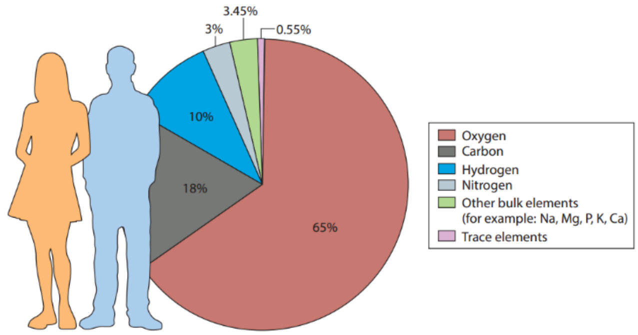
Name: _______________________

# Biology 2201

# Unit 2: Processes that Sustain Life

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




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), totaling 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**


- provides a medium for most chemical reactions
- transports dissolved substances throughout the system
- as a reactant or product in many of life's chemical reactions

**Molecules of Life**

______________________________ a large molecule

____________________________________ 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 |
|---|---|
| Carbohydrates | monosaccharides and disaccharides |
|  | complex carbohydrates (such as cellulose, starch) |

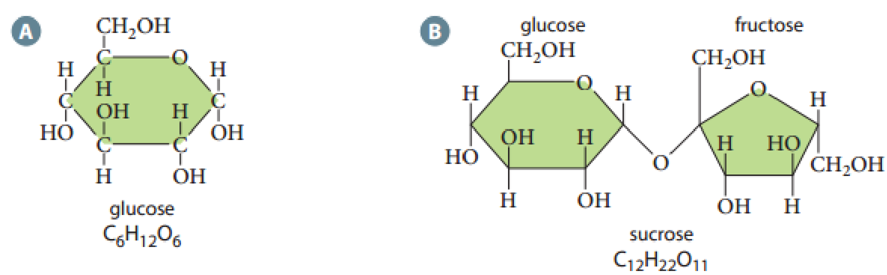
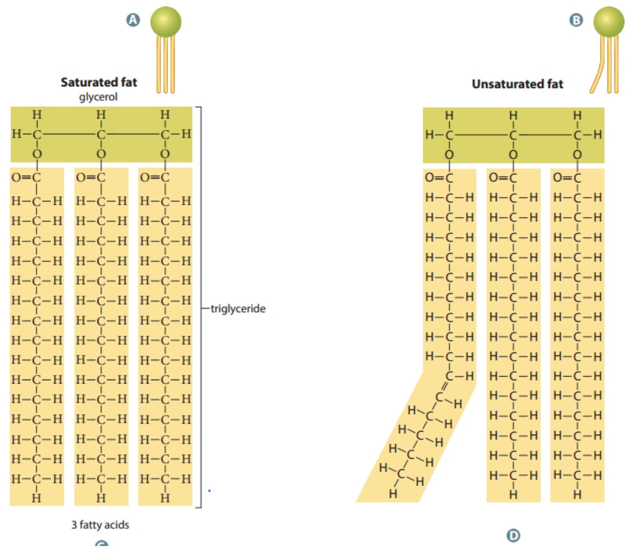



**Figure 3.11** Glucose is a monosaccharide used by cells for energy. Glucose can be extracted from corn (**A**) to make various food products. Sucrose is the disaccharide you know as white sugar. Much of the sucrose you eat comes either from sugar cane (**B**) or from sugar beets.

**Lipids: Structure and Functions**

_______________________________ are a diverse group of macromolecules with one property in common: they do not dissolve in water.




**Proteins: Structure and Function**

__________________________________ have more roles in the cell than any other type of biological molecule.

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

Proteins play a major role in all the activities of life. Illness or death can result even if one type is missing or faulty.

**Some career opportunities in biological sciences**

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

**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.

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.

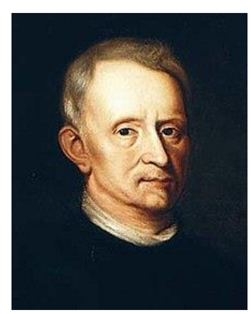
**Plant Geneticist** A plant's DNA can hold the key to properties such as disease tolerance, seed size, and productivity. Plant geneticists conduct research to understand how changes to this DNA can alter a plant's properties in a desired way. They then apply this knowledge to create new and improved 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.

___________________________ (384–322 B.C.E.) "The Father of Biology" wrote that living organisms could arise spontaneously from non-living matter. He called this __________________________________________________.



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.

________________________________ (1870) renamed
_________________________________________________
to ____________________________.

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 ___________________________________________________________

**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.

___________________________________ (1626–1697) conducted one of the first recorded controlled biological experiments.

__________________________________________________________________________________

__________________________________________________________________________________

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.

_____________________________________________________

_____________________________________________________


__________________________________________________________________________________

__________________________________________________________________________________

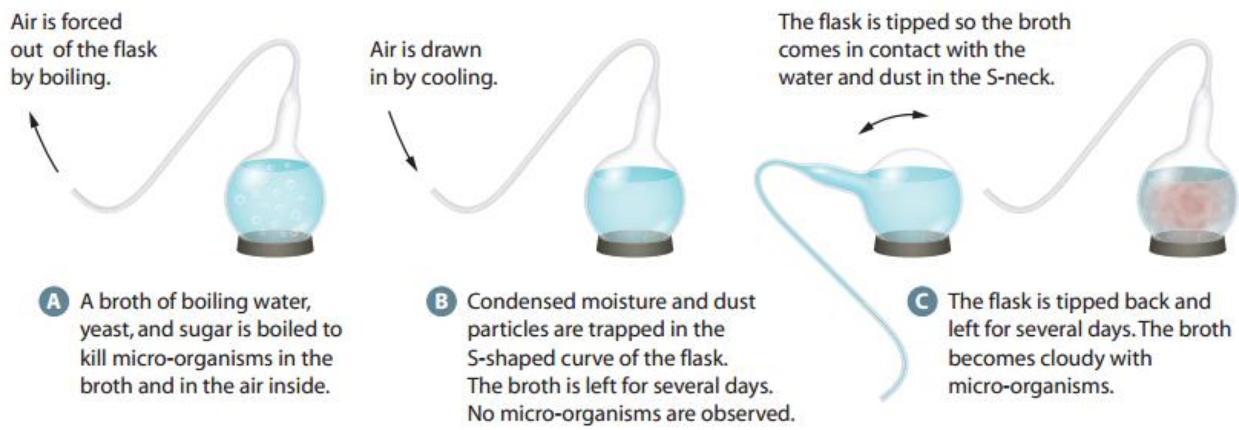
Although Redi's experimental evidence was strong, ____________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

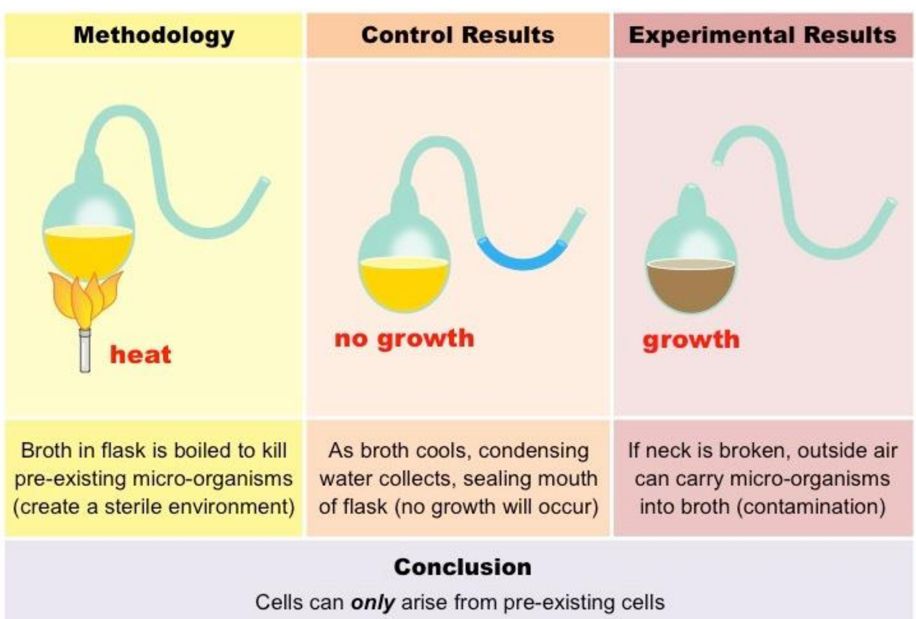
_____________________________________________ (1822–1895) Through a series of experiments, he showed that micro- organisms come from other micro- organisms in air and liquids (Figure 4.2). Pasteur is credited with disproving abiogenesis and proving biogenesis.




_____________________________ the idea that life only arises from life

_____________________________________________ a change in thinking that provided a whole new way of looking at the world.

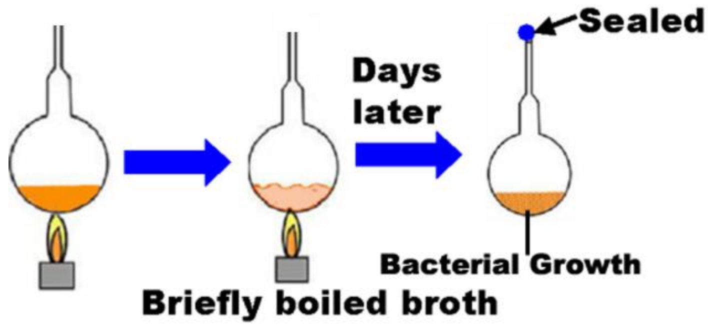
**The general acceptance of biogenesis was a paradigm shift.**




**Activity 4.1**

___________________________________

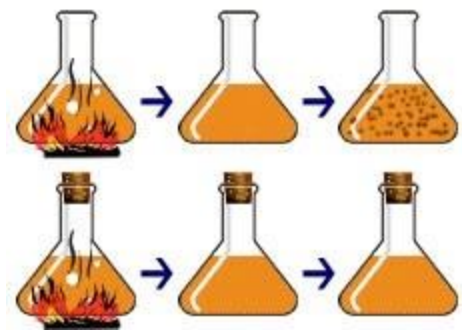
In 1748, an English naturalist and priest, John Needham (1713–1781), designs an experiment to support the idea of spontaneous generation. He brings meat broth to a boil for a short time to kill off micro-organisms in it and then transfers it to a sealed flask. He leaves a second flask with boiled broth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

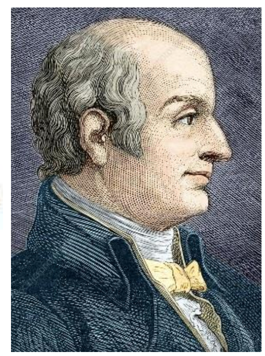



**Identify any flaws in Needham's experiment that would have influenced his results.**

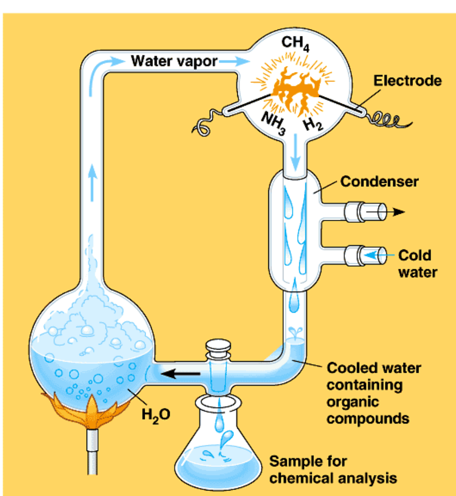
____________________________________________

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 rising from non-living matter.





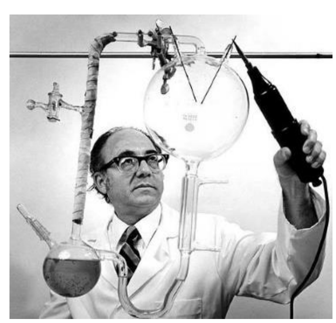
**How did Pasteur's experiment address claims that Spallanzani destroyed a vital force required for life when he sealed his experimental container?**






_________________________________ and _________________________________

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?**

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

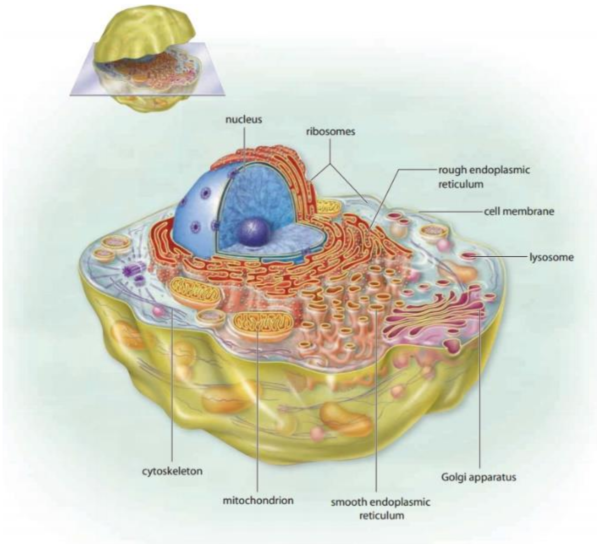



**Figure 4.11** An animal cell. Most animal cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different animals and among different parts of the same animal.

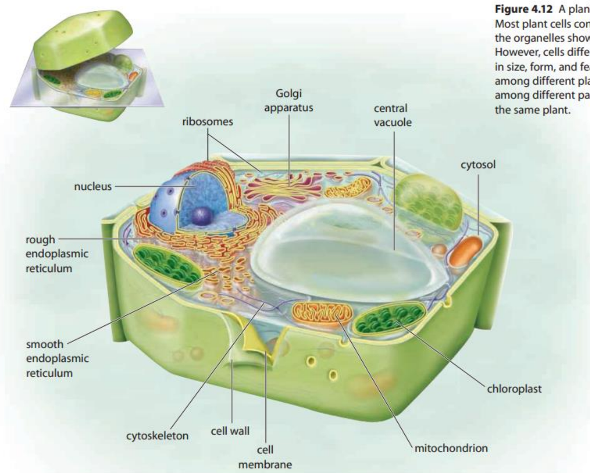



**Figure 4.12** A plant cell. Most plant cells contain the organelles shown here. However, cells differ greatly in size, form, and features among different plants and among different parts of the same plant.

**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.

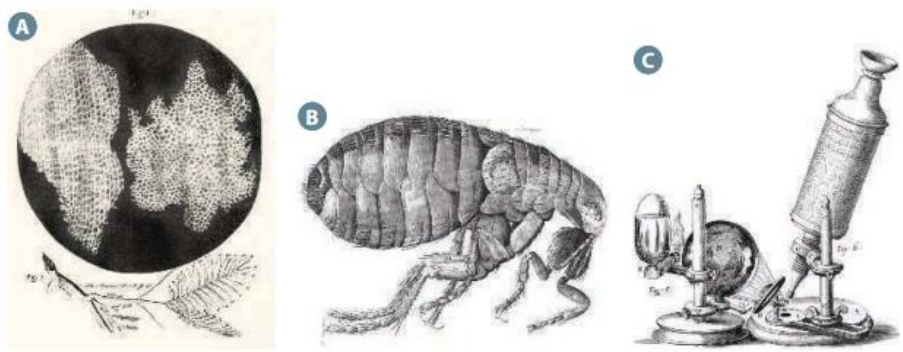
4. The activities of a multicellular organism depend on the activities of all of its cells.

**Microscopes Reveal Cellular World**

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

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

**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.




__________________________________________________________________ (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. ________________________________________

___________________________________________________________________________________________

In a letter to the Royal Society of London, van Leeuwenhoek **reports** observing tiny "_______________________________" 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 ______________________________.

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 ___________________________________________ _______________________________ (1804–1881) writes, **"All plants are made of cells."**

1839 - German physiologist __________________________________ (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.”**

Scottish botanist _____________________________________ (1773–1858) observes that cells from many diverse organisms all appear to have a darker region, which he names the ____________________________, near the centre.

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 _______________________________________________(1838–1907) develops a new intense purple dye. Microscopy experts quickly develop techniques for staining slide specimens with it.

1858 - German physiologist ____________ _____________________ (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.”**=

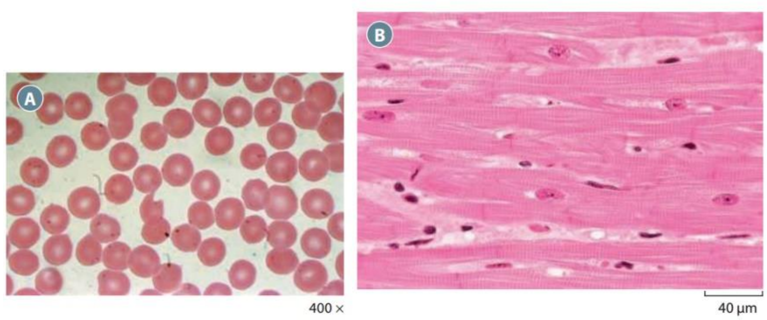



**Figure 4.6** The images of cells shown here were captured at 400× magnification through a compound light microscope. **(A)** shows human blood cells; **(B)** shows cells in human muscle tissue.

**Scientist Poster Assignment**

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

____________________________ refers to the number of times larger the image you observe is compared with the actual object.

____________________________ 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.

____________________________________________ the visual range that is in focus from foreground to background

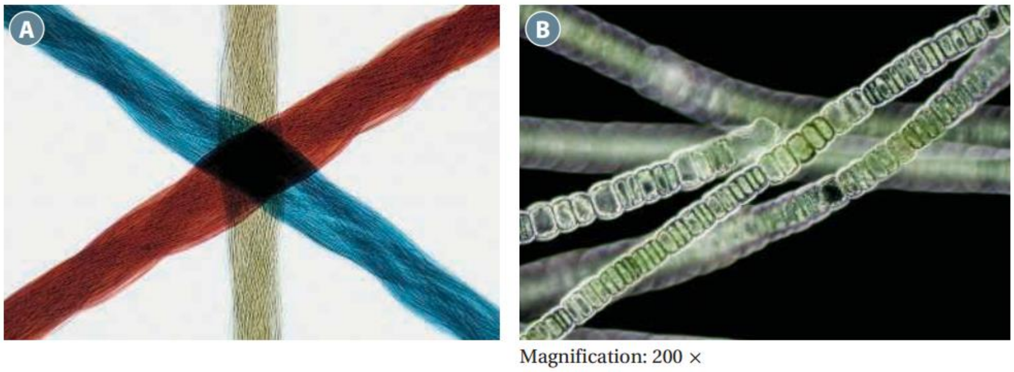
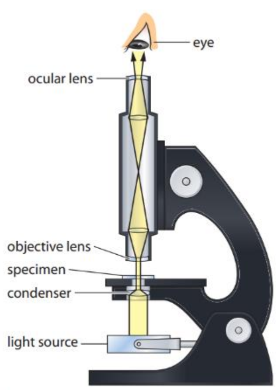



**Figure 4.7** Microscopes have a fairly short depth of field. **(A)** Only the middle thread is in focus when examined by a compound light microscope. The upper and lower threads are outside of the depth of field. **(B)** Likewise, in this image of algae, only some of the cells are in focus.

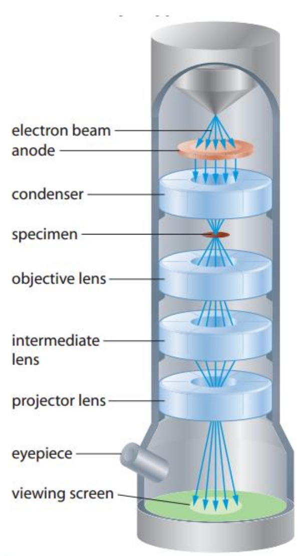
**Launch Lab: Look a Little Closer**

| | | |
|---|---|---|
| **Compound light microscope** | **Magnification range: 40× to 2000×** | **•Can be used to examine stained or unstained samples<br>• 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<br>• 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<br>• Shines beam of electrons through specimen to produce two-dimensional image |

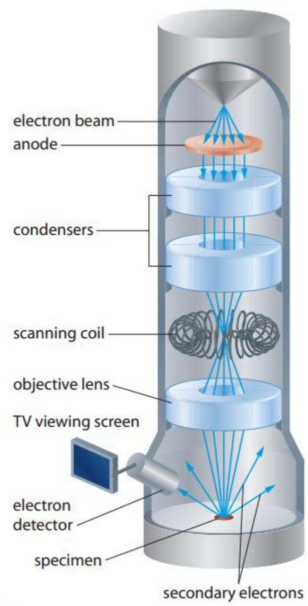
| | | |
|---|---|---|
| Scanning electron microscope | Magnification range: 1000× to 10 000× | • Specimens are cleaned, preserved, and coated with a thin layer of metal or carbon<br>• Shines narrow beam of electrons over specimen, thereby knocking secondary electrons from specimen's surface to produce an image – 3D |
| Atomic force microscopy | • Magnification range: 1000× to 10 000 000× | • No special preparation or staining of the specimen is needed<br>• Metal-and-diamond probe scans surface of specimen; responding movements of probe are used to produce three-dimensional image in near-atomic detail |



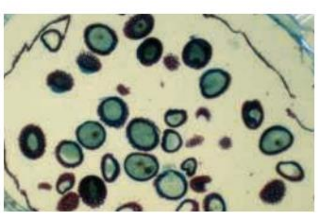

A Compound light microscope



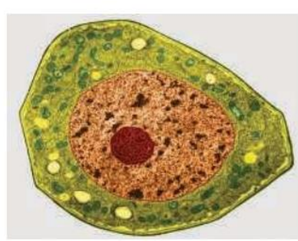

C Transmission electron microscope




D Scanning electron 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×)

**Activity 4.2**

**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!

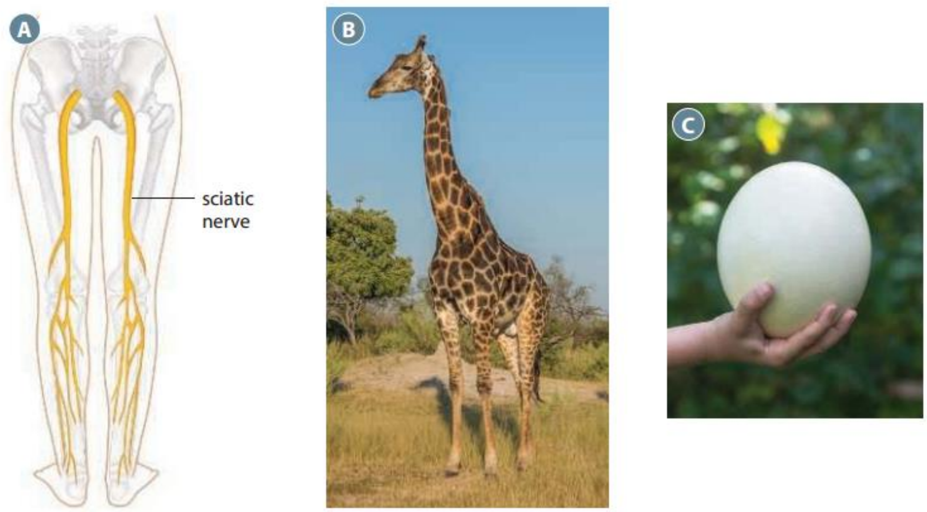



**Figure 4.10** **(A)** Nerve cells in humans can be up to 1.5 m long, but they are extremely skinny. This skinniness means that substances in the cytosol do not have to go far to get to the cell membrane. **(B)** Our nerve cells seem tiny compared with those of giraffes—giraffes may have nerve cells 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______________________________________, whose cells lack a true nucleus.

Protists, plants, fungi, and animals are ____________________________________.  The have a true nucleus.

__________________________________
a structure within a cell that performs a specific function

__________________________________
the organelle that contains the cell's chromosomes and thus controls the cell's activities

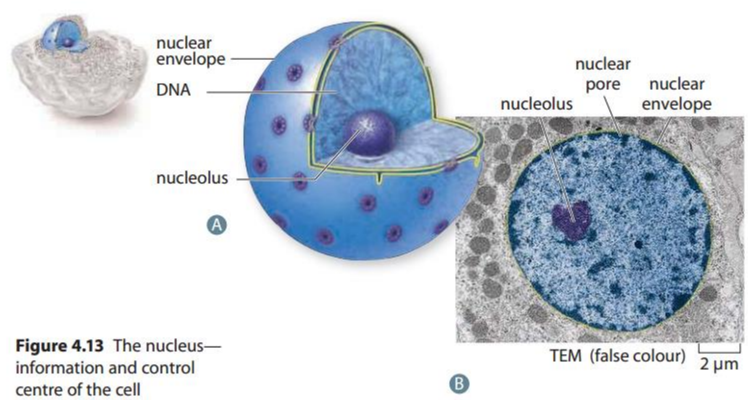
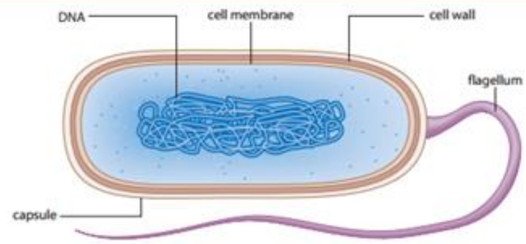
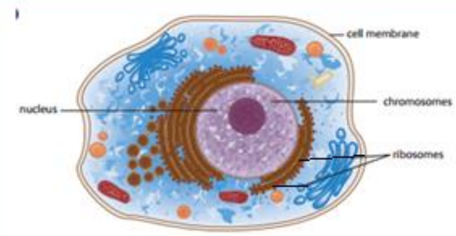
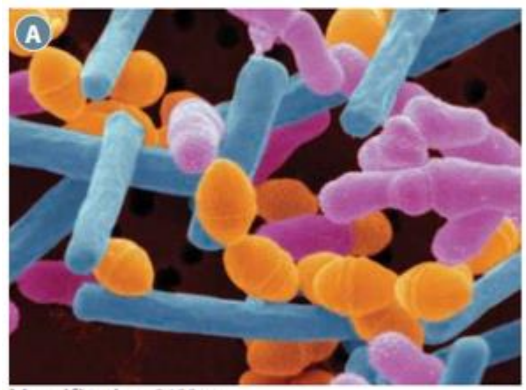



**Figure 4.13** The nucleus—information and control centre of the cell

**Table 4.1** Prokaryotic Cells and Eukaryotic Cells

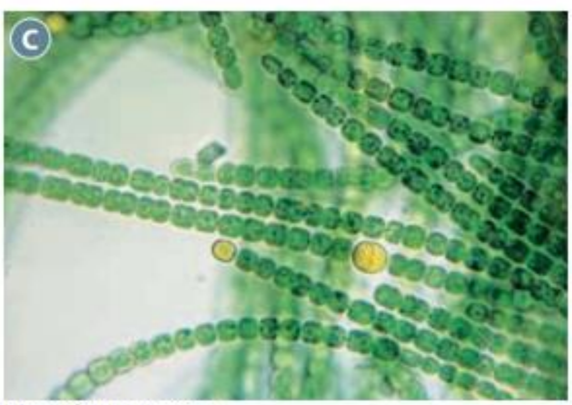
| Characteristic | Prokaryotes: Bacteria, Archaea | Eukaryotes: Protists, Plants, Fungi, Animals |
|---|---|---|
| Typical size |  <br>2–100 μm |  <br>100–1000 μm |
| Genetic material | • no nucleus; DNA not bound by a membrane<br>• one circular chromosome | • DNA in nucleus, bounded by a membrane |
| 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<br>• some are photosynthetic | • most require oxygen to make ATP<br>• some are photosynthetic |

rod-like shape.



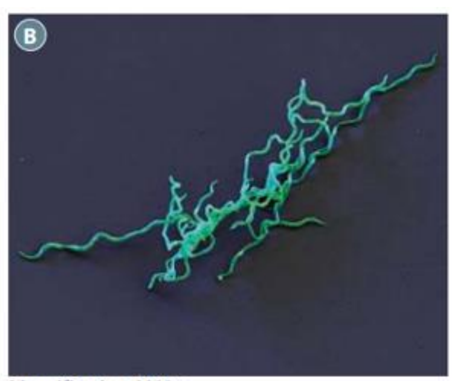
Magnification: 2400 ×

be spherical,



Magnification: 275 ×

or even helical



Magnification: 3000 ×

**Cell Membranes, the Cell Wall, and the Cytosol**

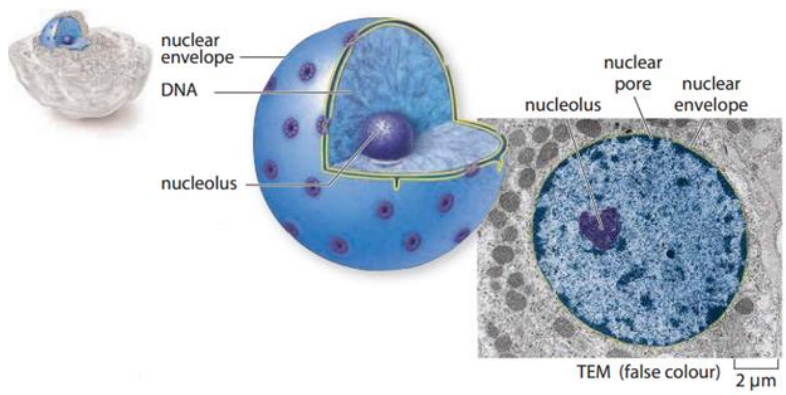
___________________________________ a **phospholipid bilayer** that encloses the cell's contents, separating and protecting the cell from its surroundings

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

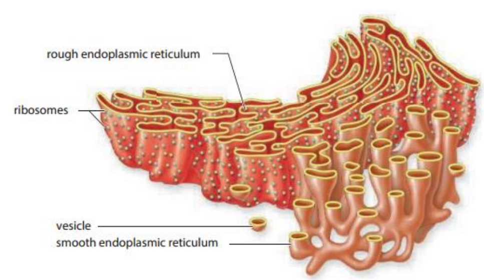
___________________________ a cell's contents, including the cytosol and organelles other than the Nucleus

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

________________________________ non-membrane-bounded structure that produces ribosomes




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




_________________________________________

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

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

_____________________

_________________________________________ an organelle that processes proteins made by the ER and packages them for transport

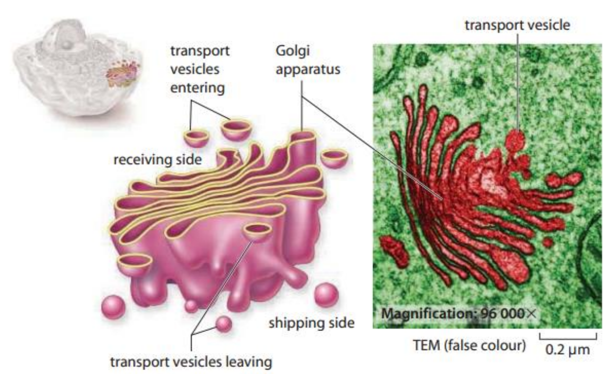



**Figure 4.15** The Golgi apparatus—the cell's centre for processing, sorting, and packaging proteins received from the rough ER.

______________________________ 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**

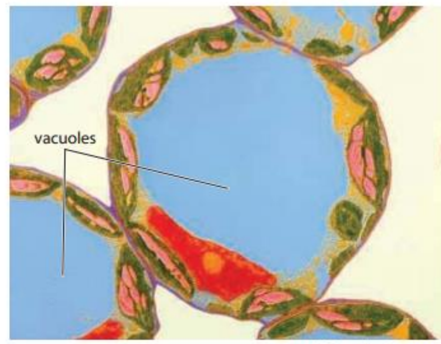



**Figure 4.16** In plant cells, like this one, vacuoles are large storage compartments. In animal cells, they are smaller transport sacs.

_____________________________ 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.

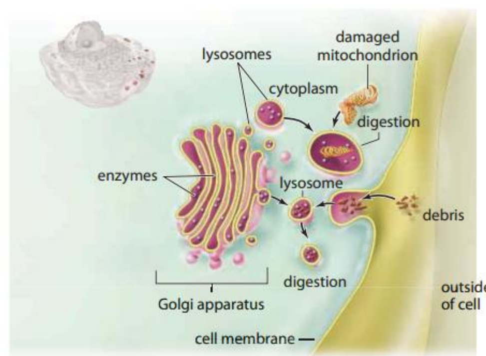



**Figure 4.17** Lysosomes—waste disposal and recycling units of the cell

**LYSOSOME FUNCTIONS**

_________________________________________: 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.

______________________________: 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.

_________________________________________________: 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.

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

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

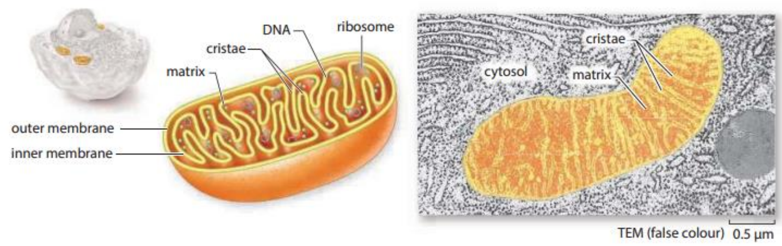
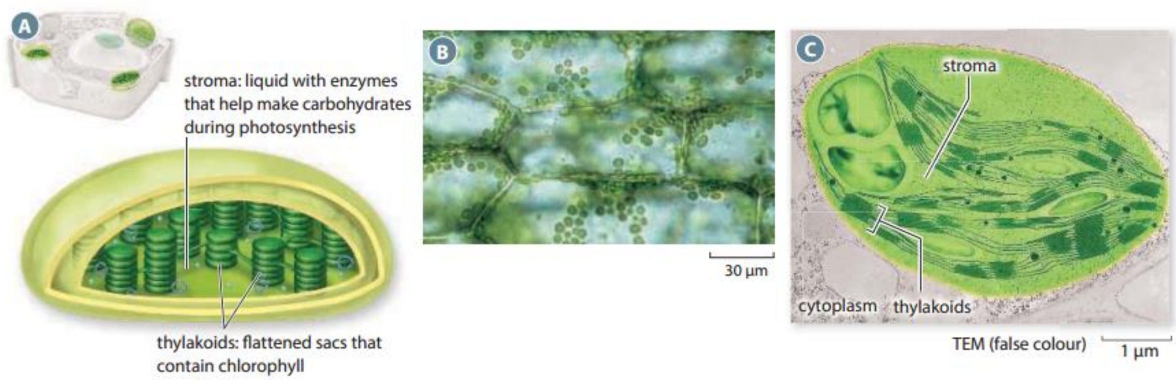


**Figure 4.19** Mitochondria—powerhouses of eukaryotic cells.

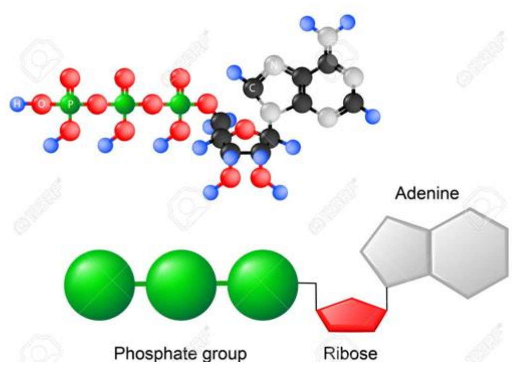
**FYI**
Mitochondria contain their own DNA and ribosomes. Mitochondria also reproduce independently of the cell that contains them.

_______________________________ organelle of plants and eukaryotic protists in which photosynthesis takes place




__________________ (____________________________________________________________________)

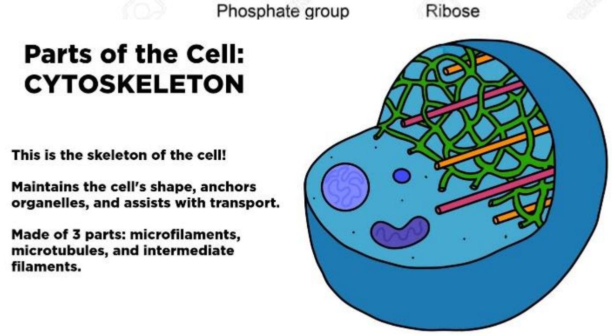
is an energy-carrying molecule that releases energy when it loses a phosphate.




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**

| 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 |

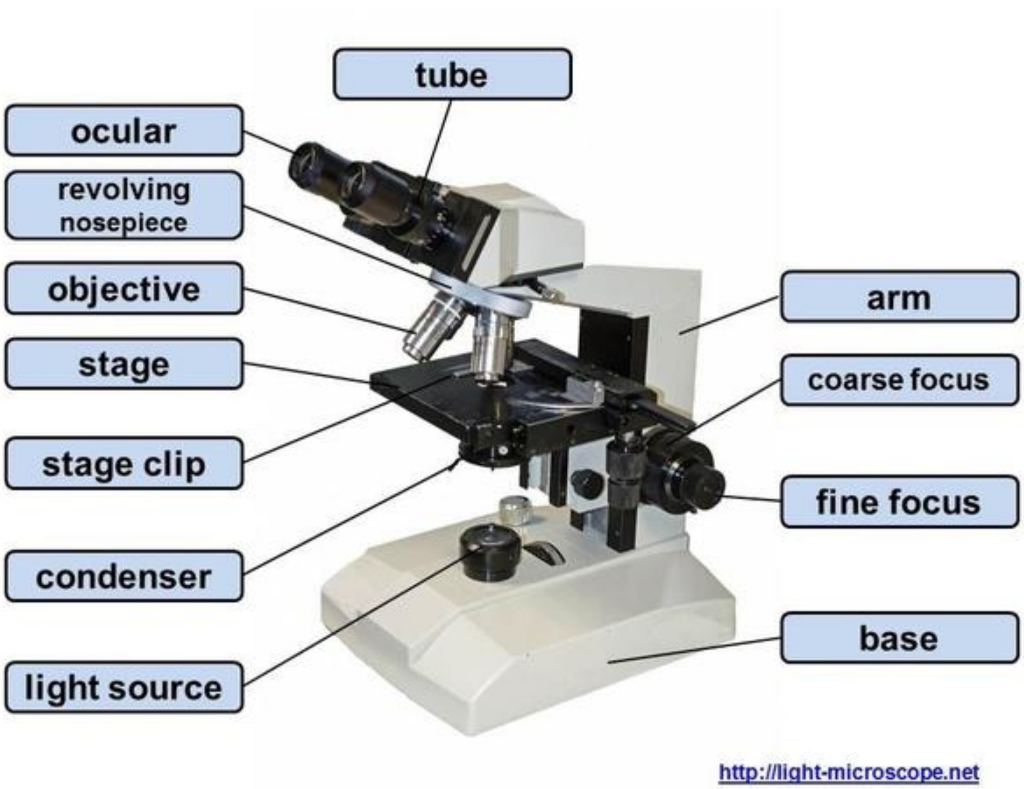
Motile – the ability to move from place to place

Video: Cell Rap Organelles 3 mins and 8 secs

**Activity 4.3**

**Using the Microscope**

1. Make sure that the low-power objective lens is in position. If not, rotate the nosepiece until the low-power objective lens clicks into place.




2. Look through the eyepiece and adjust the diaphragm until the view is as bright as possible.

3. Place a prepared slide on the stage and secure it in place with the stage clips. Make sure the object you want to view is centred over the opening in the stage.

4. Look through the eyepiece. Slowly turn the coarse adjustment knob until the object is in focus. Use the fine adjustment knob to sharpen the focus.

5. Once the object is in focus using low power, carefully rotate the nosepiece to the medium-power objective lens making sure it does not strike the surface of the slide

Adjust the focus using ONLY the fine adjustment knob. DO NOT use the coarse adjustment knob with the medium- or high-power objective lens.

6. Once you have located it under medium power you may want to try and locate the specimen under high power.

7. Rotate the nosepiece to the high power objective making sure it does not hit the slide and use the fine adjustment knob to focus.


**Biological Drawings**

A clear, concise drawing can often replace words in a scientific description. Drawings are especially important when you are trying to explain difficult concepts or describe complex structures.

Follow these steps to make a good scientific drawing:

1. Use an unlined (blank) sheet of paper and a sharp lead pencil, ideally 2H, for the drawing, title, and all labels.

2. Make sure your drawing will be large enough to show all the necessary details; a drawing about half a page in size is usually sufficient. Also allow space for the labels, which identify parts of the object you are drawing.

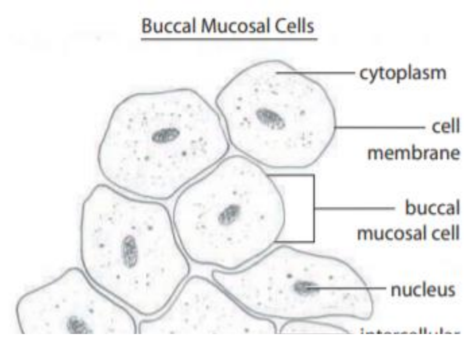
3. Make your drawing as simple as is possible

4. include the boundaries of the other cells surrounding.

5. Shading is not usually used in scientific drawings. To indicate darker areas in your drawing, use stippling (a series of dots)

6. Label your drawing carefully and completely. All labels should be horizontal, printed in lower-case, and placed in a column to the right of your drawing.

7. Use a ruler to draw a horizontal line from each label to the structure you are identifying. Make sure that none of these label lines cross each other.



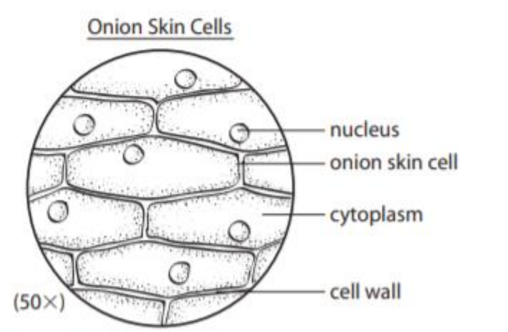




**Figure D.2** The stippling on this drawing of onion skin cells, as observed under a microscope, shows that some areas are darker in appearance than others.

8. Give your drawing a title. The title should appear immediately above the drawing. The title should be printed and underlined. Indicate the magnification of the drawing in parentheses.

**Investigation 4.A: Observing Cells**

**Cell Membrane Structure and Transport**

_______________________________ 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.

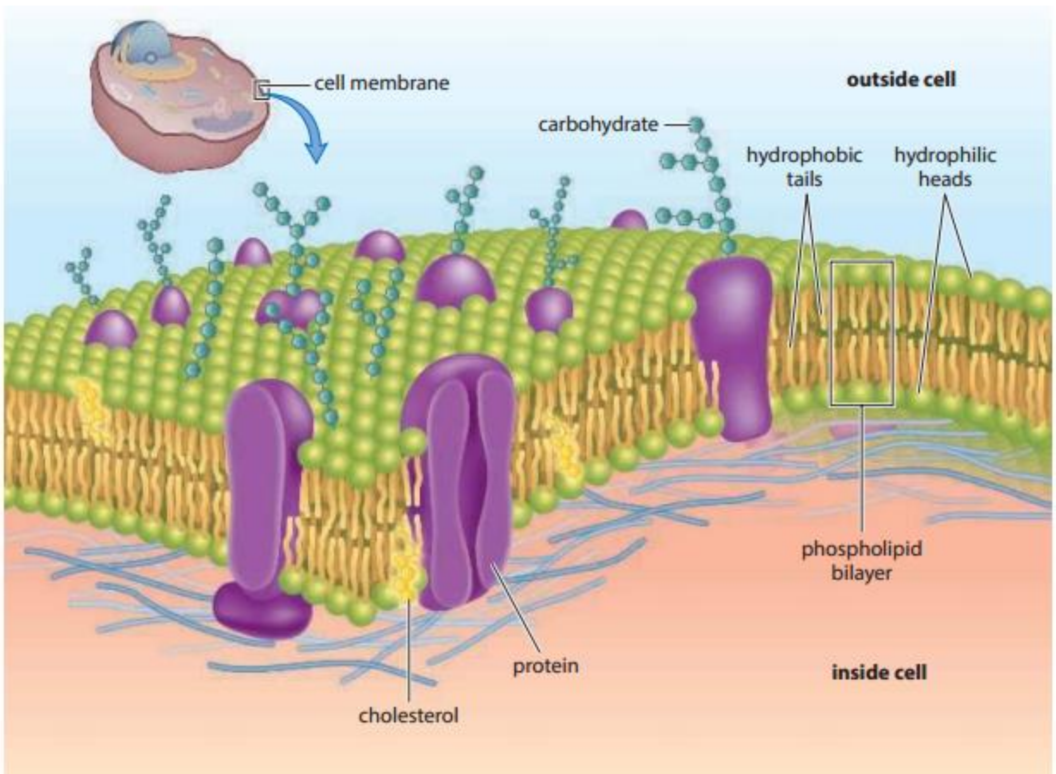



**Figure 4.22** The fluid mosaic model of the cell describes the cell membrane as a phospholipid bilayer that incorporates other molecules such as proteins.

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

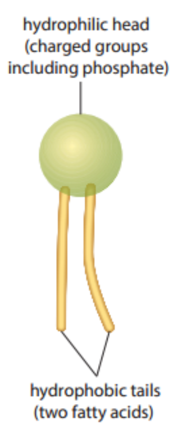



**Figure 3.16** A model of a phospholipid molecule

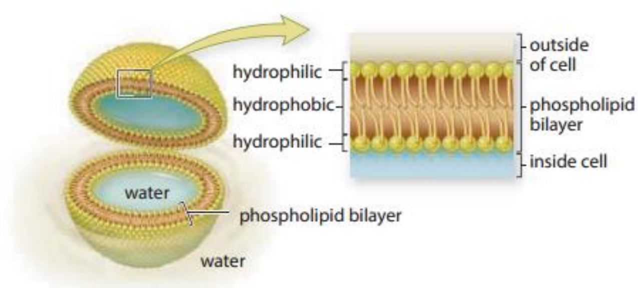



**Figure 3.17** In the two-layered, sandwich-like structure of a phospholipid bilayer, the hydrophilic surfaces are exposed to the water fluid outside and inside the cell. The hydrophobic tails face each other inside the membrane.

**Hydrophilic (water-loving)**

- describes substances made of polar molecules or ions, so they dissolve in water
- Sugar (sucrose) and table salt (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**).

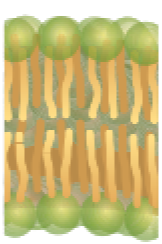
____________________________________________________ the most current description of the cell membrane: a phospholipid bilayer with embedded proteins and other functional components

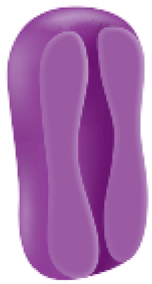
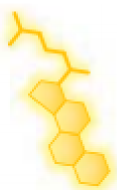
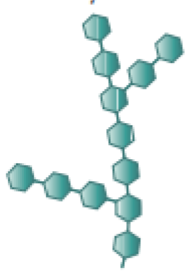
The phospholipid **tails** are **hydrophobic,** and so attract one another and form the centre of the bilayer. The phospholipid **heads** are **hydrophilic**, and so face the cytosol and the cell's exterior.

This model also explains how the cell membrane does its job of controlling what enters and leaves a cell.

**Mini Investigation of Cell Membranes**

**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<br>• Arranged in two layers | • Act as a barrier between the cell and its surroundings<br>• Hold the other components of the cell membrane |

| | | |
|---|---|---|
| Proteins  | • Most are embedded in the phospholipid bilayer<br>• Some are attached to the inside or outside surface of the phospholipid bilayer | • Some proteins transport specific substances across the membrane<br>• Some proteins are enzymes, and they control chemical reactions<br>• Some proteins transmit signals from other cells or elsewhere in the body |
| Cholesterol  | • Embedded in the phospholipid bilayer | • Helps keep fluidity of membrane consistent<br>• Reduces fluidity of membrane at high temperatures<br>• 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 |

**Investigation 3.A Testing for Macromolecules**

**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.

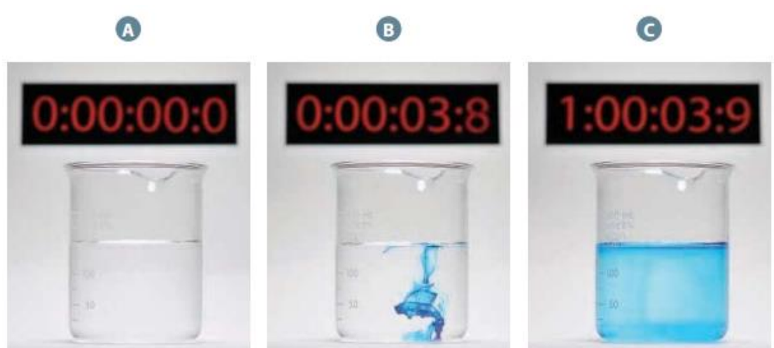



**Figure 4.24** In **(A)**, a drop of dye is just about to be placed in a beaker of water at room temperature. Diffusion occurs spontaneously because molecules are always in motion **(B)**. Even when the dye has spread throughout the beaker, as in **(C)**, the molecules are still moving. There is no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

_____________________________________________ is the movement of substances across cell membranes without the use of ATP (energy)

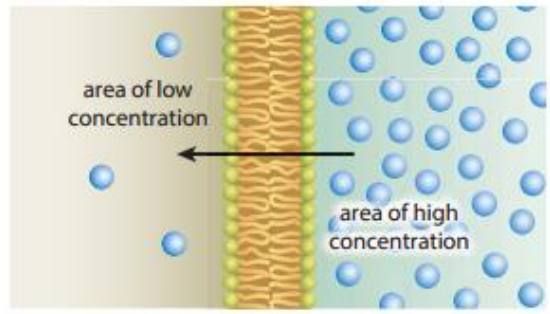
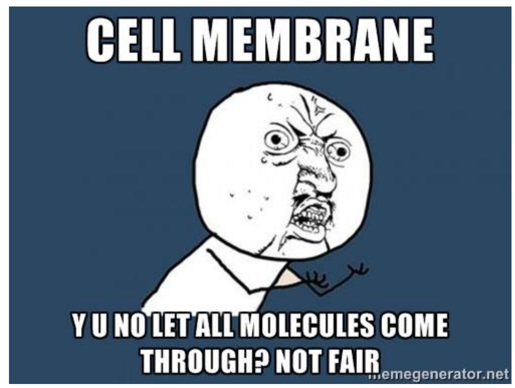



**Figure 4.25** In simple diffusion, when dissolved substances are more concentrated on one side of a cell membrane, there is an overall diffusion toward the less concentrated side.

_____________________________________________ 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.

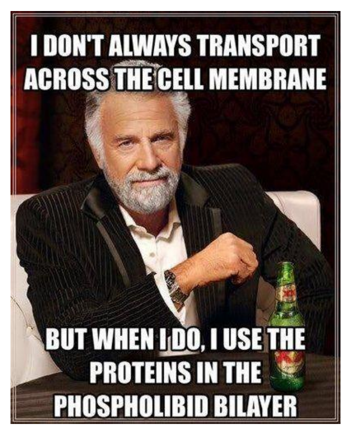
_____________________________________________

_________________ 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**)

_________________________________________________ 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.

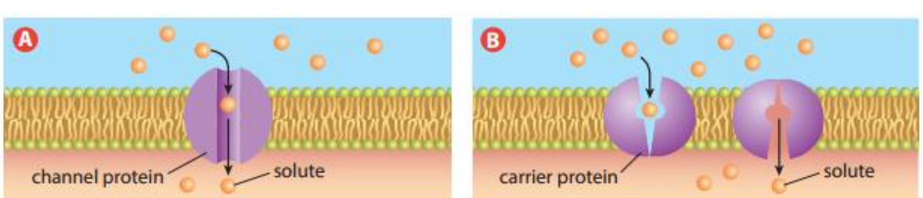
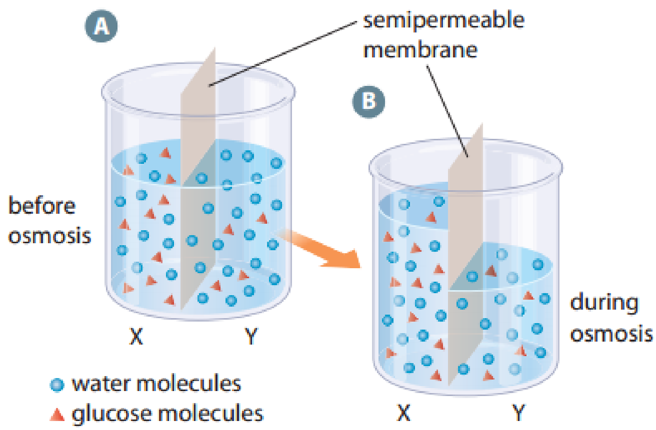



**Figure 4.26** In facilitated diffusion, substances are helped across the membrane by **(A)** channel proteins or **(B)** carrier proteins.

_______________________ the diffusion of **water** across a selectively permeable membrane

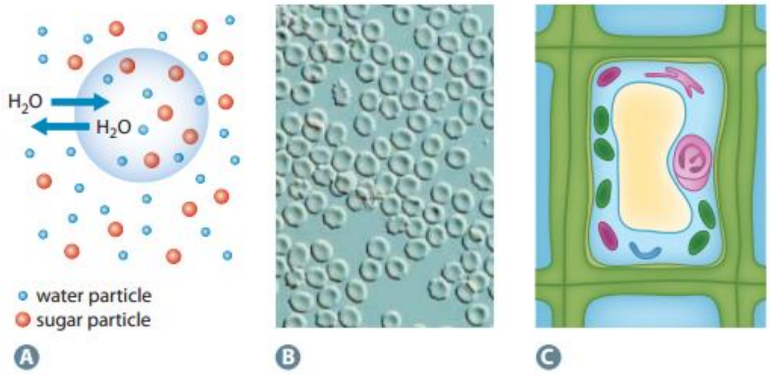
**Figure 4.27** In osmosis, there is a net movement of water, rather than dissolved substances, across a membrane. Water molecules are constantly moving across the membrane in both directions, but there is a *net* or *overall* movement of water in the direction that tends toward making the concentration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




## Effects of Osmosis on Different Cell Types

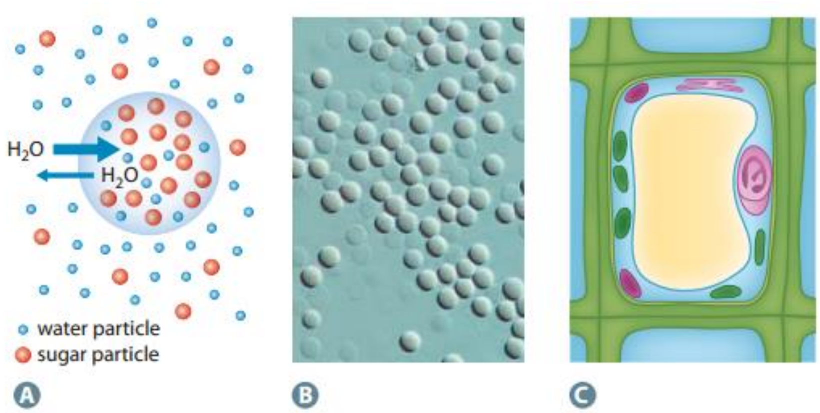
____________________________ when two solutions on either side of a selectively permeable membrane have equal solute concentrations

**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.

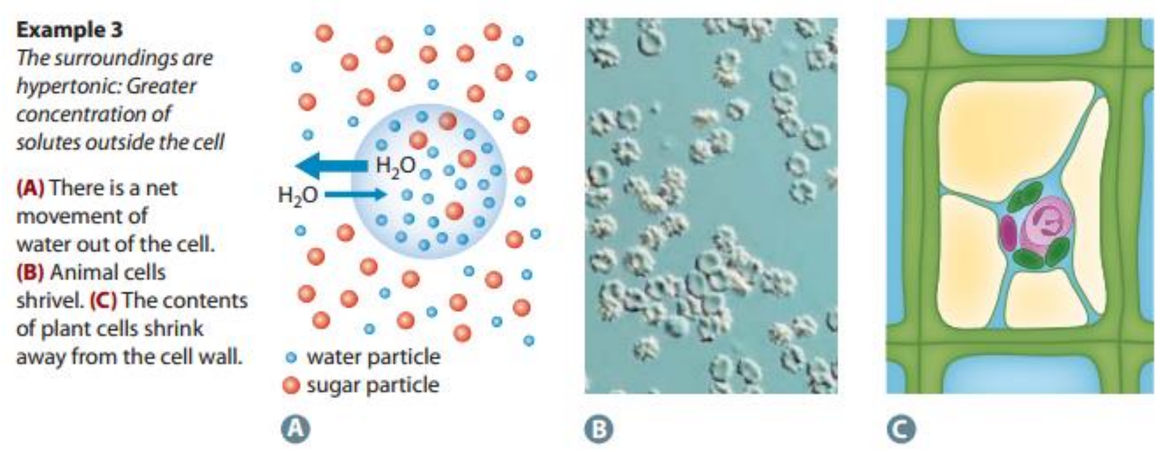



A solution of lower solute concentration is described as ____________________________ relative to a solution of higher solute concentration.

**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 ___________________________ solution, which has a higher solute concentration relative to another.




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**

**Active Transport**

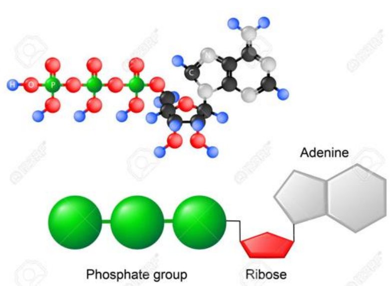
______________________________________________ movement of a substance across the cell membrane and against its concentration gradient with the expenditure of **ATP (Energy)**

- 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. ___________________________________________________________

_________________________________________________________________________________________

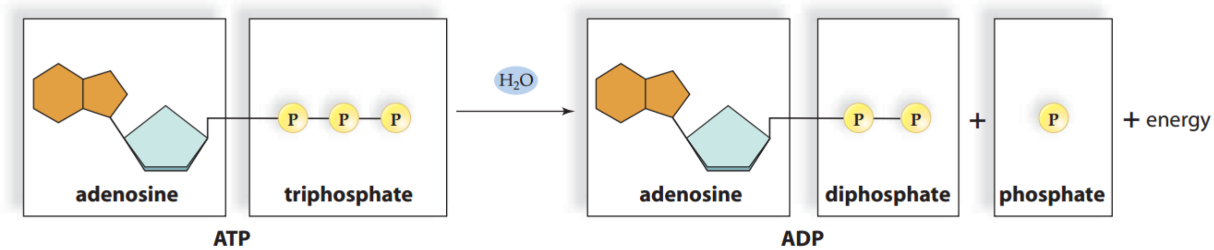
_______________________ (________________________________________________________________)

is an energy-carrying molecule that releases energy when it loses a phosphate.



**How ATP Works**

______________________________ chemical reaction that adds a molecule of water in breaking a covalent bond



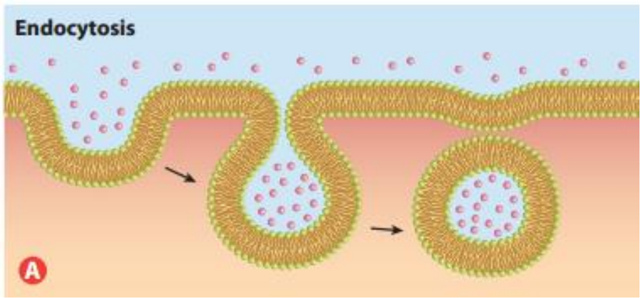

An example of active transport is seen in the **sodium-potassium pump** of animal cells. The sodium-potassium pump brings in three sodium ions at a time by active transport, and moves out two potassium ions in the same cycle. This ion pump is essential for the function of nerve cells.

**Activity 4.6 Understanding the Sodium Potassium Pump**

**Membrane-Assisted Transport**

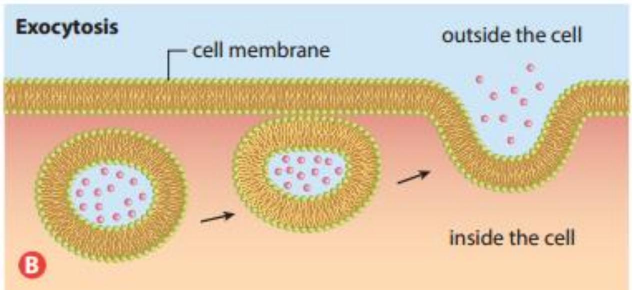
_____________________________________________ process by which the cell membrane engulfs material outside the cell to bring it inside the cell

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.




___________________________________ 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**

____________________________________________
cellular process that uses oxygen to release energy, as ATP, from glucose in the **mitochondria.**

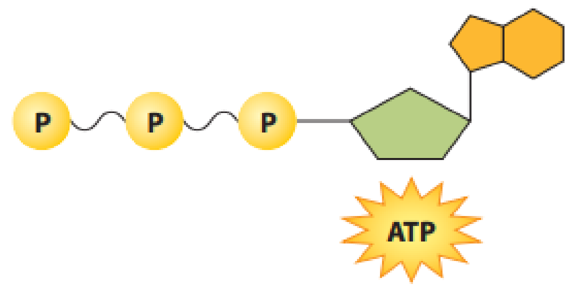


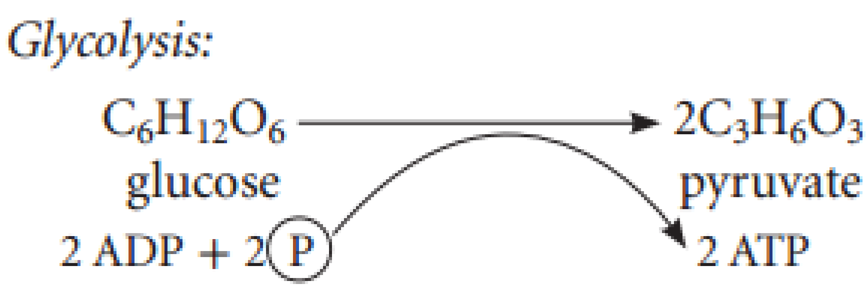
**Figure 4.33** ATP stores energy in its bonds to phosphate.

**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.

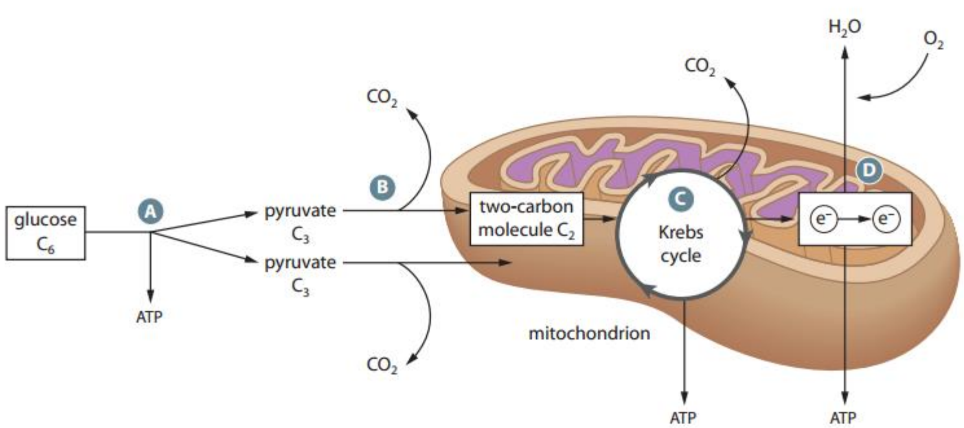
Stage 1: ___________________________________________

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: ________________________________________________________________________________

some of the energy that came from glucose is transferred to other energy-carrying molecules.



Stage 3: ___________________________________________________________________________

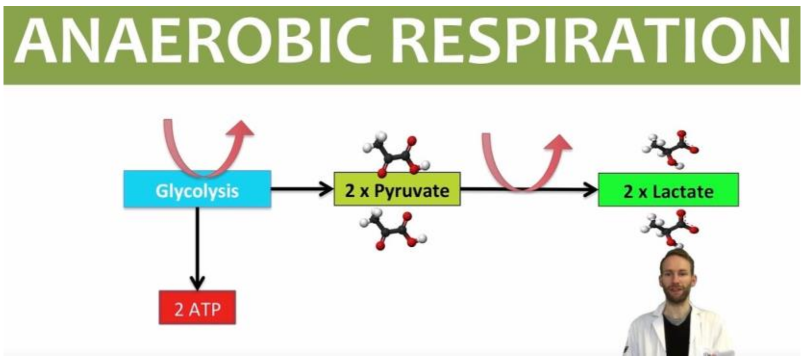
the energy-carrying molecules produced in the previous stages are used to make ATP in the membrane of the mitochondrion. This stage uses oxygen.

**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.

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

_______________________________________________ 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<br>**Yeast:** Ethanol + $CO_2$ | $CO_2$ and $H_2O$ |
| *Location* | Cytoplasm | Cytoplasm **and** mitochondrion |
| *Stages* | Glycolysis<br>Fermentation | Glycolysis<br>Link reaction<br>Krebs cycle<br>Oxidative phosphorylation |

**Activity 4.7 Seeing Green**

**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.

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

During the ________________________________________________________________, 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 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.

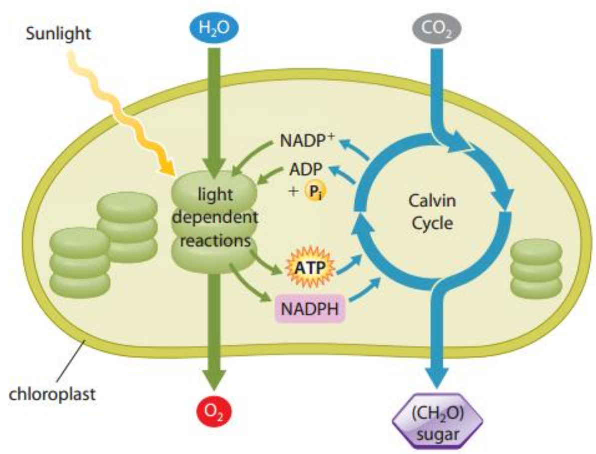



**Figure 4.36** Photosynthesis consists of two stages. The light dependent reactions harvest light energy. The Calvin cycle uses the products of the light dependent reactions to produce plant sugars.

- 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

**Complementary Processes**

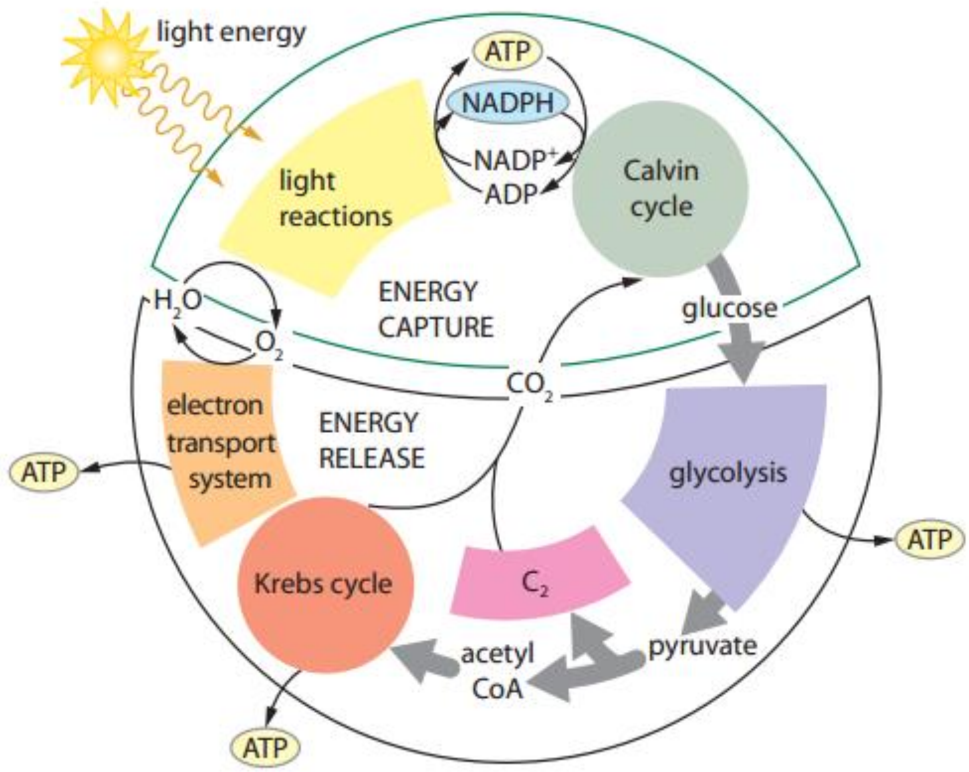



**Figure 4.37** Summary of aerobic respiration and photosynthesis