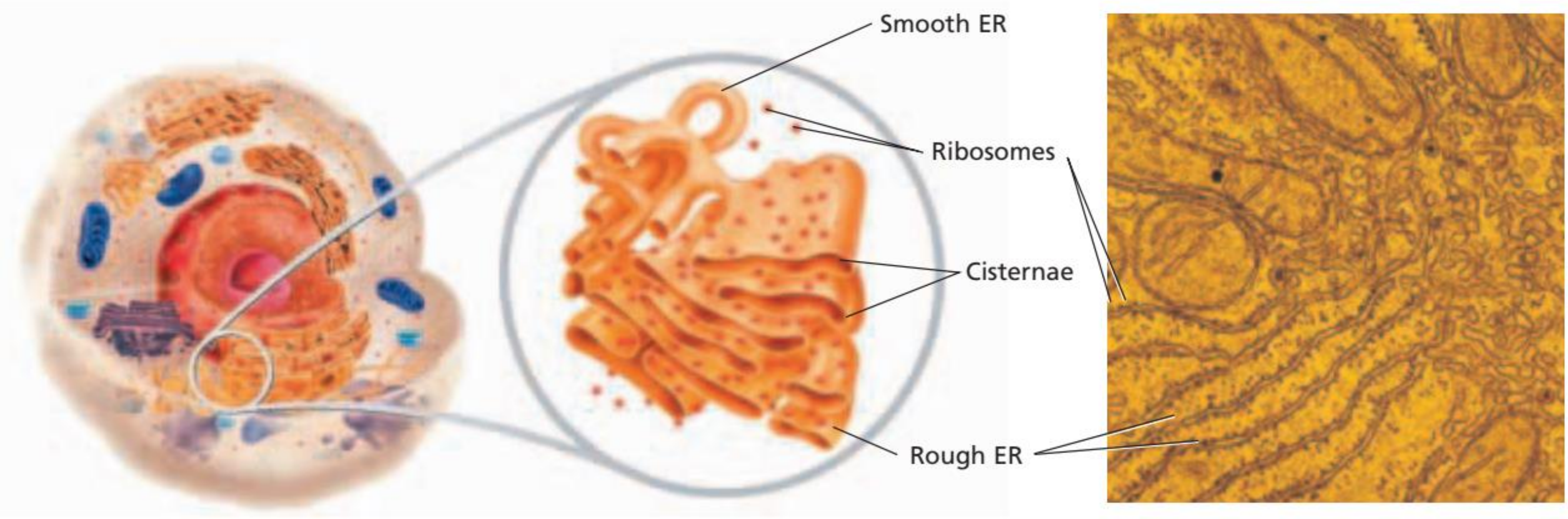
Ribosomes are particles made of ribosomal RNA and protein.

They are suspended freely in the cytoplasm or bound to endoplasmic reticulum.

A single cell, such as a human liver cell, that produces large amounts of protein, contains millions of ribosomes.



Ribosomes are the organelles responsible for building protein. Ribosomes have a large and small subunit, each made of protein and ribosomal RNA. Some ribosomes are free in the cell. Others are attached to the rough endoplasmic reticulum.



The endoplasmic reticulum (ER) serves as a site of synthesis for proteins, lipids, and other materials.
The dark lines in the photo represent the membranes of the ER, and the narrow lighter areas between the dark lines show the channels and spaces (cisternae) inside the ER.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.6

Endoplasmic Reticulum

Endoplasmic Reticulum

The endoplasmic reticulum (ER) is a system of membrane channels that traverse the cytoplasm.

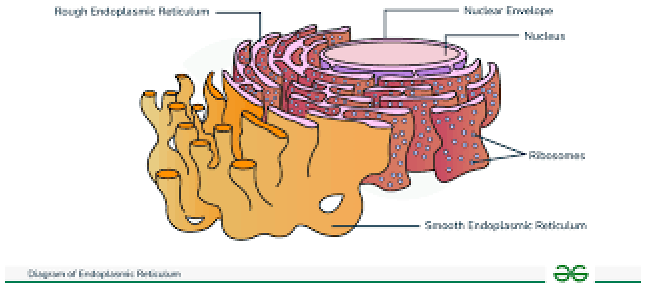
There are two varieties.

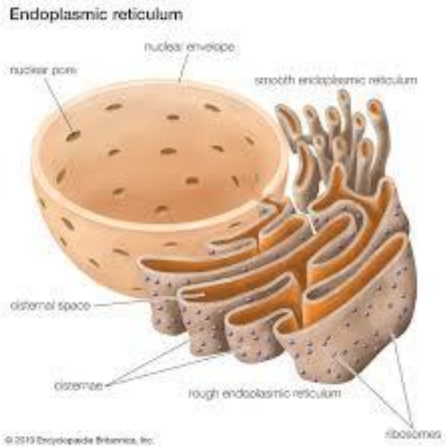
Rough ER is studded with ribosomes. Therefore, it is the site of protein synthesis as well as transport throughout the cytoplasm.

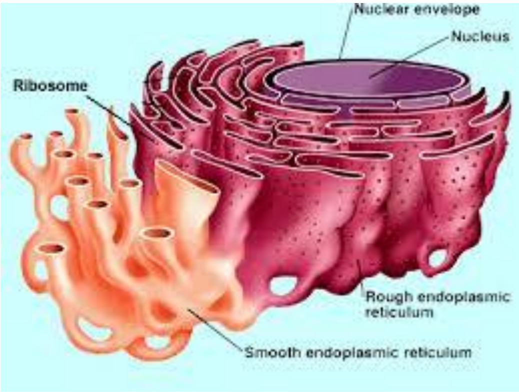
Smooth ER has many functions:

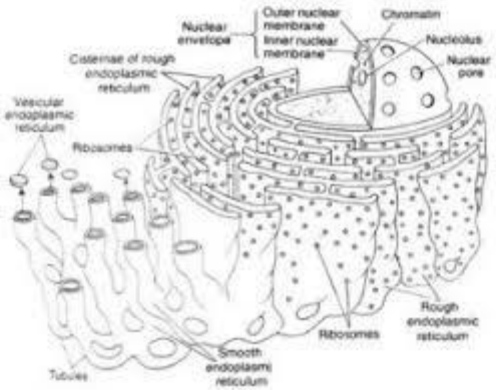
1. Synthesizes steroid hormones and other lipids
2. Connects rough ER to the Golgi apparatus
3. Detoxifies the cell
4. Carbohydrate (glycogen) metabolism

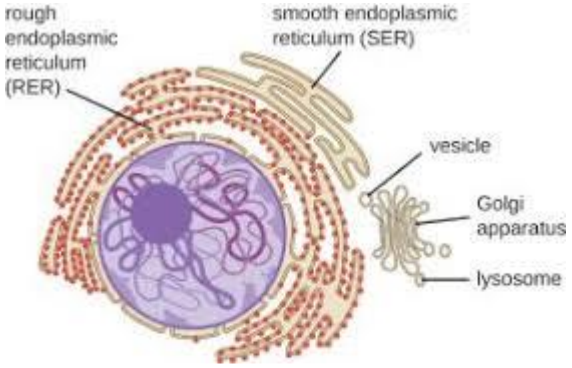
Endoplasmic Reticulum

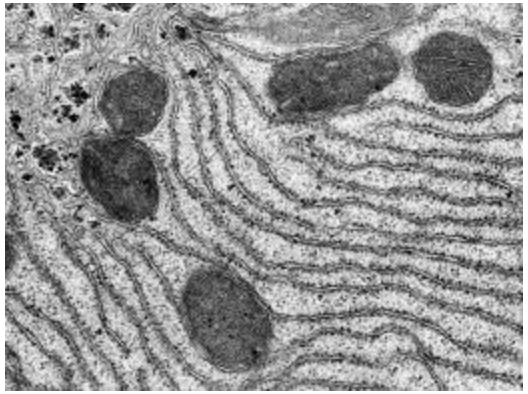


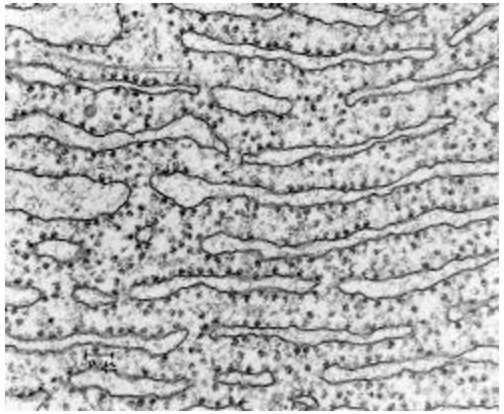












Chapter 1

Cellular and Molecular Biology

Lesson 1.4.7

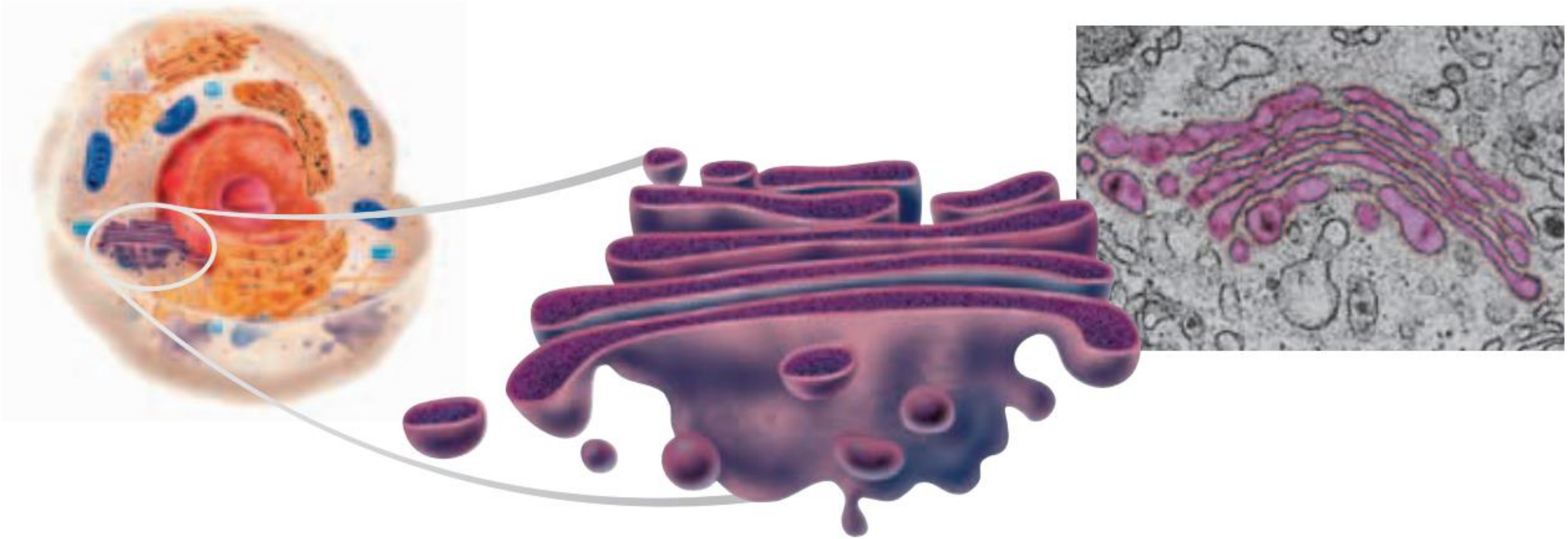
Golgi Apparatus

Golgi Apparatus

The Golgi apparatus lies near the nucleus and consists of flattened sacs of membranes stacked next to each other (like a stack of pancakes) and surrounded by vesicles.

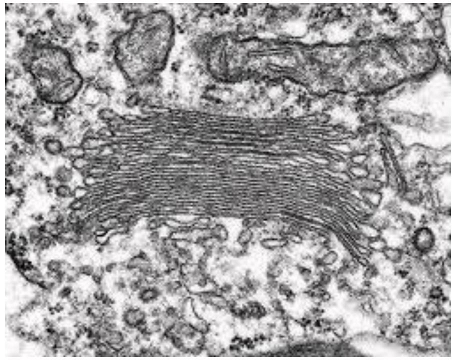
They modify, store, and package substances produced in the rough endoplasmic reticulum.

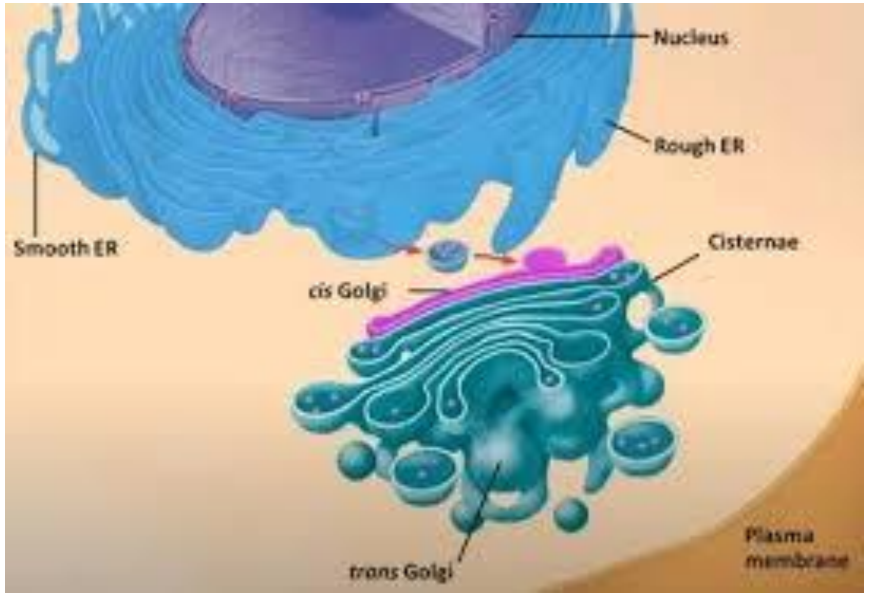
The Golgi apparatus also secretes these substances to other parts of the cell and to the cell surface for export to other cells.

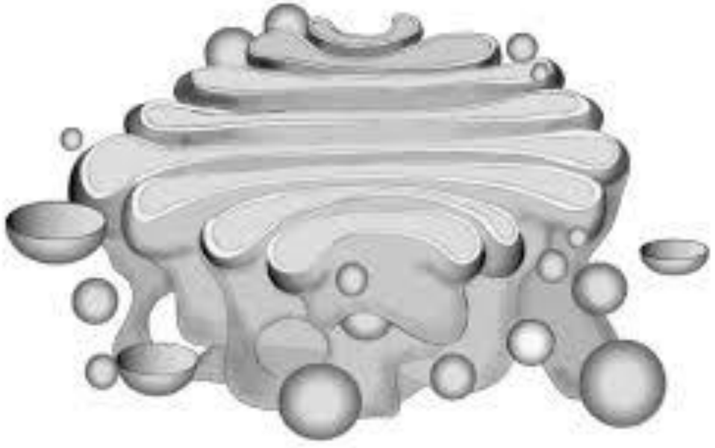


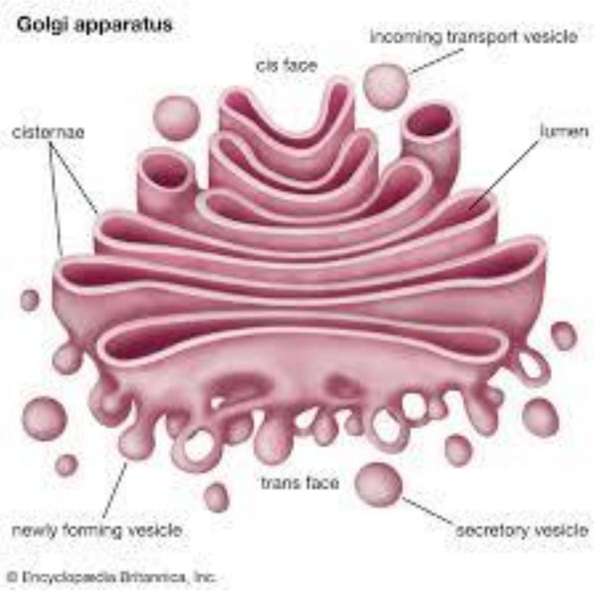
The Golgi apparatus modifies many cellular products and prepares them for export

Golgi Apparatus









Chapter 1

Cellular and Molecular Biology

Lesson 1.4.8

Lysosomes

Lysosome

A lysosome is a sac of hydrolytic (digestive) enzymes enclosed by a single membrane.

It is the principal site of intracellular digestion.

With the help of the lysosome, the cell continually renews itself by breaking down and recycling cell parts.

Programmed cell death (apoptosis) is critical to the embryonic development of multicellular organisms and is carried out by a cell's own hydrolytic enzymes.

Lysosomes have pH les than 7, it is acidic

Macrophages, the white blood cells that eat bacteria are rich in lysosomes

Some of its names in biology are:

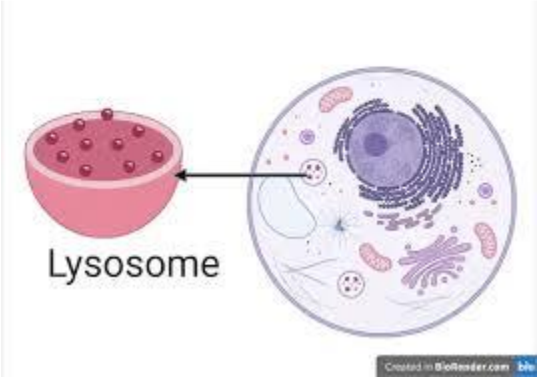
Suicidal bags

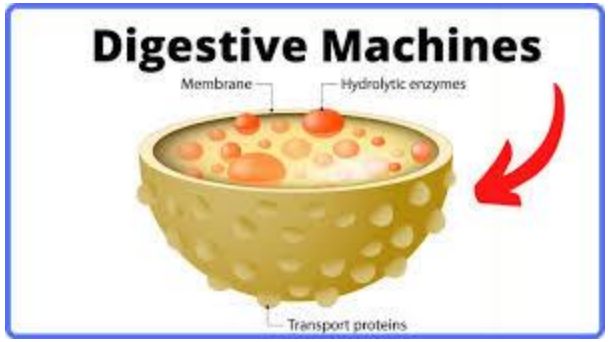
Time bomb

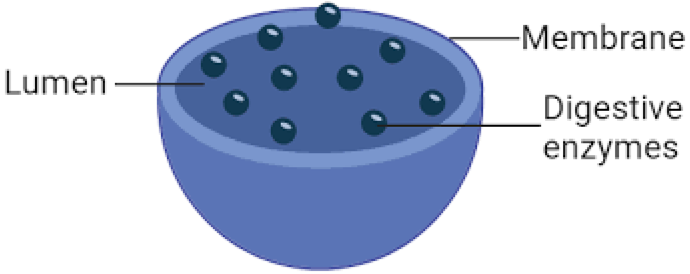
The stomach of the cell

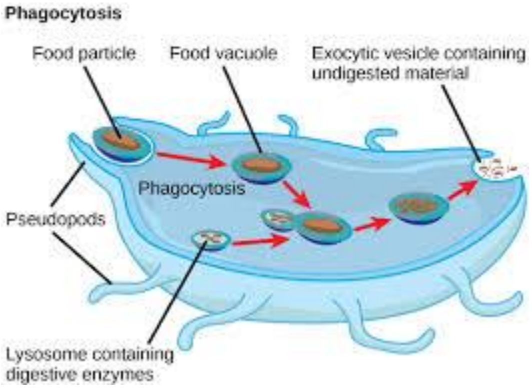
Plant cells do not usually have lysosomes. Cell vacuole does this job.

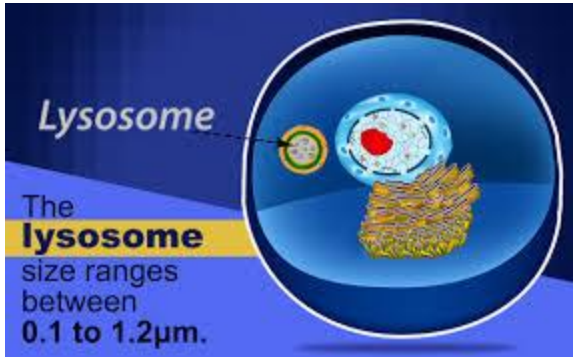
Lysosome

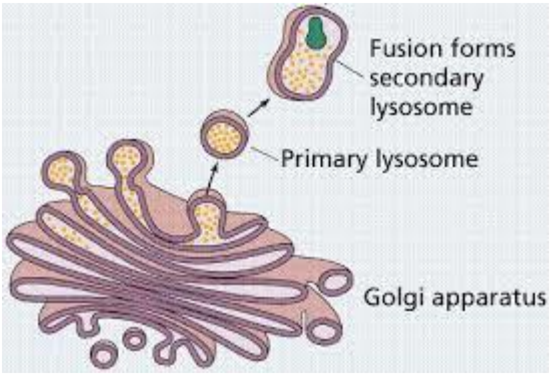

Lysosome


Digestive Machines
Membrane
Hydrolytic enzymes
Transport proteins


Membrane
Lumen
Digestive enzymes


Phagocytosis
Food particle
Food vacuole
Exocytic vesicle containing undigested material
Phagocytosis
Pseudopods
Lysosome containing digestive enzymes


Lysosome
The lysosome size ranges between 0.1 to 1.2µm.


Fusion forms secondary lysosome
Primary lysosome
Golgi apparatus

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.9

Mitochondria

Mitochondrion

The mitochondrion (plural, mitochondria) is the site of cellular respiration.

All cells have many mitochondria. A very active cell could have about 2,500 of them.

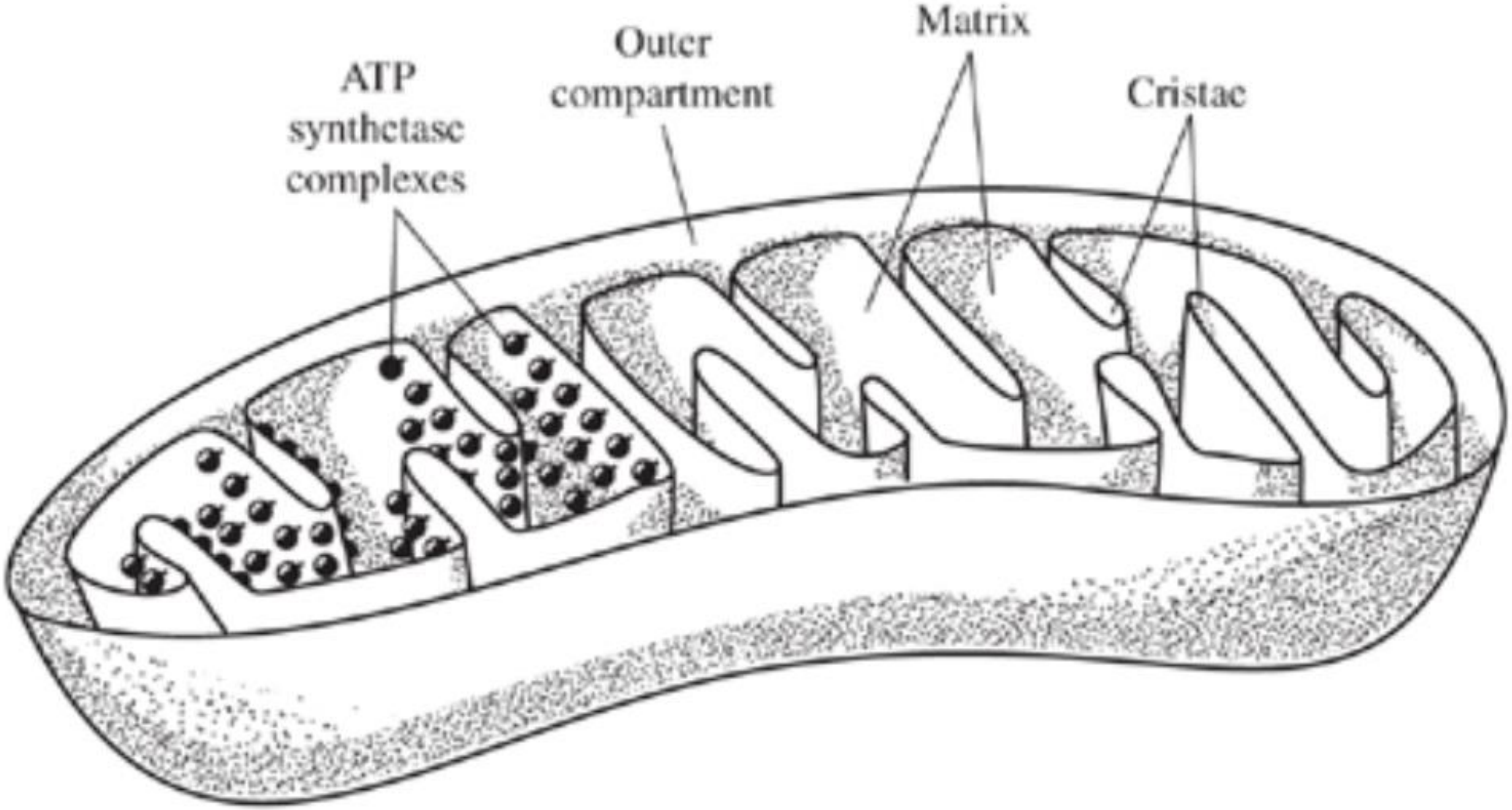
Mitochondria consist of an outer double membrane and a folded inner membranes called cristae.

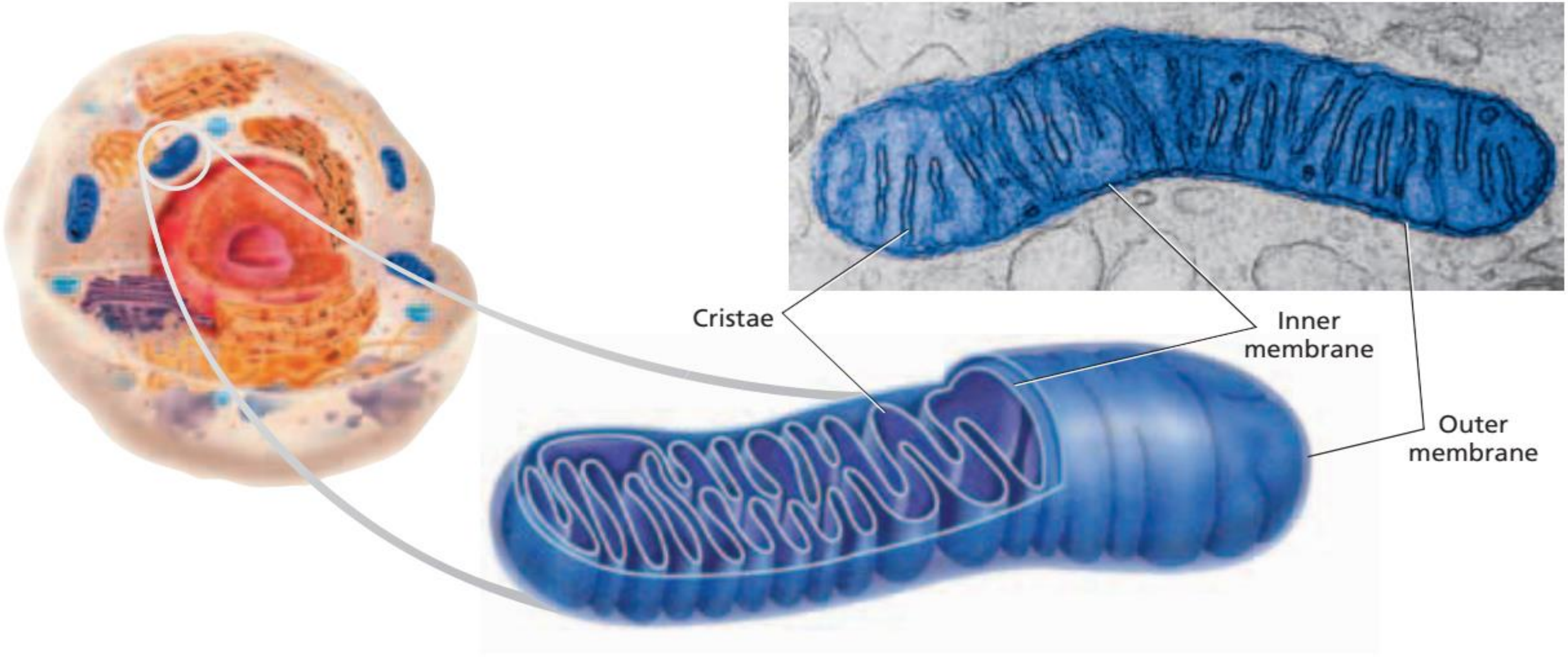
Enzymes that are important to cellular respiration are embedded in the cristae membrane.

Mitochondria contain their own DNA and can self replicate.

Remember, they were free-living prokaryotes several billion years ago. “Theory of endosymbiosis”

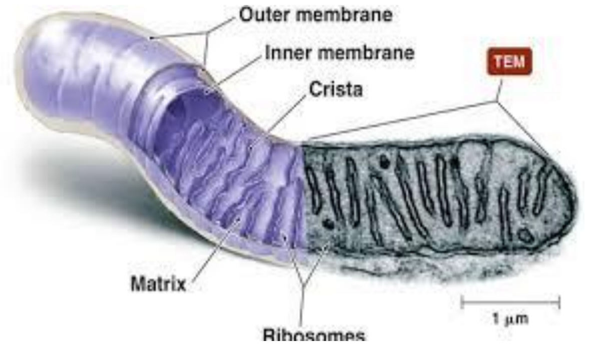
Mitochondrion

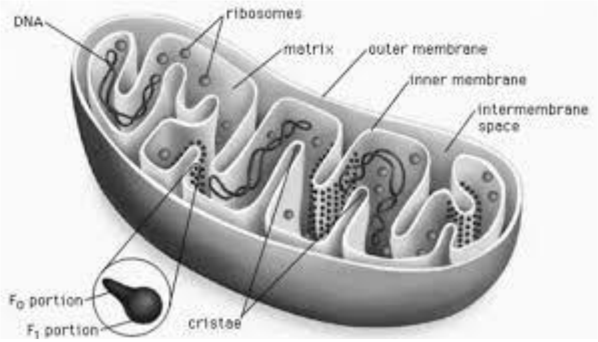


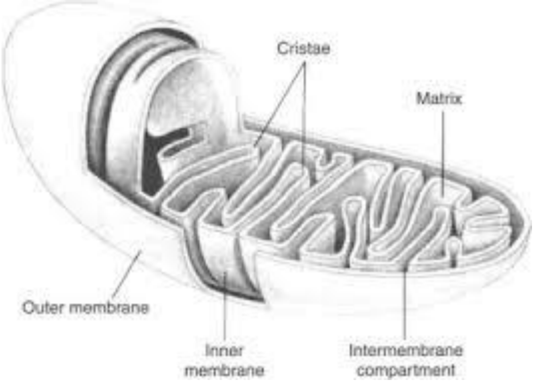


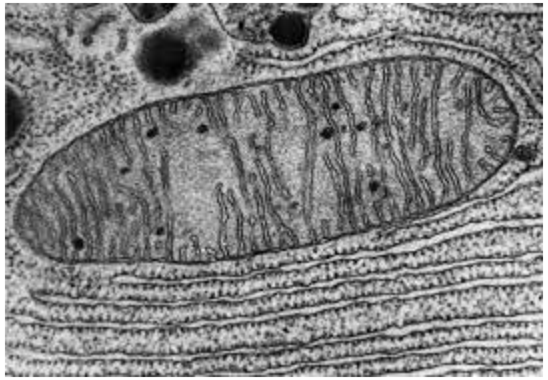
Mitochondria convert organic molecules into energy for the cell.
Mitochondria have an inner membrane and an outer membrane.
The folds of the inner membrane, called cristae, are the site of energy conversion.

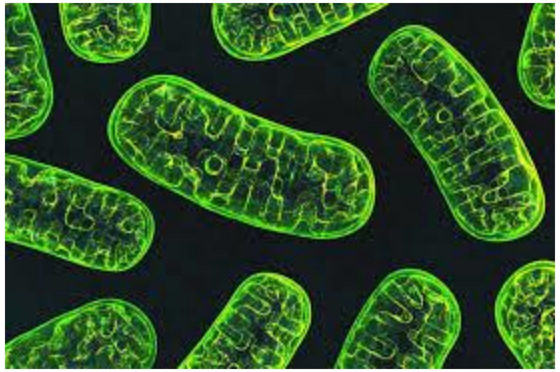
Mitochondrion











Chapter 1

Cellular and Molecular Biology

Lesson 1.4.10

Vesicles and Vacuoles

Vacuole

Vacuoles are single, membrane-bound structures that store substances for the cell

Freshwater protista, like paramecium and amoeba, have contractile vacuoles that pump excess water out of the cell.

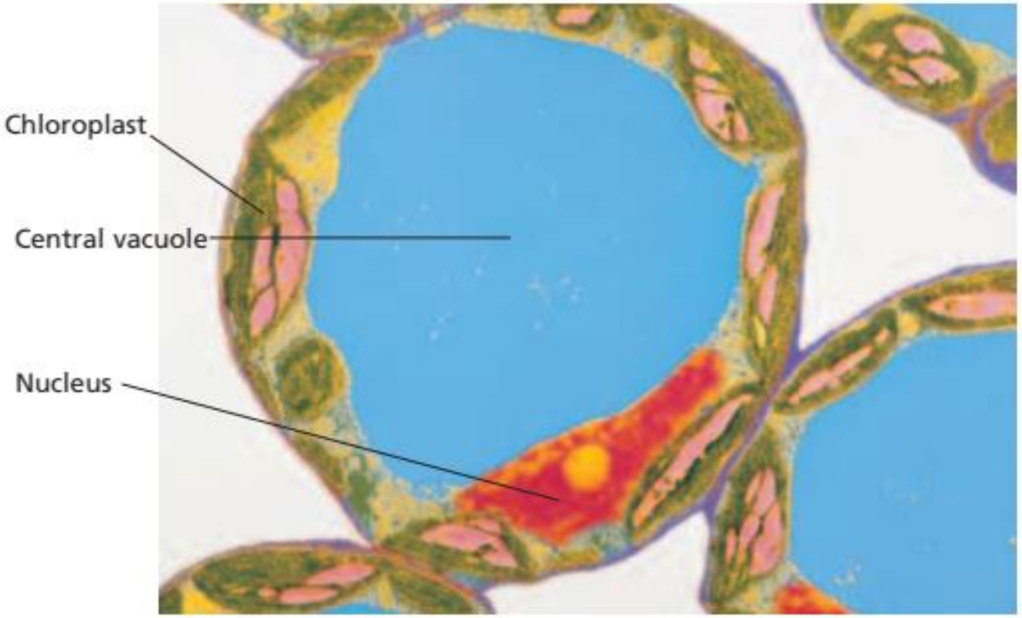
Plant cells and some specialized human (fat or adipose) cells have large central vacuoles for storage.

Vacuoles are formed by Golgi apparatus.

Vesicle

Vesicles are tiny vacuoles.

They are found in many places in cells, including the axon of a neuron, where they release neurotransmitter into a synapse.



The central vacuole occupies up to 90 percent of the volume of some plant cells. The central vacuole stores water and helps keep plant tissue firm.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.11

Plastids

Plastids

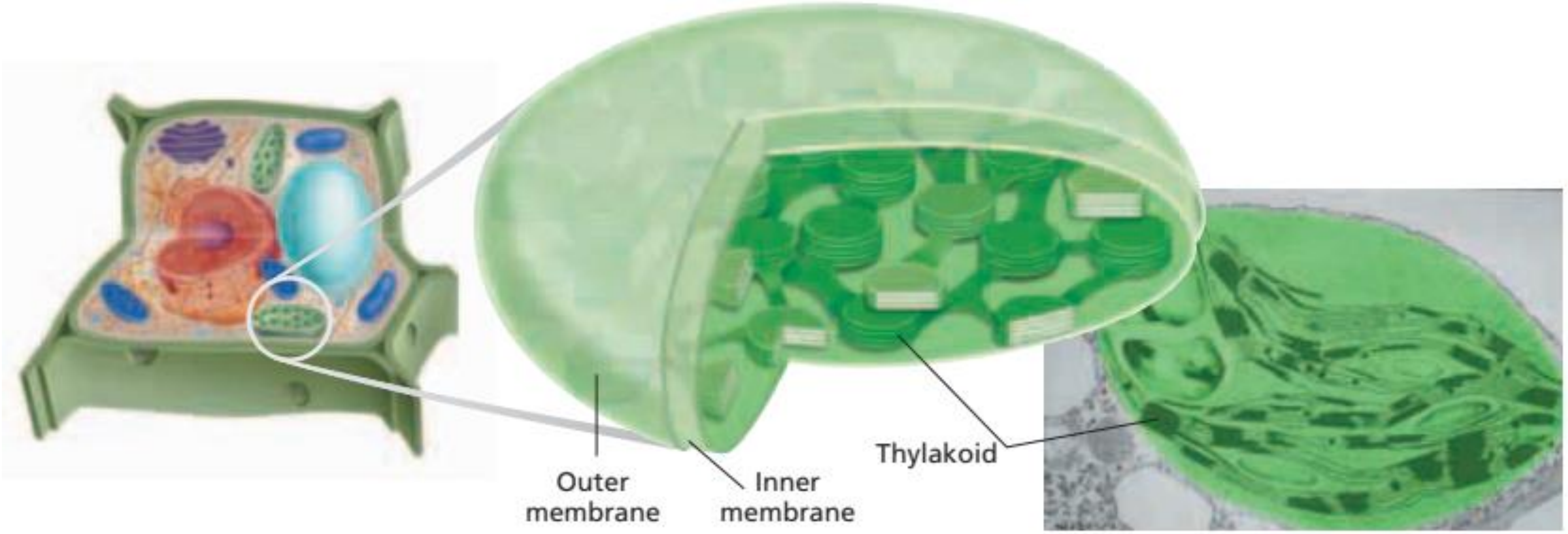
Plastids have a double membrane and are found only in plants and algae.

There are three types:

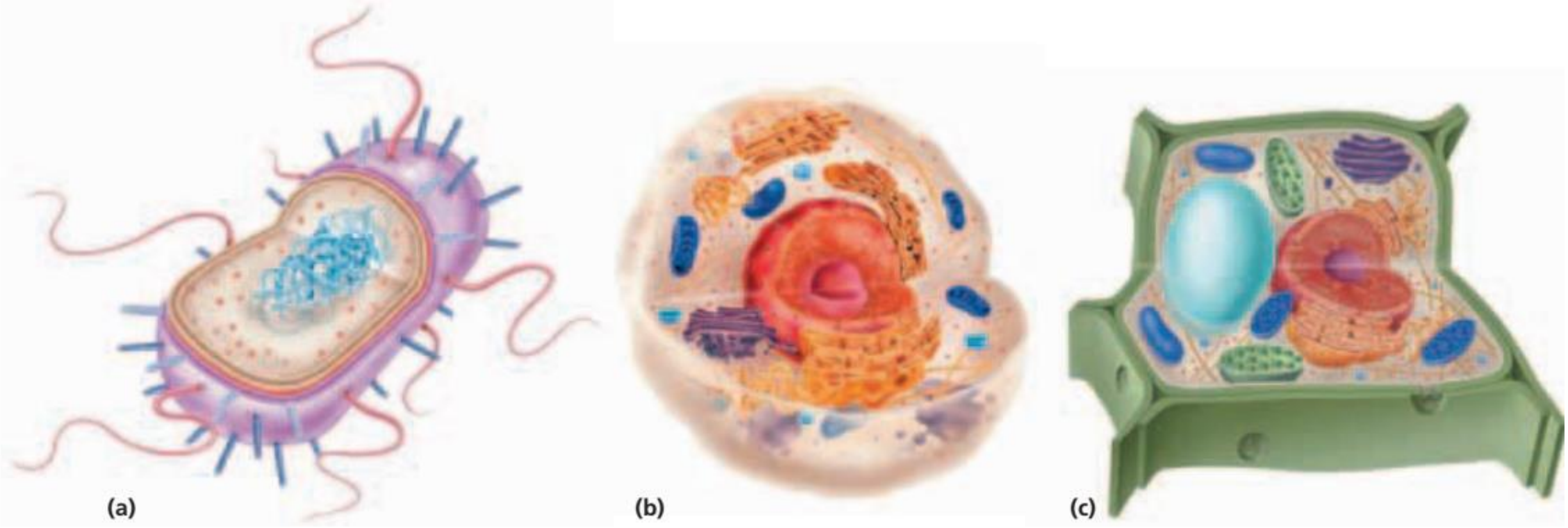
1. CHLOROPLASTS

1. LEUCOPLASTS

3. CHROMOPLASTS



A chloroplast captures energy from sunlight and uses that energy to convert carbon dioxide and water into sugar and other carbohydrates.



Prokaryotes (a) can be distinguished from eukaryotes (b and c) in that prokaryotes lack a nucleus and membrane-bound organelles. Plant cells (c) have the same organelles that animal cells do and have a cell wall, a central vacuole, and plastids.

CHLOROPLASTS

They are green because they contain chlorophyll.

They are the sites of photosynthesis.

In addition to a double outer membrane, they have an inner one that forms a series of structures called grana.

Grana are formed of sacs called thyllakoids

The grana lie in the stroma.

Chloroplasts, like mitochondria, contain their own nuclear material and can self-replicate.

Remember, they were free-living prokaryotes several billion years ago. “endosymbiosis”

LEUCOPLASTS

are colorless and store starch

They are found in roots, like turnips, or in tubers, like potatoes.

CHROMOPLASTS

store carotenoid pigments and are responsible for the red-orange-yellow coloring of carrots, tomatoes, daffodils, and many other plants.

These bright pigments in petals attract pollinating insects to flowers.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.12

Cytoskeleton

Cytoskeleton

The cytoskeleton of a cell is a complex network of protein filaments that extends throughout the cytoplasm and gives the cell its shape and enables it to move

The cytoskeleton includes two types of structures.

1. MICROTUBULES

are thick hollow tubes that make up the cilia, flagella, and spindle fibers.

They are formed from the protein tubulin.

2. MICROFILAMENTS

are made of the protein actin and help support the shape of the cell.

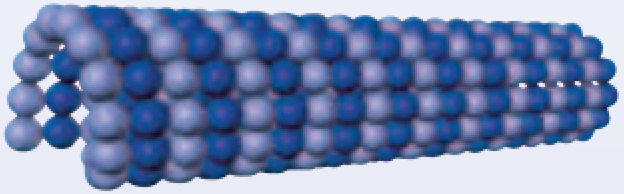
They enable:

Animal cells to form a cleavage furrow during cell division.

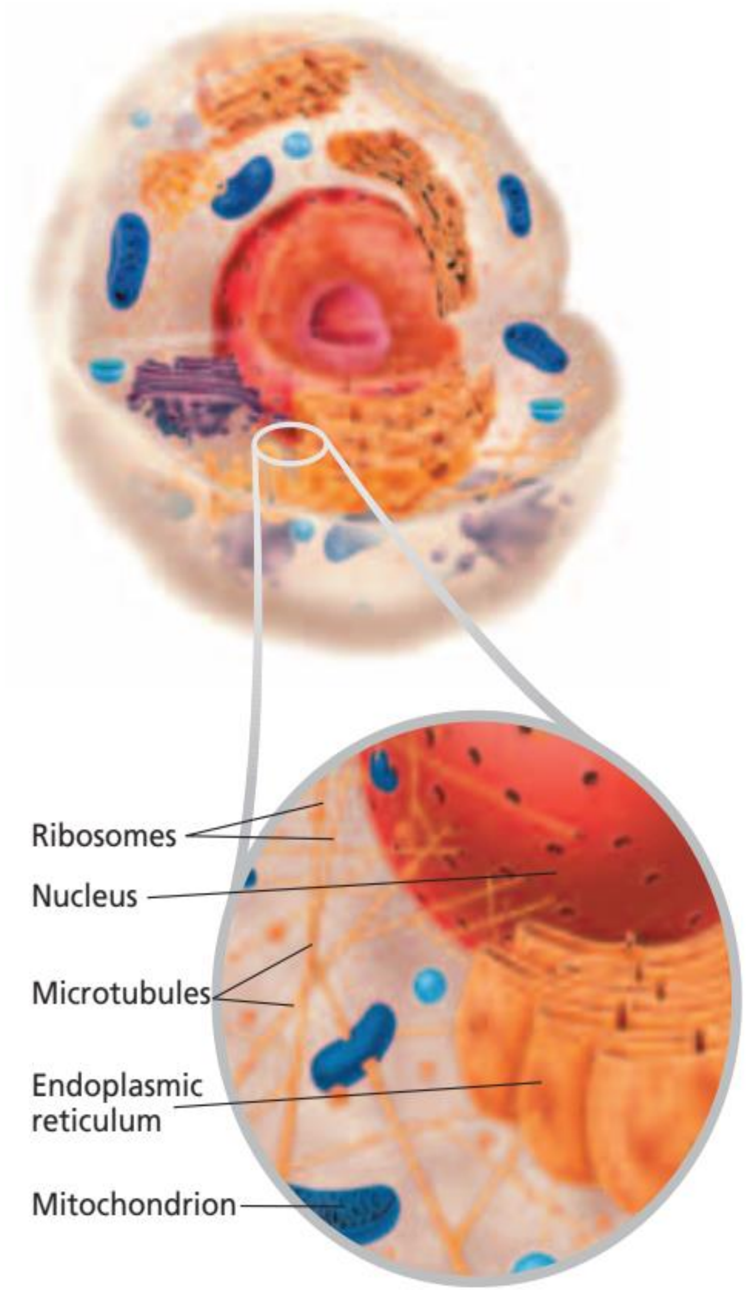
Amoeba to move by sending out pseudopods.

Skeletal muscles to contract by sliding along myosin filaments

TABLE 4-2 *The Structure of the Cytoskeleton*

Property	Microtubules	Microfilaments	Intermediate filaments
Structure	hollow tubes made of coiled protein	two strands of intertwined protein	protein fibers coiled into cables
Protein subunits	tubulin, with two subunits: α and β tubulin	actin	one of several types of fibrous proteins
Main function	maintenance of cell shape; cell motility (in cilia and flagella); chromosome movement; organelle movement	maintenance and changing of cell shape; muscle contraction; movement of cytoplasm; cell motility; cell division	maintenance of cell shape; anchor nucleus and other organelles; maintenance of shape of nucleus
Shape			

Back



Microtubules provide a path for organelles and molecules as they move throughout the cell.

Centrioles and Centrosomes

Centrioles and centrosomes lie outside the nuclear membrane and organize the spindle fibers required for cell division.

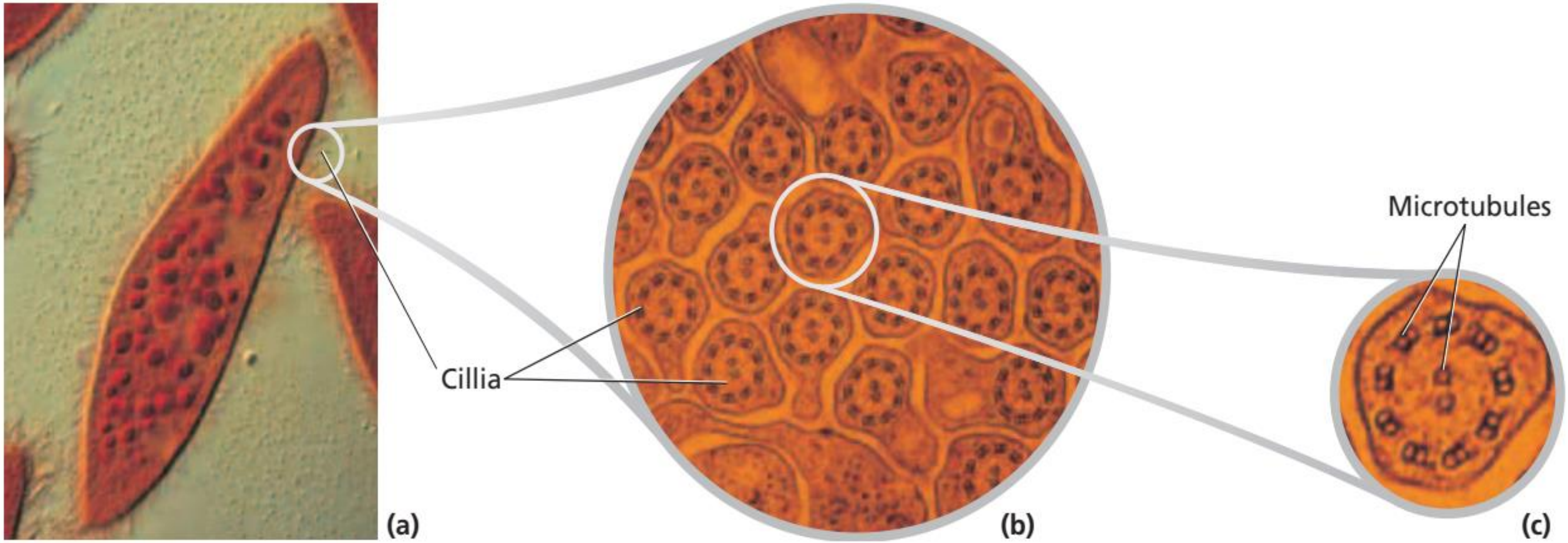
Only animal cells have centrioles and centrosomes.

Plant cells have microtubule organizing regions instead.

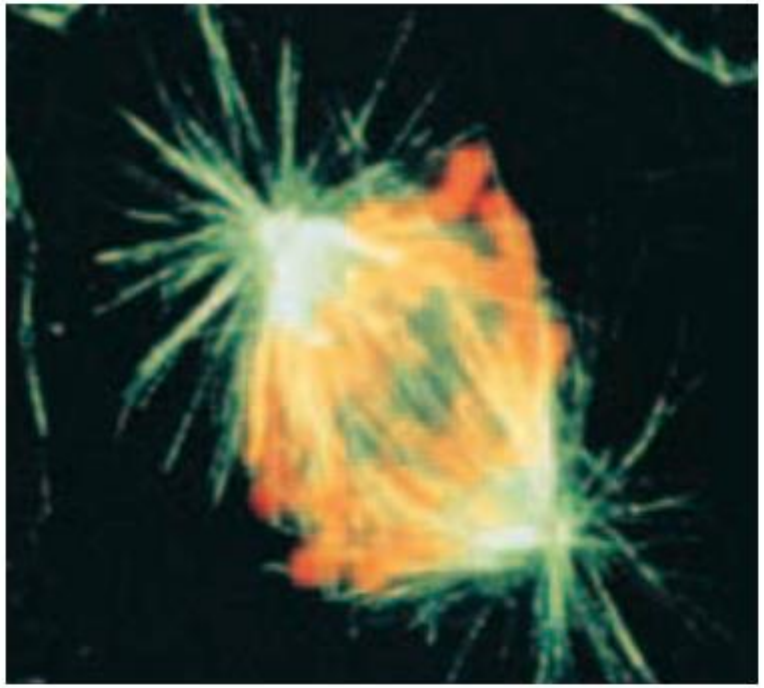
Two centrioles, at right angles to each other, make up one centrosome.

Centrioles and spindle fibers have the same structure.

They consist of 9 triplets of microtubules arranged in a circle



A SEM of a paramecium shows cilia on the surface of the cell
(a) A TEM of a cross section of those cilia
(b) Reveals the internal structure of the cilia. The characteristic 9+2 configuration of microtubules can be clearly seen (c).



During cell division, centrioles organize microtubules that pull the chromosomes (orange) apart.
The centrioles are at the center of rays of microtubules, which have been stained green with a fluorescent dye.

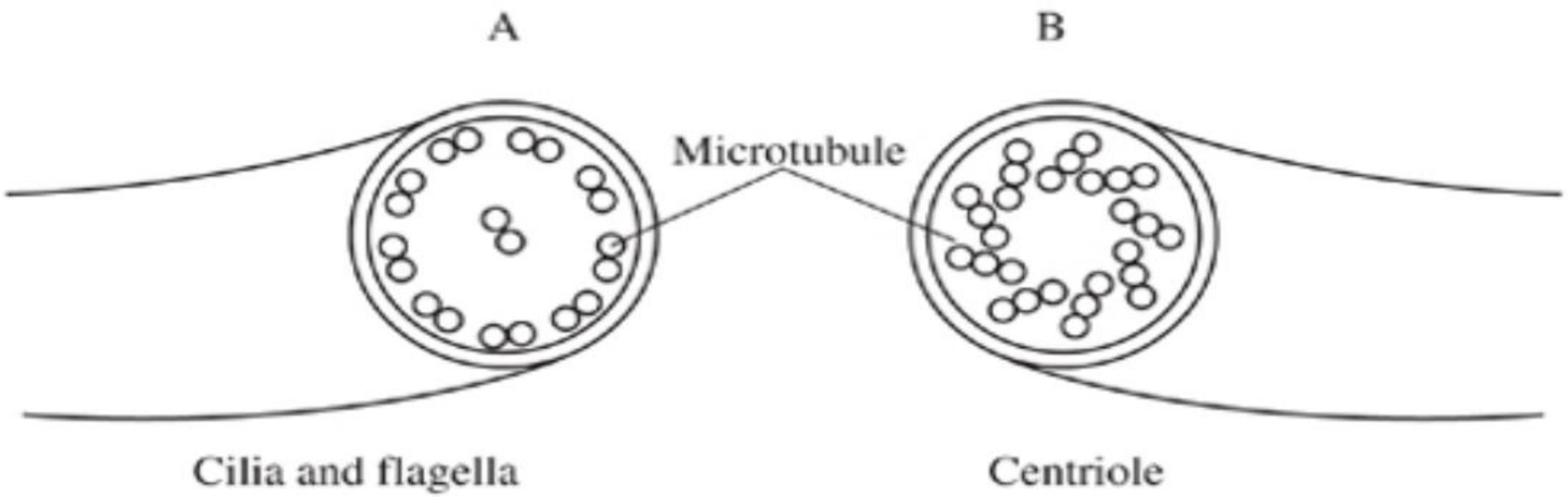
Back

Cilia and Flagella

Cilia and flagella have the same internal structure; both are made of microtubules

The only structural difference is in the length; cilia are short, and flagella are long.

Both consist of 9 pairs of microtubules organized around 2 singlet microtubules.



Cilia and flagella = 9 pairs + 2 single

Centrioles = 9 triplets

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.13

Cell Wall

Cell Wall

The cell wall is one structure not found in animal cells

Cell walls of fungi consist of chitin.

Plants and algae have cell walls made of cellulose.

Bacteria have cell walls made of peptidoglycan “called murine”.

In plant cells, the primary cell wall is located immediately outside the plasma membrane.

Some cells produce a second cell wall underneath the primary cell wall called the secondary cell wall.

When a plant cell divides, a thin gluey layer is formed between the two cell walls, which becomes the middle lamella and which keeps the two daughter cells attached.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.14

Cell Membrane (Plasma Mambrane)

Cell Membrane “Plasma Membrane”:

The cell membrane ,or plasma membrane, is a selectively permeable membrane that controls what enters and leaves the cell.

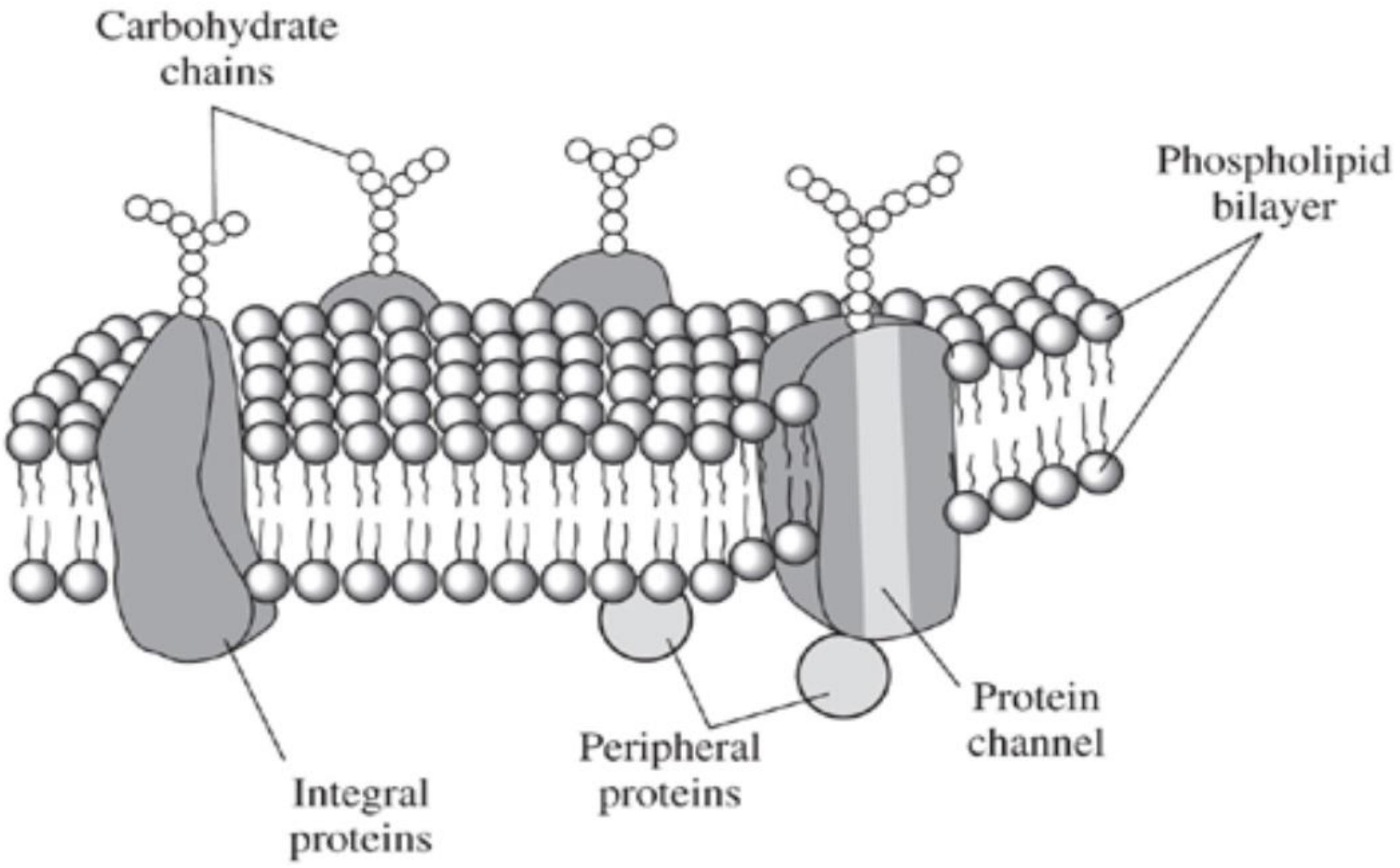
It is described as a fluid mosaic because it is made of many small particles that are able to move around in order to control what enters and leaves the cell.

The plasma membrane consists of a phospholipid bilayer with proteins dispersed throughout. This gives it the mosaic shape.

Molecules of cholesterol are embedded within the membrane, making it less fluid and more stable.

The external surface of the plasma membrane has carbohydrate chains attached to it that are important for cell-to-cell recognition.

Cell or Plasma Membrane



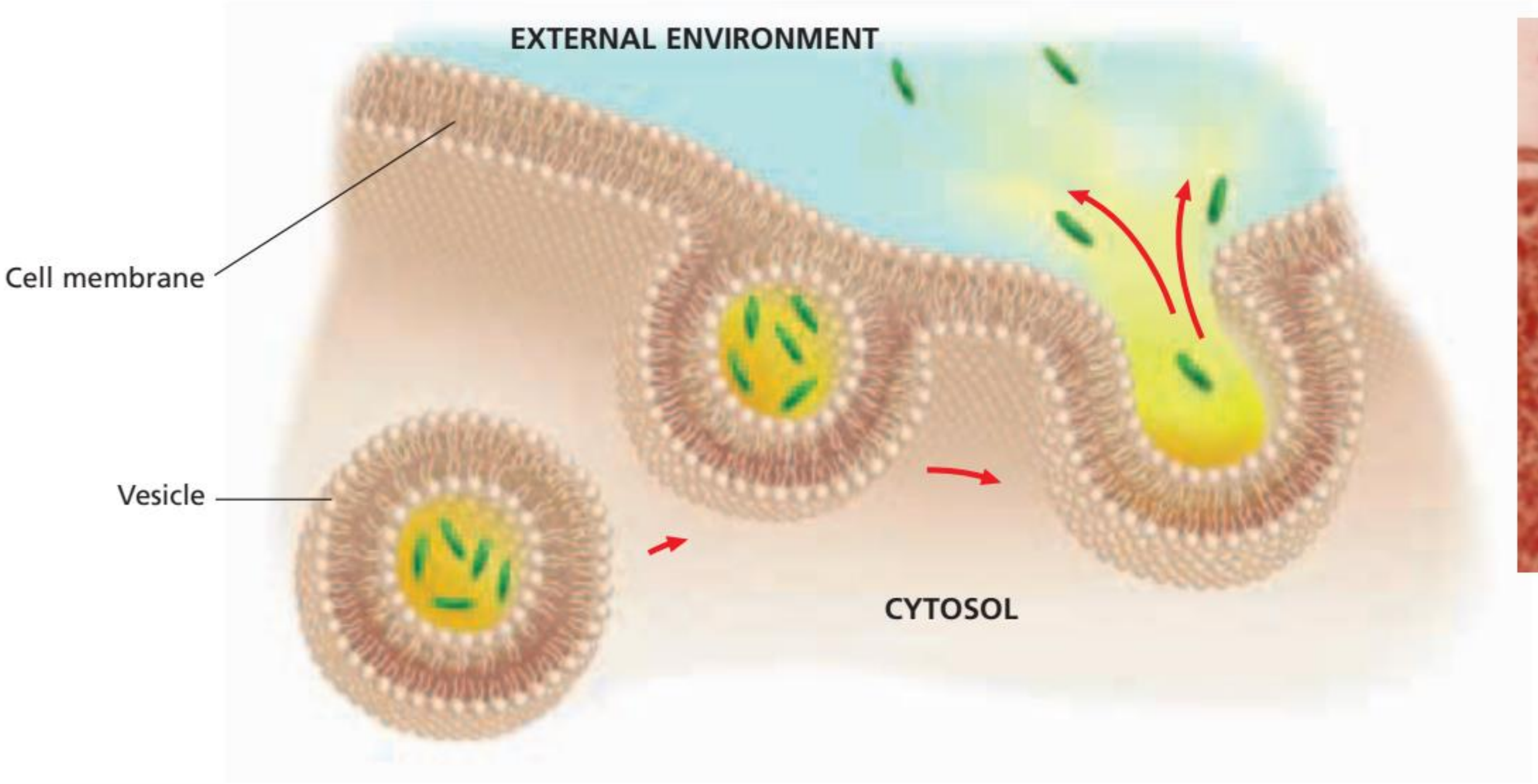
Cell or Plasma Membrane

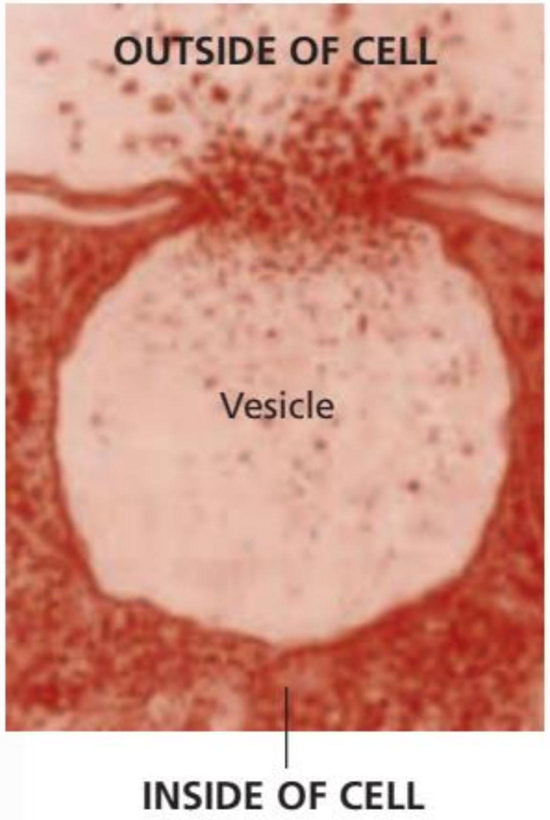
An average cell membrane consists of about 60 percent protein

These proteins provide a wide range of functions for the cell.

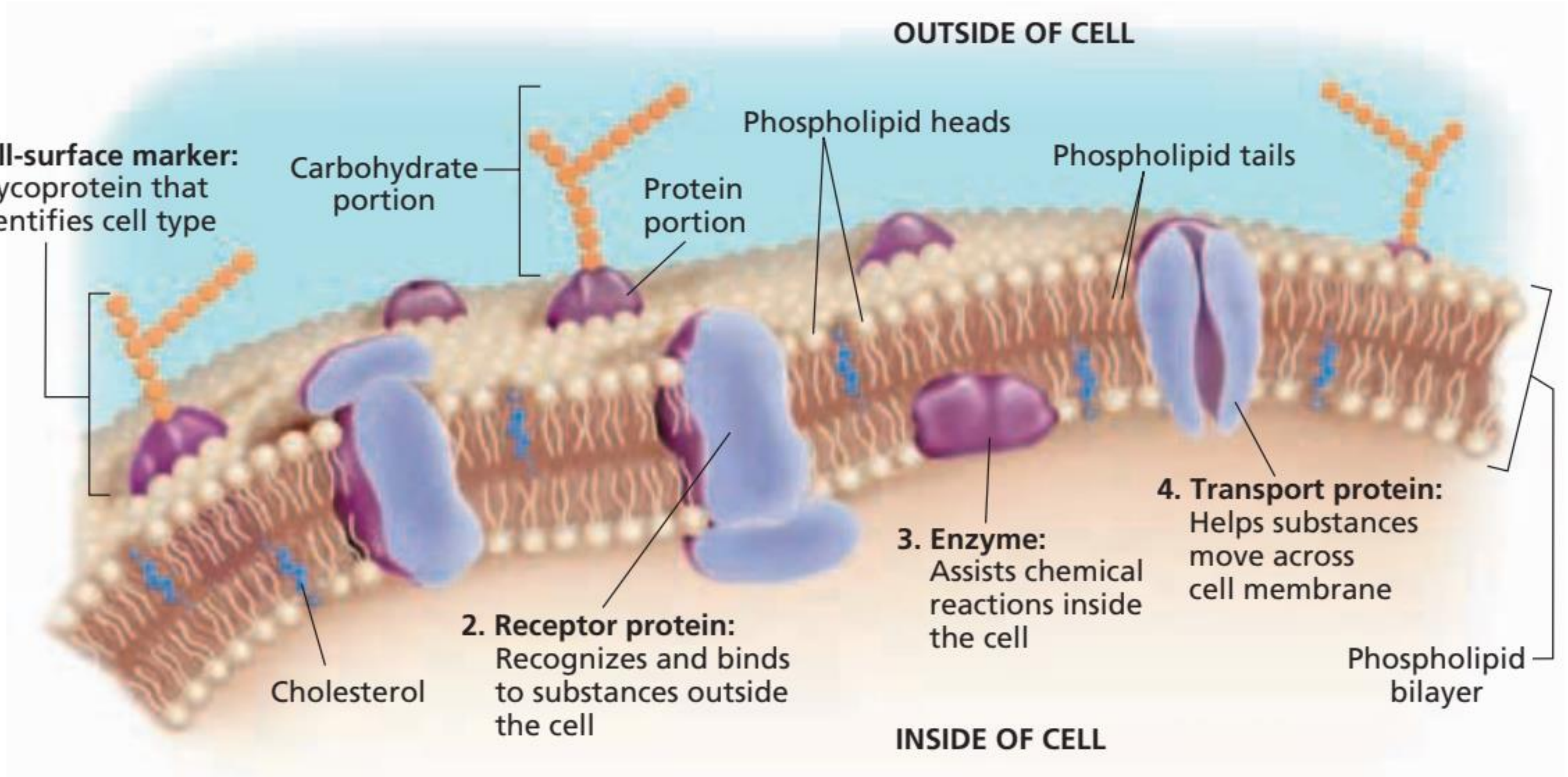
Some membrane proteins, like ATP synthetase, act as an enzyme.

Some, like those involved in the sodium-potassium pump, transport ions into and out of cells.

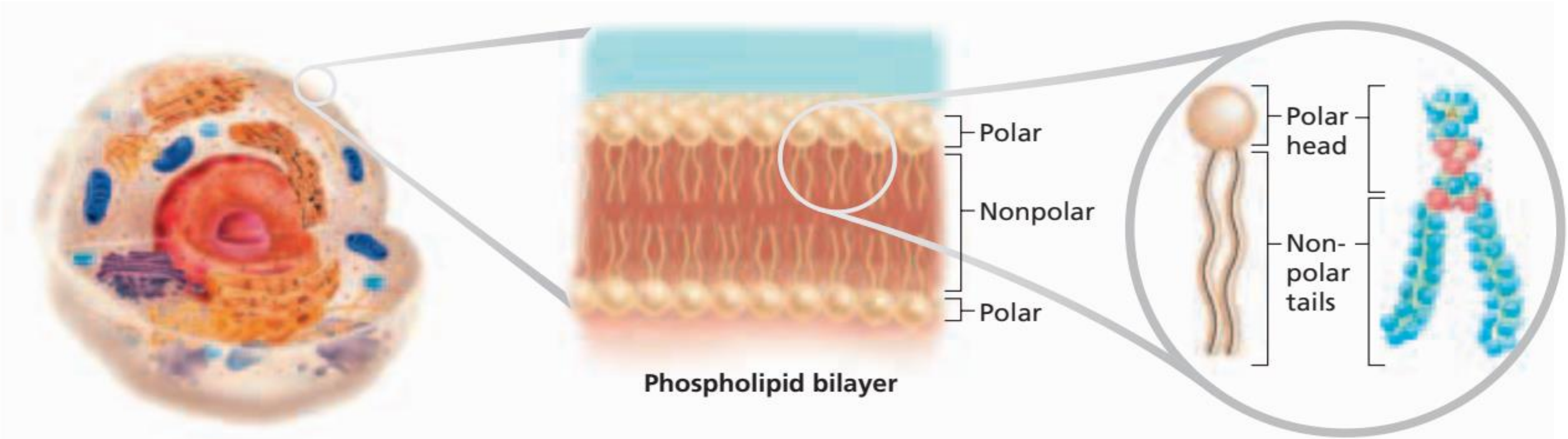




During exocytosis, a vesicle moves to the cell membrane, fuses with it, and then releases its contents to the outside of the cell



Cell membranes often contain proteins. Integral proteins include cell-surface markers, receptor proteins, and transport proteins. Enzymes are examples of peripheral proteins.

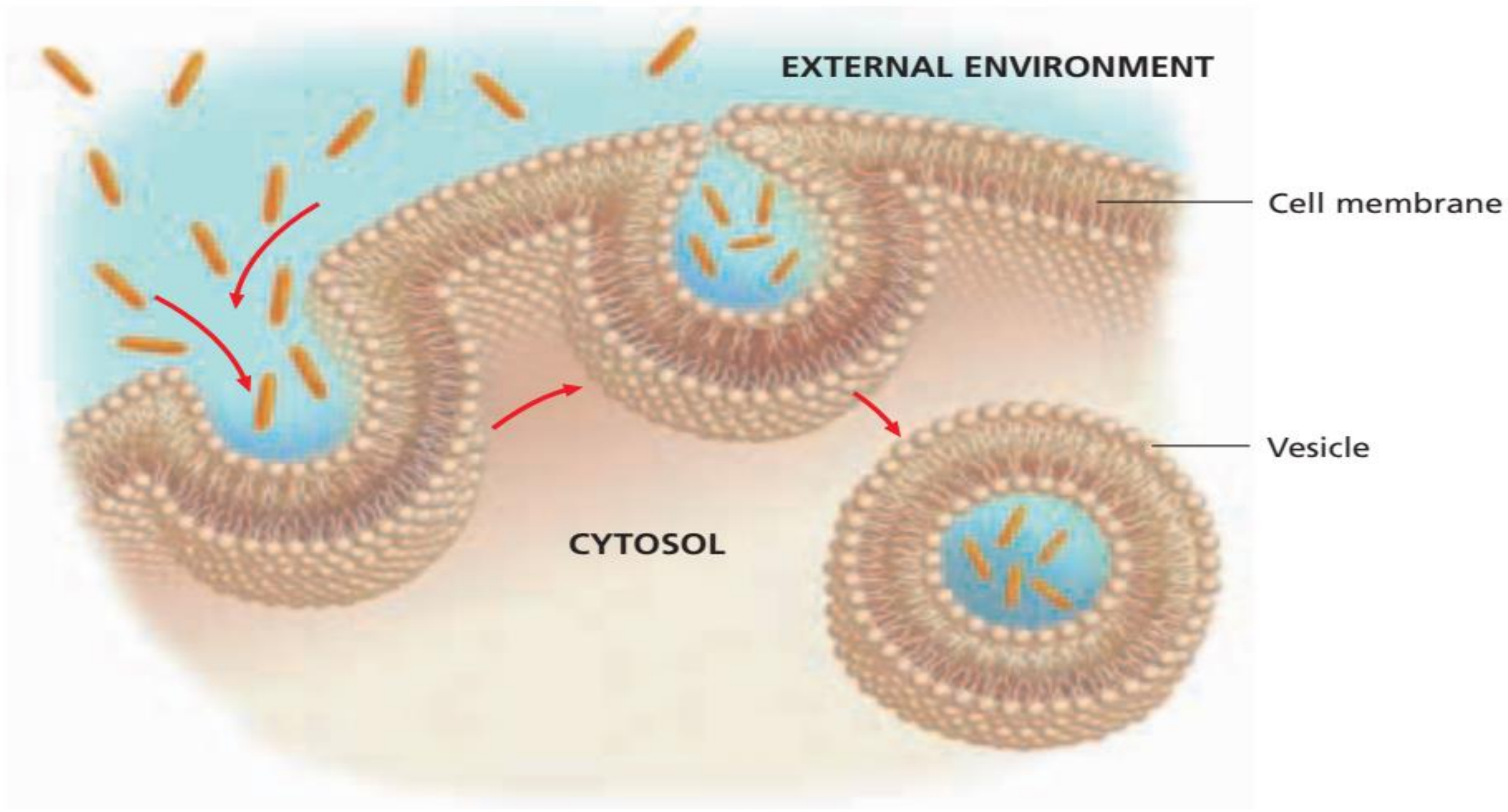


The phospholipid bilayer is the foundation of the cell membrane.

The arrangement of phospholipids in the bilayer makes the cell membrane selectively permeable.

A phospholipid's "head" is polar, and its two fatty acid "tails" are nonpolar.

Cell membranes are made of a phospholipid bilayer.
Each phospholipid molecule has a polar "head" and a two-part nonpolar "tail."



During endocytosis, the cell membrane folds around food or liquid and forms a small pouch. The pouch then pinches off from the cell membrane to become a vesicle.

Chapter 1

Cellular and Molecular Biology

Lesson 1.4.15

Animal Vs. Plant Cell

Differences Between Animal and Plant Cells

Animal Cell	Plant Cell
Centrioles and centrosomes	No centrioles or centrosomes
No chloroplasts and other plastids	Chloroplasts and other plastids
Most have small vacuoles (specialized fat storage cells are an exception)	Large central vacuoles
Plasma membrane only	Cell walls in addition to plasma membrane
Lysosomes	No lysosomes

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Thank you