Biology: The Fundamentals
Student Review Guide

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Published by Enrichment Plus, LLC

Toll Free: 1-800-745-4706 • Fax 678-445-6702
Web site: www.enrichmentplus.com

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- **Light microscope** – a common type of microscope that focuses light rays through a specimen
- **Electron microscope** – a type of microscope that focuses beams of electrons instead of light rays
- **Resolution** – the ability of a microscope to see detail
- **Wet mount slide** – a temporary type of microscope slide created by using a drop of water

Types of Microscopes

Most people can't see details clearly on anything much smaller than 0.1 mm, so biologists may use a microscope to study smaller objects. The units of length usually used for microscopic measurements are the **micrometer, µm**, which is only one-thousandth (1/1,000) of a millimeter and the **nanometer, nm**, which is one-millionth (1/1,000,000) of a millimeter.

There are several types of microscopes, and two of the most common types are the light microscope and the electron microscope. Both produce magnified images, but they work in different ways. A **light microscope**, the most common type, focuses light rays that pass through the specimen to produce a magnified image. A light microscope can be used to view cells and some cell organelles. **Electron microscopes** focus beams of electrons instead of light rays. Electron microscopes have much better **resolution —** that is, they magnify objects more and get clearer details at higher magnification than light microscopes. They can be used to view objects as small as a strand of DNA, which cannot be viewed by a light microscope. Electron microscopes can't be used to view living objects though, so both types are important to biologists.

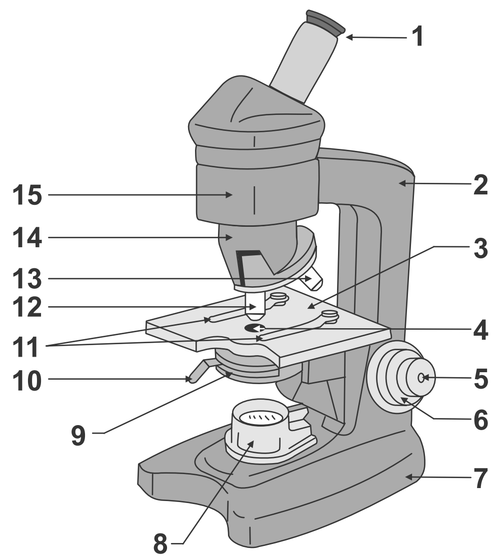
Light Microscope Versus Electron Microscope

Light Microscope	Electron Microscope
• can be used to view living objects	• objects cannot be alive
• natural color and movement can be observed	• black and white images with no movement
• poor resolution — 200 nm	• excellent resolution — 0.2 nm
• easy to use	• viewer must be highly trained
• fairly inexpensive	• very expensive

Parts of The Microscope

In order to use a light microscope, you need to study the diagram below so that you know what each part is and what each part of the microscope does.

1. **ocular or eyepiece –** contains a lens that magnifies
2. **arm –** provides support for the body tube
3. **stage –** the platform where a slide is placed to be viewed
4. **stage opening –** allows light to pass through the slide
5. **fine adjustment knob –** used to bring the specimen into sharp focus
6. **coarse adjustment knob –** used to focus the microscope
7. **base –** supports the entire microscope
8. **light or mirror –** produces or reflects light up through the specimen on the slide to the eye
9. **diaphragm –** regulates the amount of light
10. **diaphragm lever –** opens or closes diaphragm
11. **stage clips –** holds slide in place
12. **high-power objective –** provides the smallest field of view and the highest magnification
13. **low-power objective –** provides the largest field of view and the lowest magnification
14. **nosepiece –** holds the objectives and rotates to change magnification
15. **body tube –** allows light to pass up to the eye and provides the proper distance between the eyepiece lens and the objective lens.



Light Microscope Diagram

Magnification

A light microscope has several lenses that magnify what you are viewing, which is why it is sometimes called a ***compound microscope***. To find out how much magnification is being used, you first look at the eyepiece (ocular). It should be marked with a number such as 10×. This number means that the lens in the eyepiece magnifies 10 times. Now look at the low-power objective. It is also marked with a number that tells its magnification. To find the total magnification being used, you multiply the two numbers.

Note: ***The higher the magnification, the smaller the field of view.***

Example: The eyepiece of a light microscope is marked 10×, and the low-power objective is marked 4×. What is the total magnification?

$$10 \times 4 = 40$$

Multiply the ocular magnification by the objective magnification. For this example, the total magnification is 40 times.

Steps to Using A Light Microscope

To use the microscope you should follow these steps:

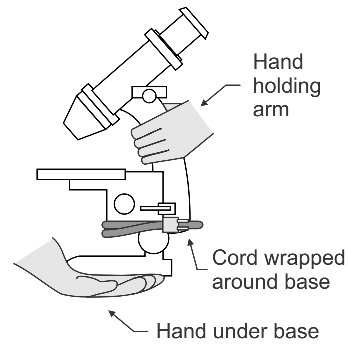


Fig. 1-19
Holding a Light Microscope

1. Figure 1-19 shows the correct way to carry a microscope. Carry the microscope with one hand under the **base** and your other hand holding the **arm**. If the microscope has a cord, make sure the cord is wrapped securely around the base and is not dangling. Place the microscope on the table with the arm towards you and the back of the base about an inch from the table's edge.

2. Wipe the **eyepiece lens (ocular)** and the lens of each **objective** with a piece of lens paper. Turn the low-power objective in line with the **body tube**. It should click into position. If the microscope is electric, plug the power cord into an electrical outlet.

3. Turn on the **light** or adjust the **mirror**, and turn the **diaphragm** so that the greatest amount of light is admitted. Place your eye to the eyepiece. You should see a uniform circle of light called the ***field of view***.

4. Place a prepared slide on the **stage** of the microscope and clip it into place. Adjust the slide with your fingers until the object is in the center of the stage opening and hold it in place with the **stage clips.**

5. While watching from the side of the microscope, turn the low power objective down as far as it will go. Do not touch the slide with the objective lens or force it when it reaches the automatic stop.

6. Place your eye to the eyepiece and, as you watch the field, turn the **coarse adjustment knob** slowly toward you. Watch for the material on the slide to appear in the field. Always use the coarse adjustment to bring the slide into focus.

7. Bring the specimen into sharp focus with the **fine adjustment knob**. As you look through the eyepiece, turn the fine adjustment knob slowly back and forth. Different fine adjustments will shift the focus to bring out details at different levels of an object.

8. Make sure that the specimen is in the exact center of the field, check for sharp focus, and turn the high-power objective into position.

9. ***Correct the high-power focus by using the fine adjustment only.*** You will notice that you can see more of the slide using the low-power objective but you don't see as much detail. When using the high-power objective, you see more detail, but the field of view is smaller.

10. After you have observed your specimen, remove the slide and turn the low-power objective back into place. Clean the lenses and stage with lens paper. Don't forget to turn off the light and unplug the microscope if needed.

11. The microscope should be covered to protect it from dust and then stored in an upright position according to your teacher's instructions.

Preparing Slides

After you know how to set up and focus a microscope using a prepared slide, you will want to make your own slides to view. A common method of making a temporary slide is called a *wet mount slide*. To make a wet mount slide, follow the steps below:

1. Get a slide and coverslip; make sure that they are clean.
2. Place your specimen in the center of the slide. Remember that it should be thin enough to allow light to pass through it.
3. Place a drop of water on the specimen.
4. Hold the coverslip at a 45° angle to the slide as shown in figure 1-20. Carefully lower the edge of the coverslip until it touches the drop of water. Then, slowly lower the coverslip so that the water drop spreads out evenly.
5. Using the method in step 4 should minimize air bubbles trapped under the coverslip. If an air bubble does get trapped, gently tap the coverslip with a pencil eraser to remove the bubble.
6. If your drop of water was large and there is excess water under the coverslip, you can remove the extra water by holding a paper towel to the edge of the coverslip. The coverslip will hold the specimen in place. Your specimen is now ready to view!

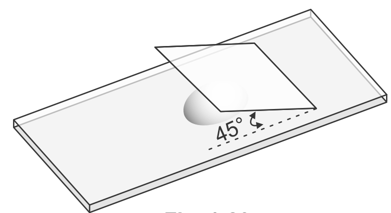
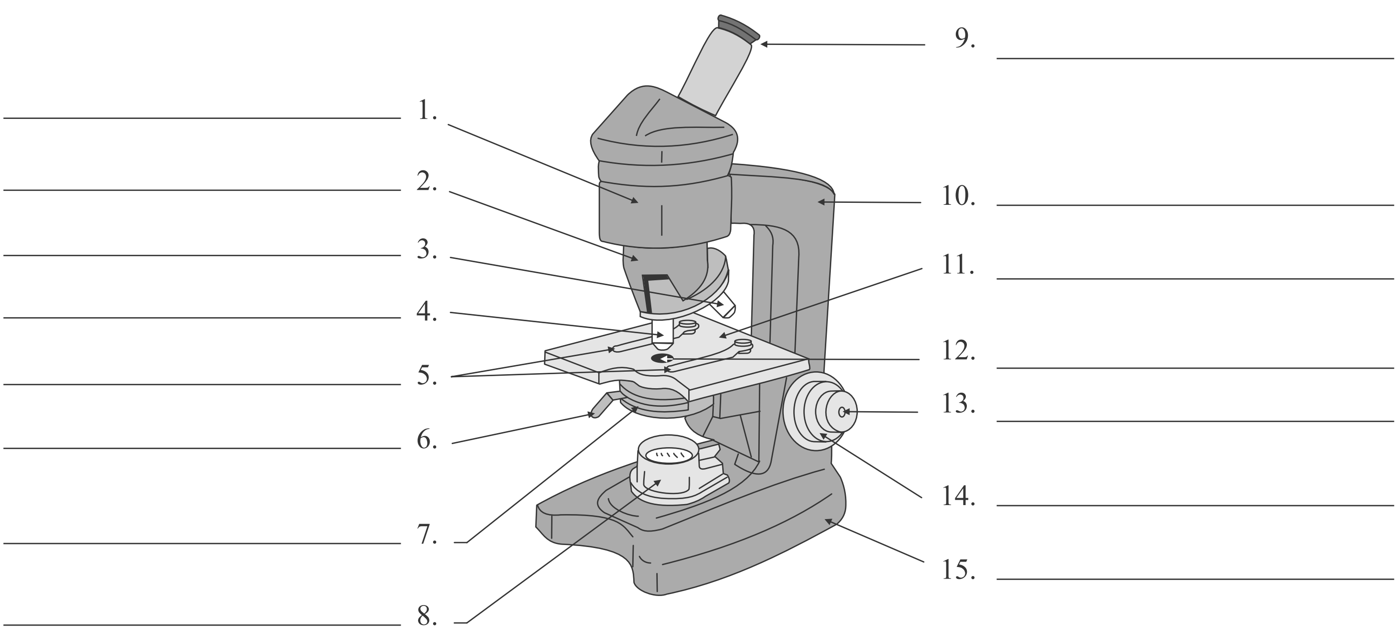


Fig. 1-20
Preparing a Wet Mount Slide

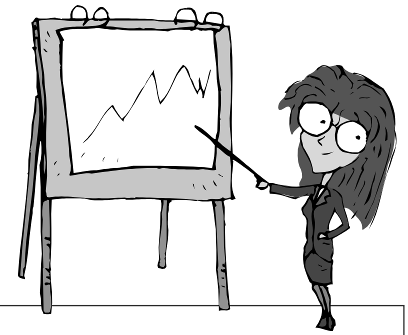
Practice 1

Label the parts of the microscope.



Analyzing Scientific Experiments

Section 3.1
Using Line Graphs to Organize and Interpret Data



Pre-View 3.1

- **Line graph** – a visual representation of data showing how something has changed over a period of time

After data has been gathered, you must interpret the information and present it in such as way that it makes sense to others. One way you saw in Section 2.3 was to summarize the information in a table. Another way to represent data is to use one or more graphs or diagrams. Graphs and diagrams present information in a way that makes data easier to interpret visually. There are different types of graphs and diagrams that can be used to display data, and each type has a specific use. Remember, you always want to choose the best way to display your data that makes it easiest to interpret.

All graphs or diagrams have several important features in common. They should always have a *title* that describes the data being presented. They should also have *labels* that identify the different parts of the graph or diagram, and they may have a *legend* (sometimes called a *key*) to identify different types of data.

Line Graphs

Line graphs are frequently used to show how something changes over time. Line graphs have an x-axis and a y-axis. The horizontal, or x-axis, is used to show the time frame or some other independent variable. The vertical, or y-axis, is used to show the dependent variable. Line graphs have several features described below:

Title: The title of a graph should give an explanation of the data given by the graph.

Axes: The x-axis is a horizontal line that is usually labeled in some unit of time. The y-axis is a vertical line, normally on the left, that is labeled with the dependent variable.

Labels: The x and y axes should be labeled to show what kind of data is being given. The units for the data should also be given.

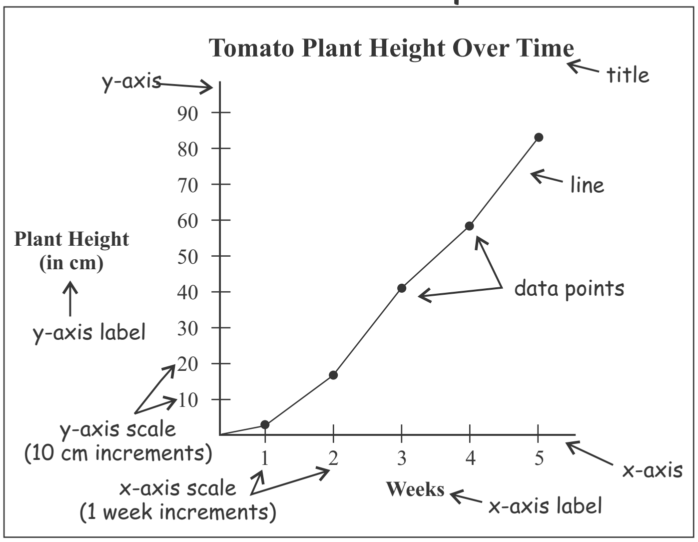
Scale: The scale is shown by the numbers that are labeled on the x and y axes. The scale is the increment of the data given on the x and y axes.

Data points and Line(s): Data points are normally marked on a line graph to show where the experimental data falls on the graph. Data points are plotted from experimental data. For example, one data point may represent the plant height on a particular day. A line graph also has one or more lines that connect the data points. Sometimes the line connects from point to point. Other times, it is more appropriate to draw a straight or smoothly curved trend line that goes through the data points but does not connect each point.

Legend (or **Key**): If several lines are shown on the same graph, the data points may be shown using different types of symbols. The legend (sometimes called a key) will explain how the symbols correspond to the data.

Using Line Graphs to Organize and Interpret Data

Well-Constructed Graph



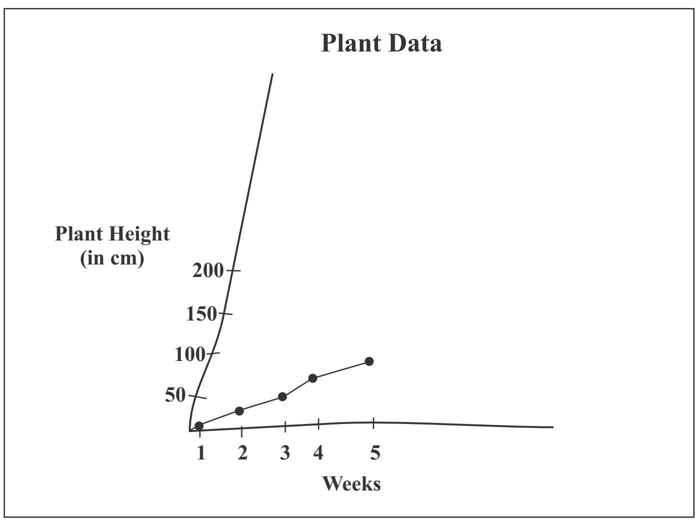
The graph on the left is a good example of how a line graph should be drawn.

Title: The title of a graph should give a general explanation of the data shown by the graph. In this example, the title is "Tomato Plant Height Over Time."

Axes and Labels: The x and y axes should be labeled to show what kind of data is being given. In this case, the x-axis represents "weeks" and the y-axis represents "plant height in centimeters."

Scale: The scale is shown by the numbers that are labeled on the x and y axes. In this example, the x-axis has a scale of one week per increment. The y-axis has a scale that is marked in 10-centimeter increments.

Poorly-Constructed Graph



Do you recognize all the reasons this graph is poorly constructed?

Title: Although this graph does have a title, it is not very descriptive of the data represented. For example, it doesn't tell what kind of plant.

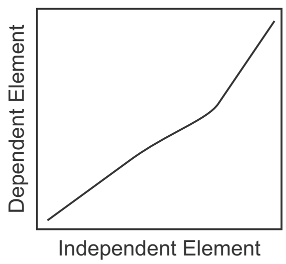
Axes and Labels: The x-axis and the y-axis are correctly labeled, but they are crooked. Be sure that you use a straight edge when drawing graphs by hand, and you will probably want to use graph paper as well.

Scale: When constructing a graph, choose a scale so that your data fills the space. In this example, the poorly chosen scale causes the data to fill only a small corner of the graph. Also, increments should be equally spaced. Notice that the spacing between the weeks is not equal.

When constructing line graphs, remember the following: Use a descriptive title that explains the data. Label the x and y axes and give the units. In the examples above, labeling the y-axis as "Plant Height" is useless unless you also give the units. Likewise, labeling the x-axis as "Time" would not be an appropriate label. No one would know what the 1, 2, 3, 4, or 5 represented — days, weeks, months, etc. Use an appropriate scale so that your data is spread out over the length and width of the graph. And of course, be very neat by drawing straight lines to represent your axes.

Trends

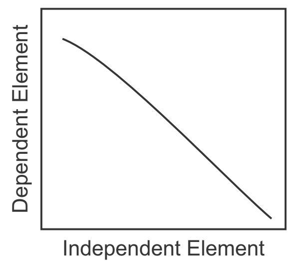
One of the most important features of line graphs is to be able to see *trends.* You can often take a trend and match it to the graph that represents the data. Take a look at five types of trends: an upward trend, a downward trend, a peaking trend, an unstable trend with ups and downs, and an unchanging data trend. The general type of line for each trend is given below. Make sure you read each example, which shows the type of data that would give that type of trend.



Upward Trend

The dependent element increases as the independent element increases.

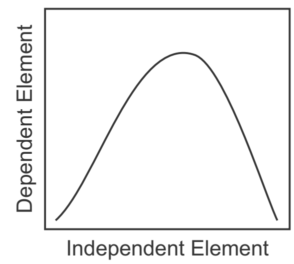
Example: A simple example of an upward trend would be the height of plants over time. As the time increases, the height of the plants also increase. This type of data would fit the pattern of an upward trend graph.



Downward Trend

The dependent element decreases as the independent element increases.

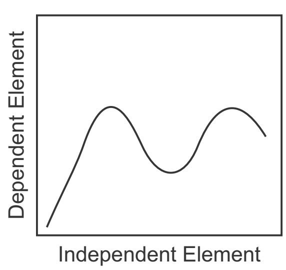
Example: A downward trend in data would be like the decrease in a bacteria population as an antibiotic increases. The line would go down as the bacteria population decreases over time.



Peaking Trend

The dependent element increases to a point and then begins to decrease as the independent element increases.

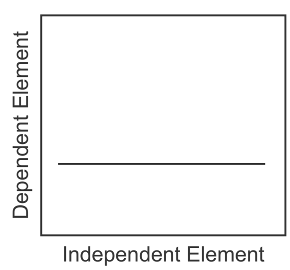
Example: A peaking trend would fit data like pain medication effectiveness. The effectiveness increases for awhile and then begins to decrease as the time increases.



Unstable Trend

The dependent element increases and decreases several times as the independent element increases.

Example: An unstable trend might be seen in a deer population during a year. The population may go up and down each season based on the births of offspring, the abundance of food, populations of predators that eat deer, and deer season for hunters.



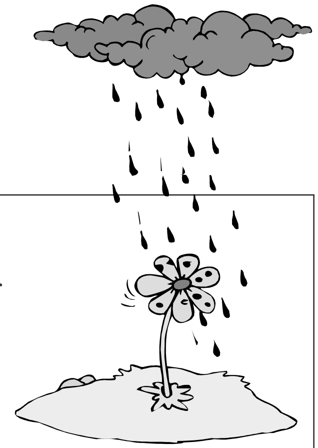
Unchanging Data Trend

The dependent element does not change (stays constant) as the independent element increases.

Example: An unchanging data trend would be seen in the height of most adults over time. As years go by, height stays the same.

Biochemical Concepts

Section 4.7
Ions and pH



Pre-View 4.7

- **Ion** – an atom or molecule that has gained or lost electrons so that it has a positive or negative charge
- **Biological process** – any process that occurs in a living organism, such as muscle movement in animals or photosynthesis in plants
- **pH** – a measure of the acidity or alkalinity of a substance
- **Acid** – a solution with more hydrogen ions than hydroxide ions; having a pH less than 7
- **Base** – a solution with more hydroxide ions than hydrogen ions; having a pH greater than 7
- **Buffer** – a substance that prevents the pH of a solution from changing even if a small amount of an acid or a base is added

Ions

Ionic bonds are bonds between atoms that have gained or lost electrons. Table salt, NaCl, has an ionic bond between one atom of sodium, Na, and one atom of chlorine, Cl. What happens when you stir salt into water? The salt disappears, or dissolves.

Ionic compounds, like NaCl, dissolve into water because the water breaks apart the ionic bond so that the compound is separated into its ions. Remember, **ions** are atoms or molecules that have an electrical charge because they have either gained or lost electrons. Salt that is dissolved into water separates into sodium ions, Na^+, and chloride ions, Cl^-.

How does water have this ability to break ionic bonds? See figure 4-12 below. Remember that water is a polar molecule with a partial positive side and a partial negative side. The positively charged hydrogens in the water molecule attract the negatively charged chloride ion. The negatively charged oxygen in the water molecule attracts the positive sodium ion. These attractions are strong enough to break the ionic bond and to separate a particle of salt into its ions.

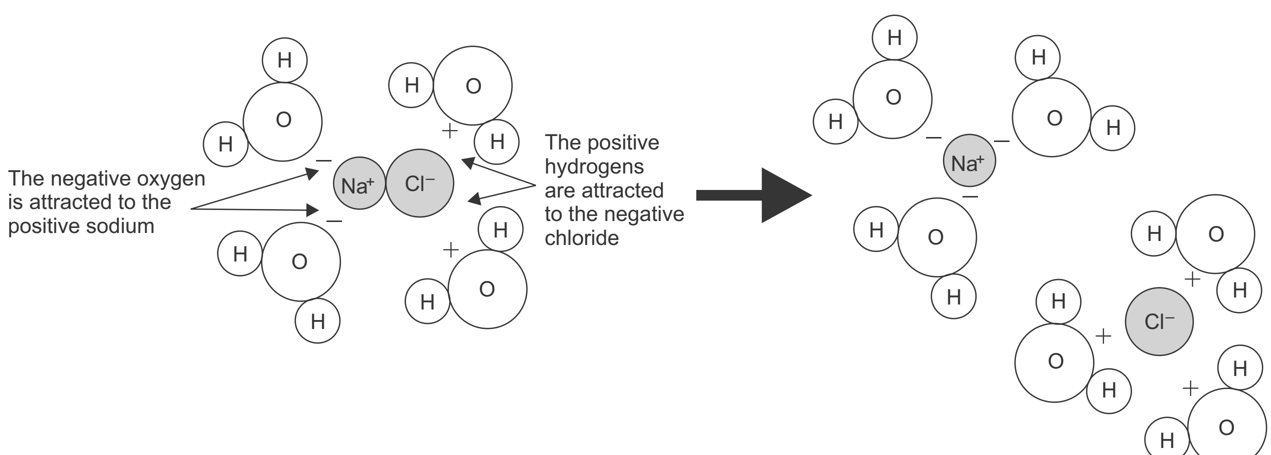


Fig. 4-12
Water molecules surround a particle of salt and pull apart the ionic bond

Ions in Living Organisms

Ions are very important in **biological processes**, which are the processes that occurs in a living organism. Since living organisms are made up of a large percentage of water, the water carries important ions to all the tissues of the organism. You will see how ions play a role in biological processes throughout this book, but for now, here's a quick summary that shows some of the ways ions are important in living organisms.

Importance of Ions in Biological Processes

Within Cells:

- In cells, sodium, potassium, calcium and other ions play an important role in the cells of living organisms, particularly in the role of cell membranes.
- Ions are charged particles, but overall, a cell must be electrically neutral. The charge of positive ions must be equal to the charge of negative ions within each cell. To maintain neutrality, a cell often uses potassium (K^+) if positive ions are needed or hydrogen phosphate (HPO_4^{2-}) if negative ions are needed.
- Ions are vital for electron transfer, a process in which electrons are moved from one place to another and a process that is essential for many types of chemical reactions that occur inside cells. Enzymes that play a role in some of these reactions often contain ions as well.

Within the Body:

- The fluid outside of cells carries all kinds of ions, but overall, this fluid must also be electrically neutral (have an overall charge of zero). The body often uses sodium (Na^+) and chloride (Cl^-) to keep fluids electrically neutral.
- The calcium ion (Ca^{2+}) is a major component of bones and teeth. It has other important functions as well, such as helping blood to clot, allowing muscles to move, and controlling heartbeat.
- Magnesium (Mg^{2+}) is another important ion. Magnesium is involved in the action of nerves and muscles and is necessary for the activity of certain enzymes. It is also present in bones and teeth along with Ca^{2+}.
- The wrong amount of ions can cause diseases. Anemia can result from not enough iron, Fe^{2+}. Too much table salt (NaCl) can cause water retention (edema) and high blood pressure in some people.

pH

Water not only dissolves and transports ions from ionic compounds, but it also can form ions from its own components. A molecule of water has a neutral charge, but the molecule can split into a positively charged hydrogen ion (H^+) and a negatively charged hydroxide (OH^-) ion.

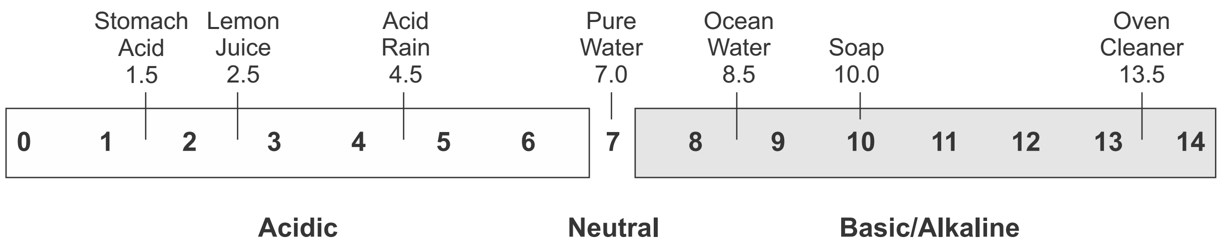
The pH scale is a measure of the concentration of H^+ ions in a solution. The more H^+ ions a solution has, the lower the pH of that solution is. The pH scale is normally shown as going from 0 to 14, with 7 being neutral. Pure water has a pH of 7; it is neutral. Any solution with a pH lower than 7 is **acidic** and has a higher concentration of H^+ ions than OH^- ions. Any solution with a pH higher than 7 is **alkaline** or **basic** and has fewer H^+ ions than OH^- ions. Your body is made for each system to work best within certain pH ranges.

Section 4.7, continued
Ions and pH

Acids are compounds that form H^+ ions in solution. These hydrogen ions attach to other water molecules to form hydronium ions, H_3O^+. Several examples of acids and their pHs are given in the diagram below.

Acid rain is a fairly weak acid with a pH of about 4.5, but it can cause environmental damage. What is acid rain and how is it produced? The burning of fossil fuels causes sulfur dioxide gas and nitrogen oxide gas to be released into the atmosphere. These gases react with water in the atmosphere to form sulfuric acid and nitric acid. The water that precipitates from the air in the form of rain, snow, fog, etc., is now acidic. Acid rain can leach minerals from the soil that are important for plant growth. Acid rain can also lower the pH of lakes and result in the death of aquatic animals.

Bases are compounds that produce OH^- ions in solution. Ocean water is a little basic with a pH of about 8.5. Soap has a pH of 10, and oven cleaner is very basic — its pH is 13.5. Your blood has a pH of 7.4 — slightly basic. When you exercise, your body produces more carbon dioxide (CO_2) than it normally does. When carbon dioxide dissolves, it forms carbonic acid, H_2CO_3, so a rise in CO_2 levels can cause the pH of the blood to drop. If it gets too low, a signal is sent to your brain that causes you to breathe deeper and faster to help get rid of the extra CO_2. Eventually the pH of your blood goes back to normal, and you start breathing normally again.



Just so that you know, most solutions will measure a pH between 0 and 14, but there are exceptions to nearly every rule! Very concentrated acids can measure a negative pH, and very concentrated bases can measure a pH above 14.

Strong Acids and Strong Bases

The terms "strong acid" and "strong base" do not necessarily correspond to the pH of a solution. It is the concentration of H^+ ions and OH^- ions that determines the pH.

The definition of a strong acid is one that completely ionizes in water. For example, hydrochloric acid, HCl, is a strong acid because when it dissolves in water, it forms H^+ ions and Cl^- ions. On the other hand, acetic acid, HC_2HO_2, is a weak acid because it only partially ionizes in water. It forms some H^+ ions and some $C_2HO_2^-$ ions, but some of it will remain as HC_2HO_2 in the solution without separating into ions. Will a strong acid have a lower pH that a weak acid? Only if the concentration of H^+ ions is greater in the strong acid.

A strong base also completely ionizes in water. Sodium hydroxide, NaOH is a strong base that forms Na^+ and OH^- ions when dissolved. Ammonium hydroxide, NH_4OH, is a weak base because some of it will break apart into NH_4^+ and OH^- ions, but the rest of it will remain together as NH_4OH.

Neutralizing Acids and Bases

When an acid comes into contact with a base, both substances are neutralized. The H^+ ions from the acid will combine with the OH^- ions in the base to form water molecules. Having an equal number of H^+ ions and OH^- ions results in a neutral pH of 7. What happens when vinegar with a pH of 2.4 is mixed with baking soda having a pH of 8.4? A chemical reaction occurs, and part of that reaction converts equal numbers of H^+ ions and OH^- ions into molecules of water. The bubbling from the reaction is carbon dioxide also being formed. If the number of H^+ ions and OH^- ions is unequal, the resulting solution will still be either acidic or basic depending on which unreacted ions are still in solution.

pH in Living Organisms

Living organisms rely on many complex chemical reactions to live. Each type of chemical reaction will occur only within a narrow range of pH. For example, the acid that your stomach produces has a pH of around 1.5. That sounds really strong, but your food would not digest properly if your stomach didn't produce that acid. Your stomach makes a special type of protein called an enzyme that helps break down food. Each type of enzyme needs a certain pH, or it will not work. If your stomach stopped producing acid, the enzymes could not do their job. Your food wouldn't be broken down, and you could not get all the nutrients from it.

Plants also have pH preferences, and most grow best in soils that are acidic. If soil pH is too high, nutrients in the soil are less available. Remember, plants get most of their required nutrients from the soil, and the nutrients must be dissolved in the water surrounding the soil before they can be transported into the plant usually through its roots. Gardeners will often adjust the pH of soil before planting. For example, if the pH of soil is too low, lime can be added to increase the pH. If the pH of soil is too high, peat moss or sulfur can be added to lower it.

In complex organisms like human beings, different pHs may be needed for different areas or organs of the body. To keep the pH of an area (or organ) fairly constant, living organisms use buffers. **Buffers** are compounds that prevent a change in pH even when a small amount of additional acid or base is added. For example, a bicarbonate buffer system is used in blood to keep the pH of blood from changing. If a living organism doesn't have the ability to keep pH fairly constant, it cannot survive.

Practice 1

Classify the following substances as either acidic or basic. In the blank, write A for acidic or B for basic.

________ 1. vinegar, pH of 2.0

________ 2. drain cleaner, pH of 14

________ 3. tomatoes, pH of 4.5

________ 4. baking soda, pH of 8.3

________ 5. milk of magnesia, pH of 10.5

________ 6. soda cracker, pH of 8.0

________ 7. sauerkraut, pH of 3.5

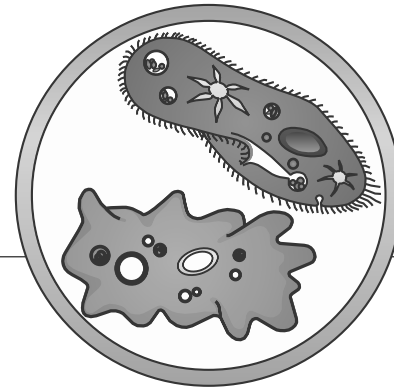
________ 8. tap water, pH of 5.8

________ 9. human spinal fluid, pH of 7.4

________ 10. apple juice, pH of 3.0

Cell Structure and Function

Section 6.1
Prokaryotic and Eukaryotic Cells



Pre-View 6.1

- **Cell** – the smallest unit of life
- **Cell membrane** – a barrier that separates a cell from its surroundings
- **DNA** – molecules in a cell that contain genetic information
- **Prokaryotic cells** – simple cells that do not have a nucleus; this type of cell is found in bacteria
- **Eukaryotic cells** – cells that have a true nucleus and make up all other organisms other than bacteria
- **Flagella** – long, hairlike filament that some single-celled organisms use to propel them forward
- **Cilia** – short, hairlike projections that some cells use for movement

You probably already know that all living things are made of cells. A **cell** is the smallest unit of life. It is the basic unit of structure of all living organisms. It is a collection of living and nonliving materials that is separated from its surroundings by a barrier called the **cell membrane**. Some organisms are made up of one single cell. Other organisms are made up of many cells that work together.

Biologists classify cells into two main groups — prokaryotic cells and eukaryotic cells. **Prokaryotic cells** are bacteria cells. All other cells are **eukaryotic cells**, so the cells that make up your body, or the cells in a rose bush, or even the cells in a ladybug are eukaryotic cells. Prokaryotic cells are much simpler than eukaryotic cells, as you'll see with the chart below and in figures 6-1 and 6-2.

Similarities and Differences in Prokaryotic and Eukaryotic Cells

	PROKARYOTIC CELLS	EUKARYOTIC CELLS
Average Cell Size	1-10µm	10-100µm
Have a Cell Wall?	YES	SOMETIMES
Have a Cell Membrane?	YES	YES
Have a Nucleus?	NO	YES
Have Cytoplasm?	YES	YES
Have DNA?	YES, in cytoplasm	YES, in nucleus
Have Ribosomes?	YES	YES
Have Membrane Enclosed Organelles?	NO	YES
Mode of Locomotion?	May have one or more flagella for locomotion	May have one or two flagella or cilia for locomotion
Found in —	bacteria only	fungi, protists, plants, animals

Although both types of cells have DNA, the DNA is found in different places. Remember that **DNA** contains the genetic material for an organism. In prokaryotic cells, the DNA is located in the cytoplasm of the cell. In eukaryotic cells, the DNA is found inside the cell's nucleus.

Both prokaryotic bacteria and single-celled eukaryotic organisms can have one or more **flagella** for locomotion. The flagellum is a long, hair-like filament that propels a cell forward.

Eukaryotic cells may also have **cilia**, which are shorter hair-like projections used like oars for movement. Multicellular organisms may have ciliated cells to produce movement, not necessarily for the cells themselves, but to produce the movement of debris. For example, cells in your nose are ciliated to move mucus and debris!

When you compare the two diagrams given in figures 6-1 and 6-2 below, you can tell how much more complex eukaryotic cells are than prokaryotic cells. The eukaryotic cell has more organelles (cell parts). Examples of cell organelles are ribosomes, mitochondria, endoplasmic reticulum, etc.

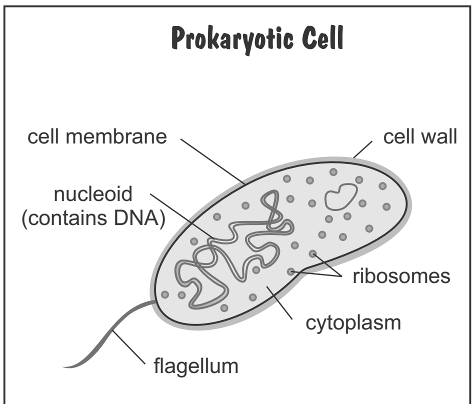


Fig. 6-1

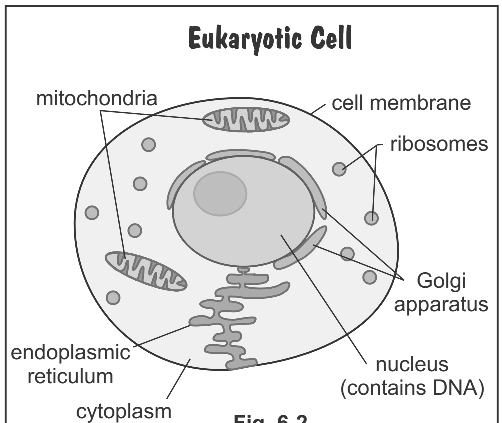


Fig. 6-2

Hint: To help you remember that eukaryotic cells are the cells that make up most organisms, including humans, think about how eukaryote is pronounced. It sounds like "you" and you are human!

Practice 1

Use figures 6-1 and 6-2 to answer the following questions.

__________________________ 1. Which cell contains DNA — prokaryotic, eukaryotic, or both?

__________________________ 2. Which cell contains mitochondria?

__________________________ 3. Do both types of cells have cell membranes, yes or no?

__________________________ 4. Which organelle labeled on the diagrams is present in the cytoplasm of both types of cells?

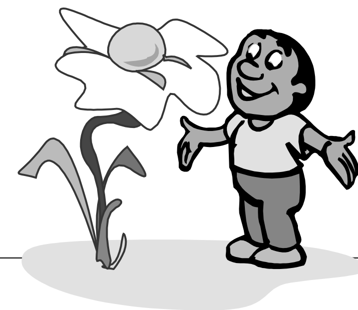
__________________________ 5. Which type of cell is more complex, prokaryotic or eukaryotic?

__________________________ 6. Do both types of cells have a nucleus, yes or no?

__________________________ 7. Which type of cell has DNA in its nucleus — prokaryotic, eukaryotic, or both?

__________________________ 8. Which type of cell would best represent a bacterium?

Cellular Energy
Section 8.4
Relationship Between Cellular Respiration and Photosynthesis



Pre-View 8.4

- **Cellular respiration** – process that converts glucose and oxygen into carbon dioxide and water and releases energy as ATP
- **Photosynthesis** – process that uses light energy to convert carbon dioxide and water into glucose and oxygen

Have you noticed that the same terms used to describe cellular respiration are also used to describe photosynthesis? What is their relationship? Look at the reaction summaries below in figure 8-11.

Cellular Respiration (Aerobic) vs. Photosynthesis

cellular respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (glucose + oxygen → carbon dioxide + water)

photosynthesis: $6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$ (carbon dioxide + water → glucose + oxygen)

Fig. 8-11

You should notice that the reactions are nearly opposites. The reactants of cellular respiration, glucose and oxygen, are the products of photosynthesis. The products of cellular respiration, carbon dioxide and water, are the reactants of photosynthesis!

The relationship between photosynthesis and cellular respiration can also be summarized in figure 8-12. Plants use carbon dioxide to produce oxygen by the process of photosynthesis. Humans and animals use oxygen and produce carbon dioxide by cellular respiration. The processes of photosynthesis and cellular respiration cycle carbon between the atmosphere and living organisms. Photosynthesis converts the inorganic carbon in carbon dioxide to organic carbon found in glucose. Cellular respiration converts the organic carbon in glucose to inorganic carbon in carbon dioxide. These two process are also part of the oxygen cycle. You'll see more about these cycles in Section 18.

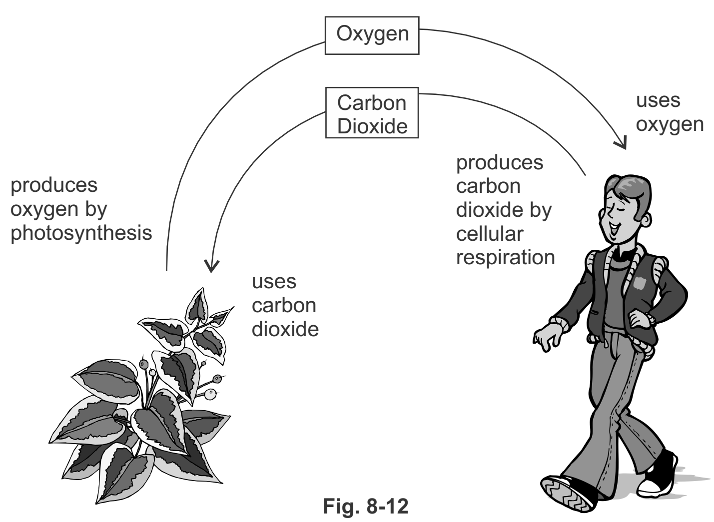
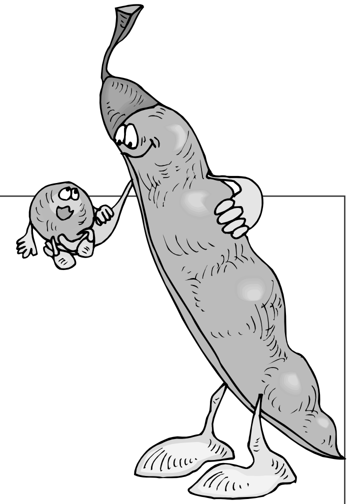


Fig. 8-12

Basic Genetics

Section 10.1
Introduction to Mendelian Genetics



Pre-View 10.1

- **Gregor Mendel** – an Austrian monk whose study of garden peas earned him the title Father of Genetics
- **Genetics** – the study of heredity
- **Heredity** – the passing of traits from one generation to the next
- **Gene** – a section of DNA that determines a specific trait, such as eye color
- **Alleles** – different forms of the same gene; for example, blue and brown are different alleles for eye color
- **Dominant** – a trait that is expressed over another trait
- **Recessive** – a trait that can be hidden by another trait
- **Genotype** – the combination of alleles for a particular trait (homozygous or heterozygous)
- **Homozygous (**or **pure)** – having two of the same alleles for a trait
- **Heterozygous (**or **hybrid)** – having two different alleles for a trait
- **Phenotype** – the physical characteristics of an organism that show how genes are expressed

In the 1800s, an Austrian monk named **Gregor Mendel** studied garden peas. He studied a LOT of garden peas — thousands of them. (Just think about it. He was living in a monastery with no TV, no radio, no telephone, no computer, no internet, no video games, and no friends to hang out with at the mall, so garden peas were pretty interesting!) He started writing his observations, and he noticed that, over time, certain patterns appeared in the plants. For many traits, the peas would have two contrasting forms. Flowers would be purple or white, plant height would be tall or short, the seeds would be wrinkled or smooth, etc. He also noticed that some of the plants were true-breeding for certain traits — that is, they always produced offspring that had traits identical to the parent plants. Then he began experimenting with the plants. Through his experiments, he was able to discover some of the basic concepts of genetics and heredity. Because of his work, Mendel is known as the Father of Genetics.

Genetics is the study of heredity, and **heredity** is the passing on of traits from one generation to the next. To study genetics, Mendel started with true-breeding parent plants. We'll label them *P* for parental. The parental plants had contrasting forms of a trait. For example, one parental plant would have white flowers, and the other parental plant would have purple flowers. When he crossed these plants, the offspring (we'll call them F1) were identical to each other and to one of the parent plants. In the case of one parent having white flowers and the other parent having purple flowers, the offspring all had purple flowers. From this, Mendel reached several conclusions, and these conclusions later became known as Mendel's Laws. It's pretty amazing that Mendel was able to come up with these laws a long time before people knew anything about DNA, genes, and chromosomes!

Genetics uses many specific terms, such as the vocabulary given in the Pre-View above. As you see each bolded word in the following text, be sure you understand what each term means. Once you understand the vocabulary, genetics is not difficult, and you may find it quite interesting.

Genes and Alleles

Do you remember reviewing the process of meiosis in Section 9.2? The process of meiosis forms gametes (sperm and egg). Remember that gametes have half the number of chromosomes as the rest of the body's cells. When an egg is fertilized by a sperm, the resulting offspring gets half of its genetic information from its mother and half from its father.

Each chromosome is made up of one long strand of DNA, and sections of the DNA contain the **genes** that determine specific traits. You get one set of genes from your mother and one set of genes from your father. Let's say your mother has blue eyes, but your father has brown eyes. Your mother may give you a gene for blue eyes, and your father may give you a gene for brown eyes. You get two different forms of the same gene. These different forms are called **alleles**.

Mendel's Law of Dominance

Mendel concluded that biological inheritance is determined by what he called "factors" from the parents. We now refer to Mendel's factors as *genes*. Mendel noticed that one trait appeared more often than the other trait, and the gene for that trait was **dominant** over the other gene. The gene that was not dominant was called **recessive**. The dominant gene hid the recessive gene. Mendel's observation became known as the **Law of Dominance.** In the case of eye color, the gene for brown eyes is dominant over the gene for blue eyes. For an individual who has one allele for blue eyes and one allele for brown eyes, he will have brown eyes.

Mendel found that when he crossed pure purple-flowered plants with pure white-flowered plants, all of the offspring would have purple flowers. When he crossed pure tall plants with pure short plants, all of the offspring were tall. Pure yellow-seeded plants and pure green-seeded plants produced yellow-seeded offspring. The traits for purple flowers, tall plants, and yellow seeds in pea plants are all dominant. If an organism has one dominant allele, the dominant trait will always show. A recessive trait shows only when no dominant allele is present.

We use capital letters for dominant alleles and lowercase letters for recessive alleles. Since they are forms of the same gene, the same letter is used. For example, *W* represents the allele for purple flowers, and *w* represents the allele for white flowers. Different letters are normally used for different traits.

Genotype and Phenotype

The **genotype** of an organism is the combination of alleles it has for a particular trait. A pair of letters (examples: **Bb, dd,** or **EE**) is used for each trait in a genotype because one gene — one letter — comes from momma organism, and one comes from daddy organism, so each baby organism has two genes (two letters) for each trait. For most traits there are three possible genotypes: BB, Bb, or bb.

- If there are <u>two capital</u> letters or <u>two lowercase</u> letters in the genotype (like BB or bb), then the trait is called **homozygous** or **pure**. The alleles for the trait are the same.
- If there is one capital letter and one lowercase letter (like Bb), then the genotype is called **heterozygous** or sometimes **hybrid**. The alleles for the trait are different.

The **phenotype** is the physical characteristics of an organism — what it looks like. The phenotype is the expression of the genes for a particular trait. For example, different phenotypes may be black hair or blonde hair, freckles or no freckles, white flowers or purple flowers, right handed or left handed, etc.

Example: In guinea pigs, brown fur is dominant, and white fur is recessive. The allele for brown fur is shown by B, and the allele for white fur is shown as b. What are the possible genotypes of guinea pigs regarding fur color? What are the hair color phenotypes for guinea pigs?

GENOTYPE	DEFINITION	PHENOTYPE
BB	homozygous dominant (or pure dominant)	brown fur
Bb	heterozygous (or hybrid)	brown fur
bb	homozygous recessive (or pure recessive)	white fur

From the chart, you can see that there are three different combinations of genotypes. A guinea pig can be homozygous dominant, BB; homozygous recessive, bb; or heterozygous, Bb.

You can also see that there are only two phenotypes, either brown fur or white fur. Two of the genotypes, BB and Bb, give the same phenotype, brown fur.

Practice 1

Match the following genetic terms to their definitions.

________ 1. gene		A. different forms of the same gene
________ 2. chromosomes		B. strands of DNA and protein
________ 3. alleles		C. having the same alleles for a trait
________ 4. genotype		D. piece of DNA that tells about a specific trait
________ 5. phenotype		E. the allele form that always expresses itself over another form
________ 6. homozygous		F. physical characteristics of an organism
________ 7. dominant		G. having different alleles for a trait
________ 8. heterozygous		H. the specific genes an organism has

Molecular Genetics and Technology

Section 12.3
Transcription and Translation

Pre-View 12.3

- **RNA** – a single strand of nucleotides; different types are used to translate instructions from DNA into making proteins
- **Transcription** – the process occurring in the nucleus of a cell that copies the instructions from a part of DNA onto a strand of messenger RNA
- **Messenger RNA** – a type of RNA that transfers the code from DNA in the nucleus to the cytoplasm
- **Codon** – a sequence of three nucleotide bases that represents the code for one amino acid
- **Translation** – the process occurring in the cytoplasm of a cell that builds proteins
- **Ribosomal RNA** – a type of RNA that "reads" the codons from messenger RNA
- **Transfer RNA** – a type of RNA that carries an amino acid and transfers it to the protein chain being assembled in the ribosome
- **Stop codon** – a sequence of three nucleotide bases that indicates the end of protein synthesis

How do the genes on a chromosome determine how proteins are made? The sequence of nucleotide bases on a strand of DNA is like a language. The only letters in the language are A, T, C, and G, which stand for the four nucleotide bases. Words in this language are made up of three letters. There are 64 possible "words" that can be made from the four letters. Genes are like sentences made up of these three letter words. Each three letter word represents an amino acid. There are 20 amino acids. Some of the 64 "words" represent the same amino acid, and other "words" are like a period at the end of the sentence and indicate a "stop." Amino acids bond together to form polypeptides, and polypeptides bond together to form proteins. Each "word" represents an amino acid, and the sequence of amino acids in the "sentence" determines the type of protein that is made. To help you visualize this relationship, study figure 12-4.

The DNA Sequence of a Gene is the "Code" for a Protein

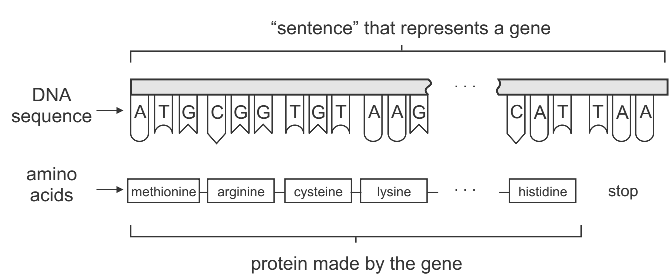


Fig. 12-4

Figure 12-4 shows a few of the steps in the process of making proteins, but some of the steps are not shown. These steps are called transcription and translation. Let's look at those in more detail.

Transcription

RNA is different from DNA in that it contains the sugar ribose instead of deoxyribose. It pairs A with U instead of T, and it is a single strand, not a double strand. There are different types of RNA: messenger RNA, transfer RNA, and ribosomal RNA. The DNA, which is inside the nucleus, has the information to make the proteins, but the proteins are actually made outside of the nucleus on the ribosomes. Something has to happen to send the information from the DNA to the ribosomes. That "something" is **transcription**, a process that copies the instructions in the DNA onto a strand of **messenger RNA (mRNA)**.

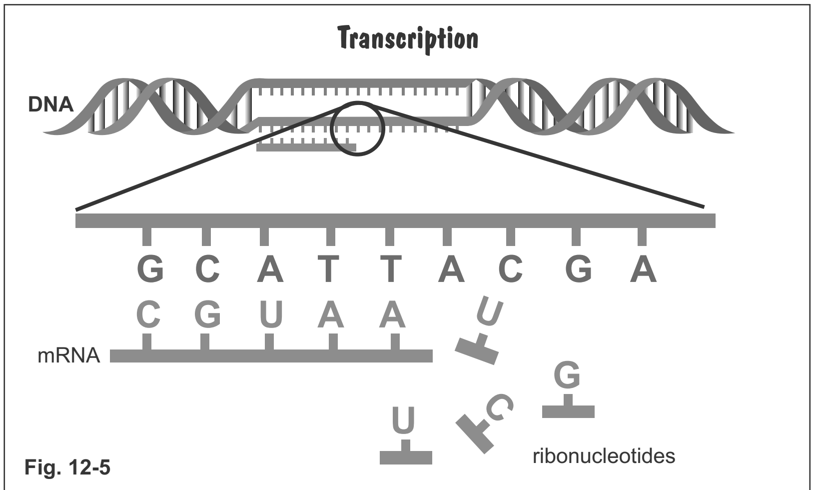
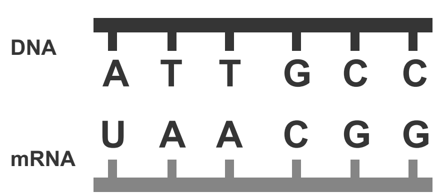


Fig. 12-5

Transcription begins when DNA unzips as it did in replication. This time free RNA nucleotides pair with the nitrogen bases on one strand of the unzipped DNA. Since RNA contains uracil (U) instead of thymine (T), adenine (A) pairs with uracil (U), and cytosine (C) still pairs with guanine (G). If the DNA strand has the nucleotide sequence of G-C-A-T-T-A-C-G-A, the bases on the RNA would be C-G-U-A-A-U-G-C-U. When the base pairing is finished, the mRNA breaks away from the DNA strand, and the two DNA strands zip back together. The mRNA goes out of the nucleus and into the cytoplasm of the cell.

The nitrogen bases in the mRNA also form groups of three bases called **codons**. Each codon is the "code" for an amino acid. (A codon is the three letter "word" that we talked about earlier.) Combinations of the twenty different amino acids then make up proteins in all organisms. Since the nucleotide sequence can create an almost endless number of different proteins and results in all the different kinds of living organisms, it is called the *universal genetic code*.

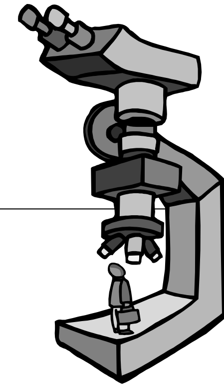
Example 1: During transcription, a section of the DNA has a nucleotide sequence of A-T-T-G-C-C. What would be the sequence of nucleotides that forms the mRNA complement for this section of DNA?



Instead of asking for the nucleotides that form the other "side" of the DNA, this question is asking for the RNA nucleotides that would match up with this sequence. Remember for RNA, U instead of T bonds to A, and G and C still bond together. The RNA complement would be U-A-A-C-G-G.

Kingdom Classifications

Section 15.1
The Six Kingdom System



Pre-View 15.1

- **Six Kingdom System** – classification system that includes Animalia, Plantae, Fungi, Protista, Eubacteria, and Archaebacteria
- **Archaebacteria** – newest kingdom that includes organisms that look like bacteria but have different characteristics than "normal" bacteria
- **Eubacteria** – typical bacteria that were classified as Monera in the five kingdom system
- **Prokaryotic** – describes single-celled organisms that do not have a true nucleus
- **Eukaryotic** – describes cells that have a nucleus and other membrane-bound organelles
- **Autotrophic** – describes organisms that make their own food
- **Heterotrophic** – describes organisms that cannot make their own food

The History of Kingdom Systems

When Aristotle first began to classify organisms, he divided them into two main kingdoms, plants and animals. You are probably most familiar with these two kingdoms. As scientists began using microscopes, they discovered microscopic organisms. They also discovered differences in cell structure between different organisms. They discovered that some organisms have characteristics that make it difficult to classify them as either plant or animal. Two kingdoms no longer worked, and eventually they decided on a **five kingdom system**: Animalia, Plantae, Fungi, Protista, and Monera.

The Six Kingdom System

These five kingdoms were used for a while, and many people still think in terms of these five kingdoms. However, more recently, something else interesting happened. With the new technology that became available, scientists discovered that some bacteria have different gene sequences than any other organism living on earth. This discovery led to the formation of a new kingdom called the **archaebacteria**, or "ancient bacteria." In addition to having different gene sequences, these bacteria also have chemical specializations in their cell walls, and they live in the most extreme conditions. All other bacteria were placed in the kingdom **Eubacteria**. Today most scientists use a **six kingdom system** for classification: Animalia, Plantae, Fungi, Protista, Eubacteria, and Archaebacteria. (Not to confuse the point, but some scientists classify the six kingdoms into three main "domains," with a domain being a taxon above kingdom. As we continue to learn more and more, these classification systems may change again!)

The Six Kingdoms

- **Archaebacteria** (newest kingdom) – organisms that resemble bacteria but live in extreme conditions
- **Eubacteria** (known as the **Monera** kingdom in the five kingdom system) – typical bacteria
- **Protista** – examples are algae, protozoa, slime molds
- **Fungi** – examples are molds, mushrooms, yeasts
- **Plantae** – examples are mosses, ferns, grasses, vegetable plants, trees
- **Animalia** – examples are sponges, jellyfish, worms, snails, insects, fish, frogs, lizards, birds, kangaroos

Section 15.1, continued
The Six Kingdom System

Remember that a kingdom is the largest classification group. Organisms in each kingdom share many cellular characteristics. For example, are the organisms unicellular or multicellular? Are the organisms' cells **prokaryotic** (no membrane bound organelles) or **eukaryotic** (have membrane-bound organelles)? Do the cells have a cell wall? If so, what is it made of? Does the organism make its own food (**autotrophic**), or must it obtain food (**heterotrophic**)? Note that organisms that make their own food usually have chloroplasts in their cells, which enable them to carry out photosynthesis. Only a few types of organisms can make their own food without chloroplasts, and those are the ones that undergo chemosynthesis instead of photosynthesis. The chart below shows these main cellular characteristics for organisms in the six kingdoms.

Kingdom	Type of cells	Nucleus?	Cell Wall?	Makes Its Own Food?	Main Types of Reproduction
Archaebacteria (or Archae)	Unicellular	No	Yes, but not made of peptidoglycan	Some do, mostly by chemosynthesis	binary fission, conjugation
Eubacteria (Monera)	Unicellular	No	Most do, usually made of peptidoglycan	Some do, mostly by photosynthesis	binary fission, conjugation
Protista	Unicellular or Multicellular	Yes	Some do, mostly made of cellulose	Some do by photosynthesis	binary fission, conjugation, mitosis, meiosis
Fungi	Unicellular or Multicellular	Yes	Yes, made of chitin and cellulose	No	fission, fragmentation, budding, spores (sexual and asexual)
Plantae	Multicellular	Yes	Yes, made of cellulose	Yes, by photosynthesis	vegetative propagation, sexual spores, pollination
Animalia	Multicellular	Yes	No	No	internal or external fertilization

Practice 1

For each organism described, choose the MOST likely kingdom that the organism belongs to. Each kingdom will be used only once.

________ 1. a prokaryotic, unicellular organism that may contain chloroplasts

________ 2. a eukaryotic, unicellular organism that may contain chloroplasts

________ 3. a multicellular organism whose cells do not have a cell wall

________ 4. a multicellular organism that has a cell wall but does not make its own food

________ 5. a multicellular organism the makes its own food using photosynthesis

________ 6. a unicellular organism that lives in complete darkness deep on the ocean floor near a volcanic vent

A. Archaebacteria
B. Eubacteria
C. Protista
D. Fungi
E. Plantae
F. Animalia

Environmental Interdependence

Section 19.4
Food Chains, Food Webs, and Energy Pyramids

Pre-View 19.4

- **Food chain** – a simple representation of how energy is passed from a producer to consumers
- **Food web** – a more complex representation of how energy is passed from producers to consumers in an ecosystem
- **Trophic level** – each "step" in a food chain that represents how many times energy has been transferred from one organism to the next
- **Energy pyramid** – a representation in the shape of a pyramid that shows how energy is passed from one trophic level to the next
- **Top consumer** (or **top predator**) – animal at the top of a food chain; usually a carnivore that has no natural predators

Food Chains

The simple explanation for the flow of energy from autotrophs to heterotrophs is called a **food chain**. A simple example of a food chain is shown in figure 19-2.

Example of a Food Chain

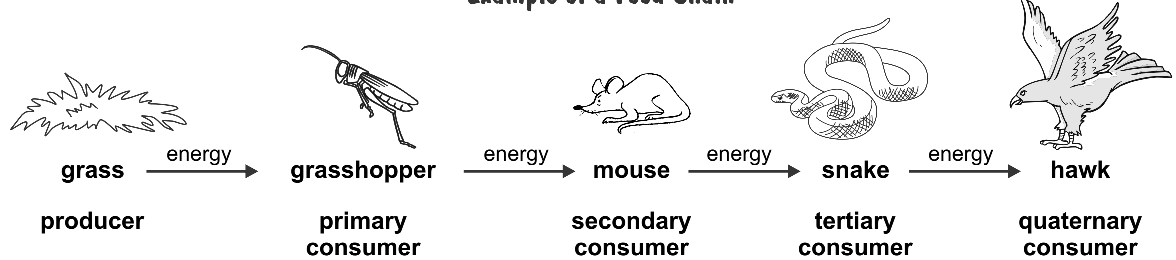


Fig. 19-2

In the food chain shown in figure 19-2, the grass is the producer. The grasshopper eats the grass, so it is the primary consumer. The grass gives energy to the grasshopper. The mouse eats the grasshopper, so the mouse is the secondary consumer. The mouse gets its energy from the grasshopper. The snake then eats the mouse. The snake is the tertiary consumer, which simply means "third level" consumer. The snake is then eaten by the hawk. The hawk is the quaternary consumer, or "fourth level" consumer. So you can see how a food chain represents how energy is passed from one organism to the next.

Note: Don't let the terms "tertiary" and "quaternary" scare you. "Tertiary" is another word for "third." Quaternary is another word for "fourth."

Example 1: In the food chain given in figure 19-2, which organisms are predators? Which are prey?

The mouse, the snake, and the hawk are all predators. The grasshopper is prey for the mouse, the mouse is prey for the snake, and the snake is prey for the hawk.

Biology

DIRECTIONS

Read each question and choose the BEST answer.

SAMPLE A

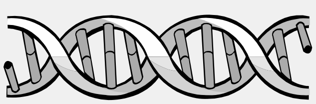
Which of the following instruments would a biologist MOST likely use to dispense a measured amount of liquid?

A A test tube
B A beaker
C A burette
D An Erlenmeyer flask

Ⓐ Ⓑ Ⓒ Ⓓ

SAMPLE B

The diagram below represents which of the following molecules?



F RNA
G DNA
H A protein
J A carbohydrate

Ⓕ Ⓖ Ⓗ Ⓙ

20 **The fungus *Fusarium oxysporium* can cause Panama disease in banana plants. Fungus spores in the soil invade the water-conducting vessels of the banana plant. The spores germinate and grow in the vascular tissue and soon produce more spores. In response to this fungus, the plant produces a gel that clogs the infected vessels in an attempt to localize the infection. However, the fungus can spread rapidly, and if the fungus invades most of the vascular tissues, the plant will soon die. Once the plant dies, the spores enter again into the soil where they can survive many years.**

What causes the banana plant to die once it is infected by the fungus?

F Over-production of sugar
G Inadequate sunlight
H Destruction of roots
J Lack of water

Ⓕ Ⓖ Ⓗ Ⓙ

---

21 **In the oxygen cycle, which of the following processes releases oxygen gas back into the atmosphere?**

A Cellular respiration
B Transpiration
C Photosynthesis
D Combustion

Ⓐ Ⓑ Ⓒ Ⓓ

---

22 **A strand of DNA has the following base sequence.**

A C G - G T A - A G C

What would be the complementary mRNA strand?

F T G C - C A T - T C G
G A C G - G U A - A G C
H U G C - C A U - U C G
J A C G - G T A - A G C

Ⓕ Ⓖ Ⓗ Ⓙ

GO ON

Biology
Practice Test 1
Evaluation Chart

Circle the questions you answered incorrectly on the chart below, and review the corresponding sections in the book. Read the instructional material, do the practice exercises, and take the section review tests at the end of each section.

If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):
1	13.5	26	16.7, 20.1	51	20.2
2	21.3	27	19.4, 21.4	52	9.1, 9.2
3	7.1, 7.3	28	6.2	53	12.3
4	1.1, 1.3	29	2.1, 2.2, 2.4	54	12.5
5	4.2, 4.3, 4.4, 4.5	30	1.7	55	8.1
6	13.2	31	6.1, 6.3, 9.1, 9.4, 15.1	56	10.1, 10.2, 10.3, 11.4
7	4.6	32	16.6	57	16.6
8	5.1, 5.2	33	12.1, 12.4	58	12.1
9	2.1, 2.2	34	3.1, 21.4	59	10.1, 10.2, 11.2
10	6.1, 6.3	35	6.1, 15.2	60	10.1, 10.2, 11.3, 11.4
11	2.1	36	9.2, 9.3, 12.4	61	14.4, 14.5
12	6.4	37	6.4, 16.6	62	8.2
13	13.4	38	12.1, 12.3, 12.4	63	10.1, 10.2, 11.1
14	10.1, 10.2	39	12.3	64	13.5
15	19.2, 19.3, 19.4	40	10.1, 10.2, 11.4	65	19.2
16	2.1, 2.2	41	4.7	66	6.4
17	3.1	42	3.4	67	14.1, 14.2
18	4.7	43	14.1, 14.2, 14.3	68	19.2
19	17.8, 20.1, 20.2, 20.3	44	12.4	69	10.1, 10.2, 11.2
20	16.6	45	20.3	70	14.1, 14.2
21	8.3, 18.3	46	19.3		
22	12.1, 12.2, 12.3	47	5.6		
23	12.5, 13.5	48	9.4		
24	17.8, 19.2	49	16.2		
25	5.4	50	8.3		