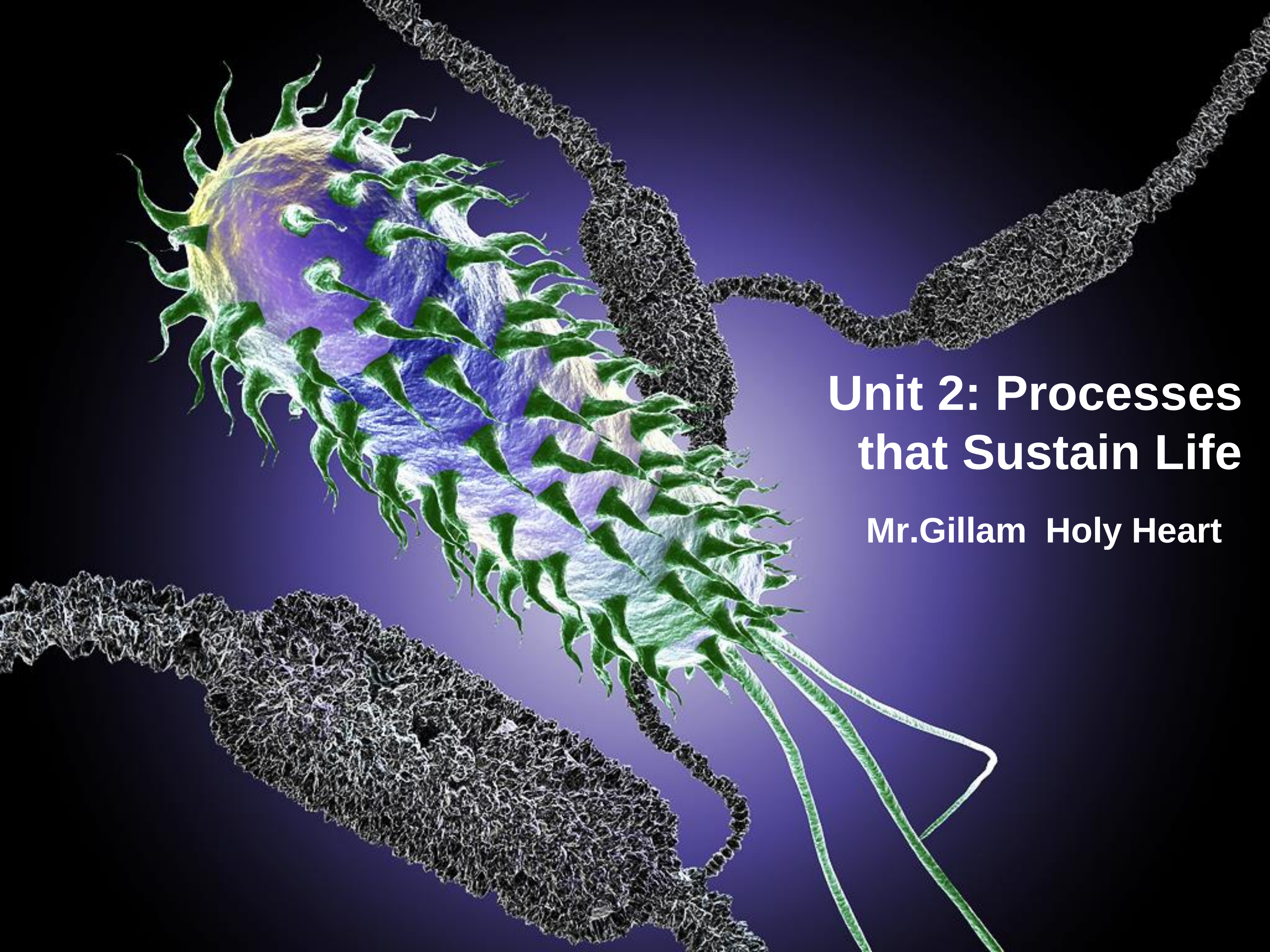


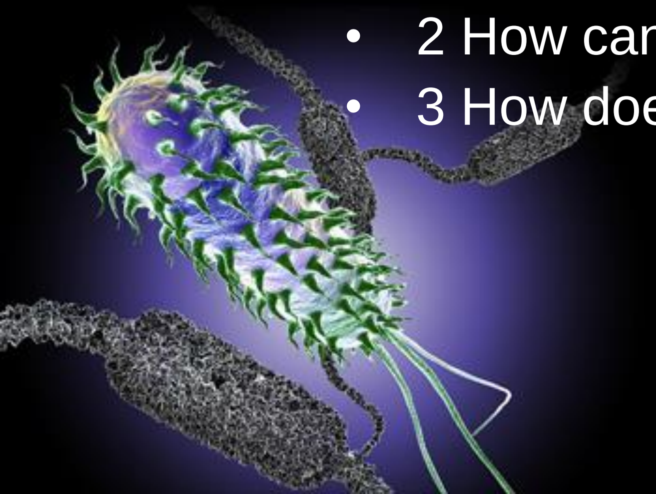
Unit 2: Processes that Sustain Life

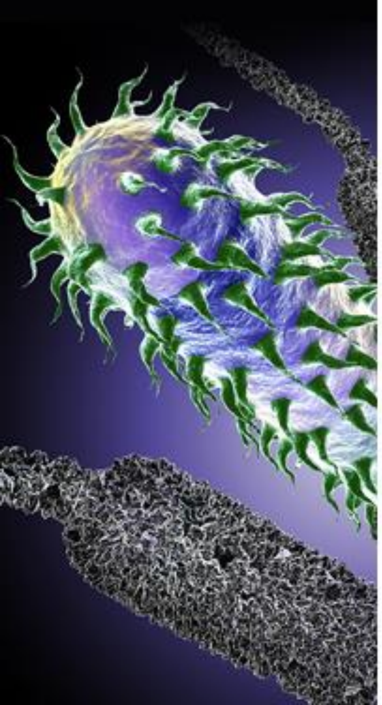
Mr.Gillam Holy Heart

Unit 2: Introduction

- In this unit, you will
- recognize the structure and function of key molecules and macromolecules in cells
- use and evaluate microscope technologies and other means to study cell structures and activities

- FOCUS QUESTIONS
- 1 What are living things composed of?
- 2 How can we study cells?
- 3 How does cell function depend on cell structure?





- Biochemistry
  - The study of the activity and properties of molecules that are important in cells and other biological systems

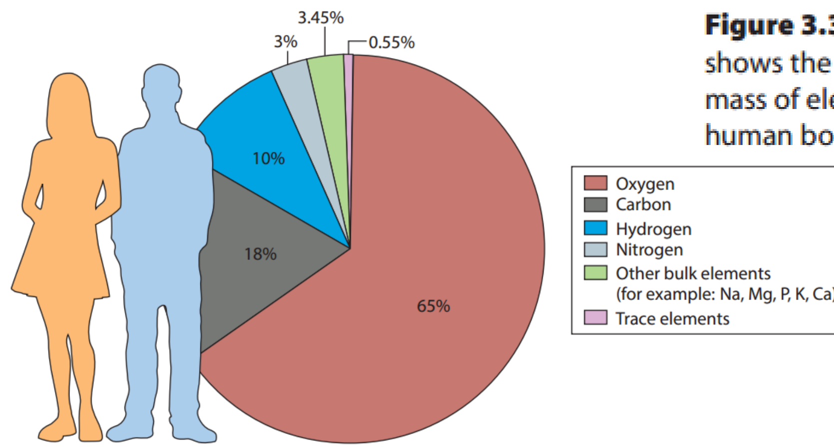


Figure 3.3 This pie graph shows the composition by mass of elements in the human body.

  - Only about 25 elements are essential to life.
  - carbon (C), hydrogen (H), oxygen (O), and nitrogen (N) account for 96 percent of the human body.
  - sodium (Na), magnesium (Mg), phosphorus (P), potassium (K), and calcium (Ca), totalling about 3.5 percent of the
  - iron (Fe) and iodine (I), are trace elements, meaning they are required in tiny amounts.
  - A person whose diet is deficient in any mineral can become ill or die.

Water: Essential to Living Systems

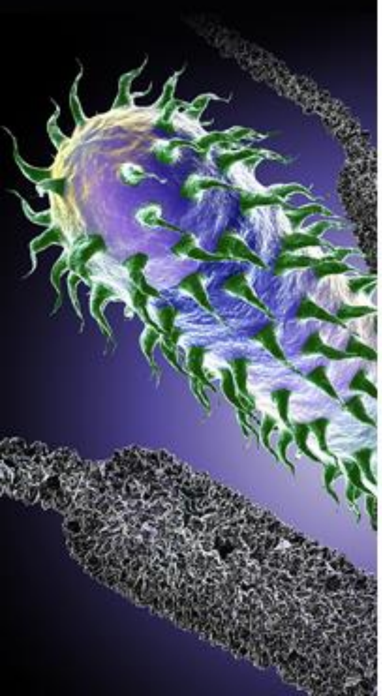
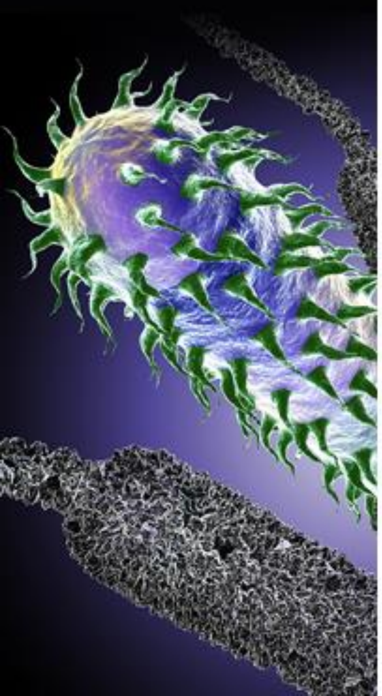


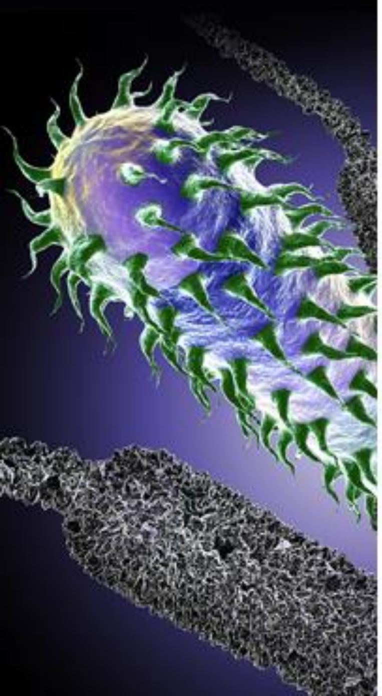
Table 3.1 Water's Unusual Properties

Property	Explanation	Example(s)
Water dissolves many substances.	"Like dissolves like." Because water is a polar molecule, it dissolves compounds made of ions or polar molecules.	Water provides a medium in which substances can undergo chemical reactions in living systems. Within living systems, water solutions (such as blood plasma) transport dissolved substances to where they are needed. 
Water regulates temperature.	Water has a strong ability to resist temperature changes. It takes more heat to raise water's temperature than it takes for most other liquids. Also, a lot of heat is required to change water from a liquid to a gas.	When sweat evaporates from skin, water molecules must absorb energy to escape into the air. When they evaporate they absorb thermal energy from the body. This cools the body and thus helps to regulate body temperature. 
Water expands as it freezes.	Ice is less dense than liquid water. As water freezes, the ice floats on the surface of the denser liquid water below.	When the air temperature drops, a small amount of water freezes at the lake's surface. A solid cap of ice forms, which traps heat in the water below, preventing the water from freezing further and protecting aquatic organisms from freezing. 



Water: Essential to Living Systems

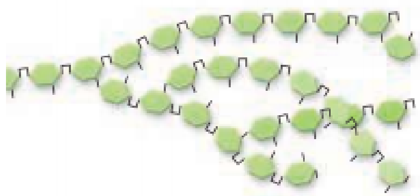
Water takes part in life's chemical reactions.	Nearly all of life's chemical reactions occur in the watery solution that fills and bathes cells. In addition, water is either a reactant in or a product of many of life's chemical reactions.	In photosynthesis, plants use the Sun's energy to assemble food using carbon dioxide and water. Oxygen, which nearly all organisms require, is released.	
Water is cohesive.	Hydrogen bonds contribute to a property of water called *cohesion*—the tendency of water molecules to stick together. The water molecules at the surface of water hold together so strongly that they form a "skin" at the surface.	Surface tension allows insects, such as this water skimmer, to literally walk on water.	
Water adheres to other substances.	Water also demonstrates *adhesion*, an attraction to the molecules of other substances. Adhesion provides an upward force on water and counteracts the pull of gravity.	Adhesion causes water molecules to stick to the inner surface of a glass tube or the water-conducting vessels in a plant. When evaporation draws water out from a plant's leaves, the remaining water in the stem is pulled up by adhesion and cohesion.	



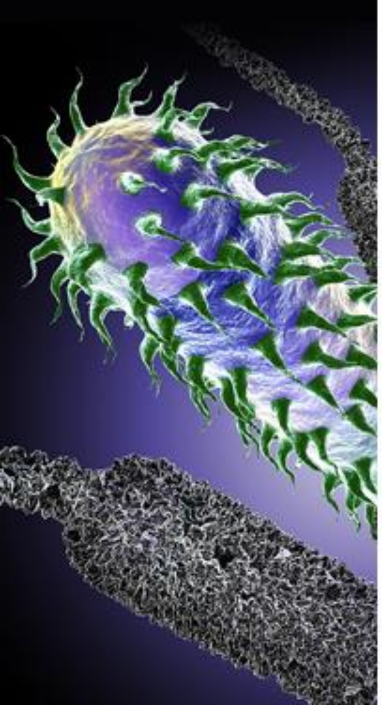
Molecules of Life

- macromolecule a large molecule

- carbohydrate biomolecule containing carbon, hydrogen, and oxygen; includes sugars
  - **simple carbohydrate monosaccharides and disaccharides; simple sugar**
  - **complex carbohydrate many monosaccharides joined together to make polysaccharides**

Category	Examples	Chemical Structure	Functions(s)
Carbohydrates 	monosaccharides and disaccharides	single and double rings composed of C, H, and O	Provide quick energy
	complex carbohydrates (such as cellulose, starch)	polymers of monosaccharides	Provide structure to cells and organisms; store energy

FYI
In nature, glucose is found in honey and in sweet fruits such as grapes. On food labels, it often goes by the name dextrose.



Molecules of Life

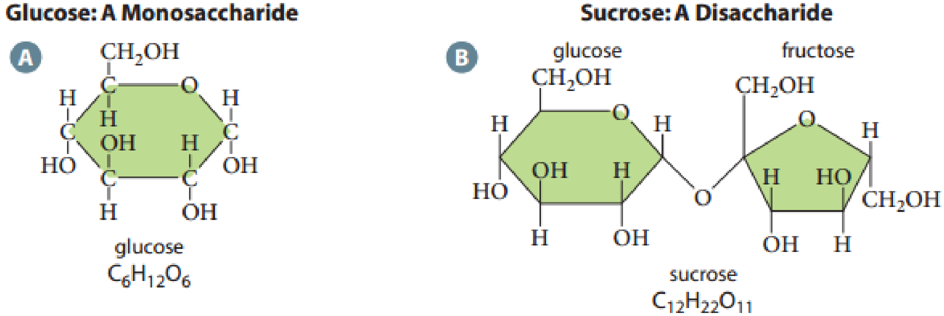


Figure 3.11 Glucose is a monosaccharide used by cells for energy. Glucose can be extracted from corn (**A**) to make various food products. Sucrose is the disaccharide you know as white sugar. Much of the sucrose you eat comes either from sugar cane (**B**) or from sugar beets.

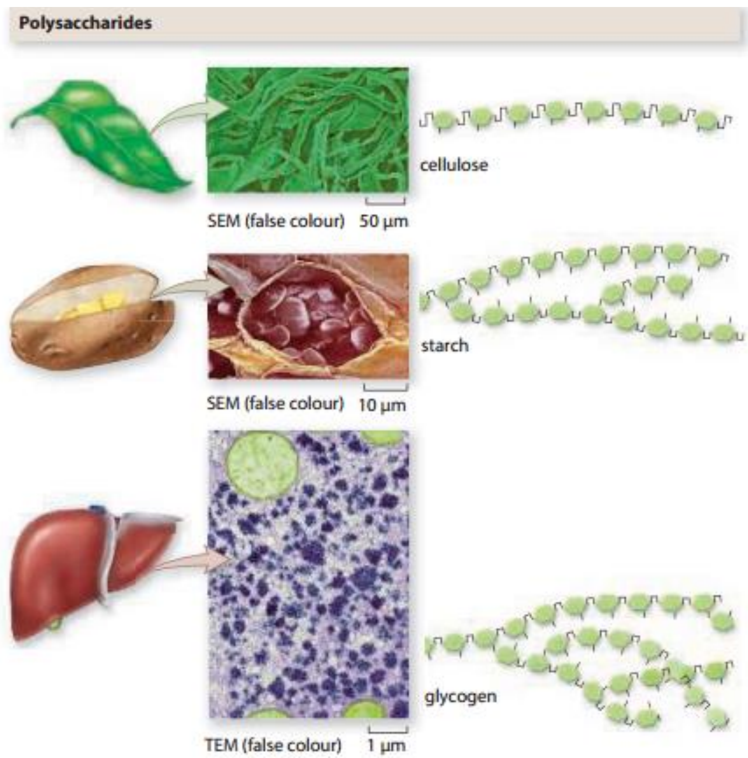
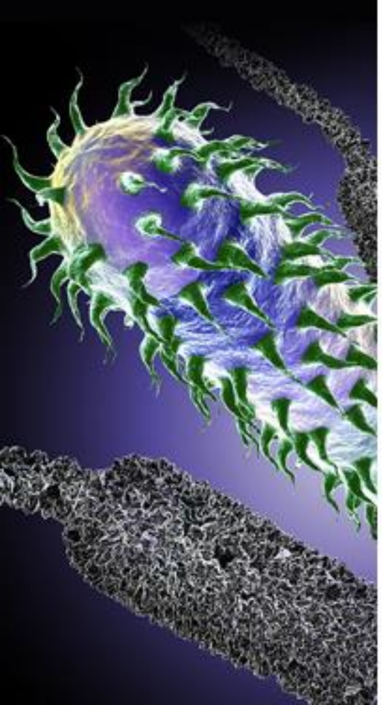


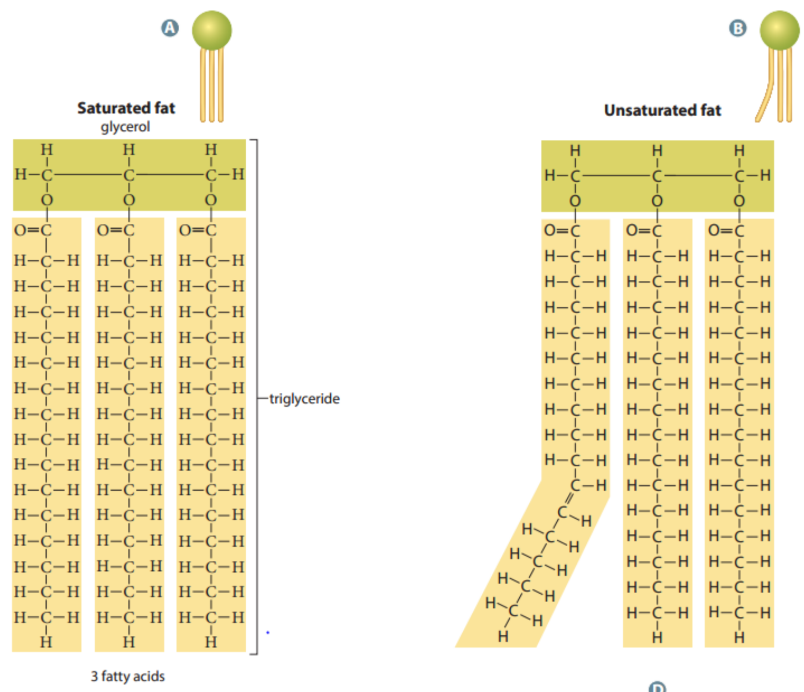
Figure 3.12 Three important polysaccharides are cellulose, starch, and glycogen. They are all made up of glucose monomers. But they are linked together differently, which results in different properties.



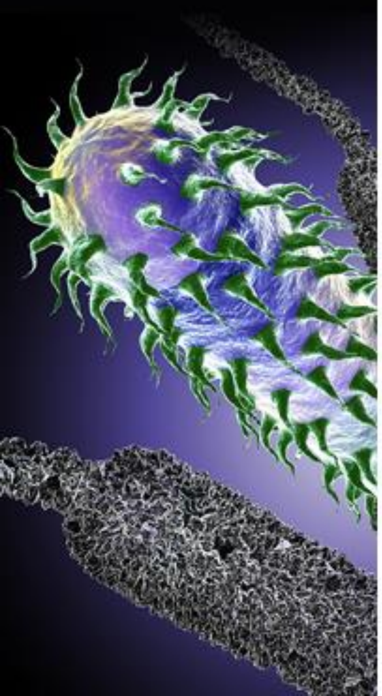
Molecules of Life

- Lipids: Structure and Functions
- Lipids are a diverse group of macromolecules with one property in common: they do not dissolve in water.

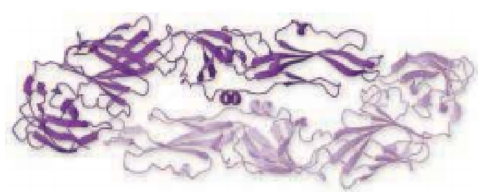
Lipids 	triglycerides	glycerol + 3 fatty acids	Store energy
	phospholipids	glycerol + 2 fatty acids + phosphate-containing group	Form major part of biological membranes
	steroids	4 fused rings, mostly C and H	Stabilize animal membranes; act as sex hormones
	waxes	long C-based chains	Various functions, including protection

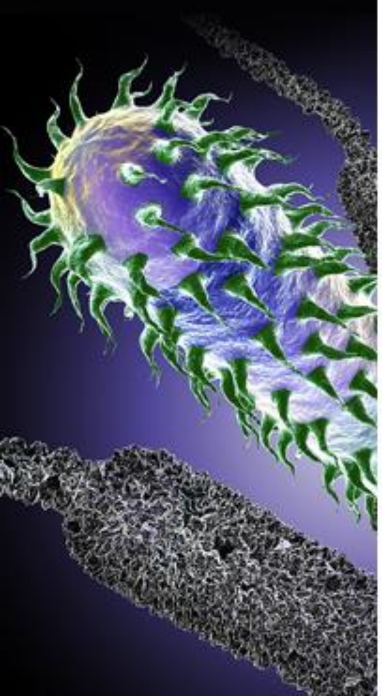


Molecules of Life



- Proteins: Structure and Function
- Proteins have more roles in the cell than any other type of biological molecule.
- Proteins control what enters and leaves a cell, carry oxygen in blood, aid in blood clotting, build hair and fingernails, support the body's tissues, break apart food molecules, allow muscles to contract, help cells to communicate, defend the body against germs, and take part in many other processes.
- Proteins play a major role in all the activities of life. Illness or death can result even if one type is missing or faulty.

Proteins 	amino acids	polymers of amino acids	Carry out nearly all the functions of the cell



- Some career opportunities in biological sciences

A researcher tests a new anti-cancer medication on cells grown in the laboratory (Figure 3.1).

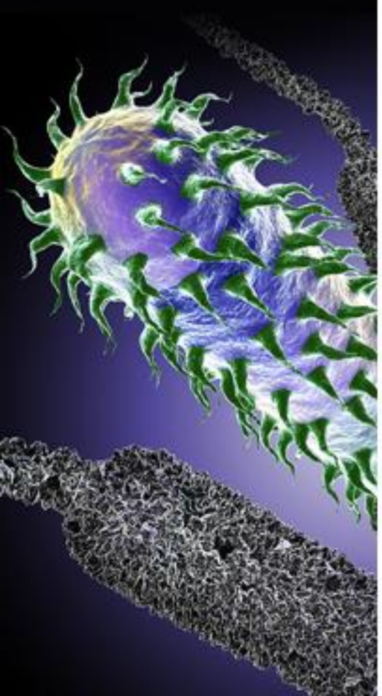
A technician analyzes a blood sample from an elite athlete for the presence of illegal drugs.

A child receives just the right amount of anesthetic to stay safely unaware during an operation.

Figure 3.1 Understanding cells has allowed researchers to grow cells in the laboratory. This allows scientists to test products and medications directly on cells and to observe how the cells react.

Plant Geneticist A plant's DNA can hold the key to properties such as disease tolerance, seed size, and productivity. Plant geneticists conduct research to understand how changes to this DNA can alter a plant's properties in a desired way. They then apply this knowledge to create new and improved plants. Often working for agricultural and chemical companies, plant geneticists may also conduct research and teach courses at the university level. While a bachelor's degree in a related field such as genetics or biochemistry is the minimum requirement for this career, many plant geneticists have a master's or doctorate degree.

The Cell Theory

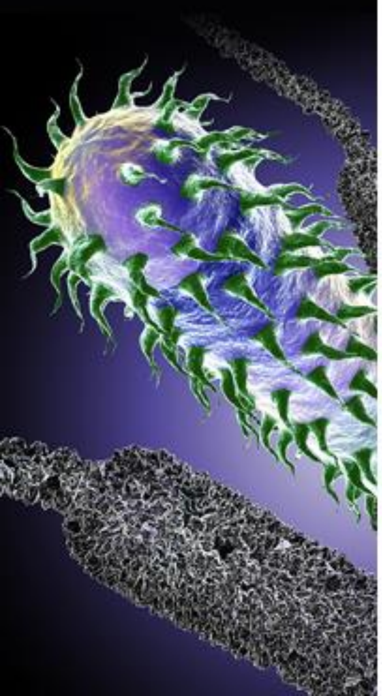


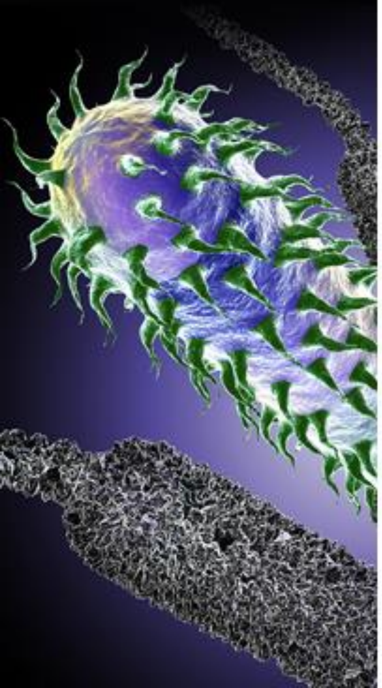
History

- For thousands of years, people observed that maggots (fly larvae) seemed to appear suddenly in meat that had been left rotting for several days.
- Frogs and salamanders seemed to appear suddenly in mud.
- They thought that these organisms appeared from nothing.

- Aristotle (384–322 B.C.E.) “The Father of Biology” wrote that living organisms could arise spontaneously from non-living matter. He called this spontaneous generation.

- Jan Baptista van Helmont (1577–1644), stated that mixing a dirty shirt with several wheat grains would produce adult mice after 21 days. These mice would then produce more mice by mating.





- Thomas Huxley (1870) renamed spontaneous generation to abiogenesis.

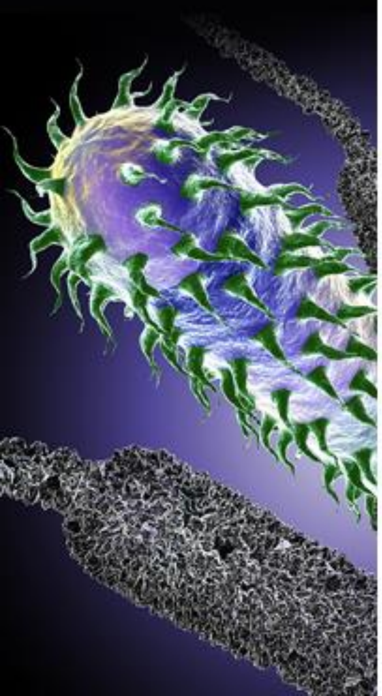
- William Harvey (1578–1657), suggested that maggots hatch from eggs that are too small to be seen.

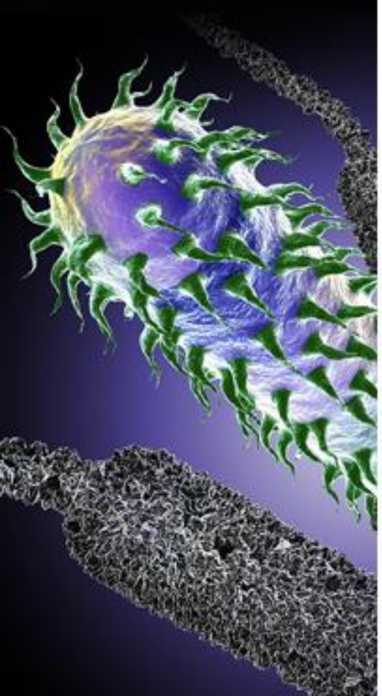
- Abiogenesis
  - the idea that life can develop from non-living matter; also called spontaneous generation

Figure 4.1 Where did the animals in this compost heap come from? The hypothesis of spontaneous generation would suggest that these organisms arose out of non-living materials.

- Francesco Redi (1626–1697) conducted one of the first recorded controlled biological experiments.
- His hypothesis was that only flies would produce more flies.
- To test this hypothesis, he placed rotting meat in two uncovered jars (his control group) and two jars that he covered with cloth (his experimental group).
- Over time, the control jars were filled with maggots and flies.
- However, the experimental jars were free of insects. His experiment effectively demonstrated that maggots do not appear in meat if flies cannot land on it.

- Although Redi's experimental evidence was strong, it was not enough to change many people's firmly held belief in spontaneous generation.





- Louis Pasteur (1822–1895) Through a series of experiments, he showed that micro- organisms come from other micro- organisms in air and liquids (Figure 4.2). Pasteur is credited with disproving abiogenesis and proving biogenesis.

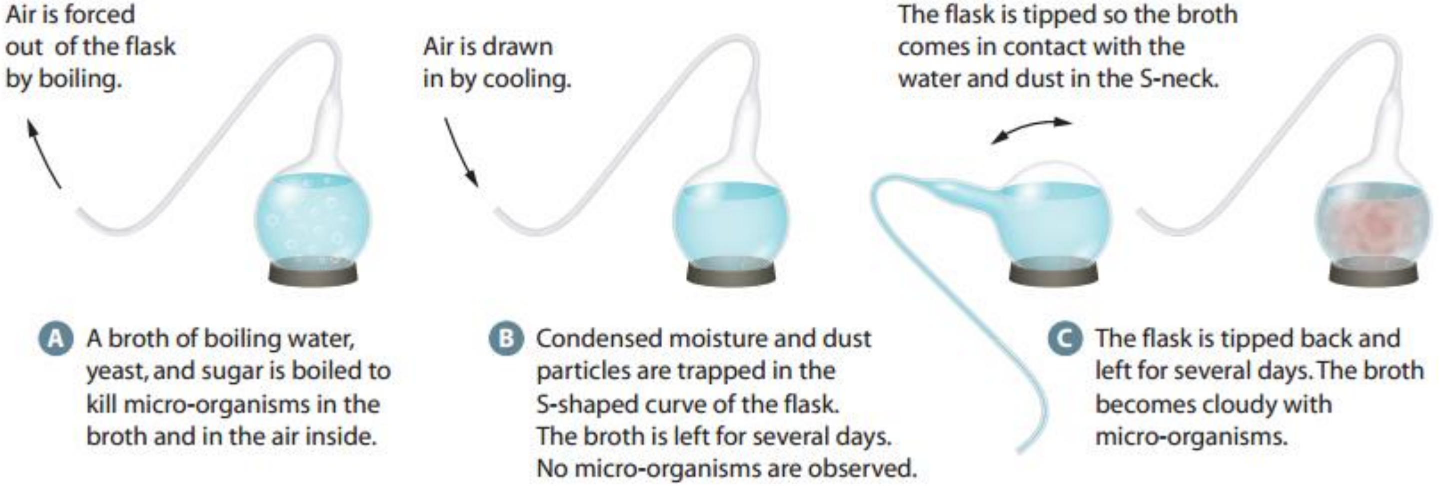
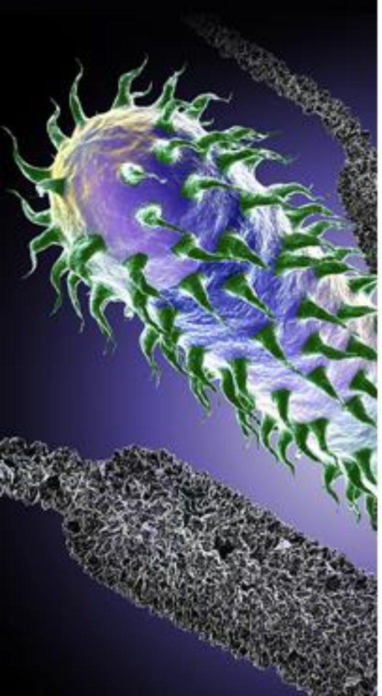
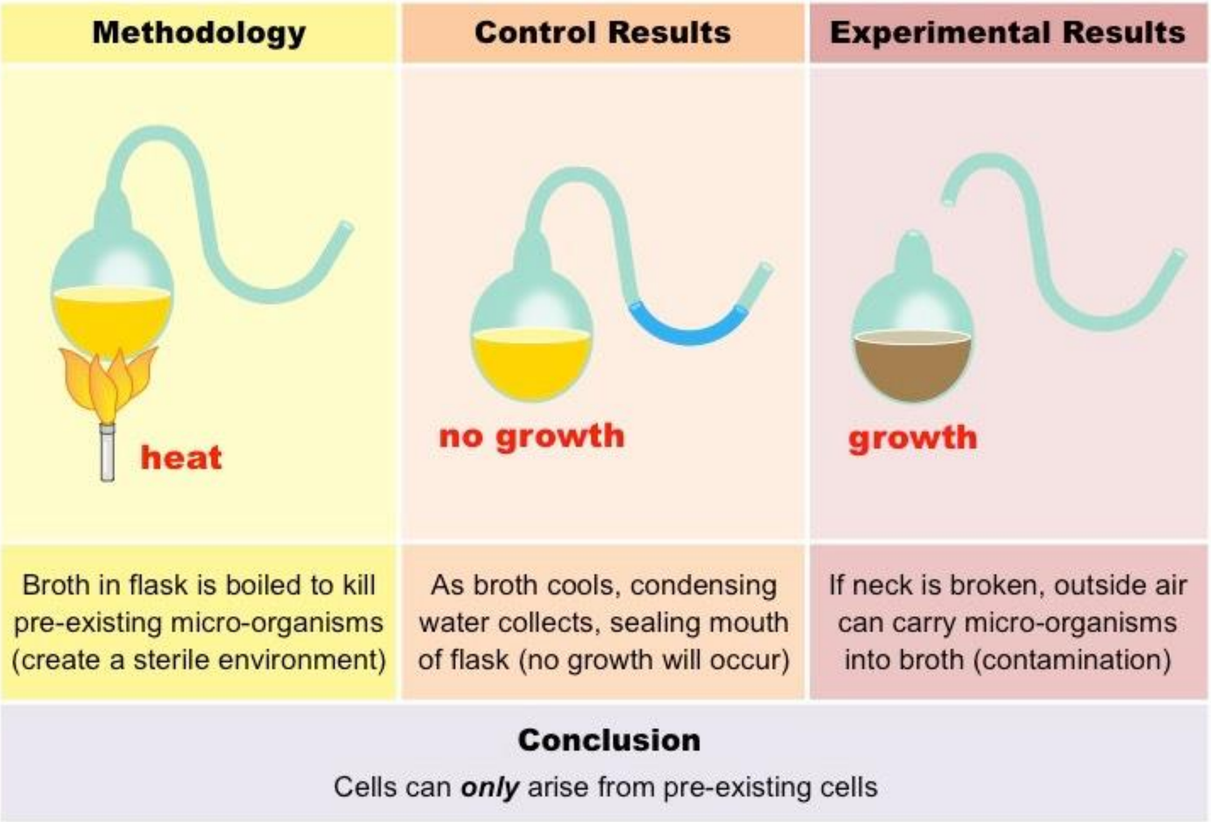


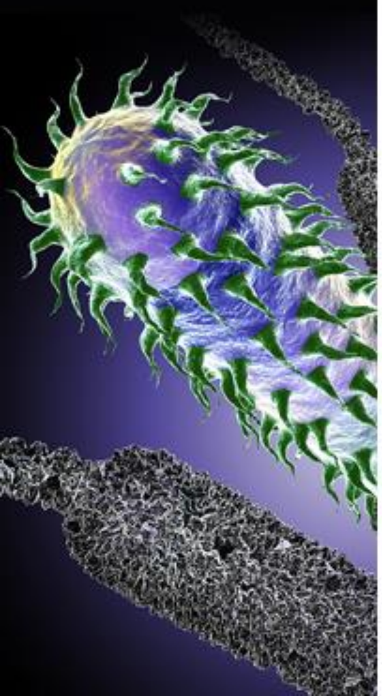
Figure 4.2 Pasteur used flasks with S-shaped necks to show that micro-organisms come from other micro-organisms, and do not appear by spontaneous generation.

- Biogenesis
  - biogenesis the idea that life only arises from life
- Paradigm Shift
  - a change in thinking that provided a whole new way of looking at the world.
  - The general acceptance of biogenesis was a paradigm shift.

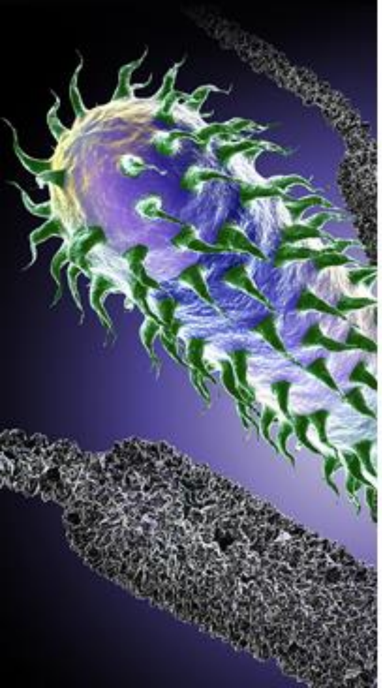




Deep Learning



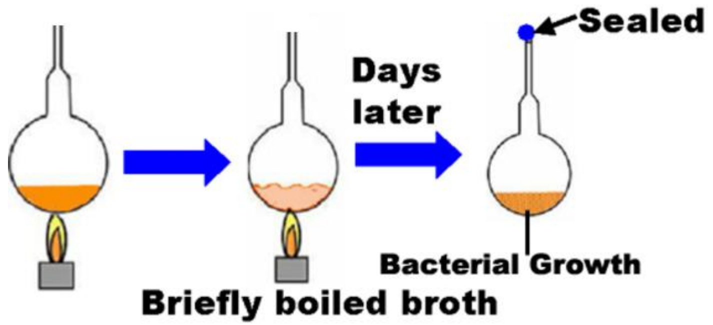
Activity 4.1 Handout

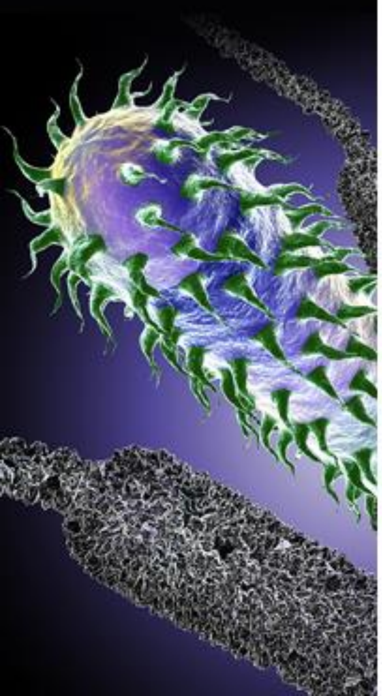


John Needham

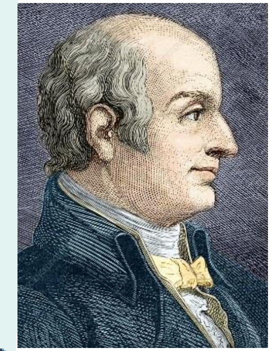
In 1748, an English naturalist and priest, John Needham (1713–1781), designs an experiment to support the idea of spontaneous generation. He brings meat broth to a boil for a short time to kill off micro-organisms in it and then transfers it to a sealed flask. He leaves a second flask with boiled broth open. Within days, the broth in both flasks is teeming with micro-organisms. Needham reports his findings as evidence in favour of spontaneous generation.

Identify any flaws in Needham’s experiment that would have influenced his results.





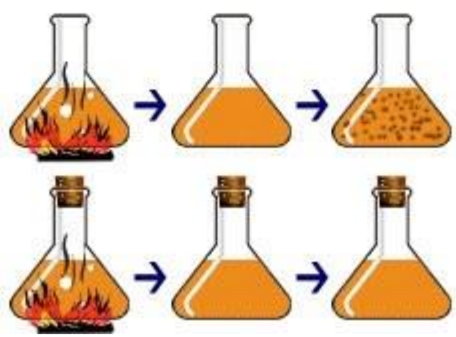
Lazzaro Spallanzani

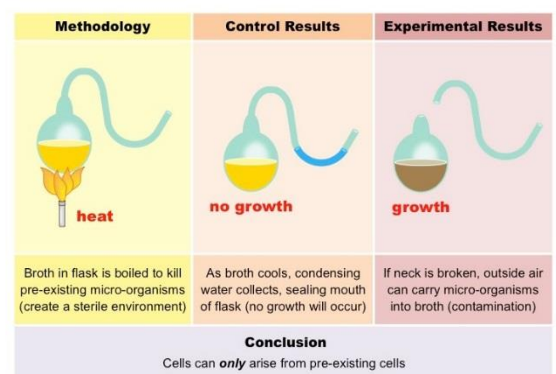


An Italian biologist, Lazzaro Spallanzani (1729–1799), learns of Needham's experiment and is skeptical of his results and conclusions. Spallanzani repeats the experiment, but boils the broth for a longer time. No life appears in the sealed flask. Supporters of the spontaneous generation hypothesis claim that boiling killed a vital principle contained in air. This vital principle, they argue, is what is responsible for life arising from non-living matter.

Pasteur uses heat to kill off micro-organisms in a flask. He then conducts an experiment with S-necked flasks to show that, even in the presence of air, micro-organisms do not arise in heat-treated broth.

How did Pasteur's experiment address claims that Spallanzani destroyed a vital force required for life when he sealed his experimental container?

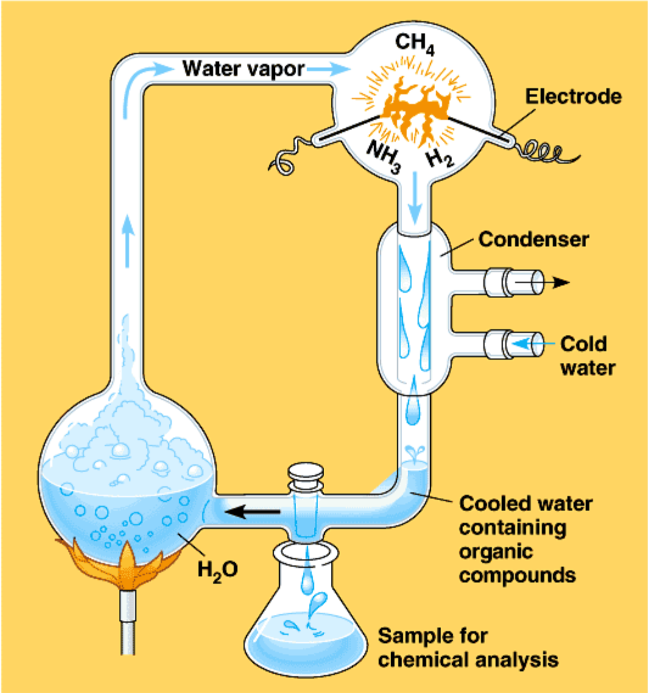


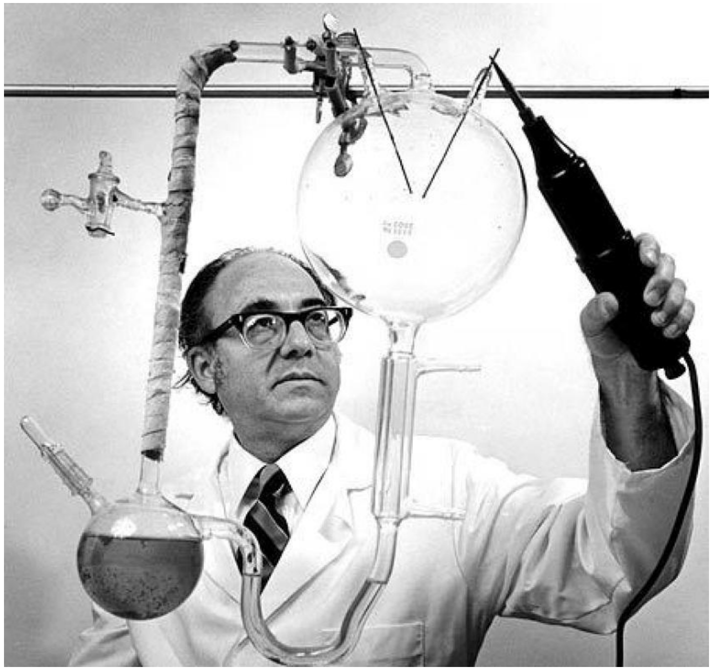


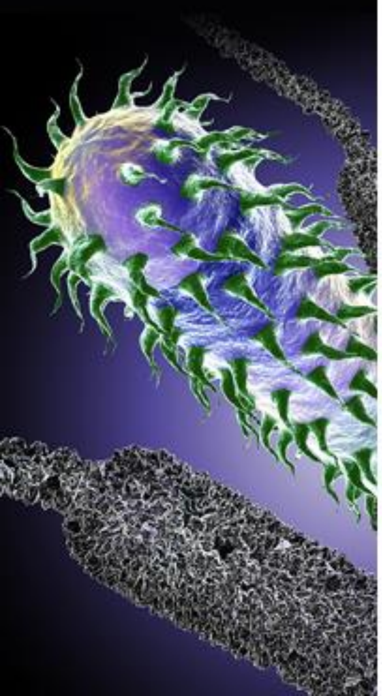
Harold Urey and Stanley Miller

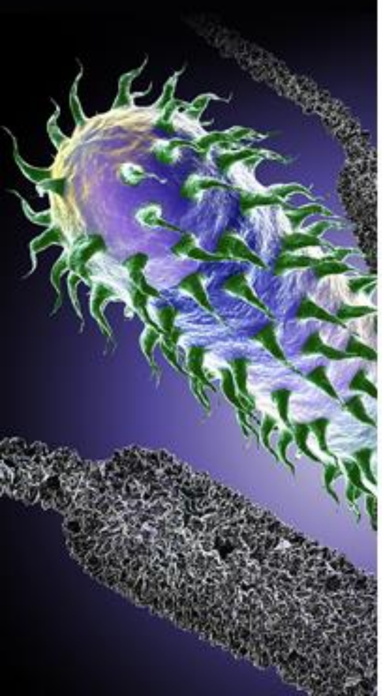
In 1953, scientists Harold Urey and Stanley Miller mix water, methane, hydrogen, and ammonia and subject the mixture of non-living matter to electric discharges to simulate lightning. This experiment results in the spontaneous production of organic chemicals that are components of all living cells.

In what way do Urey and Miller’s experimental results affect the biogenesis-abiogenesis controversy?









- Cell
  - the smallest unit of life that can exist on its own as a single-celled organism or as part of multi-celled organism.

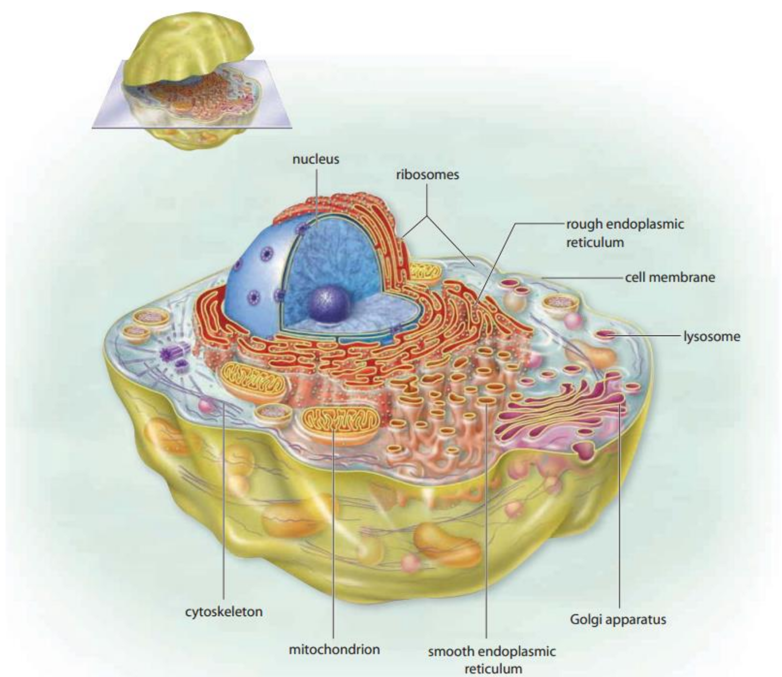


Figure 4.11 An animal cell. Most animal cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different animals and among different parts of the same animal.

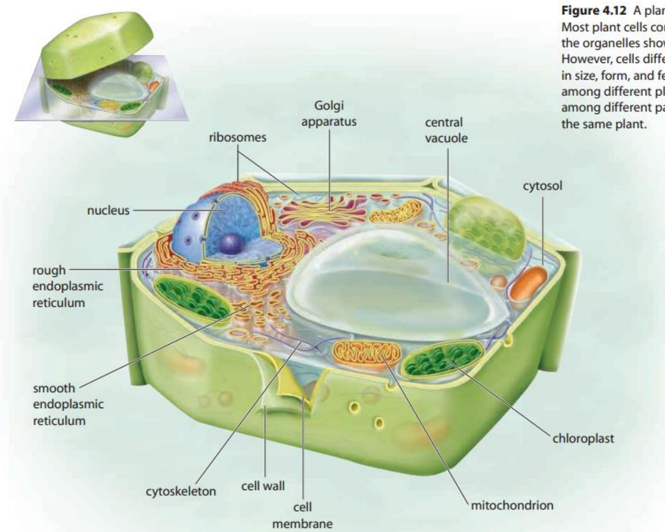
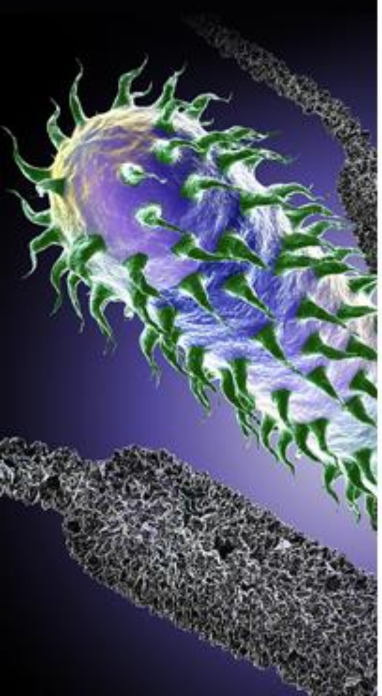


Figure 4.12 A plant cell. Most plant cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different plants and among different parts of the same plant.

The Cell Theory

- 1.All organisms are made of one or more cells.
- 2. Cells are the basic units of structure and function in all organisms.
- 3. All cells come from other, already existing cells.
- 4. The activities of a multicellular organism depend on the activities of all of its cells.



Microscopes Reveal Cellular World

- First known recorded reference to eyeglasses is made by English friar and philosopher Roger Bacon (1214?–1294).

- Robert Hooke (1665) used a simple microscope of his own design to look at cork. He called the little boxes or units that he observed cells.

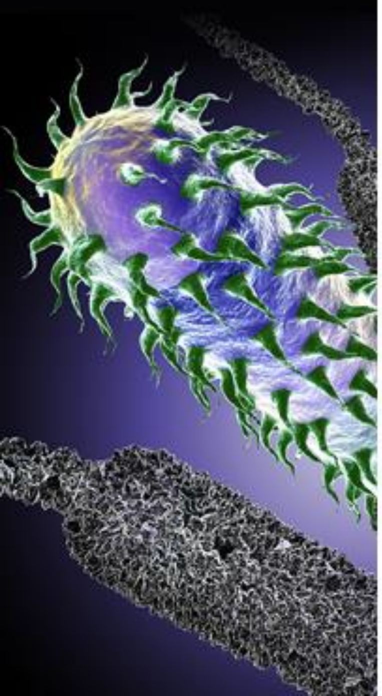
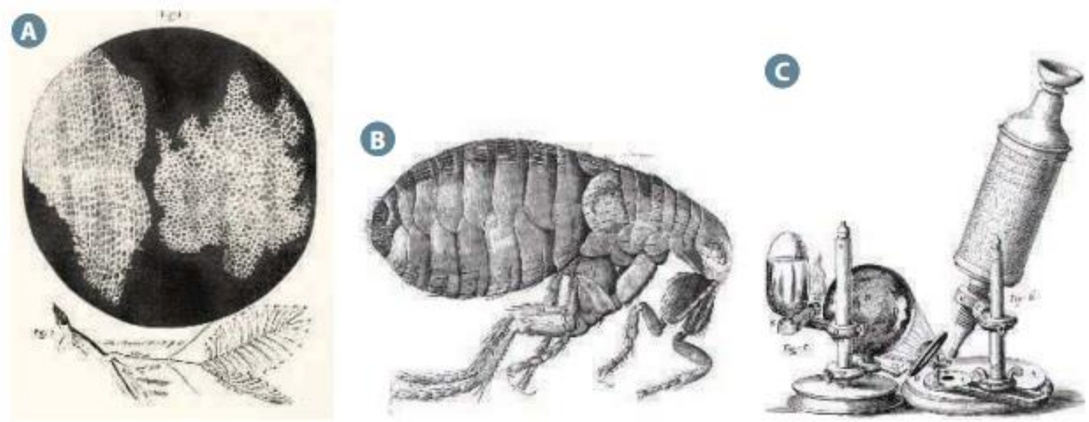


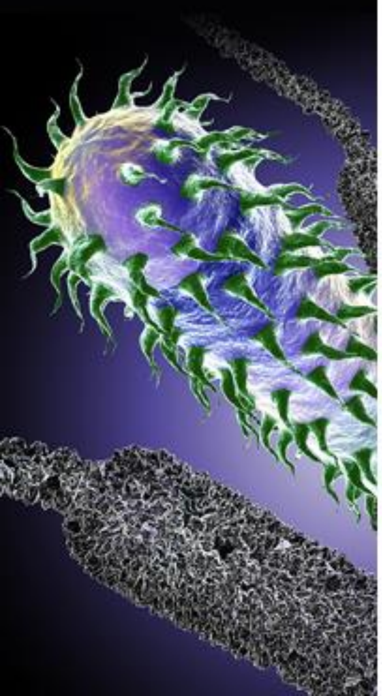
Figure 4.3 Robert Hooke examined cork **(A)** and other objects such as insects **(B)** using microscopes of his own design **(C)**. Hooke chose the name *cells* for the little units he saw in cork because they looked to him like the cubicles in which monks studied and prayed, which were called *cellae* in Latin.



- Antoni van Leeuwenhoek (1660s), reads Hooke's book and designs his own single-lens microscopes. Some of his microscopes are as much as six times more powerful than compound microscopes of the time. He created much better glass lenses.

- In a letter to the Royal Society of London, van Leeuwenhoek reports observing tiny “animalcules” in standing water. Hooke confirms the observations using a different microscope.

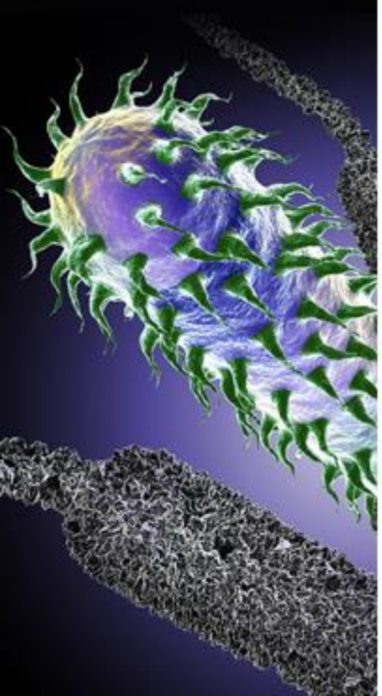
- While examining dental plaque in 1683, van Leeuwenhoek observes “many very little living animalcules, very prettily a-moving.” This observation is thought to mark the discovery of bacteria.

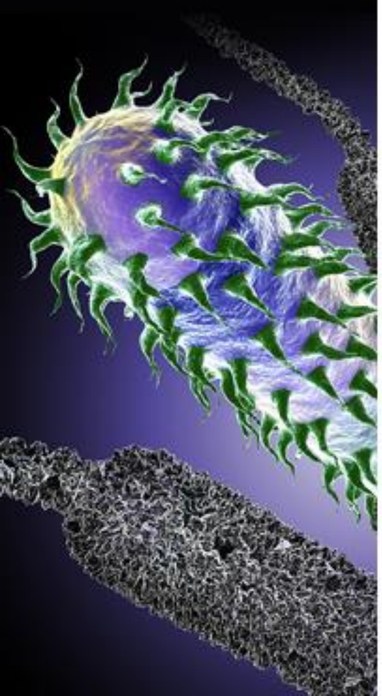


- 1700s - Microscopes become sturdier but glass quality is still low.
- 1800s - Better glass-making technologies lead to improved lens quality. Many English manufacturers compete to produce the best microscope.

- 1838 - German botanist Matthias Jakob Schleiden (1804–1881) writes, “All plants are made of cells.”

- 1839 - German physiologist Theodor Schwann (1810–1882) writes, “All animals are made of cells.” Also, Schwann modifies and expands on his earlier statement: “Cells are organisms, and entire animals and plants are collectives of these organisms.”

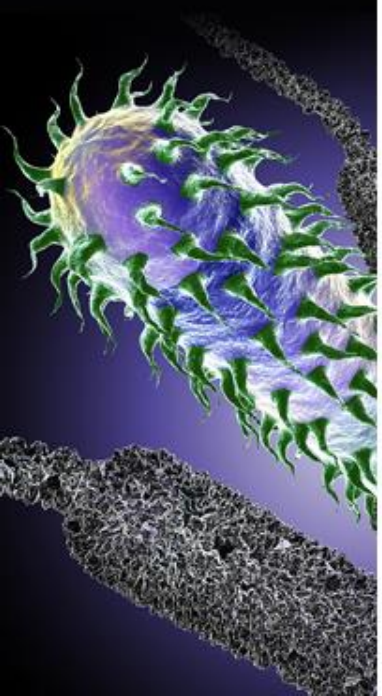




- 1846 - German biologist Hugo von Mohl (1805–1872) writes, “Protoplasm is the living substance of the cell.” Around 1847, von Mohl expands on his earlier statement: “Cells are made of protoplasm enveloped by a flexible membrane.”

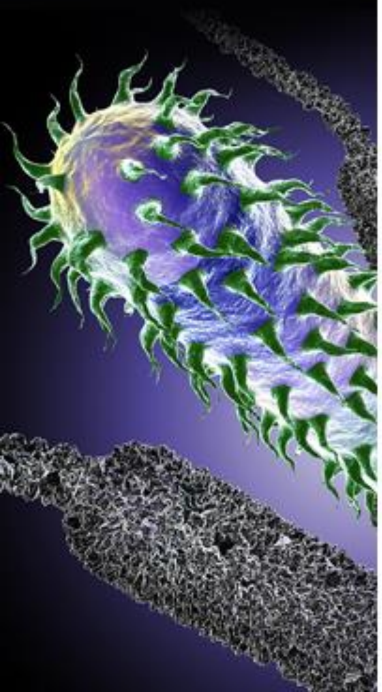
- 1856 - English chemistry student William Henry Perkin (1838–1907) develops a new intense purple dye. Microscopy experts quickly develop techniques for staining slide specimens with it.

- 1858 - German physiologist Rudolph Virchow (1821–1902) writes, “Cells are the last link in a great chain (that forms) tissues, organs, systems, and individuals...Where a cell exists, there must have been a pre-existing cell...Throughout the whole series of living forms...there rules an eternal law of continuous development.”



- Complete Google Slides assignment on scientists for homework on the google classroom
- *** Needs to be complete for grading

- [Video: Wacky History of Cell Theory]
- 6 mins and 11 secs



- Magnification refers to the number of times larger the image you observe is compared with the actual object.
- Resolution refers to the ability of the microscope to show details at a given magnification. An image with good resolution has sharp, easily distinguished details. An image with poor resolution looks blurry.

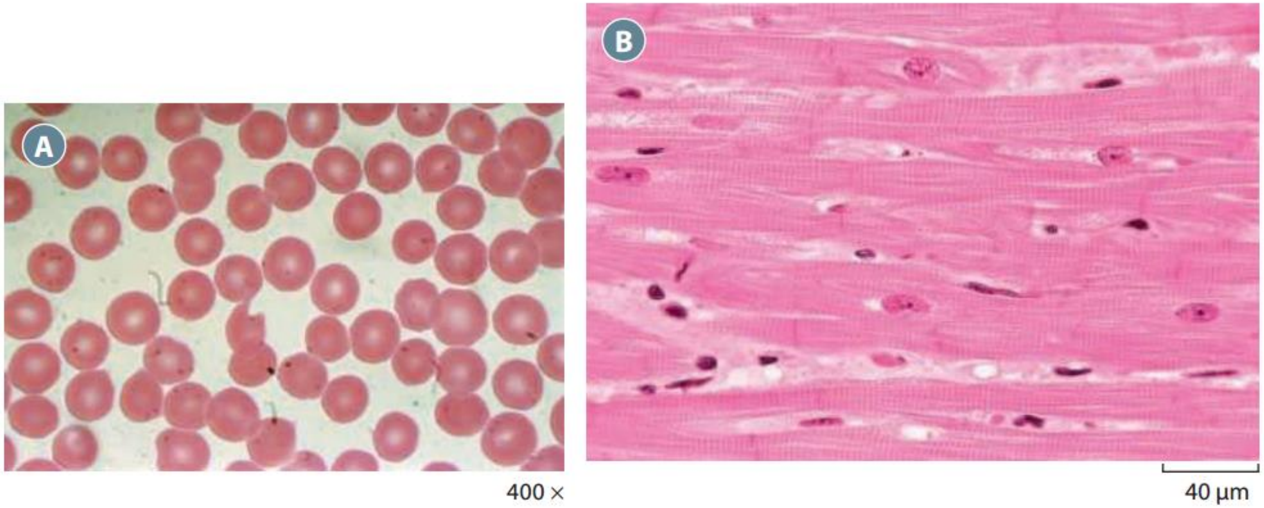
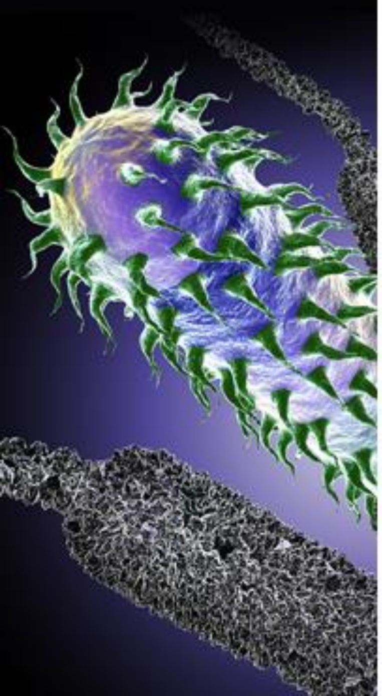
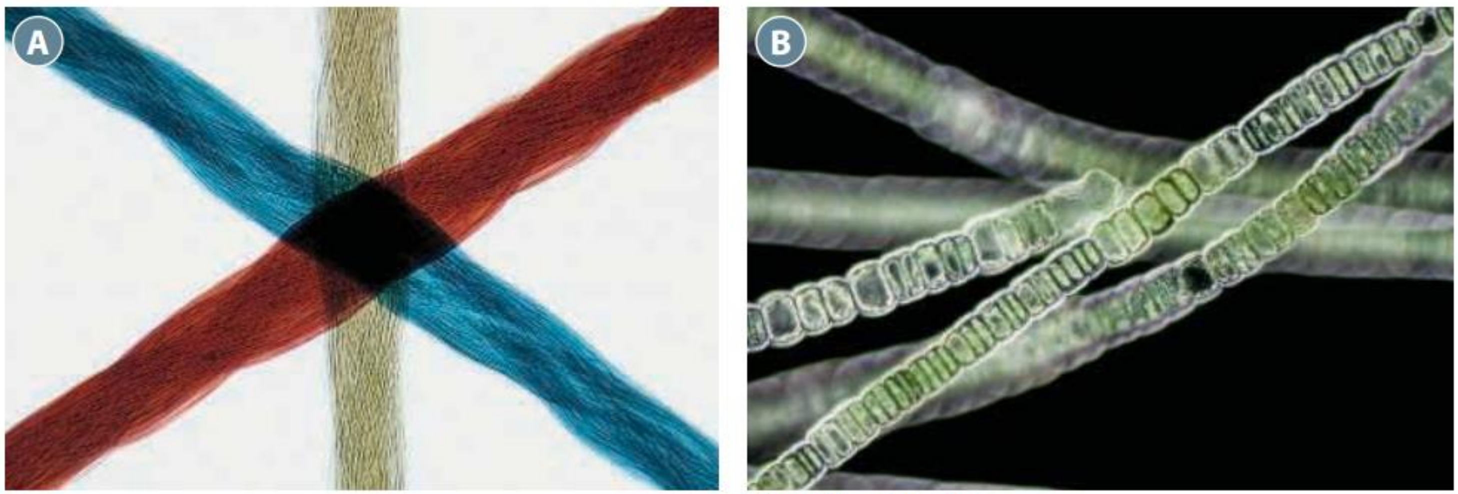


Figure 4.6 The images of cells shown here were captured at 400× magnification through a compound light microscope. **(A)** shows human blood cells; **(B)** shows cells in human muscle tissue.

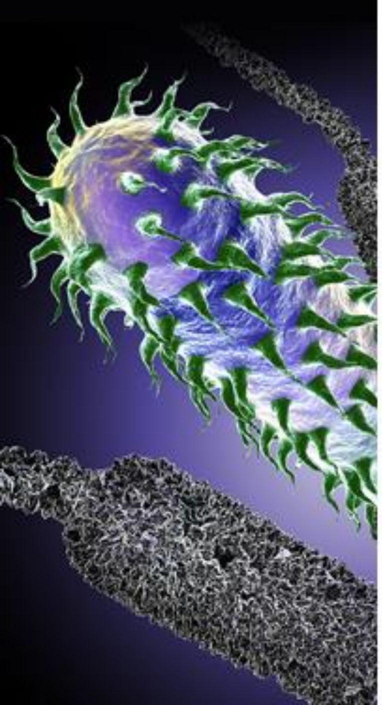


- Depth of Field the visual range that is in focus from foreground to background



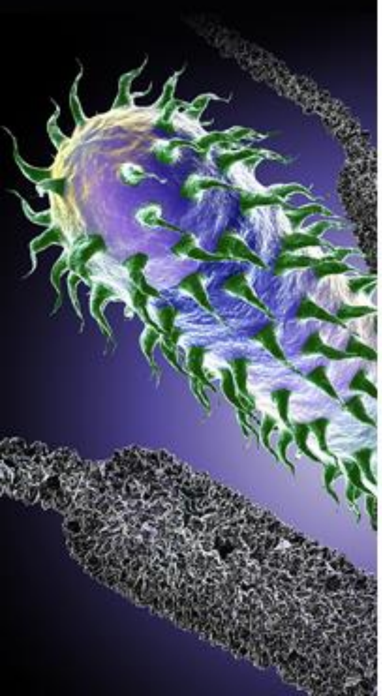
Magnification: 200 ×

Figure 4.7 Microscopes have a fairly short depth of field. **(A)** Only the middle thread is in focus when examined by a compound light microscope. The upper and lower threads are outside of the depth of field. **(B)** Likewise, in this image of algae, only some of the cells are in focus.



Types of Microscopes

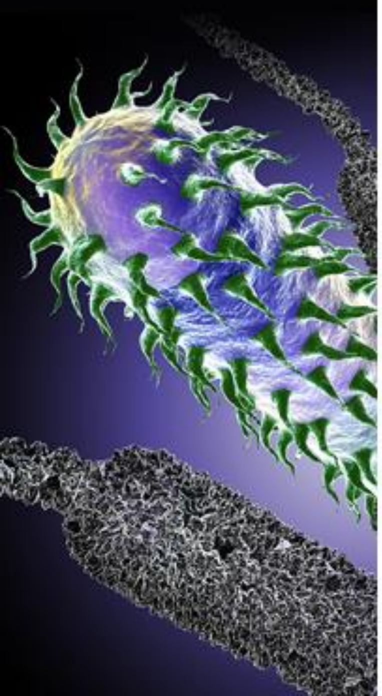
Compound light microscope	Magnification range: 40× to 2000×	•Can be used to examine stained or unstained samples • Uses light rays and lenses to produce image
Fluorescence microscopy	• Magnification range: 40× to 2000×	• Can be used to examine naturally fluorescent specimens or specimens stained with fluorescent dyes • Shines ultraviolet or near-ultraviolet radiation on specimens to make them fluoresce
Transmission electron microscope	• Magnification range: 700× to 1 000 000×	• Specimens are embedded in plastic, sliced into thin sections, and stained with a heavy metal or salt of a heavy metal • Shines beam of electrons through specimen to produce two-dimensional image

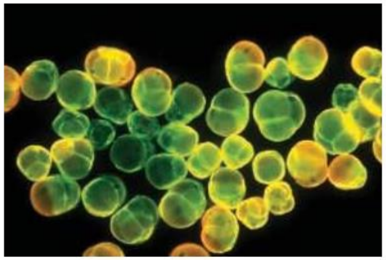


Types of Microscopes

Scanning electron microscope	**Magnification range: 1000× to 10 000×**	**• Specimens are cleaned, preserved, and coated with a thin layer of metal or carbon** **• Shines narrow beam of electrons over specimen, thereby knocking secondary electrons from specimen's surface to produce an image**
Atomic force microscopy	• Magnification range: 1000× to 10 000 000×	• No special preparation or staining of the specimen is needed • Metal-and-diamond probe scans surface of specimen; responding movements of probe are used to produce three-dimensional image in near-atomic detail

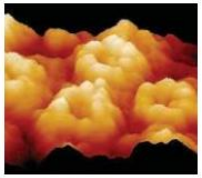
Types of Microscopes



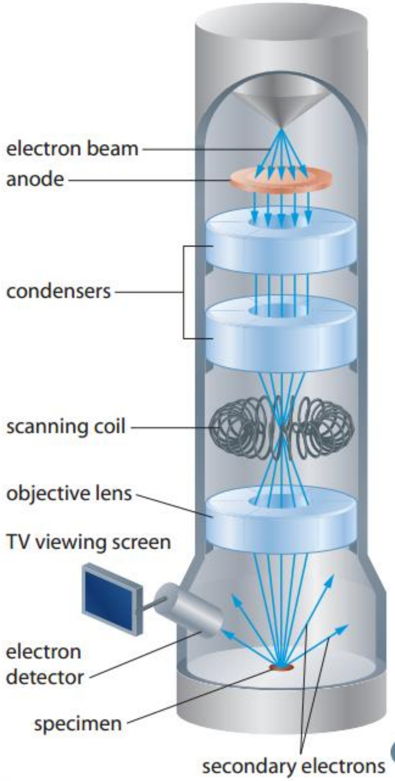


Pollen grains viewed with a fluorescence microscope (60×)

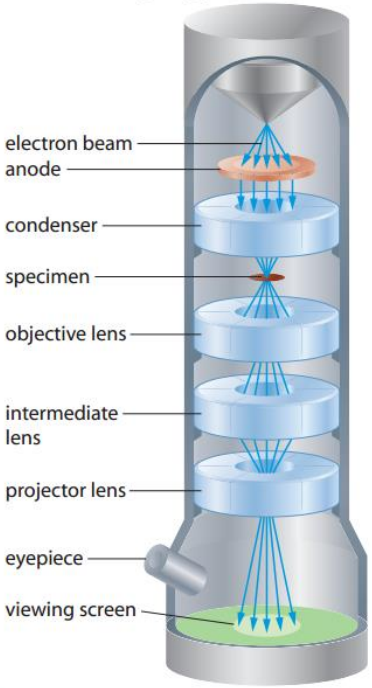
B Fluorescence microscopy



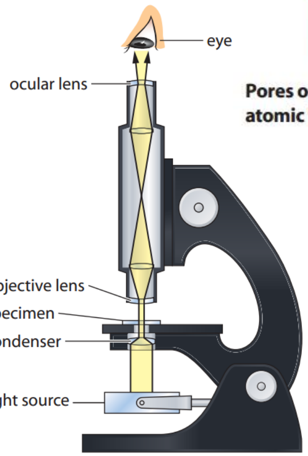
Pores on a cell nucleus viewed with an atomic force microscope (150 000×)



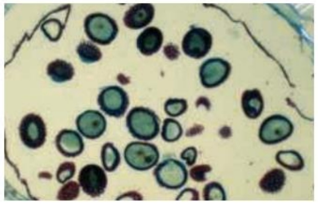
D Scanning electron microscope



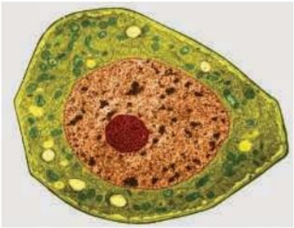
C Transmission electron microscope



A Compound light microscope



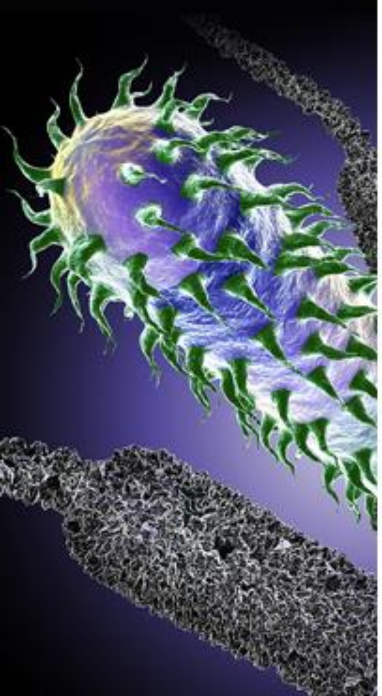
Pollen grains viewed with a light microscope (300×)

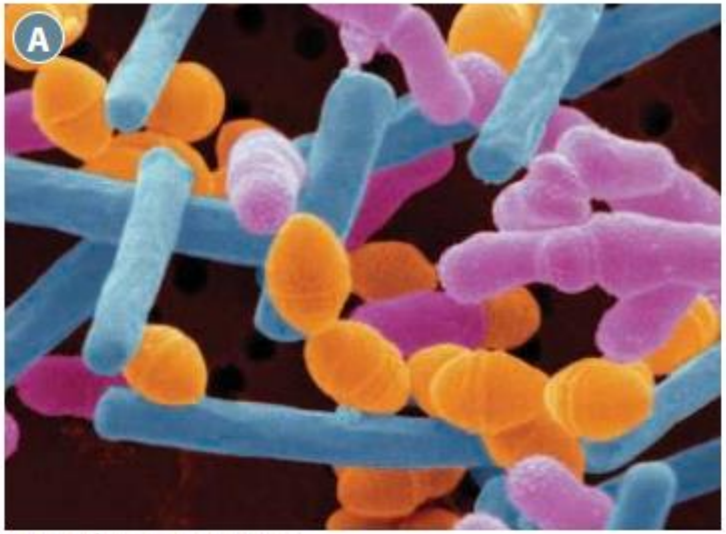


Pollen grain viewed with a transmission electron microscope (approx. 825×)

Pollen grains viewed with a scanning electron microscope (1368×)

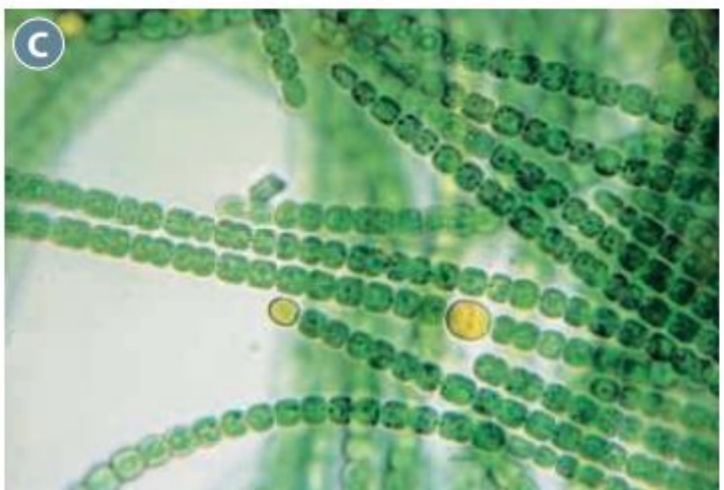
Cell Types and Structures





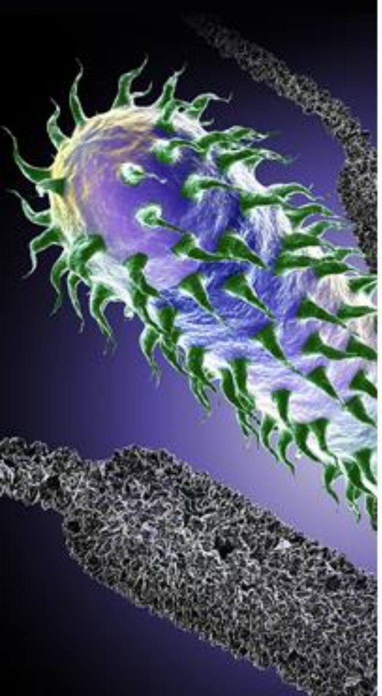
Magnification: 2400 ×

Magnification: 3000 ×



Magnification: 275 ×

Figure 4.9 **(A)** Yogurt bacteria include spherical cells and rod-like cells. **(B)** The bacteria that cause Lyme disease are corkscrew-shaped. **(C)** *Anabaena* is a photosynthetic bacterium that forms long chains of cells. The two different cell types in the chain have different functions.



Deep Learning Activity 4.2 Handout

ACTIVITY 4.2 **TURN DOWN THE VOLUME**

TARGET SKILLS

Investigating the relationship between cell surface area and cell size

Cells use their cell membranes to exchange materials with their surroundings. Cell membranes also provide a work surface for some biochemical reactions. How well does cell surface area keep pace with an increasing cell volume?

Procedure

Part A

1. Collect a ruler and 27 cubes of equal size.

a) Measure the width (w) of one of the cubes.

b) Calculate the surface area for one side of the cube using $w \times w = w^2$.

c) Calculate the total surface area for one cube using $6w^2$.

d) Calculate the volume of the cube using $w \times w \times w = w^3$.

e) State the surface-area-to-volume ratio of the cube.

2. Use eight cubes to build a larger cube. Repeat the measurements and calculations from step 1 for your larger cube.

3. Use all 27 cubes to build an even larger cube. Repeat the measurements and calculations for surface area and volume for this large cube.

Part B

4. Calculate the surface area and volume for three or more spheres of radii 100 μm, 200 μm, 300 μm, and so on, using the following formulas.

a) Surface area of a sphere = $4\pi r^2$

b) Volume of a sphere = $\frac{4}{3}\pi r^3$

c) State the surface-area-to-volume ratio for each sphere.

Analysis

1. Describe what happened to the surface-area-to-volume ratio as

a) the width of the cubes increased

b) the radii of the spheres increased

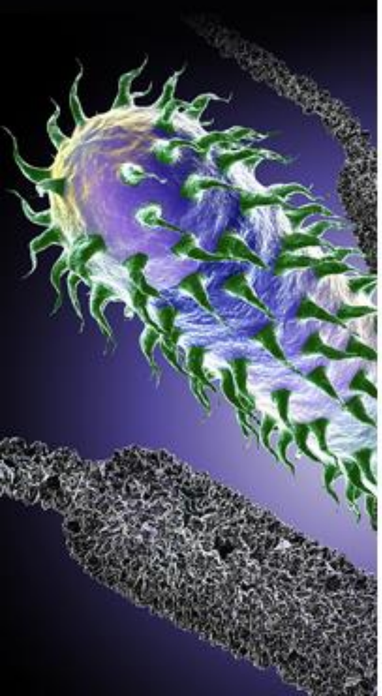
2. Explain what limits the size of most cells.

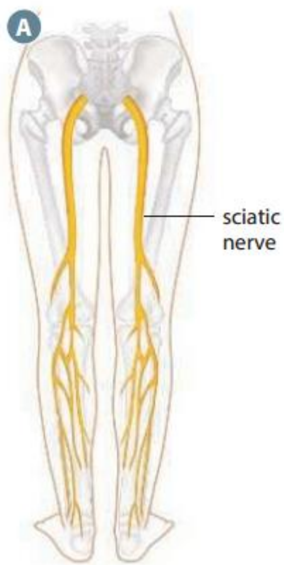
- ***Needs to be handed in for grading

Cell Size

- One feature that most cells share is their small size. They are typically less than a tenth of a millimetre in diameter. They need to be small because nutrients, water, oxygen, carbon dioxide, and waste products enter or leave the cell through its surface, the cell membrane. If a cell gets too large, its interior becomes too large for substances to be efficiently transferred to and from the cell membrane.

FYI
The human body contains a huge number of cells. Estimates range from 10 trillion to 100 trillion. However, most of these are not human cells—they are bacteria!





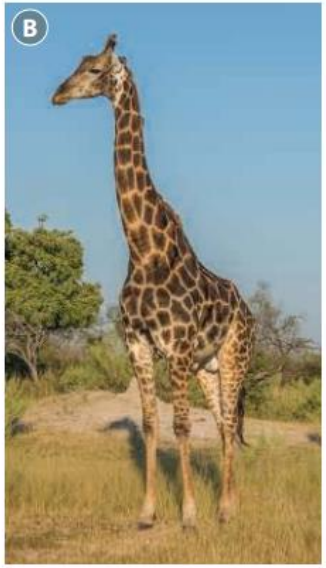
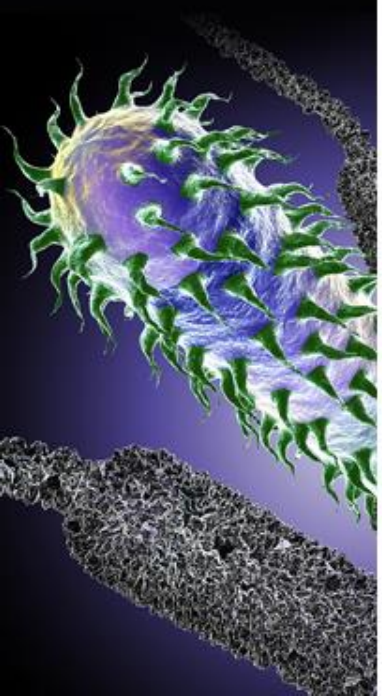


Figure 4.10 **(A)** Nerve cells in humans can be up to 1.5 m long, but they are extremely skinny. This skinniness means that substances in the cytosol do not have to go far to get to the cell membrane. **(B)** Our nerve cells seem tiny compared with those of giraffes—giraffes may have nerve cells as long as 5 m! **(C)** The ostrich egg is a single cell with a large mass—about 1.4 kg.



- Bacteria and archaea are prokaryotes, whose cells lack a true nucleus.
- Protists, plants, fungi, and animals are eukaryotes. The have a true nucleus.
- organelle a structure within a cell that performs a specific function
- nucleus the organelle that contains the cell’s chromosomes and thus controls the cell’s activities

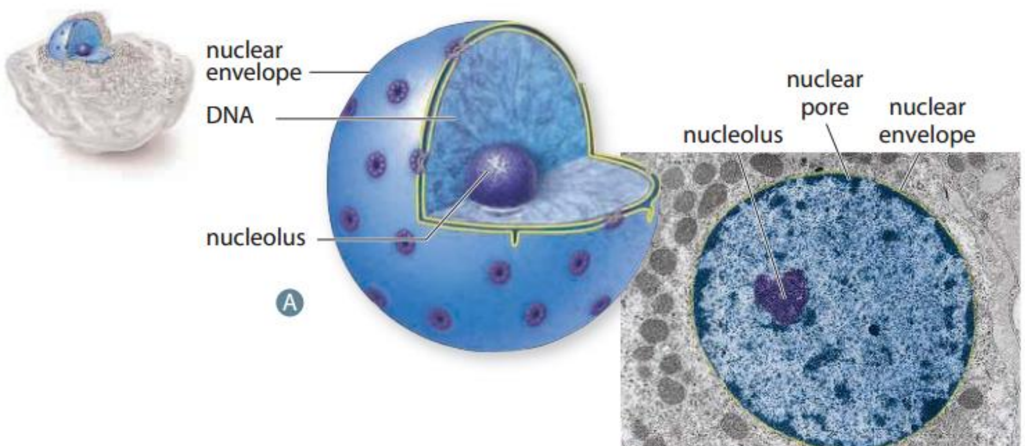


Figure 4.13 The nucleus—information and control centre of the cell

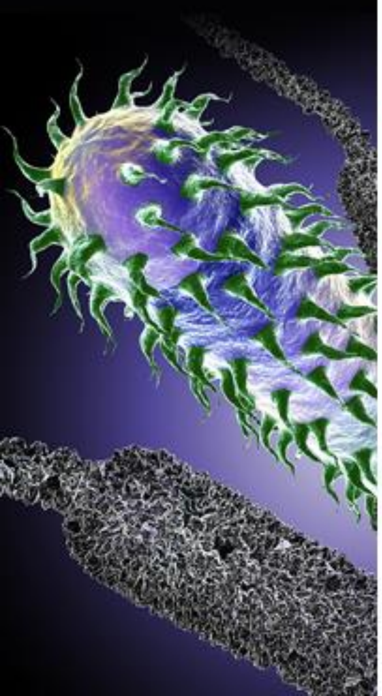
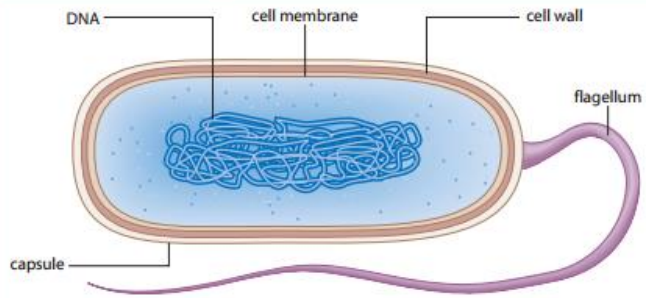
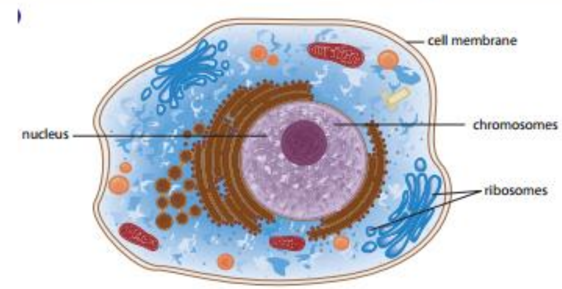


Table 4.1 Prokaryotic Cells and Eukaryotic Cells

Characteristic	Prokaryotes: Bacteria, Archaea	Eukaryotes: Protists, Plants, Fungi, Animals
Typical size	 2–100 μm	 100–1000 μm
Genetic material	• no nucleus; DNA not bound by a membrane • one circular chromosome	• DNA in nucleus, bounded by a membrane
Division of genetic material	• not by mitosis or meiosis	• mitosis and meiosis
Reproduction	• asexual	• asexual or sexual
Number of cells	• unicellular	• unicellular or multicellular
Organelles	• has ribosomes but membrane-bound organelles are absent	• has both ribosomes and membrane-bound organelles
Metabolism	• varies; includes cells that require oxygen to make ATP and cells that do not • some are photosynthetic	• most require oxygen to make ATP • some are photosynthetic

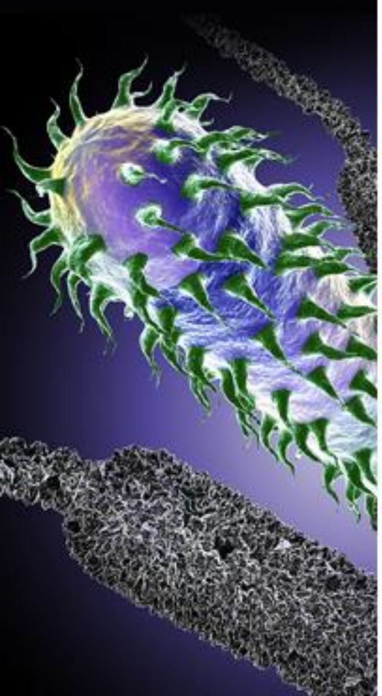
Cell Membranes, the Cell Wall, and the Cytosol

- cell membrane a phospholipid bilayer that encloses the cell's contents, separating and protecting the cell from its surroundings

- cell wall a strong, rigid structure that surrounds the cell membrane in plant cells; made mainly of cellulose

- cytoplasm a cell's contents, including the cytosol and organelles other than the Nucleus

- cytosol a jelly-like fluid in which all the organelles in a cell are suspended. The cytosol also contains dissolved ions and molecules.



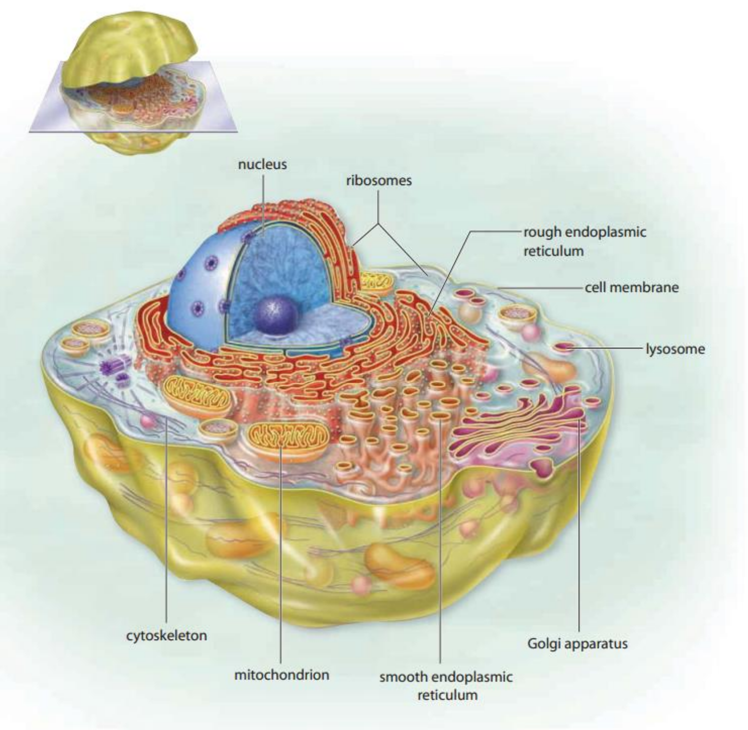
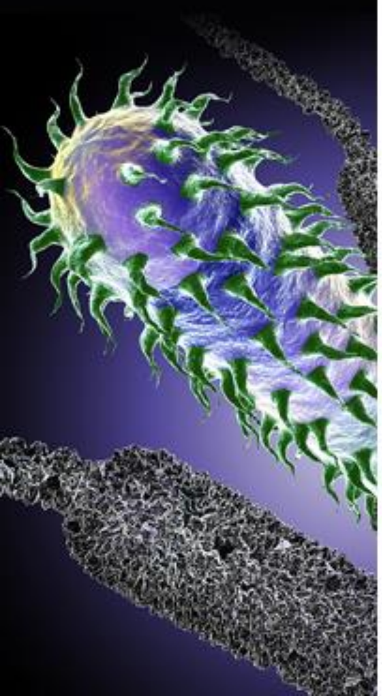
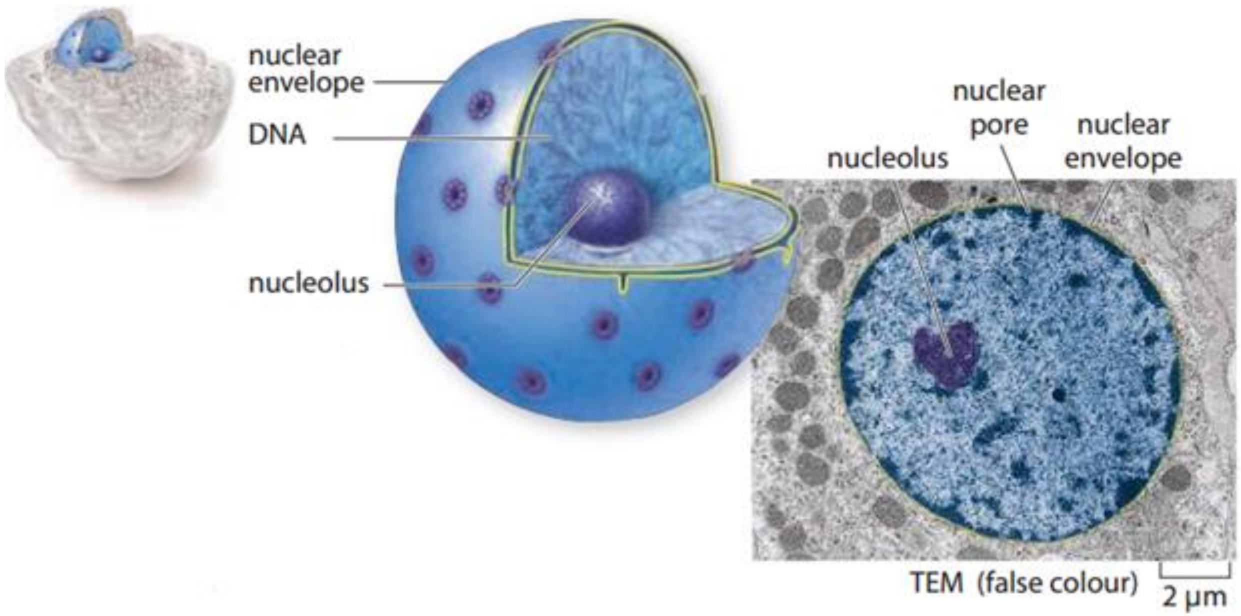


Figure 4.11 An animal cell. Most animal cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different animals and among different parts of the same animal.

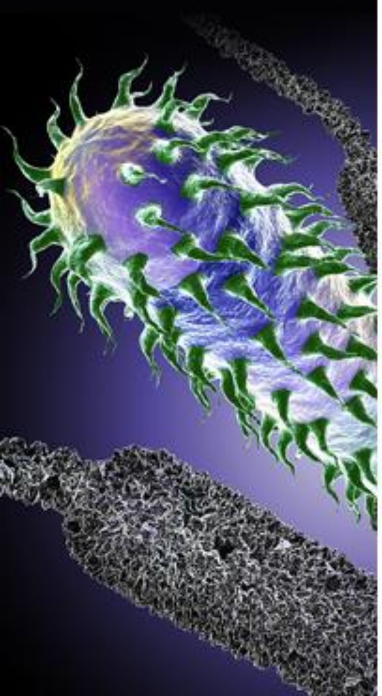


- nucleolus non-membrane-bounded structure that produces ribosomes



- ribosome small non-membrane-bounded organelle that builds proteins. Some ribosomes, called free ribosomes, float within the cytoplasm.

- endoplasmic reticulum an organelle that consists of the smooth ER, involved in production of lipids and steroids, and rough ER, involved in protein production and packaging



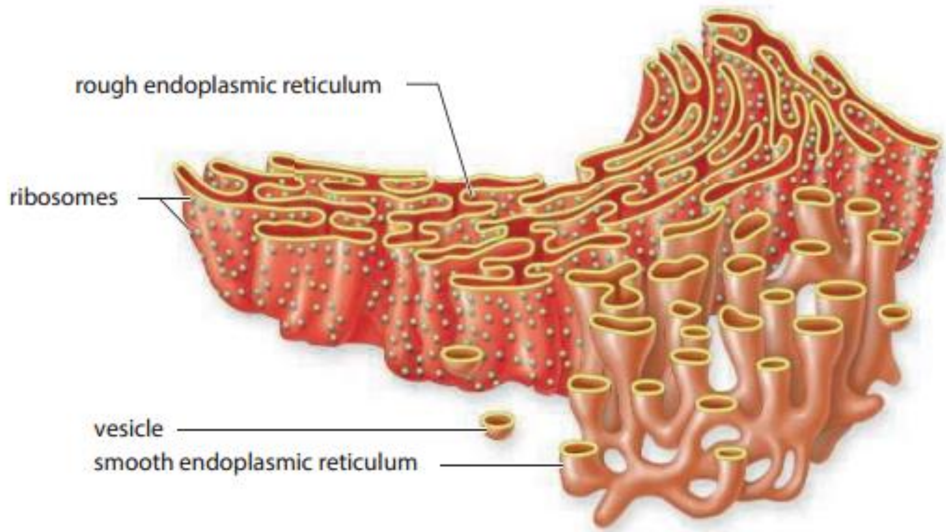
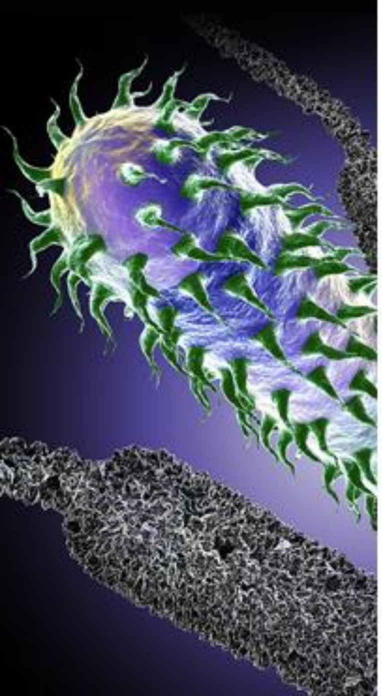


Figure 4.14 The smooth ER has many roles, including making steroids and other lipids. The rough ER works with the ribosomes on its surface to produce proteins for use elsewhere in the organism.



- vesicle small container made of membrane used for storage and transport in the cell

- Golgi apparatus an organelle that processes proteins made by the ER
- and packages them for transport

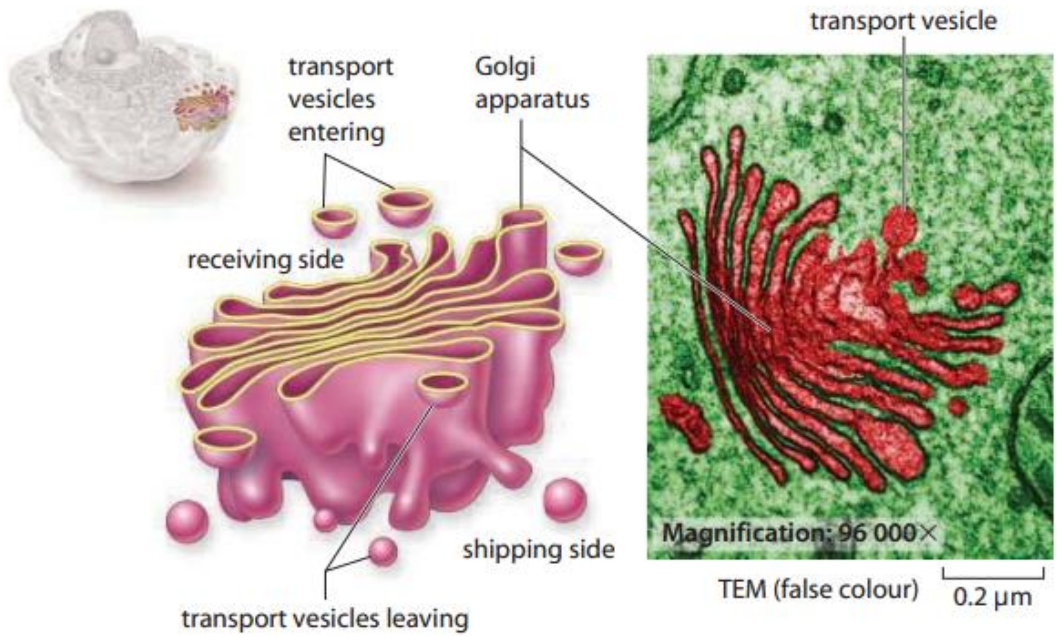
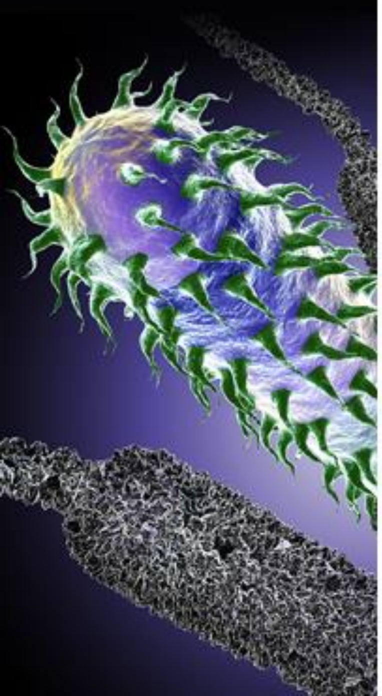


Figure 4.15 The Golgi apparatus—the cell's centre for processing, sorting, and packaging proteins received from the rough ER.

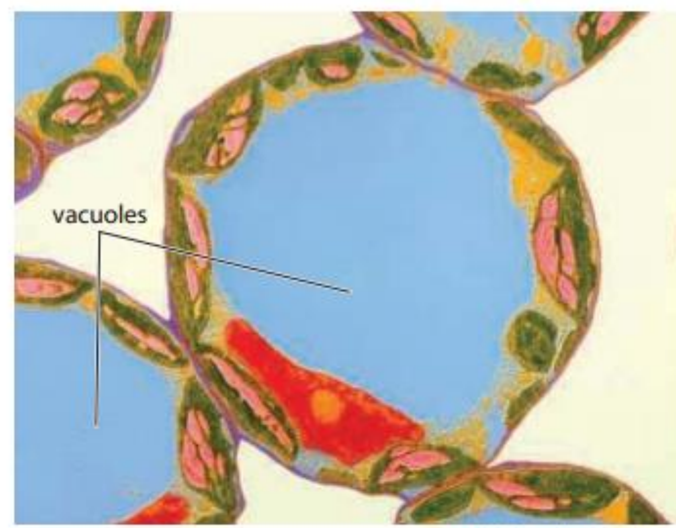
FYI

The unusual-sounding name of the Golgi apparatus (also known as Golgi body) comes from Italian doctor Camillo Golgi. He was the first to observe the organelle through a microscope in 1897.



- vacuole organelle that acts as a storage compartment; in plant cells, they are very large and have multiple functions
  - **stores macromolecules, such as proteins, and ions, such as potassium and chloride**
  - **helps keep the plant cell firm by maintaining outward pressure on the cell wall**
  - **serves as a disposal site for substances that could harm the cell**
  - **may contain coloured substances that attract pollinating insects**
  - **may contain substances that are harmful or bad-tasting to animals**

  - **They are very large in plant cells (compared to the size of the cell) and fairly small in animal cells. Plant cells often have a large central vacuole. This central vacuole may occupy 80 percent or more of the volume of a mature plant cell**



TEM (false colour) 2200×

Figure 4.16 In plant cells, like this one, vacuoles are large storage compartments. In animal cells, they are smaller transport sacs.

- lysosome organelle that contains enzymes that digest macromolecules (proteins, polysaccharides, fats, and nucleic acids)

- lysosomes are containers, or sacs, surrounded by membrane and containing enzymes. The rough ER makes the membranes and enzymes. These components are then transported to the Golgi body to be made into lysosomes.

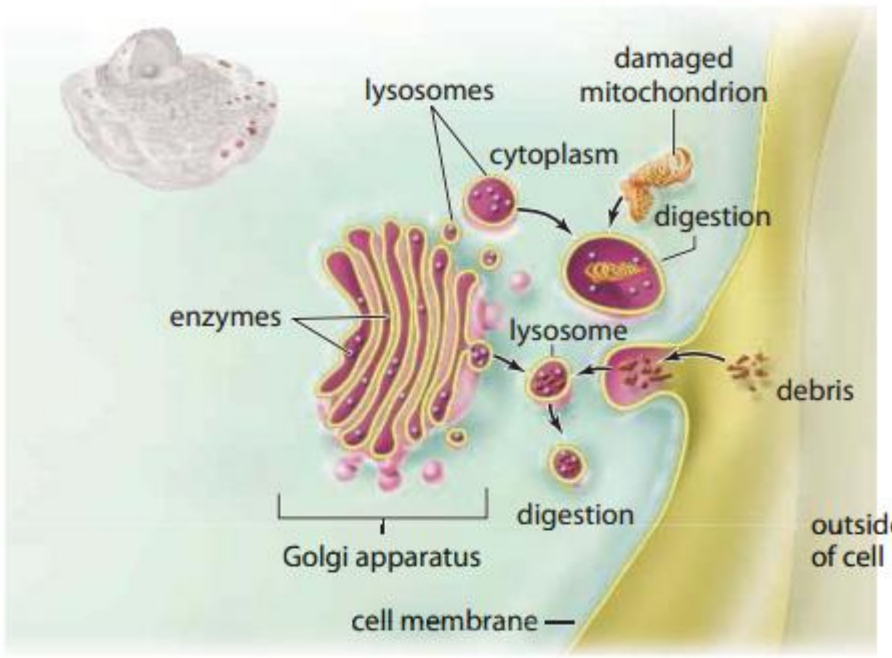
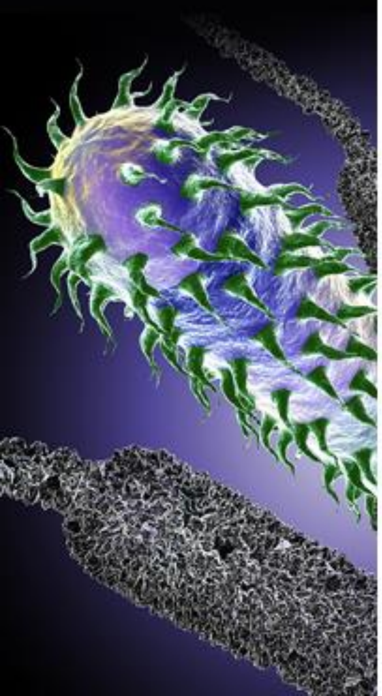
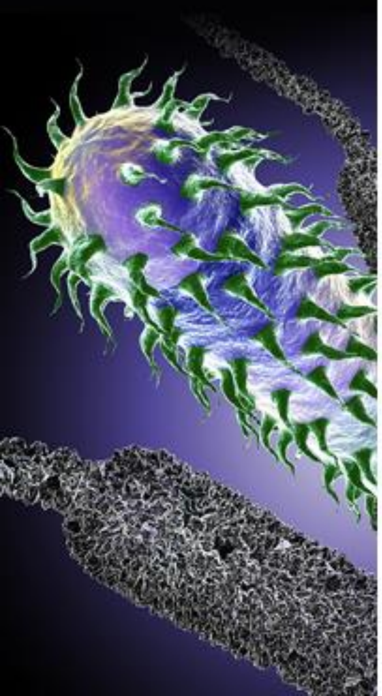


Figure 4.17 Lysosomes—waste disposal and recycling units of the cell





- LYSOSOME FUNCTIONS

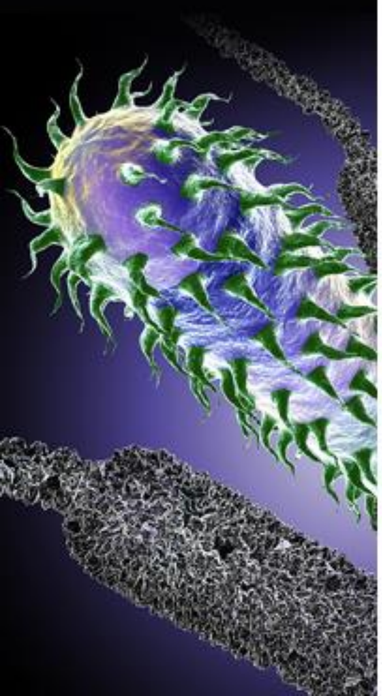
Fighting disease: In humans, cells called macrophages absorb and digest harmful bacteria. The bacterium is taken into the macrophage in a vacuole, which then fuses with a lysosome. The lysosome contents break down the macromolecules in the bacterium, killing it.

Digestion: As a cell absorbs a food particle, a vacuole pinches off from the cell membrane. The vacuole fuses with a lysosome, and the enzymes in the lysosome break down the food molecules.

Recycling cell components: Lysosomes surround damaged or non-functioning organelles, breaking down their components so that the cell can re-use them. In a human liver cell, lysosomes recycle half of the macromolecules in the cell each week.

Killing the cell: The simultaneous release of the contents of many lysosomes can kill a cell that the organism does not need.

Figure 4.18 The hands of a human embryo are webbed until lysosomes digest the excess tissue. Sometimes this does not occur and a person is born with some of the webbing intact, a condition called syndactyly.



- mitochondrion organelle that is the site of cellular respiration, producing ATP for cellular functions

FYI
Mitochondria contain their own DNA and ribosomes. Mitochondria also reproduce independently of the cell that contains them.

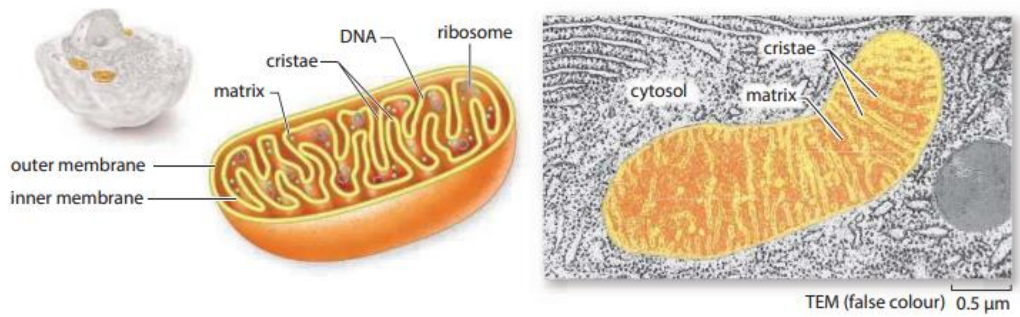


Figure 4.19 Mitochondria—powerhouses of eukaryotic cells.

- chloroplast organelle of plants and eukaryotic protists in which photosynthesis takes place

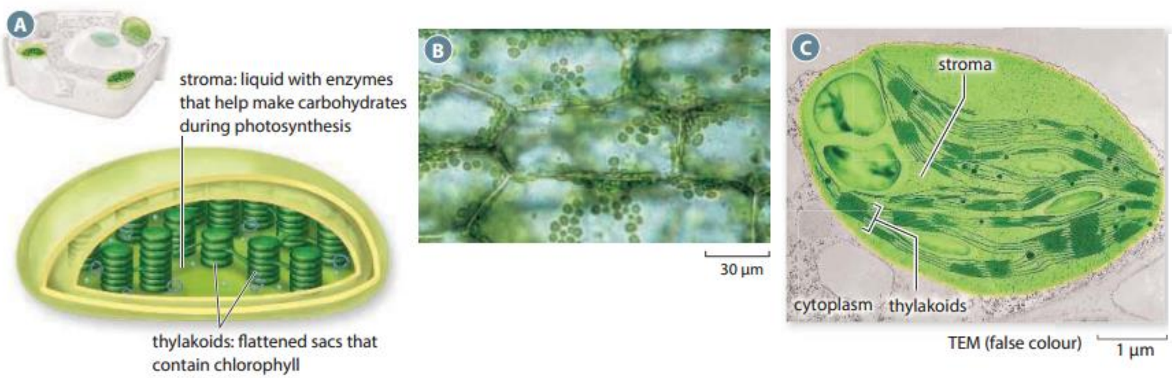
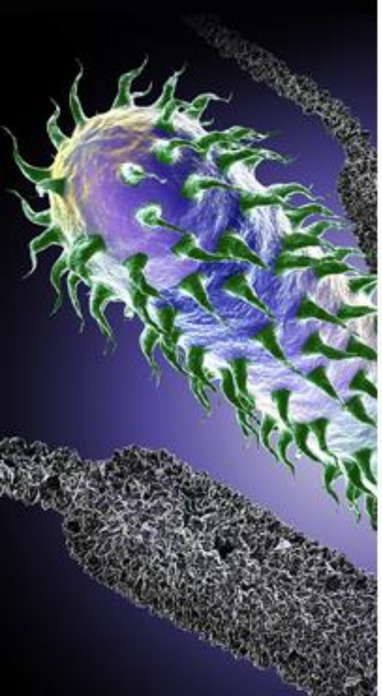
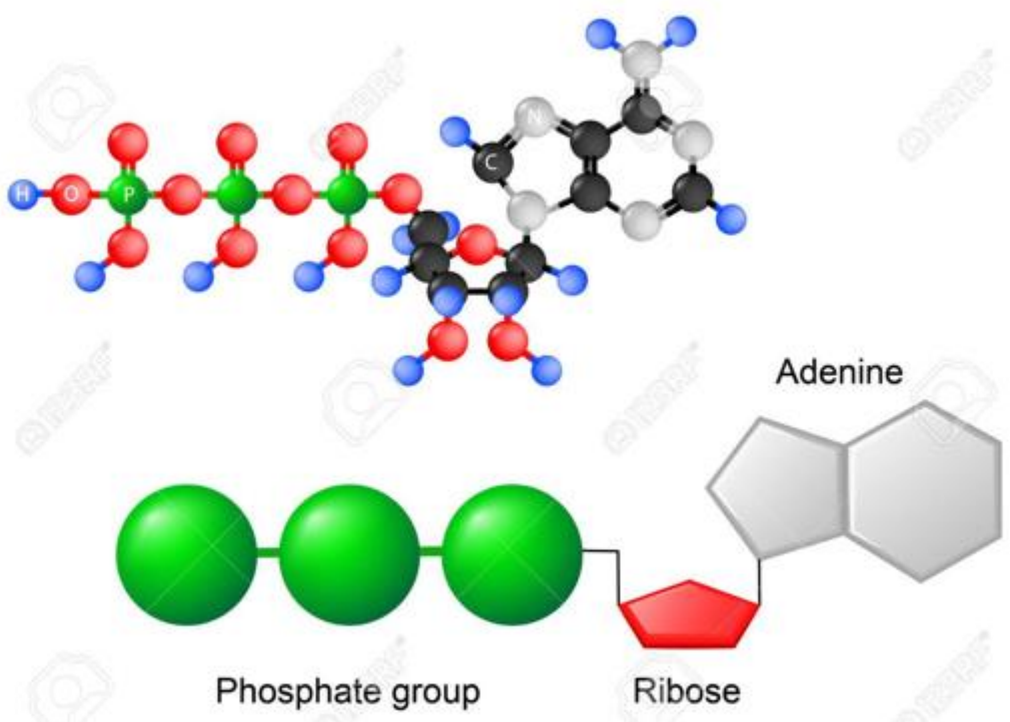
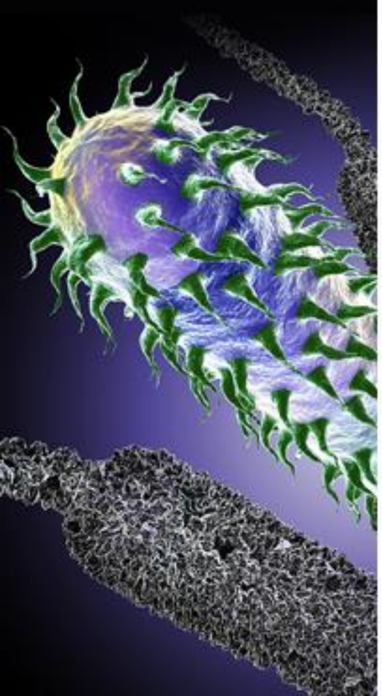


Figure 4.20 Chloroplasts **(A)** are the food producers of plant cells. You can see chloroplasts through a compound light microscope **(B)**, but their internal structure becomes clearer when viewed with an electron microscope **(C)**.

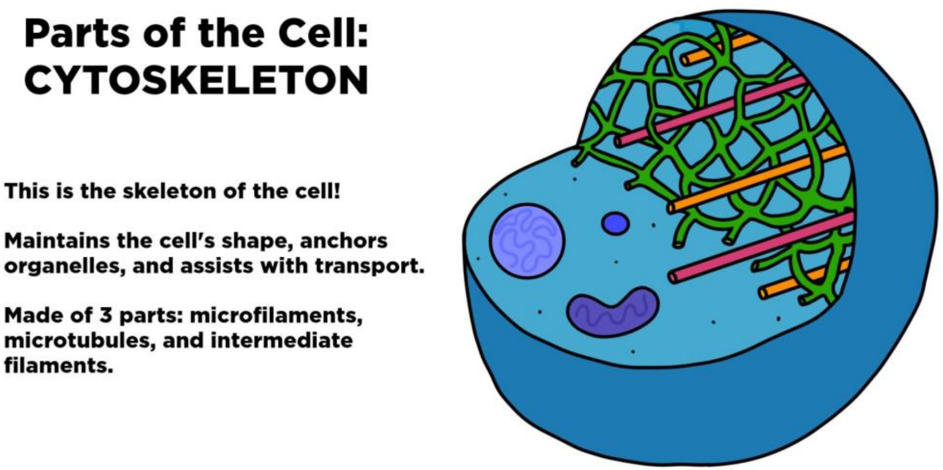


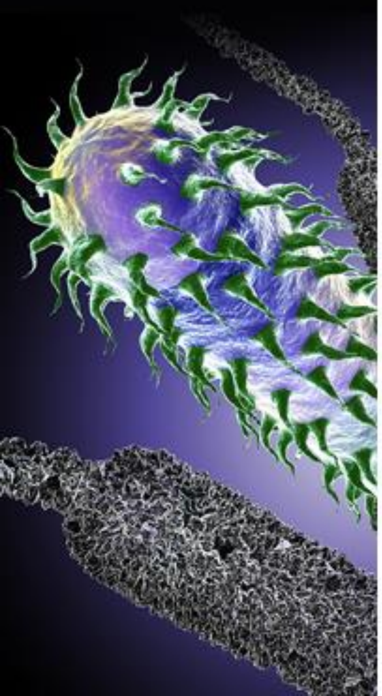
- ATP (adenosine triphosphate)
  - is an energy-carrying molecule that releases energy when it loses a phosphate.





- The cytoskeleton is a network of fibres that extends throughout the cytosol. It supports the cell and helps maintain its shape. This is especially important in animal cells, which do not have rigid cell walls.
- The movement of the cytoskeleton can cause muscle cells to contract.
- The cytoskeleton is also involved in the movement of individual organelles. The fibres of the cytoskeleton help to guide vesicles as they travel through the cytosol.





Review

- Video: Cell Organelles
- 14 mins and 16 secs
- Bozeman Science

Animal vs Plant Cell

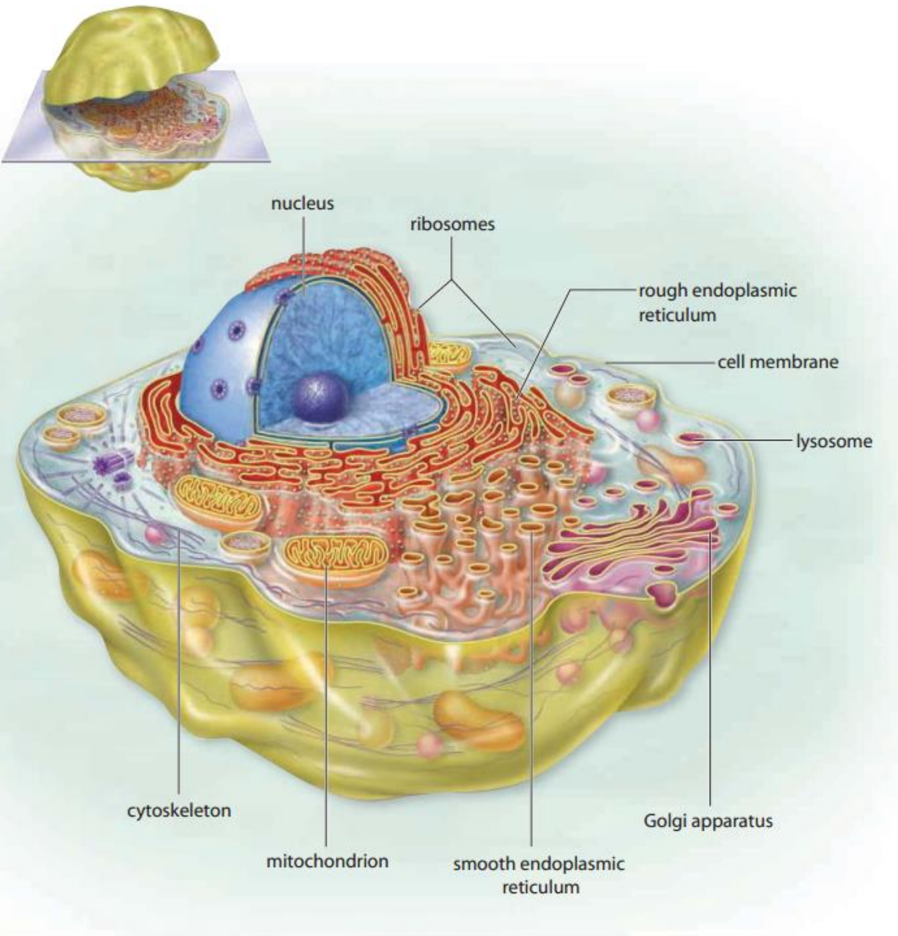


Figure 4.11 An animal cell. Most animal cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different animals and among different parts of the same animal.

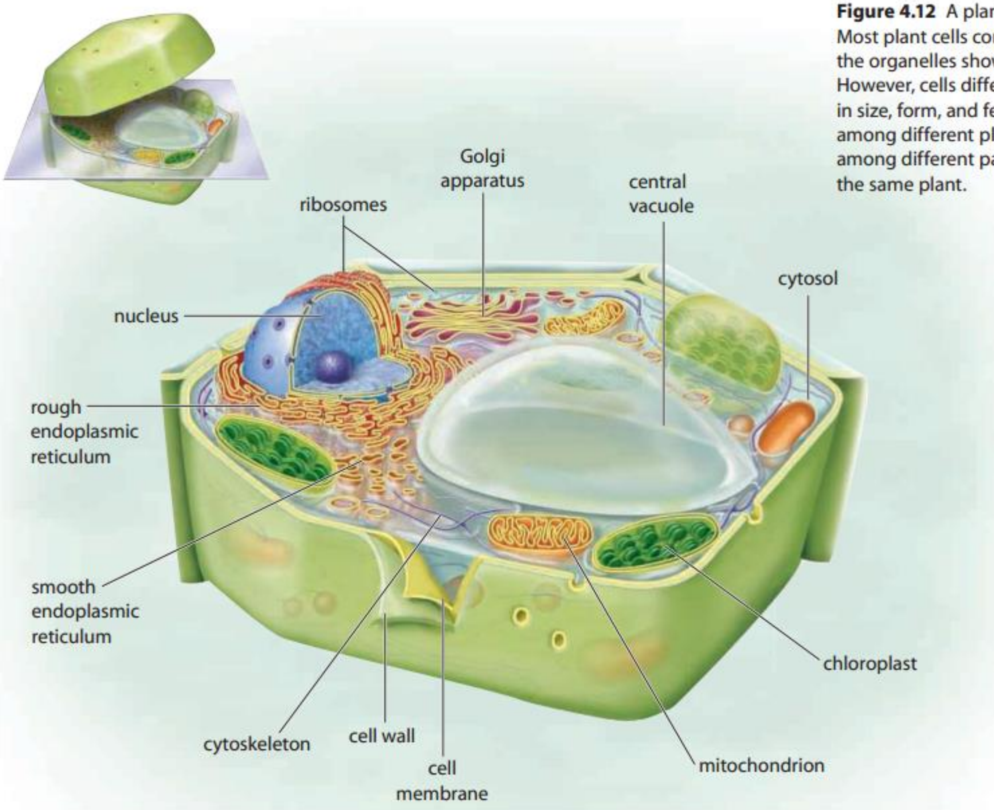
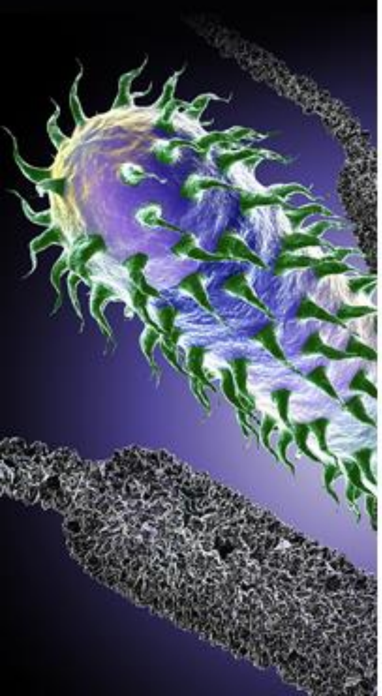


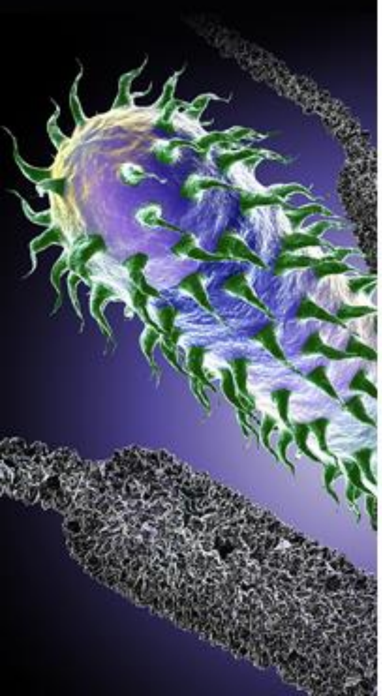
Figure 4.12 A plan
Most plant cells co
the organelles sho
However, cells diff
in size, form, and fe
among different pl
among different pa
the same plant.



Animal	Plant
Has none or small vacuoles throughout the cell	Has one large central vacuole
Does not have a cell wall	Has a cell wall
Does not have chloroplasts	Has chloroplasts
Motile	Non-motile

- Motile – the ability to move form place to place
- Video: Cell Rap Organelles 3 mins and 8 secs

Deep Learning Activity 4.3

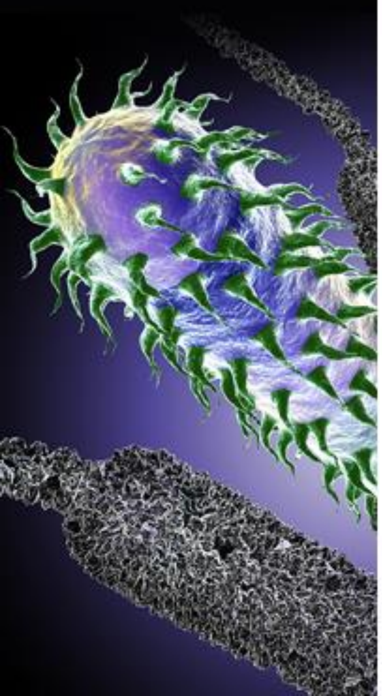


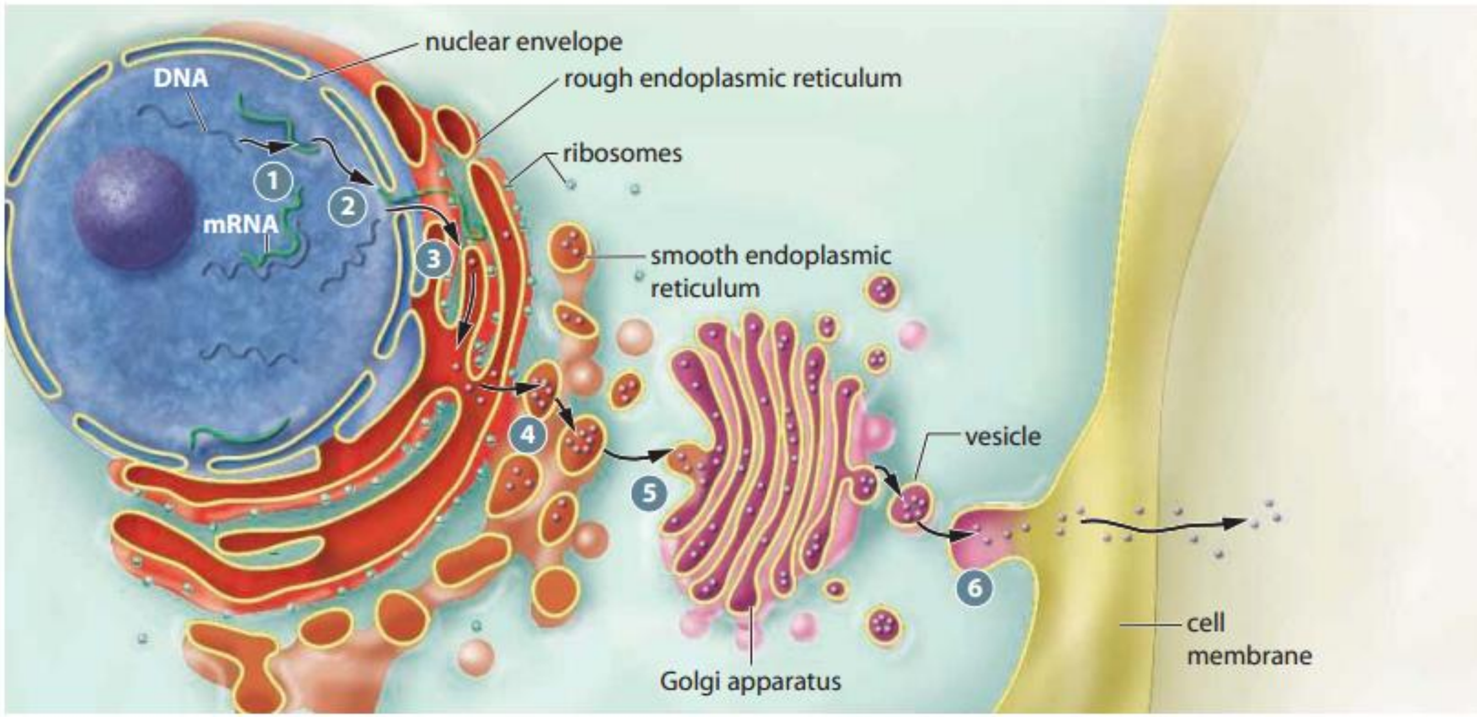
ACTIVITY 4.3 THE ORGANELLE GAME

Your teacher will provide your group with a set of cards. Each card contains a picture of an organelle, the name of an organelle, or a brief description of an organelle.

- Get in groups and place the cards face down. See who can pair up the most going one at a time.

Organelles Working Together



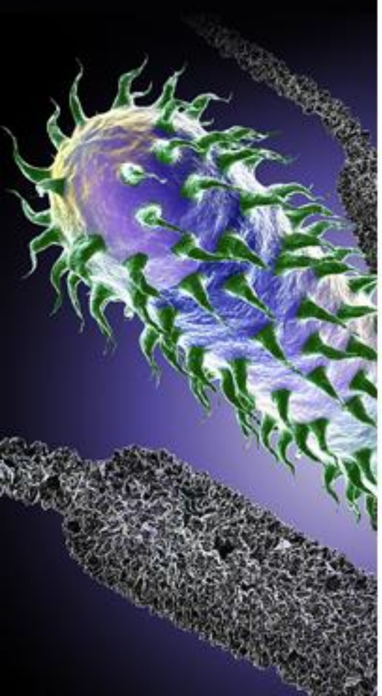


1. Insulin protein information from DNA is copied to RNA.
2. RNA exits the nucleus.
3. At ribosomes on surface of rough ER, information from RNA is used to make a protein that will become insulin.
4. Vesicles from smooth ER package the protein for transport to Golgi apparatus.
5. In Golgi apparatus, the proteins are processed to form insulin protein and packaged for export out of the cell.
6. Insulin is released from the cell when vesicles fuse with the cell membrane.

- **Investigation 4.A - Microscope Lab**
- ***** Needs to be handed in for grading**

Cell Membrane Structure and Transport

- cell membrane a phospholipid bilayer that encloses the cell’s contents, separating and protecting the cell from its surroundings
- It is in charge of what gets in and out of the cell. Its job is similar to that of a security guard who decides who and what is allowed to enter and leave a building.



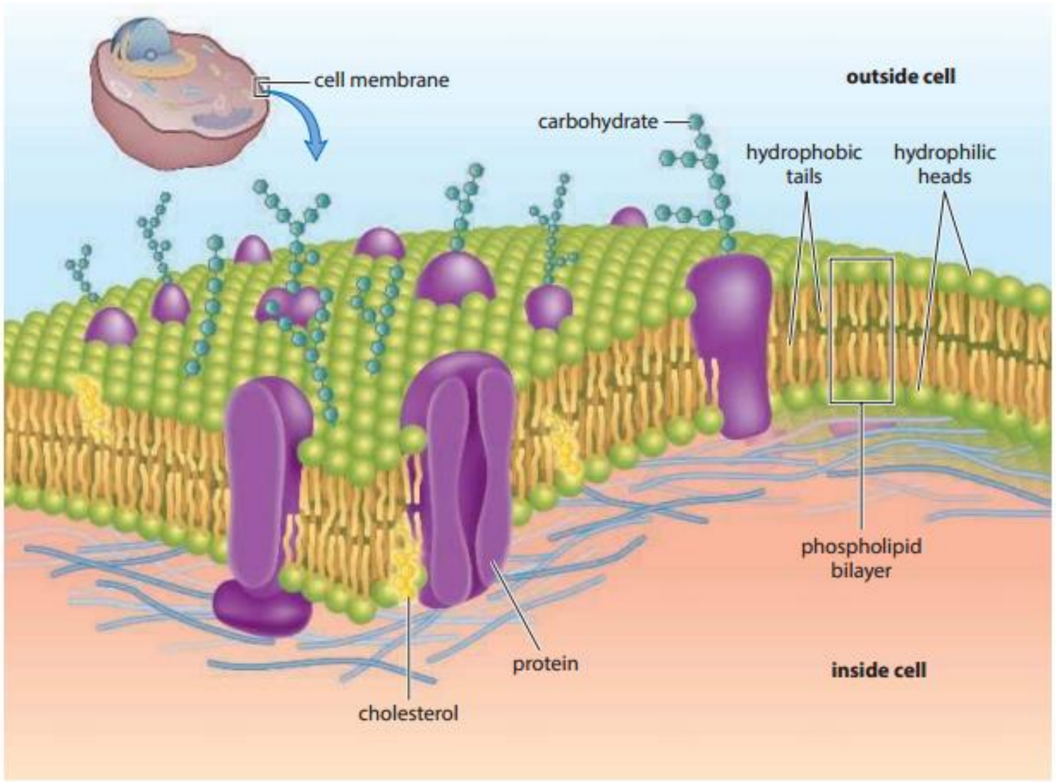
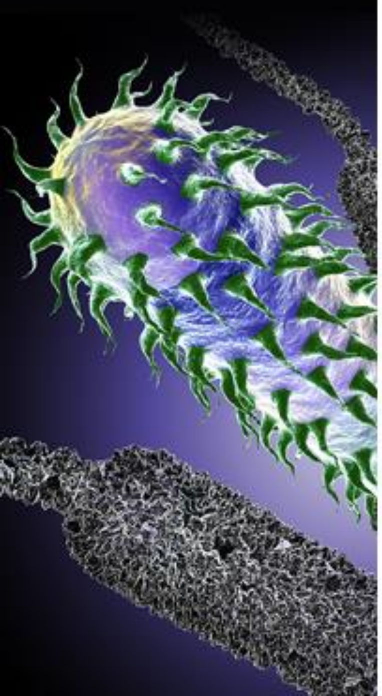


Figure 4.22 The fluid mosaic model of the cell describes the cell membrane as a phospholipid bilayer that incorporates other molecules such as proteins.

- phospholipid a type of lipid consisting of two fatty acids and a phosphate-containing group bonded to glycerol



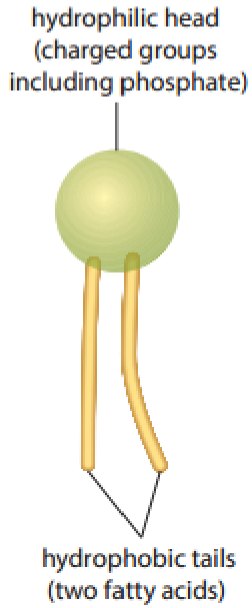


Figure 3.16 A model of a phospholipid molecule

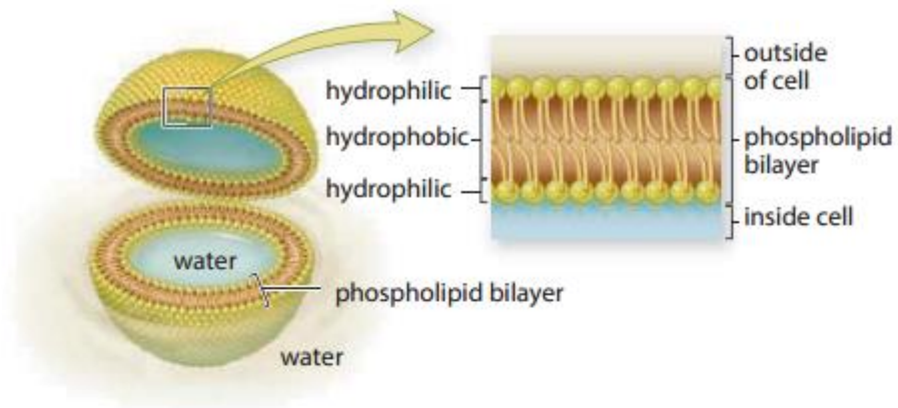


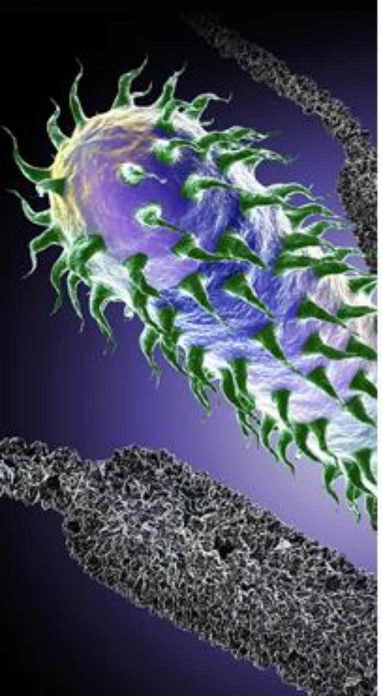
Figure 3.17 In the two-layered, sandwich-like structure of a phospholipid bilayer, the hydrophilic surfaces are exposed to the water fluid outside and inside the cell. The hydrophobic tails face each other inside the membrane.

- Hydrophilic (water-loving)
  - describes substances made of polar molecules or ions, so they dissolve in water
  - Sugar (sucrose) and table sale (sodium chloride)

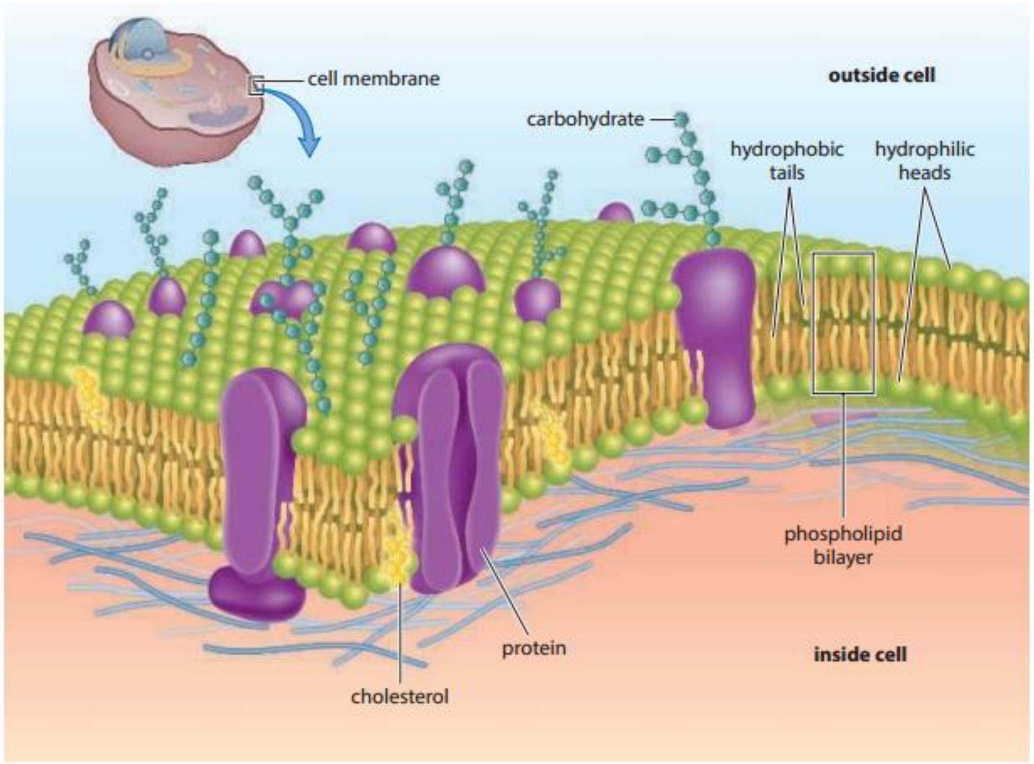
- Hydrophobic (water-fearing)
  - describes substances made of non-polar molecules, so they do not dissolve in water
  - Wax and oil

  - Water alone will not remove grease from hands, dishes, or clothes, because grease is hydrophobic and does not dissolve in water.
  - Dry cleaning companies use non-polar solvents to remove oily spots from fabric.
  - Detergents contain special molecules that attract both water and fats, so they can dislodge greasy substances and carry them down the drain.
  - Detergent molecules have hydrophilic ends and hydrophobic ends.

Figure 3.9 The leaves in (**A**) have a waxy layer called cutin that is hydrophobic, so water forms beads on the surface. The waxy layer also helps trap water in the leaf. Hydrophobic coatings are often applied to protect wood products, as shown in (**B**).



- fluid mosaic model the most current description of the cell membrane: a phospholipid bilayer with embedded proteins and other functional components
- The phospholipid tails are hydrophobic, and so attract one another and form the centre of the bilayer. The phospholipid heads are hydrophilic, and so face the cytosol and the cell's exterior.
- This model also explains how the cell membrane does its job of controlling what enters and leaves a cell.



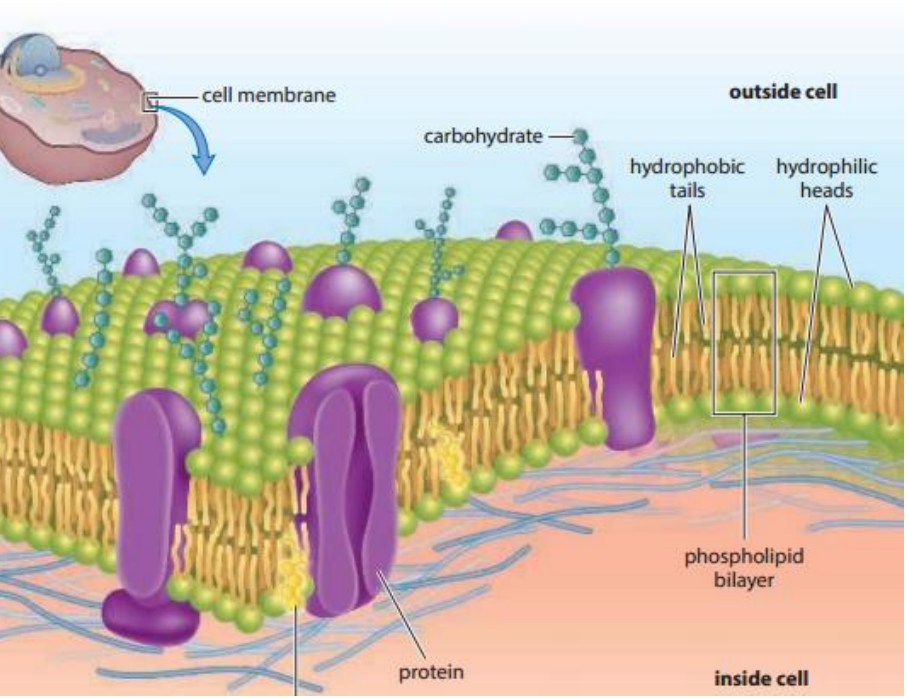
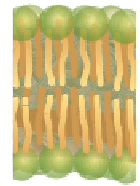
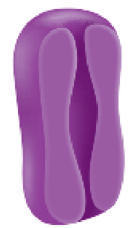
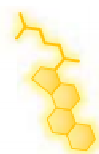
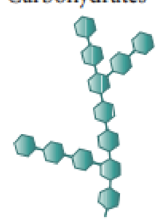


Table 4.2 Parts of the Cell Membrane and Their Structures and Functions

Cell Membrane Part	Structure	Functions
Phospholipids 	• Provide the overall structure for the cell membrane • Arranged in two layers	• Act as a barrier between the cell and its surroundings • Hold the other components of the cell membrane
Proteins 	• Most are embedded in the phospholipid bilayer • Some are attached to the inside or outside surface of the phospholipid bilayer	• Some proteins transport specific substances across the membrane • Some proteins are enzymes, and they control chemical reactions • Some proteins transmit signals from other cells or elsewhere in the body
Cholesterol 	• Embedded in the phospholipid bilayer	• Helps keep fluidity of membrane consistent • Reduces fluidity of membrane at high temperatures • Increases fluidity of membrane at low temperatures
Carbohydrates 	• Attach to proteins or phospholipids and protrude outside the cell	• Allow other cells to "recognize" the cell as belonging to the organism and not an intruder

Passive Membrane Transport

- Diffusion is the movement of particles of matter from an area of higher concentration to an area of lower concentration.

- Concentration is the amount of a substance in a given volume.

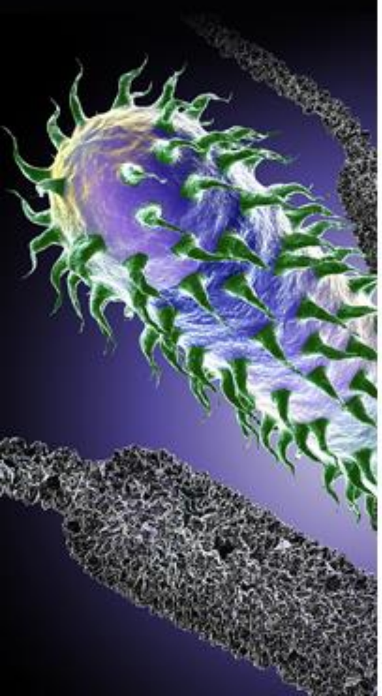
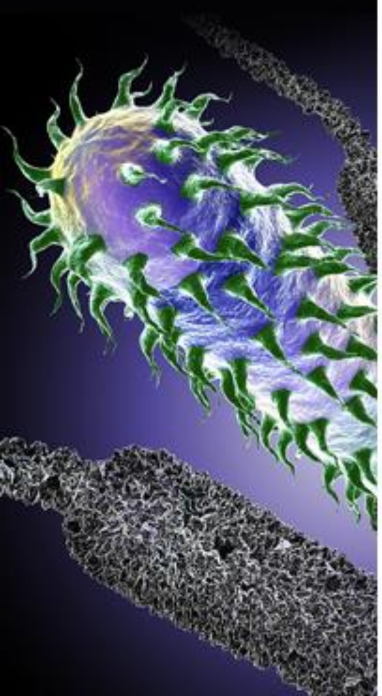


Figure 4.24 In **(A)**, a drop of dye is just about to be placed in a beaker of water at room temperature. Diffusion occurs spontaneously because molecules are always in motion **(B)**. Even when the dye has spread throughout the beaker, as in **(C)**, the molecules are still moving. There is no visible change, though, because there is no net movement of molecules in any particular direction.

- passive transport is the movement of substances across cell membranes without the use of ATP (energy)

- simple diffusion a form of transport across a cell membrane in which a substance passes directly through the membrane in a direction that is down the concentration gradient for that substance



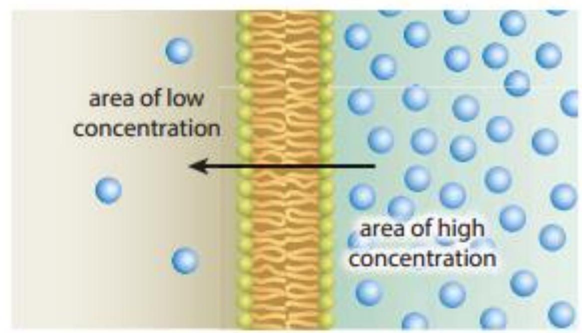
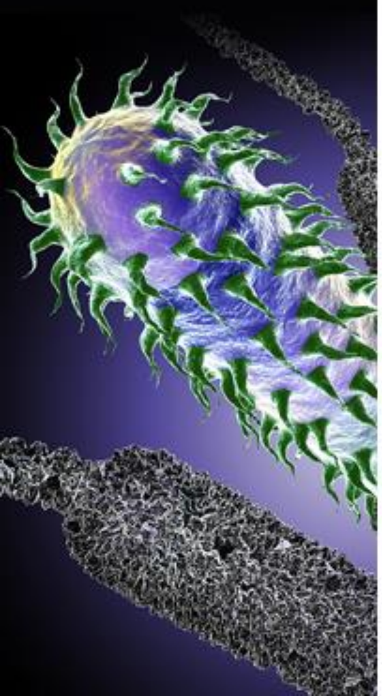


Figure 4.25 In simple diffusion, when dissolved substances are more concentrated on one side of a cell membrane, there is an overall diffusion toward the less concentrated side.

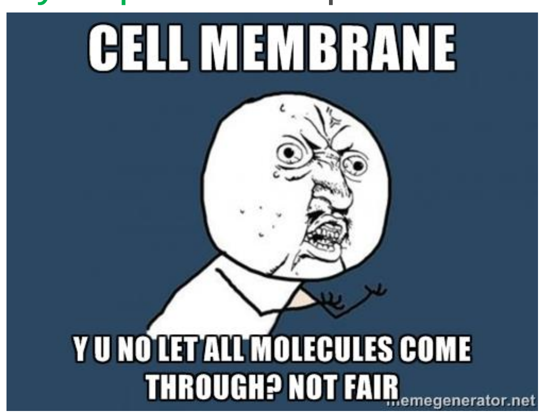


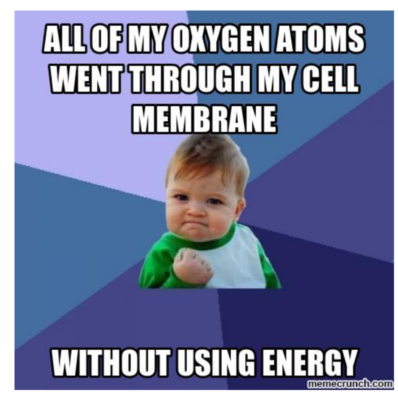
- selectively permeable membrane a thin, film-like structure that allows some substances but not others to pass through

- Because ions and polar molecules carry a charge, they dissolve in water but cannot easily pass through the hydrophobic core of the phospholipid bilayer.

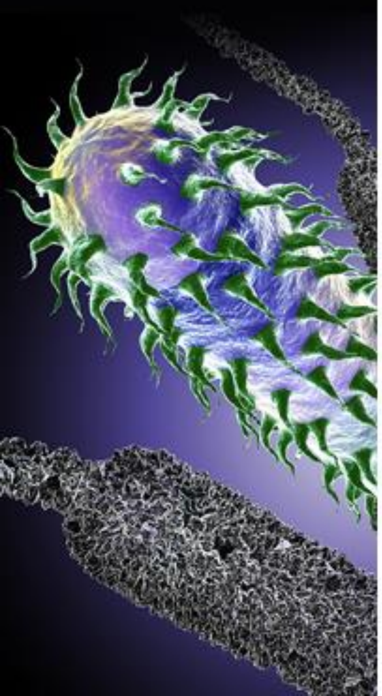
- However, some other substances can pass directly through the bilayer.

- small, uncharged molecules (such as water, oxygen, and carbon dioxide)
- small hydrophobic or lipid molecules (such as fatty acids)





- facilitated diffusion the transport of a substance through proteins in the cell membrane in a direction that is down the concentration gradient for that substance
- Different proteins act in different ways to help substances across the membrane:
- A protein can provide a channel through which the particle can travel.
- Ions such as chloride and sodium cross the membrane in this way.
- A carrier protein can bind to the particle, transporting it across the membrane and releasing it. Large polar molecules such as glucose cross the membrane in this way.



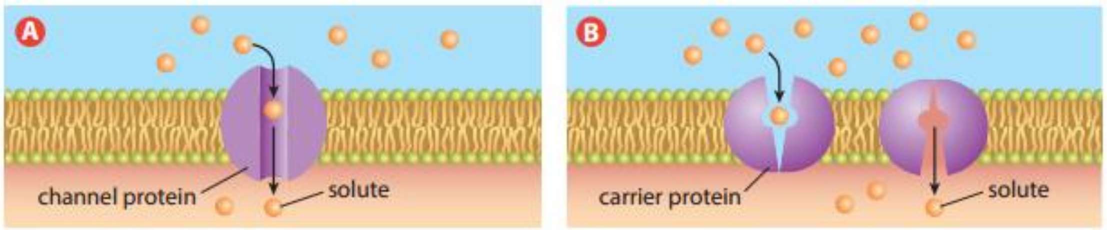
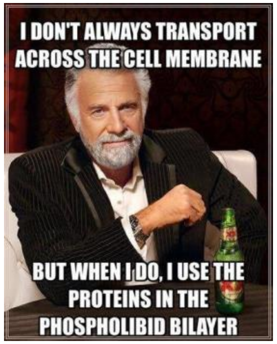


Figure 4.26 In facilitated diffusion, substances are helped across the membrane by **(A)** channel proteins or **(B)** carrier proteins.



- osmosis the diffusion of water across a selectively permeable membrane

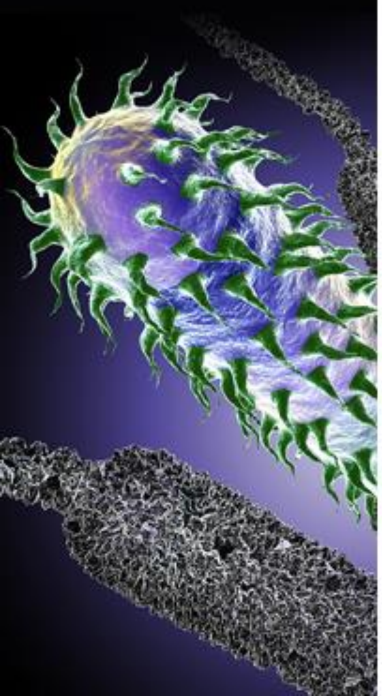
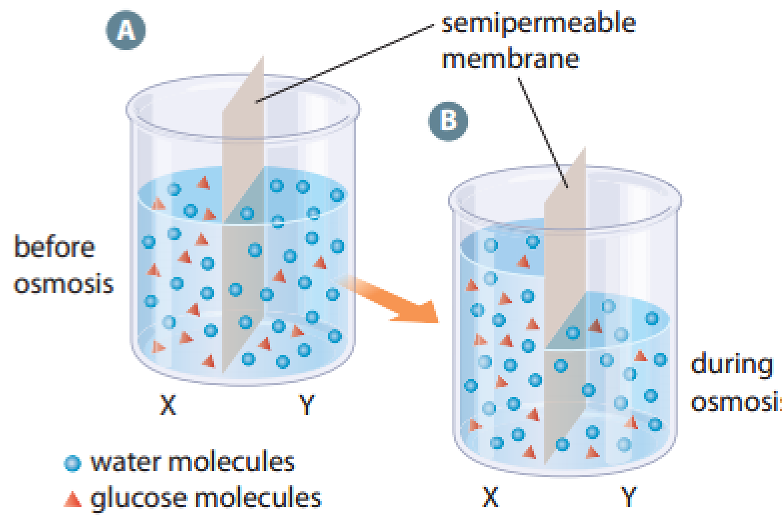
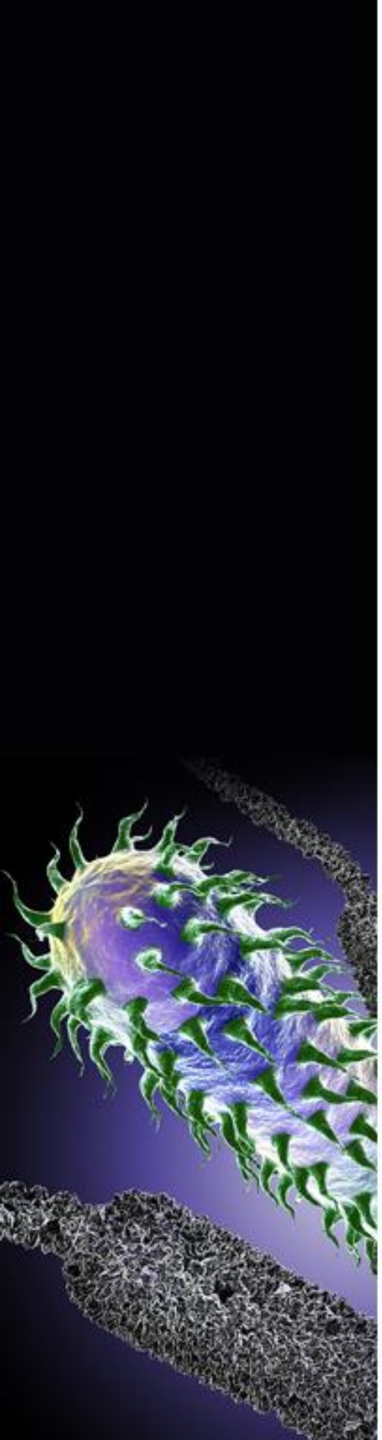


Figure 4.27 In osmosis, there is a net movement of water, rather than dissolved substances, across a membrane. Water molecules are constantly moving across the membrane in both directions, but there is a *net* or *overall* movement of water in the direction that tends toward making the concentration on both sides equal.

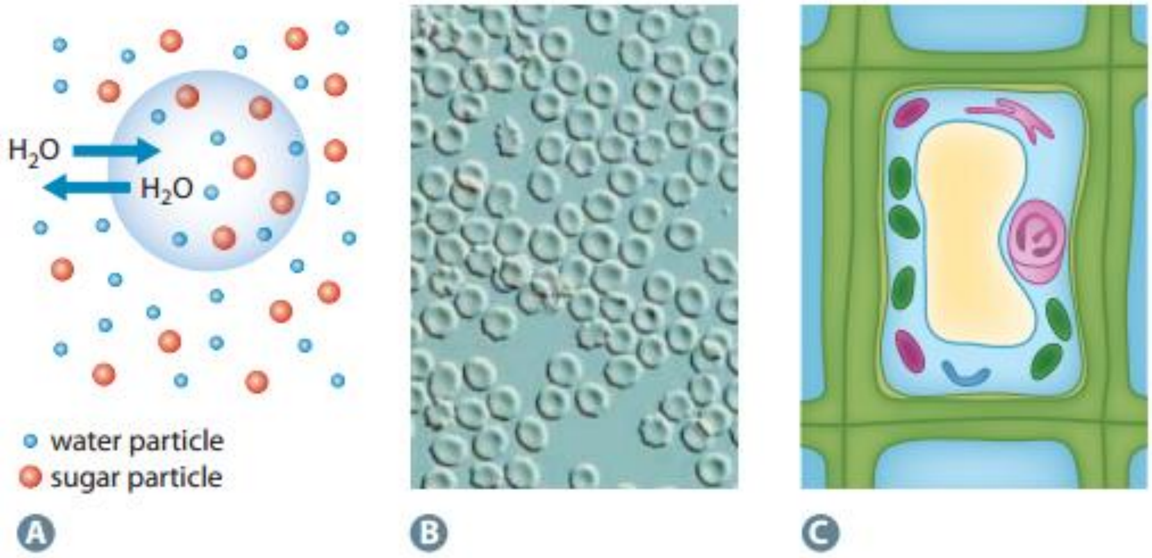


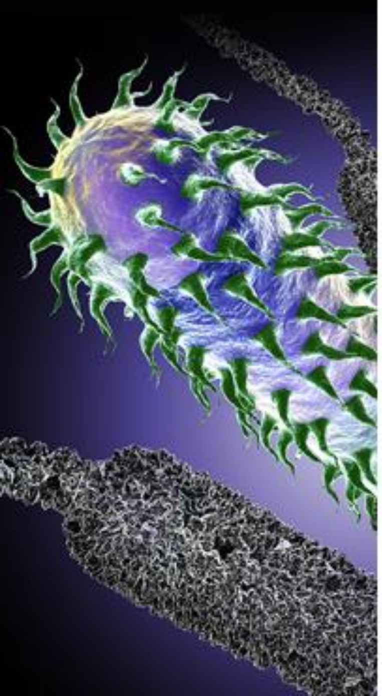


Effects of Osmosis on Different Cell Types

- Isotonic when two solutions on either side of a selectively permeable membrane have equal solute concentrations

Example 1
Isotonic conditions: Equal concentration inside and out
(A) Water particles move in and out of the cell at the same rate. **(B)** Animal cells, such as the blood cells shown here, retain their normal shape. **(C)** Plant cells are a normal shape but lack firmness.

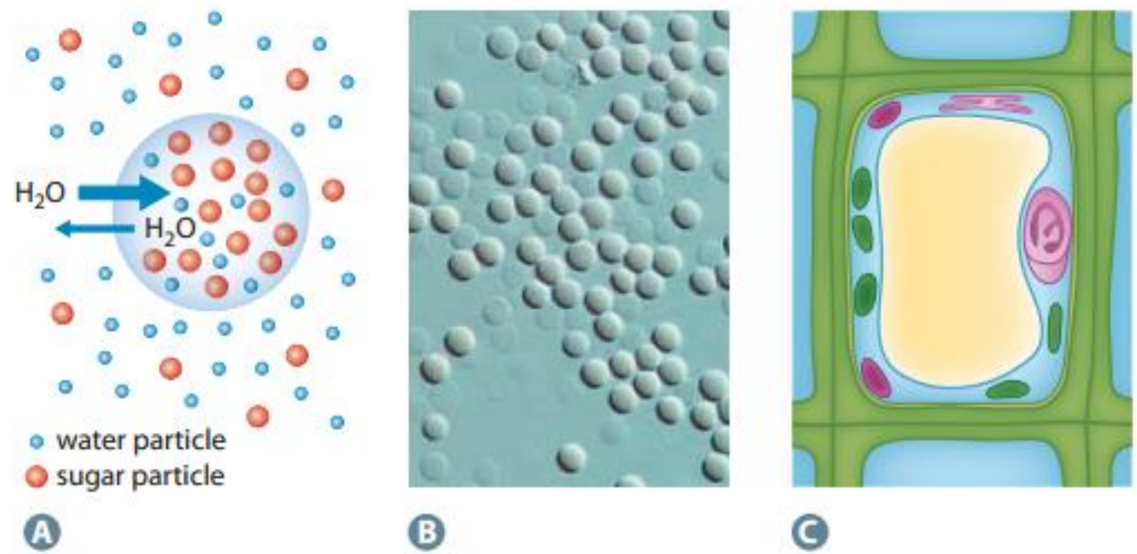


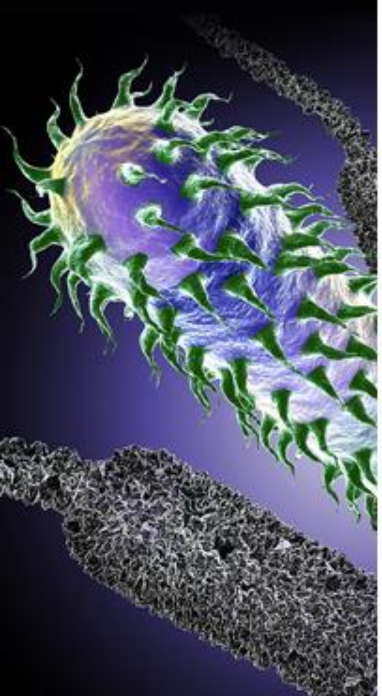


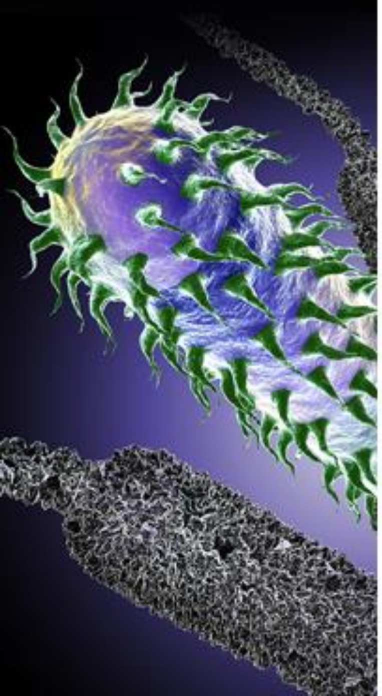
- A solution of lower solute concentration is described as hypotonic relative to a solution of higher solute concentration.

Example 2
The surroundings are hypotonic: Greater concentration of solutes inside the cell

(A) There is a net movement of water into the cell. **(B)** Animal cells swell and may burst. **(C)** Plant cells become firm.





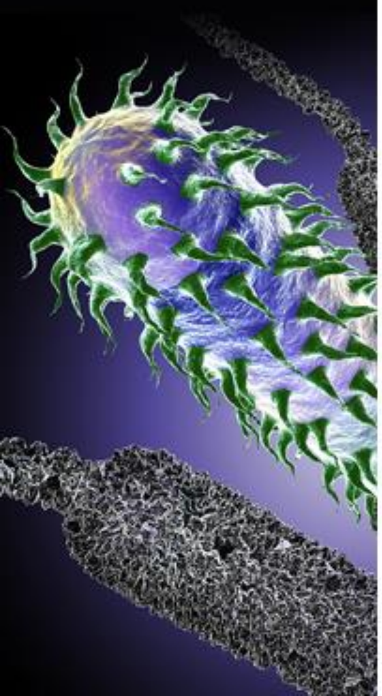


- The opposite is true for a hypertonic solution, which has a higher solute concentration relative to another.

Example 3
The surroundings are hypertonic: Greater concentration of solutes outside the cell

(A) There is a net movement of water out of the cell. **(B)** Animal cells shrivel. **(C)** The contents of plant cells shrink away from the cell wall.

- In other words, water moves by diffusion from the area of higher concentration of water to the area of lower concentration of water.



- Investigation 4.B Osmosis Lab
- *** Needs to be passed in for grading

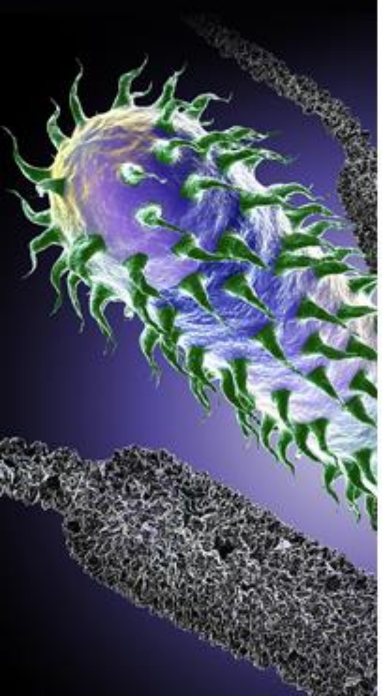
Active Transport

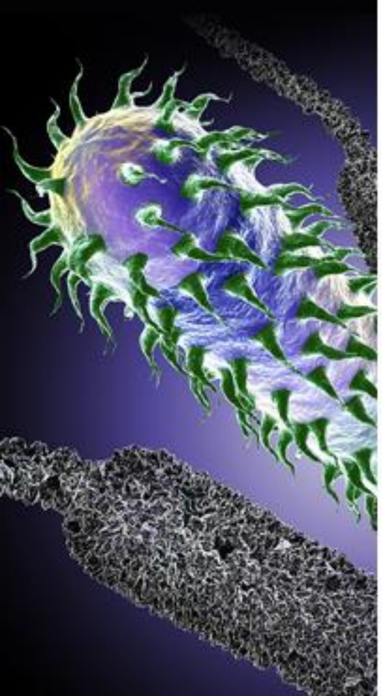
- active transport movement of a substance across the cell membrane and against its concentration gradient with the expenditure of ATP (Energy)

- In human digestion, nutrients such as amino acids, small proteins, and vitamins are dissolved in fluid that moves through the intestine.

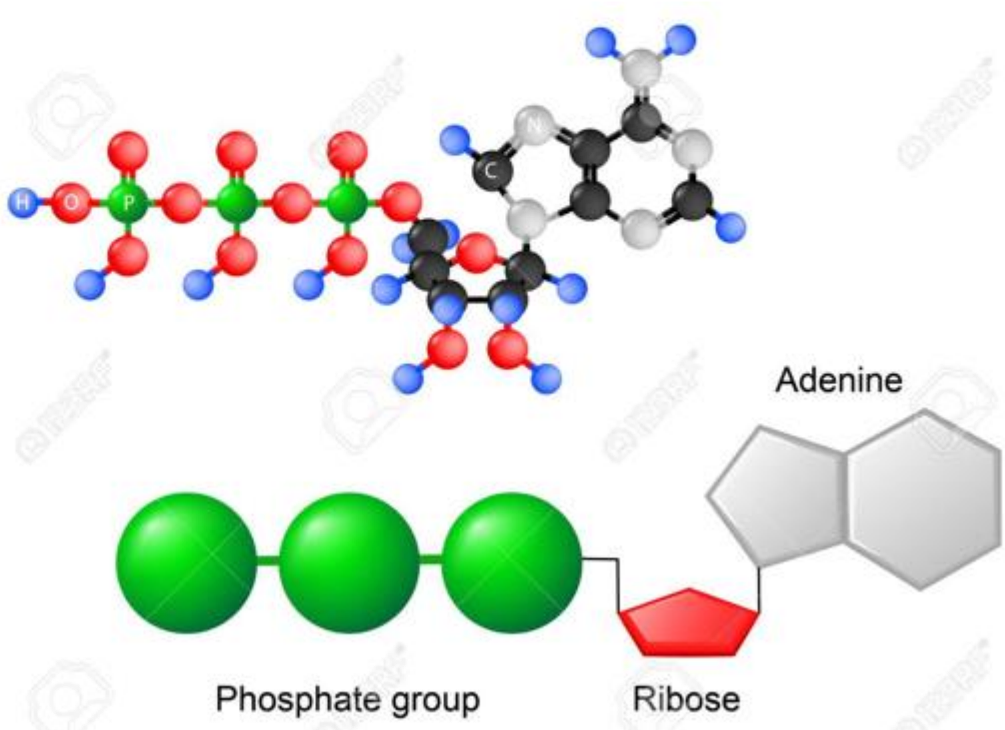
- The cells that line the intestine must absorb these nutrients in order to transmit them to the bloodstream so they can be carried where they are needed throughout the body.

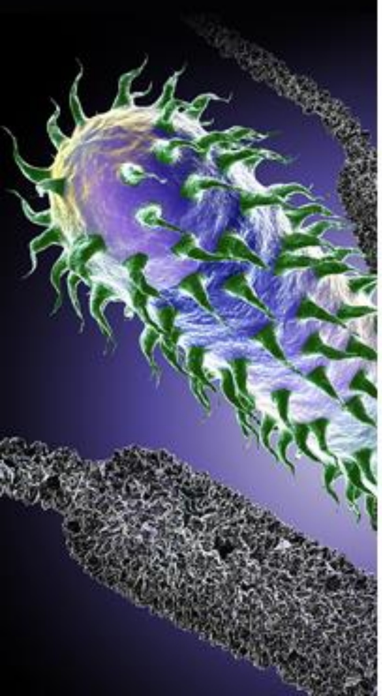
- But the concentration of the nutrients is low in the fluid in the intestines compared to the concentration in the cells. Therefore, the nutrients cannot be absorbed by passive transport.





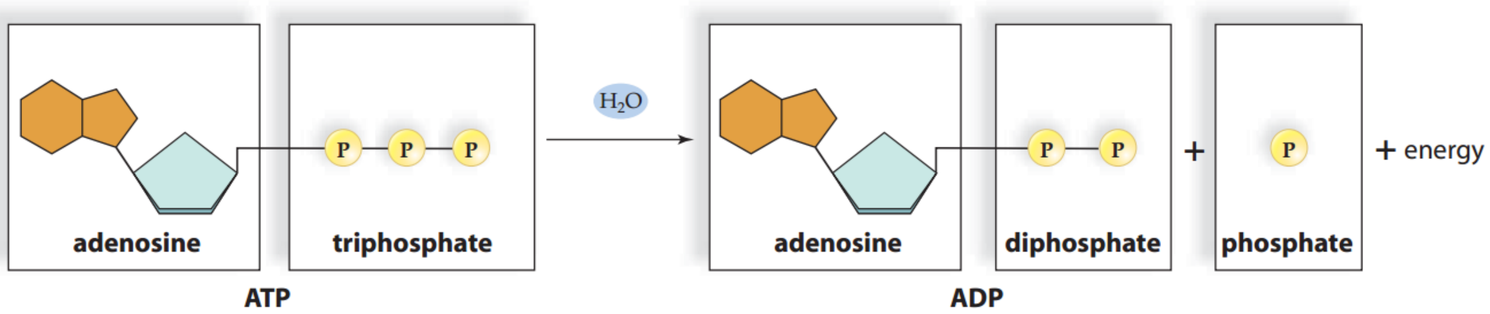
- ATP (adenosine triphosphate)
  - is an energy-carrying molecule that releases energy when it loses a phosphate.





How ATP Works

- Hydrolysis
  - **chemical reaction that adds a molecule of water in breaking a covalent bond**



- An example of active transport is seen in the sodium-potassium pump of animal cells. The sodium-potassium pump brings in three sodium ions at a time by active transport, and moves out two potassium ions in the

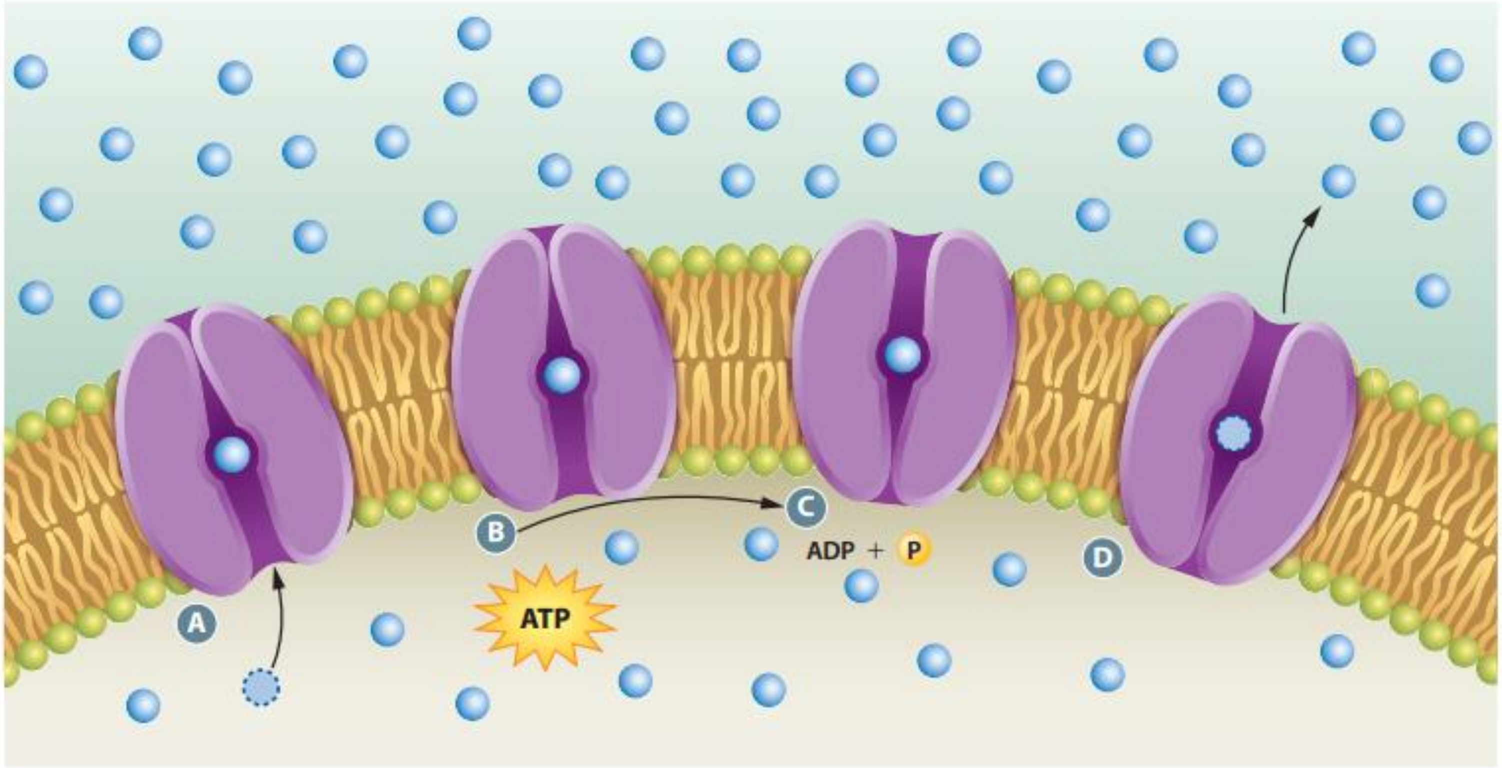
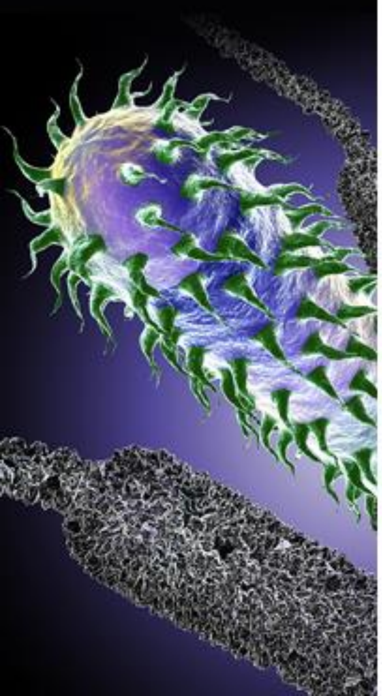


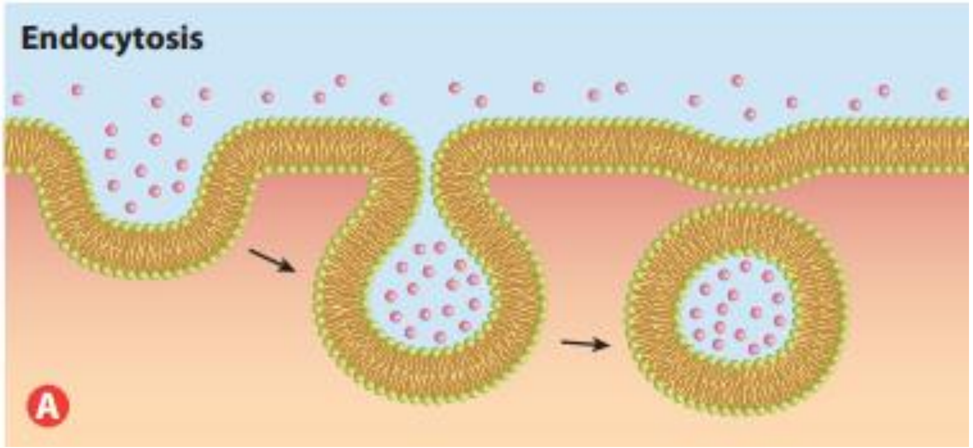
Figure 4.30 In active transport, proteins embedded in the cell membrane pump substances across the cell membrane against their concentration gradient. At **(A)**, a specific ion enters the membrane pump. At **(B)**, ATP is split, releasing energy and forming ADP at **(C)**. At **(D)**, the ion is transported through the membrane.

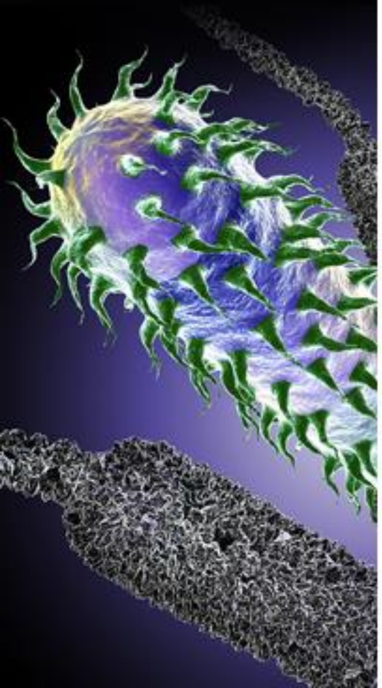


Membrane-Assisted Transport

- endocytosis process by which the cell membrane engulfs material outside the cell to bring it inside the cell

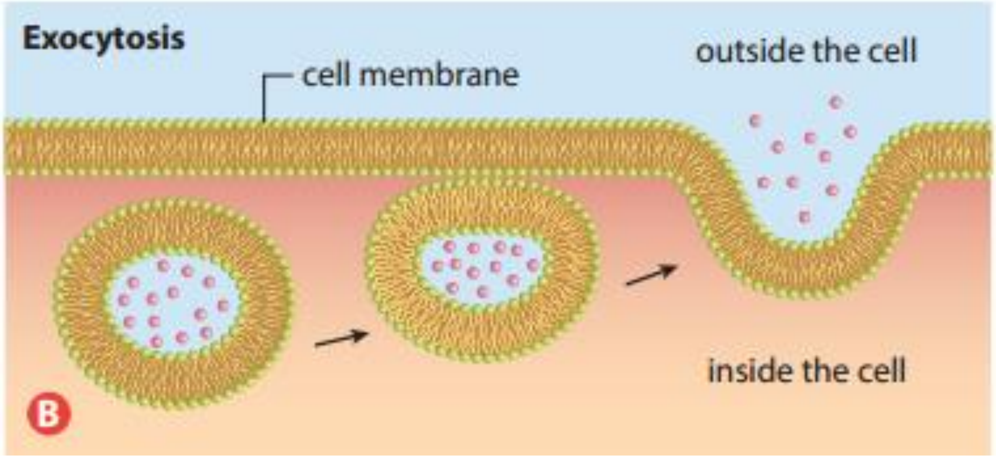
- In endocytosis, the cell membrane folds around the substance to be taken up by the cell. The fold pinches off, forming a vesicle or vacuole that can then travel within the cell. White blood cells remove harmful organisms by taking them up through endocytosis. The vacuole containing the organism fuses with a lysosome, killing the organism.

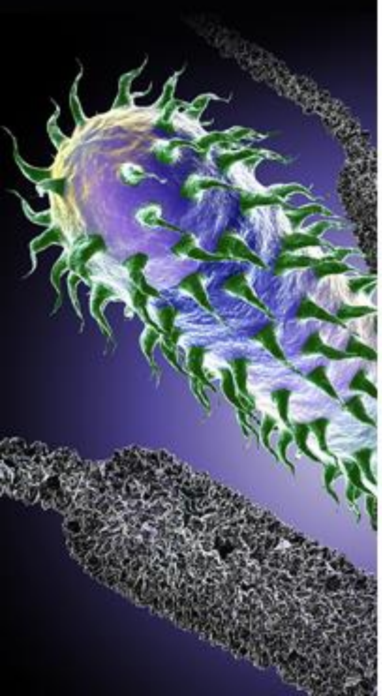




- exocytosis process by which a vacuole fuses with the cell membrane and releases its contents outside the cell

- exocytosis is one way for the cell to remove waste. It is also the way cells release molecules for use elsewhere in the body. For example, exocytosis allows nerve cells to send chemical signals to other cells.





Energy Transformations in Cells

- aerobic respiration cellular process that uses oxygen to release energy, as ATP, from glucose in the mitochondria.

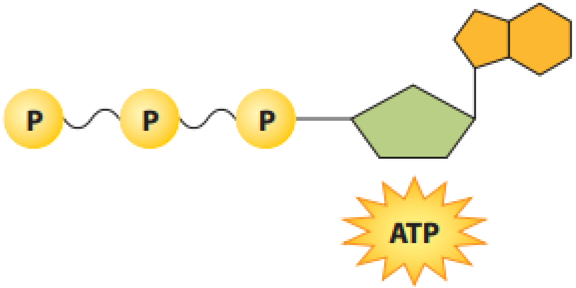
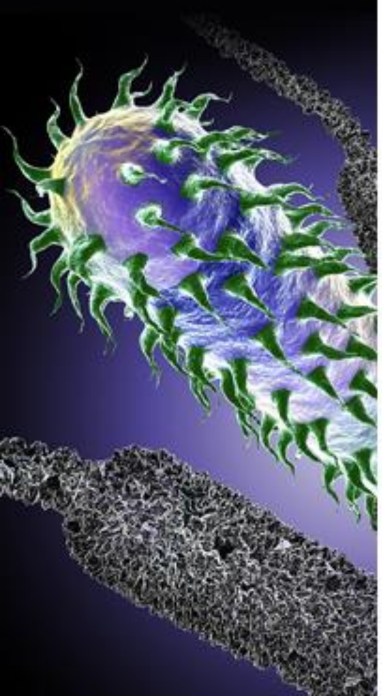
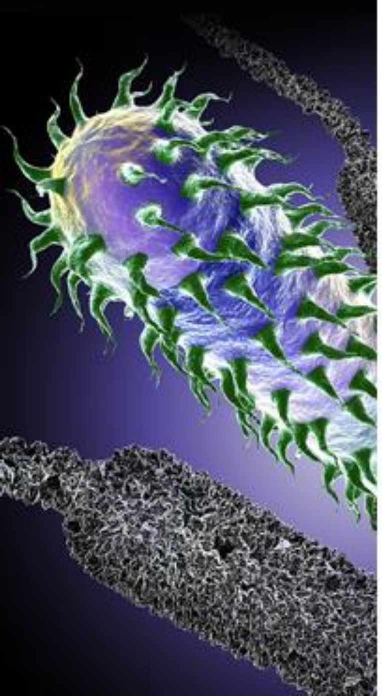


Figure 4.33 ATP stores energy in its bonds to phosphate.

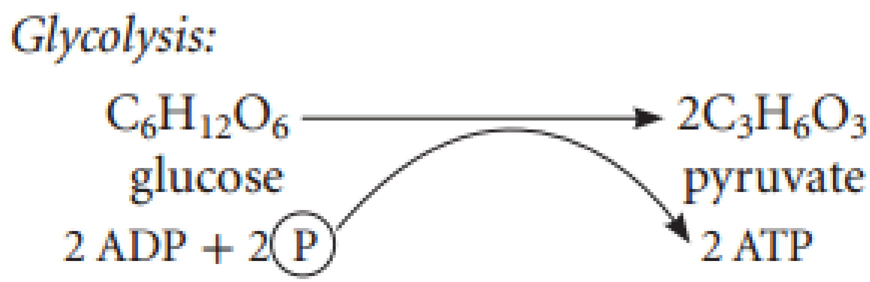


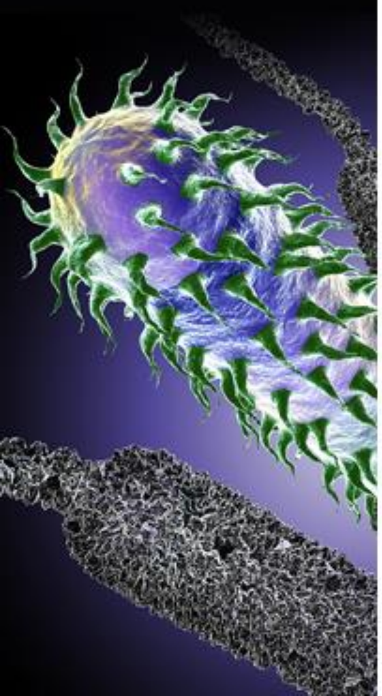


Cellular Respiration: Releasing Stored Energy

- Aerobic respiration actually consists of many, many chemical reactions. Each reaction is catalyzed by a particular enzyme. These reactions take place in four stages. The first stage, glycolysis, takes place in the cytosol. The remaining stages take place in mitochondria.

- Stage 1: Glycolysis
- In glycolysis, a glucose molecule splits into two 3-carbon molecules called pyruvate. The net result of the process, in addition to the splitting of glucose, is that two molecules of ATP are formed. The process is represented below.





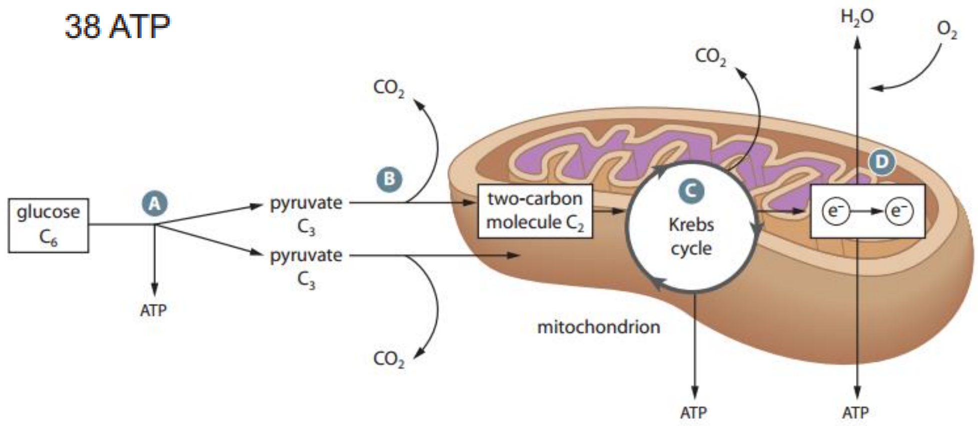
- Stage 2: Krebs cycle – takes place inside the mitochondrion
- some of the energy that came from glucose is transferred to other energy-carrying molecules.

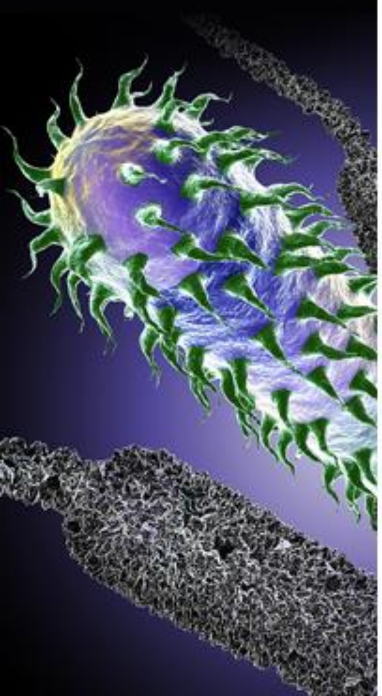
- Stage 3: oxidative phosphorylation
- the energy-carrying molecules produced in the previous stages are used to make ATP in the membrane of the mitochondrion. This stage uses oxygen.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

glucose oxygen → carbon dioxide water

38 ADP + 38 Ⓟ → 38 ATP



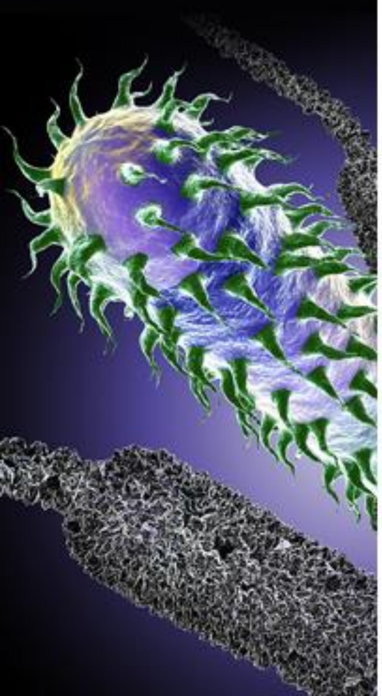


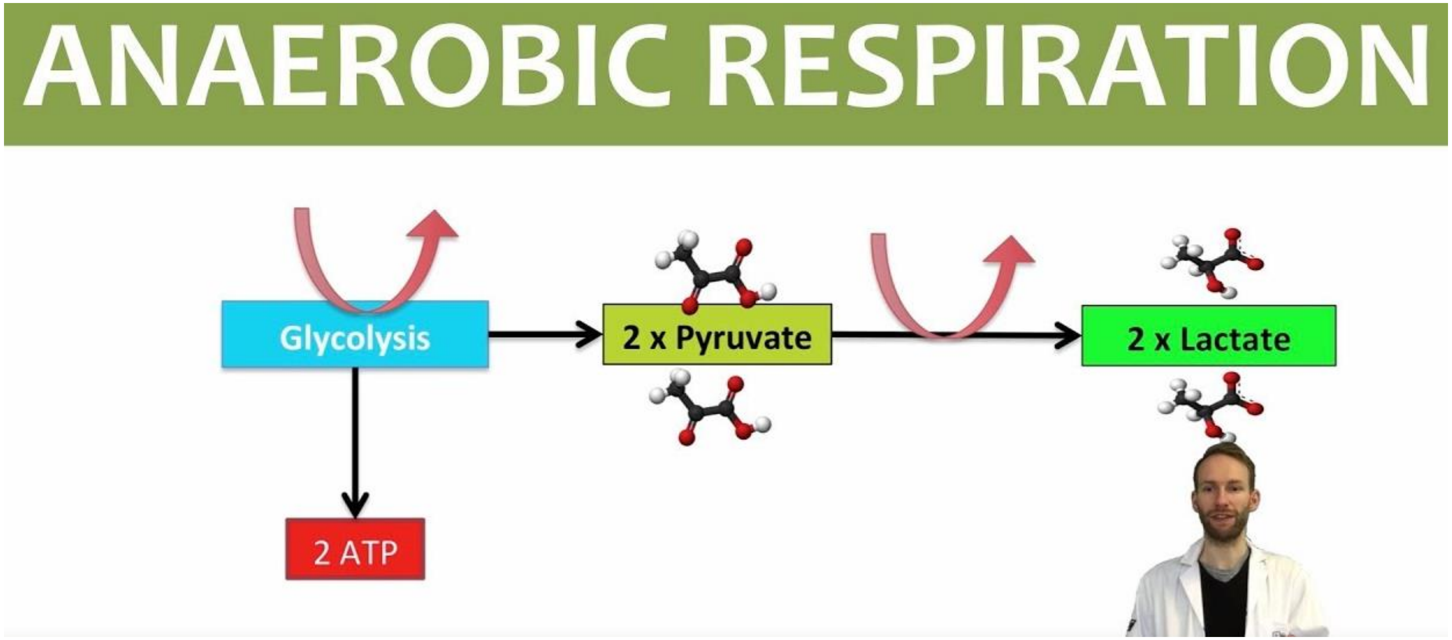
Summing Up Aerobic Respiration

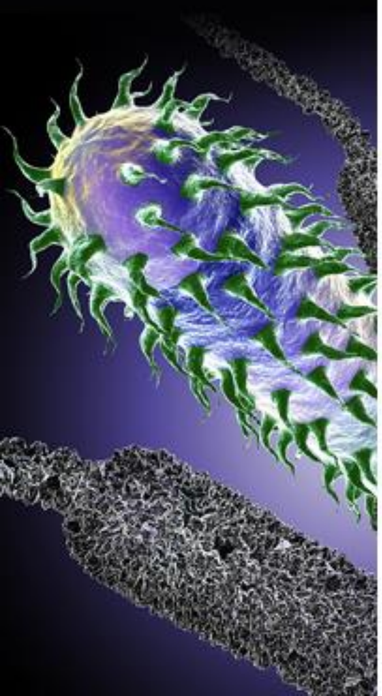
- For every one molecule of glucose that undergoes aerobic cellular respiration, a maximum of 36 to 38 ATP molecules can form. Six oxygen molecules are consumed in the reaction, and six molecules each of carbon dioxide and water are produced.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{Cellular respiration}} 6CO_2 + 6H_2O + ATP$$

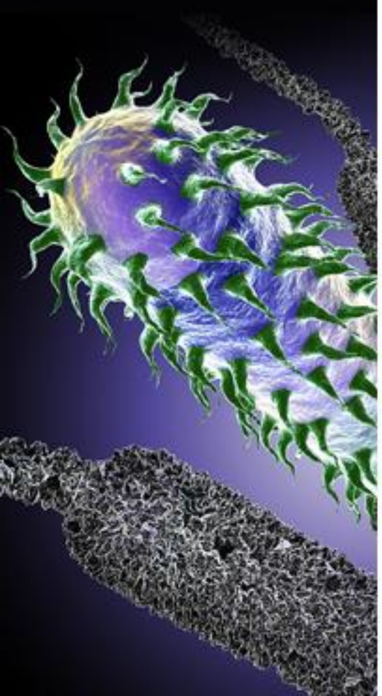
- anaerobic respiration
- glucose breaks down without oxygen. The chemical reaction transfers energy from glucose to the cell. Anaerobic respiration produces lactic acid , rather than carbon dioxide and water. Unfortunately this can lead to painful muscle cramps





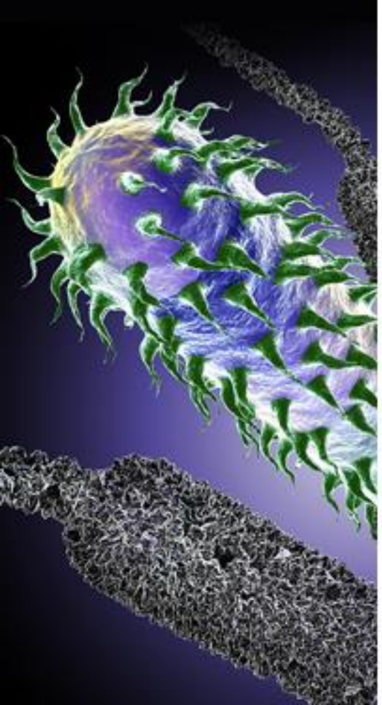


	Anaerobic	Aerobic
Reactants	Glucose	Glucose **and** oxygen
Combustion	Incomplete	Complete
Energy Yield	Low (2 ATP)	High (36 – 38 ATP)
Products	**Animals:** Lactic acid **Yeast:** Ethanol + CO_2	CO_2 and H_2O
Location	Cytoplasm	Cytoplasm **and** mitochondrion
Stages	Glycolysis Fermentation	Glycolysis Link reaction Krebs cycle Oxidative phosphorylation



Photosynthesis

- Plants are said to make their own food. They do this through the process of photosynthesis, which takes place in the chloroplasts of plant cells.
- Photosynthesis occurs in two stages: the light dependent reactions and the Calvin cycle.
- During the light dependent reactions, chlorophyll pigments absorb light energy. The pigments then transfer this energy to two energy-carrying molecules—ATP and NADPH.
- This stage of photosynthesis uses a molecule of water and produces a molecule of oxygen.
- The Calvin cycle, the second stage of photosynthesis, uses the products of the light dependent reactions to convert carbon dioxide into glucose. These reactions occur in the stroma of the chloroplast.



- Photosynthesis takes place in the chloroplast. Chlorophyll traps light energy in the light dependent reactions and produces two energy-carrying molecules—ATP and NADPH. The Calvin cycle uses the products of the light dependent reactions to make plant sugars.
- Six carbon dioxide molecules are combined with six water molecules to create one molecule of sugar and six molecules of diatomic oxygen

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

carbon dioxide | water | glucose | oxygen

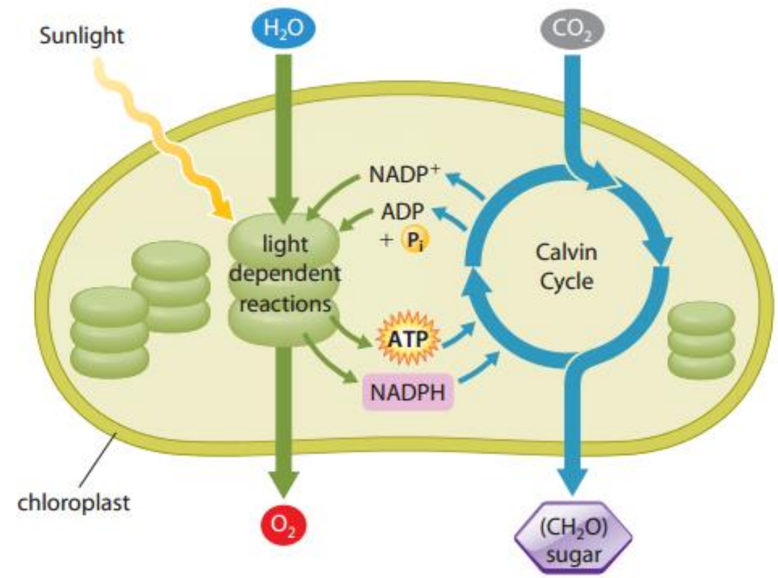
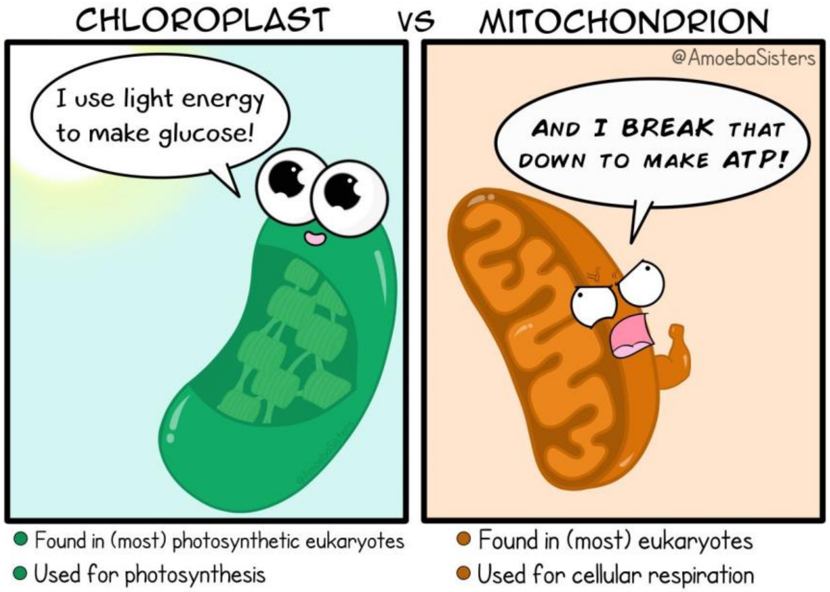


Figure 4.36 Photosynthesis consists of two stages. The light dependent reactions harvest light energy. The Calvin cycle uses the products of the light dependent reactions to produce plant sugars.

Complementary Processes



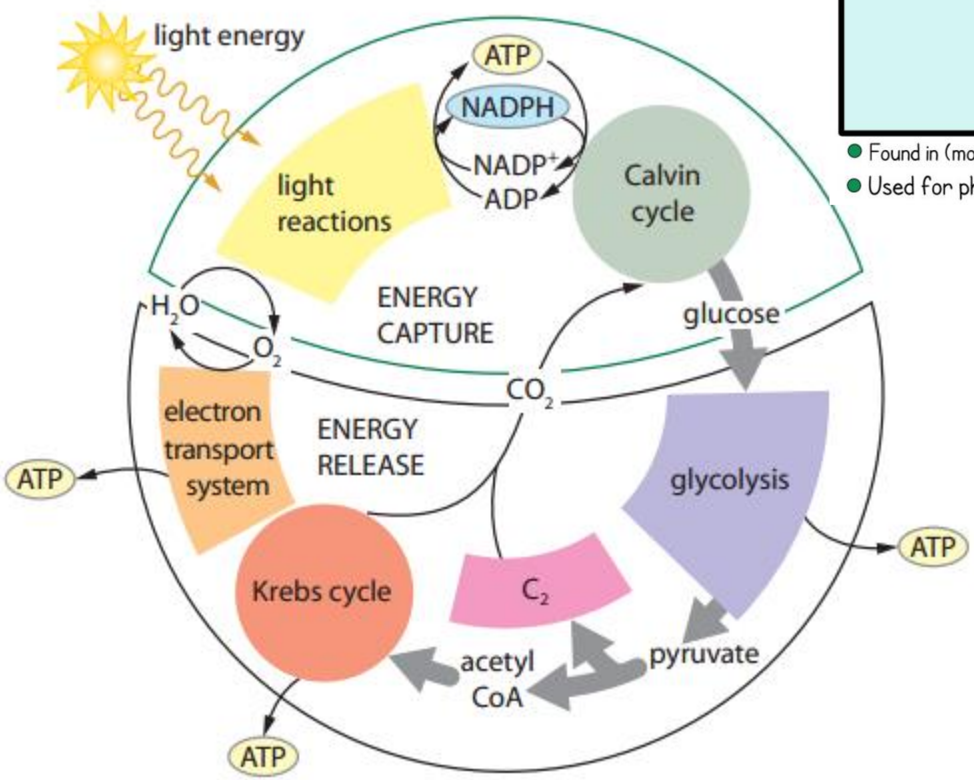


Figure 4.37 Summary of aerobic respiration and photosynthesis