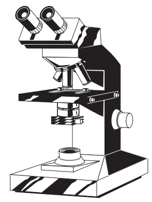
Biology

Course No. 2000310

Bureau of Instructional Support and Community Services
Division of Public Schools and Community Education
Florida Department of Education

1999

This product was developed by Leon County Schools, Exceptional Student Education Department, through the Curriculum Improvement Project, a special project, funded by the State of Florida, Department of Education, Division of Public Schools and Community Education, Bureau of Instructional Support and Community Services, through federal assistance under the Individuals with Disabilities Education Act (IDEA), Part B.



Biology

Course No. 2000310

revised by
Greg Danner

edited by
Greg Danner
Sue Fresen

graphics by
Rachel McAllister

page layout by
Blanche Blank

Curriculum Improvement Project
IDEA, Part B, Special Project

LEON COUNTY SCHOOLS

Exceptional Student Education

Curriculum Improvement Project
Sue Fresen, Project Manager

Leon County Exceptional Student Education (ESE)
Ward Spisso, Director of Exceptional Education and Student Services
Diane Johnson, Director of the Florida Diagnostic and Learning Resources System (FDLRS)/Miccosukee Associate Center

School Board of Leon County
Tom Young, Chair
Joy Bowen
J. Scott Dailey
Maggie Lewis
Fred Varn

Superintendent of Leon County Schools
William J. Montford

Table of Contents

Acknowledgments

The staff of the Curriculum Improvement Project wishes to express appreciation to the content revisor and reviewers for their assistance in the revision of *Biology* from original material by content, instructional, and design specialists from Broward and Leon county school districts.

Content Revisor

Greg Danner
Science Teacher
Tallahassee, FL

Copy Editor

Deborah Shepard
English Teacher
Lincoln High School
Tallahassee, FL

Review Team

Steve Fannin
Science Teacher
Lincoln High School
Tallahassee, FL

Sue Gauding
ESE Teacher
Godby High School
Tallahassee, FL

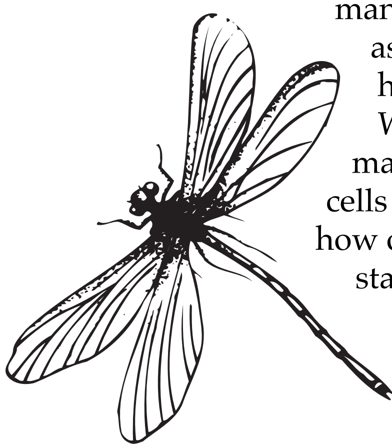
Lawrence A. Weiner
Chief Operating Officer
Integrated Environmental
Solutions Corporation
McLean, VA

Production Staff

Sue Fresen, Project Manager
Blanche Blank, Text Design Specialist
Rachel McAllister, Graphic Design Specialist
Curriculum Improvement Project
Tallahassee, FL

Introduction

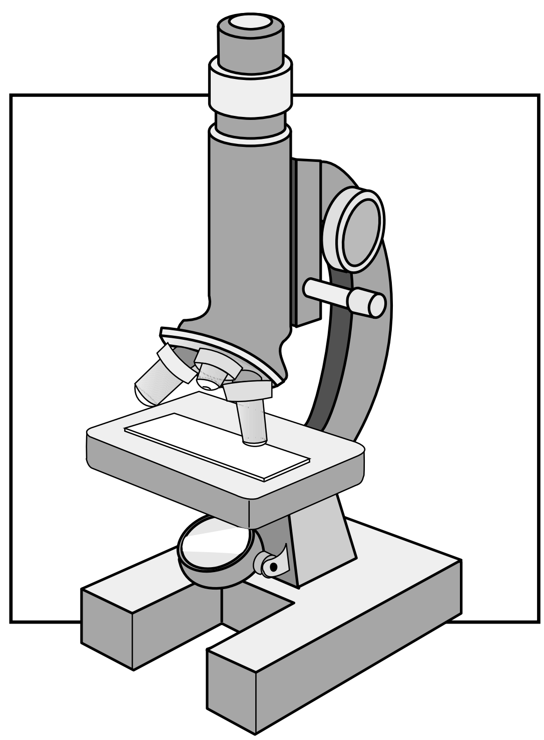
Biology is the study of life. Think of all of the examples of life that surround you. You could start with your own life—the wonderful functions of your body: eyes that can search the room, a brain that directs your efforts, the give-and-take of the muscles that turn your head. You could consider how each cell in each organism is a mini-factory carrying out vital processes. You could think about the wonderful variety of life: sea cucumbers in the salty sea, grasshoppers in the garden, and lions on the plains of Africa. Examples of life range from your own wiggling fingers to poison tree frogs in the jungles of the Amazon.

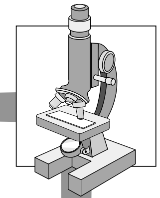


Biology gives us a framework for studying life in all its many forms. With the scientific method, we can ask questions and get answers. We can explore how our muscles actually produce movement. We can find out how the energy in a hamburger makes its way from our mouths to the tiny little cells buried deep in our bodies. We can find out how old cells make new cells—how we ourselves started out as one cell and each became millions of cells. We can learn how a sea cucumber finds a mate and why a tree frog would need to be poisonous.

Biology is a lively topic. It's something to get excited about. When you begin to look at life closely, to explore and examine the many different processes that keep life going, you begin to realize life is a marvelous, powerful force.

Unit 1: Biology and the Scientific Method





Vocabulary

Study the vocabulary words and definitions below.

apparatus	the equipment or tools needed for a specific task (*pl*. apparati) *Example*: forceps are dissecting apparati
biologist	a person who studies the science of life
biology	the study of living things; the science of life
conclusion	the logical evaluation of a theory as shown by data from an experiment or evidence from experience
control	that part of the experiment where the variable is not changed
data	information recorded on all aspects of an experiment
experiment	an activity designed to test a hypothesis
fact	something known with certainty
hypothesis	a statement that may explain a group of related observations (*pl.* hypotheses)

metric system .... an international system of measurement based on multiples of 10

microscope .... an instrument with a series of magnifying lenses for inspecting objects too small to be seen in detail by the unaided eye

observation .... something learned through the senses—sight, hearing, taste, smell, or touch

problem .... a question that can be answered through observation and experimentation

science .... the system by which data is gathered, problems are solved, and theories are developed; it seeks to describe the scope and function of the universe

scientific method .... a logical, orderly way to solve a problem or answer a question using experimentation and observation

superstition .... an untested or untestable belief upheld by faith in magic or chance

theory .... a generalized explanation of events based on the conclusions of several experiments made by several people over a long period of time

variable .... a condition that can be changed throughout the experiment to test the hypothesis

Introduction

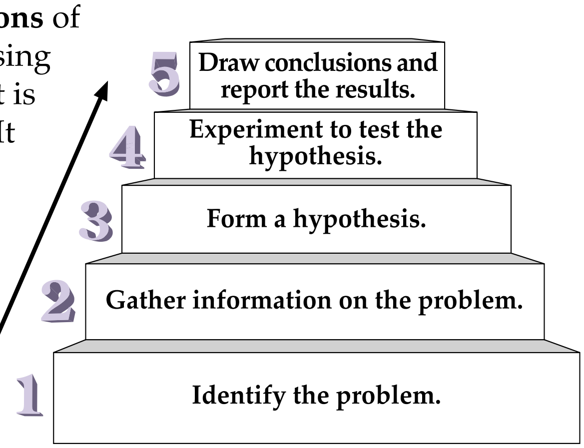
Biologists are people who study the **science** of life. Science provides a way to ask questions about the world around us and to find reliable answers. Biologists and other scientists use a system to investigate questions that is called the **scientific method**. Though this term may sound rather technical, all of us use the scientific method to some extent each day as we make sense of information.

Science is an exciting exercise because it gives us a way to investigate the things that puzzle us. **Biology**, as the science of life, involves everything around us—the trees outside the window as well as the fingernail on your little finger. It's more than a subject that begins and ends as you open and close this book. So crank up that scientific method and look around: Ask why, find out how… get the **facts**!

The Scientific Method: What Is It?

People once used **superstition** and myth to explain everyday happenings such as thunder ("the gods must be angry") to the origins of tadpoles ("they come from the mud"). People now try to explain such mysteries with the help of the scientific method. The scientific method is a way to logically answer questions.

The scientific method involves several steps. First, you identify a **problem** or an area of interest. You state it as a question that you think you can answer through further investigation. Second, you gather more information about the problem. Third, you construct a statement that you think explains what you have observed. This statement is called a **hypothesis**. Fourth, you carry out an **experiment** to test your hypothesis. You must make careful **observations** of the results of your experiment. Using these, you draw a **conclusion** that is supported by your observations. It is important to note a few points about conclusions. Conclusions are based on observations from experiments. They are not based on observing the entire universe. For that reason,



conclusions can do only a few things. A conclusion can show a hypothesis is untrue. Conclusions cannot prove a hypothesis is true. At first, this may seem strange, but remember:

Remember

- conclusions can prove a hypothesis is untrue
- conclusions can support a hypothesis or state it seems likely
- conclusions can never prove a hypothesis is true

Whatever conclusions you reach, the conclusion is only a part of the scientific method. It relies on the rest of the scientific method being performed properly.

Remember, the scientific method involves the following five steps:

1. Identify the problem.
2. Gather information on the problem.
3. Form a hypothesis.
4. Experiment to test the hypothesis.
5. Draw conclusions and report the results.

Though it's easy to laugh at the superstitions of people from long ago, strange notions based on mistakes in thinking are not limited to the far past. In fact, when we look at some of the wrong conclusions people have drawn from their observations, even recently, it gives us even more reason to apply the scientific method very carefully to problems we face today.

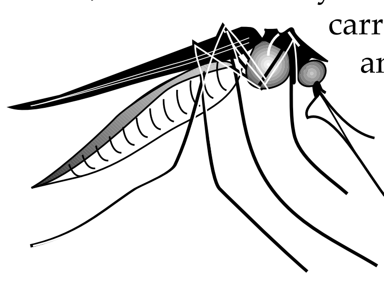
The Scientific Method in Action

The problem of yellow fever is a good example of how the scientific method was used to fight myth and superstition. Yellow fever is a disease that used to kill thousands of people, particularly in the southern United States and throughout Central and South America. Large numbers of people died in outbreaks of this disease as recently as the early 1900s. Until the turn of the century, people didn't know where this disease came from. Some burned fires in an effort to clean the air, thinking it somehow came from bad air. In Jacksonville, Florida, authorities would fire cannons across the St. Johns River, hoping the vibrations would chase the disease away.

However, in collecting information on yellow fever, some scientists noticed that outbreaks of the disease mainly occurred in swampy areas—areas with lots of mosquitoes. When these scientists presented their hypothesis that mosquitoes carried the disease, some people—including other scientists—thought this was such a stupid idea that they slashed their window screens to show their disbelief in this explanation.

As an experiment for testing their hypothesis, the scientists suggested widespread mosquito extermination. The number of mosquito bites was the **variable** they wanted to change. Areas where the number of mosquito bites remained the same served as a **control** for their experiment**.** As people wiped out mosquitoes by draining swamps and other places where they breed, there were fewer outbreaks of the disease.

From this **data**, many formed the conclusion that mosquitoes were indeed the carriers of the disease. Using this conclusion to investigate the disease further, scientists finally discovered that one specific type of mosquito carries a virus that causes yellow fever. From this and other scientific investigations, biologists have come up with the **theory** that communicable diseases are caused by living organisms, not "bad air" or other superstitions. A theory is a general description of activity based on many supported hypotheses.

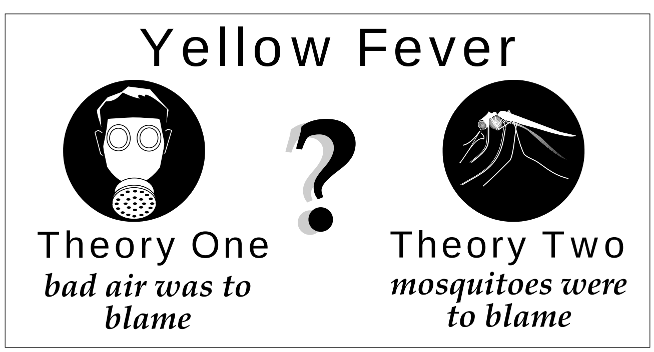


Talking About It

From this story it's obvious that open discussion between scientists is very important in solving scientific problems. What if the scientists who believed that mosquitoes were the carriers of yellow fever had been unable to present their opinion and test their hypothesis? Even though many people thought they were crazy, some pursued their hypothesis using the scientific method. The story of yellow fever is an important lesson in how even supposed experts argue among themselves and how every hypothesis has value until it is proven wrong.

Scientists present their work for discussion by publishing it in scientific journals. You may have heard of the *New England Journal of Medicine* or the *American Naturalist*. In these journals, scientists describe their experiments clearly and present their measurements in the **metric system**, a system of measurement that is used worldwide for science (see Metric Tables, pages 329-330). This gives other scientists a chance to read about new work and discoveries to decide whether the scientific method was used correctly to form conclusions. Other scientists may even go so far as to repeat an experiment to see if they get the same results that were reported. In this way scientists can check each other's work.

The scientists who investigated yellow fever were exploring a new problem. As we mentioned above, other scientists investigated previous results. Since the conclusion of the investigation into yellow fever, other experiments have been conducted. These theories have been used to make predictions. Another reason to investigate is to check how well a theory predicts. Occasionally, two theories may be proposed. In this case, scientists investigate to see which theory best fits the results.



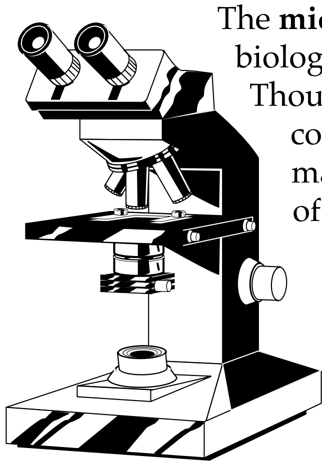
With yellow fever, we could consider that there were two theories. One theory said bad air was to blame, and another said mosquitoes were the culprits. We have learned that the mosquito theory seems to have been better. As we mentioned before, though, no theory is ever proven true. It is possible (though highly unlikely) that some new theory may better describe how people catch yellow fever. This is one of the most important ideas in science. No matter how well one theory may work, another may work better. It may describe more or predict more. This process leads to the occasional discarding of theories.

What happens when such a theory is discarded? One result is that we have a better understanding of the universe. Most such changes are small. As we saw with yellow fever, sometimes the changes are drastic. As time passes, we gain a more refined view of the world and universe. Scientists don't think they will ever achieve absolute truth, but they will continue to improve upon what we know. Each day we get a better picture of our world.

It's important that each of us use the scientific method when we read the newspaper each day. Does the news seem to present the facts fairly? Does the writer seem to jump to conclusions that disagree with the data? What about advertisements? Does a television cost any less if you rent to own instead of saving up your money and paying for it all at once?

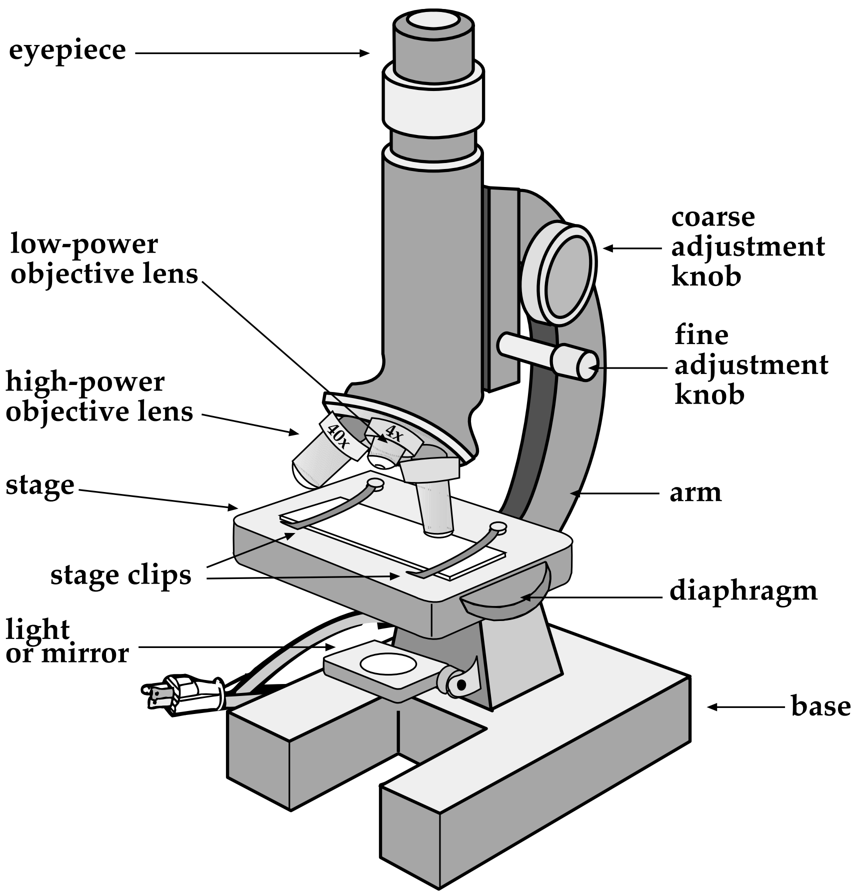
Experimental Equipment

Biologists and other scientists have come up with a variety of tools. These different tools, called **apparati**, are for testing their hypotheses through experiments. You're probably familiar with one common apparatus, the microscope. The computer is another apparatus. There are some items that you will have to practice to know and use well. Basic equipment is described on page 11, Scientific Apparatus.



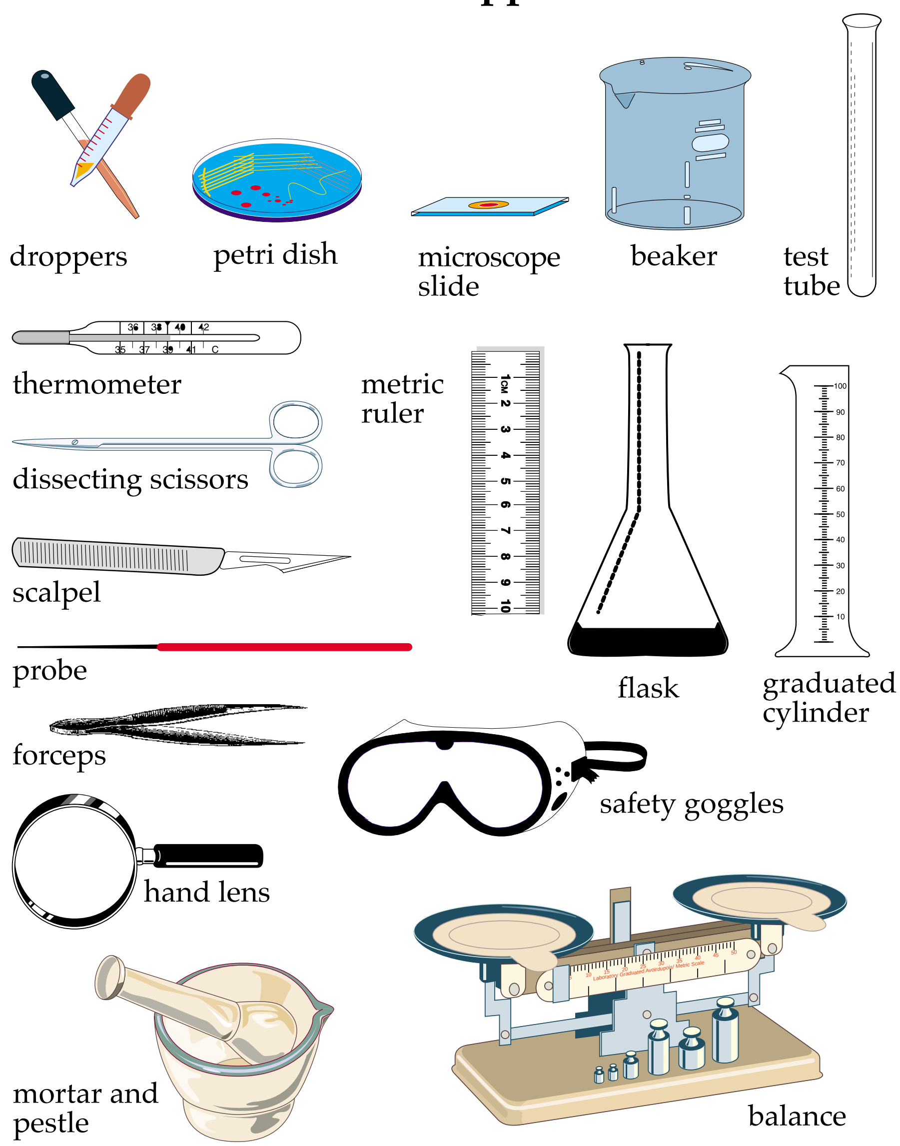
The **microscope** is one of the most important tools in biology because it increases our powers of observation. Though the microscope may seem like a rather complicated machine, it's really just a set of magnifying lenses. It magnifies both through the lens of the eyepiece and a second lens nearer the thing you're examining. When you use a microscope, you prepare the thing you wish to observe—the specimen—by placing it on a glass slide. Then, when the slide is placed on the microscope stage, light passes through both the specimen and through the lenses. The image you see is magnified many times.

Parts of the Microscope



The other lab equipment you will be using, for the most part, includes containers for mixing and tools for measuring. Become familiar with their names so that you'll be comfortable using them in experiments.

Scientific Apparatus



Safety in the Lab

Working safely usually means using common sense. Because most of us are sensible people, it's easy to think we know all we need to know about safety. However, that's not necessarily the case in a laboratory setting. The laboratory is at least a little bit unfamiliar to most students. Therefore, situations might come up where the sensible thing to do isn't obvious. That's why it's important to look at safety rules developed by people who are used to working in laboratories and have experience with the dangers that might arise in a laboratory.

Read the Safety Guidelines below. Learn them well enough that they become second nature when you're working in a lab. They will save you from mistakes that have hurt other people as they were working. These rules are designed to protect you.

Safety Guidelines

1. Read and follow all directions while working in the laboratory.
2. Wear protective gear, such as aprons, at all times. Wear goggles when working with dangerous or hot chemicals, or any time your teacher instructs you to do so.
3. NEVER taste or directly inhale chemicals. Waft chemicals to smell them. Your teacher can show you how.
4. DO NOT bring food or drink into the lab.
5. Wash hands thoroughly after each lab.
6. DO NOT rub eyes or put hands in mouth.
7. Dress in a way that helps you work safely and efficiently in the lab. Tie your hair back. Wear cotton—it doesn't catch fire as easily as nylon or polyester. Always keep your shoes on while in the lab. Roll up long or loose sleeves.
8. DO NOT look directly down into the mouth of a filled test tube. DO NOT point the mouth of a filled test tube at another student. Liquid can splash into eyes.
9. DO NOT perform any experiments unless the instructor is in the room.
10. Report ALL minor and major accidents to your instructor.
11. Know the location of the safety shower, eye wash, and fire blanket. Know how to use these important pieces of safety equipment.
12. Turn off gas burners and the gas outlets when no one is using them. NEVER leave a lit burner unattended.
13. Keep lab tables clean and neat to prevent accidents. Wipe all areas at the end of the lab.
14. MAKE SAFETY A HABIT!

Summary

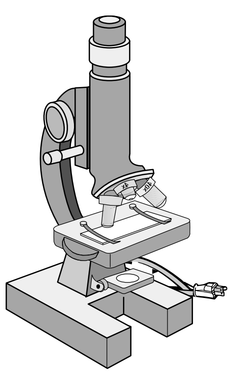
The scientific method gives us a framework for posing and answering questions. It consists of the following steps:

1. Identify the problem.
2. Gather information on the problem.
3. Form a hypothesis.
4. Experiment to test the hypothesis.
5. Draw conclusions and report the results.

Open discussion allows scientists to compare the results of their experiments. A commitment to review by other scientists is essential. Scientists use the metric system as a standard system of measurement for all experiments.

Scientists conduct investigations on new problems to check old theories, to test how well a theory predicts, and to compare theories. These investigations sometimes lead to large changes; more often, changes are small. These changes take place because a conclusion is never proven true. Sometimes theories are discarded. The result of all this is an improved view of the world.

Scientific equipment, particularly microscopes, is useful in studying biology. Practicing safety in the laboratory protects you, your classmates, and the scientific equipment you use.



Careers in Biology

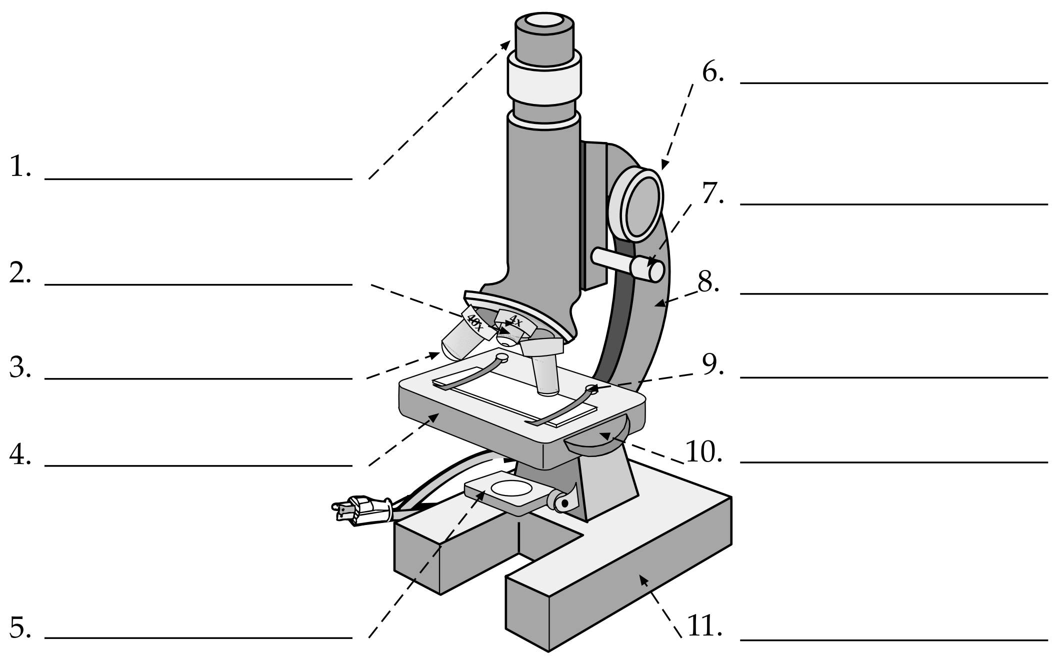
Laboratory Technician

Laboratory technicians assist in the operation of scientific labs. These labs can vary widely to include medical research labs, chemistry labs, or pharmaceutical labs. The work done by a technician may be overseen or monitored by scientists, doctors, or others who direct the investigation. Some technicians receive on-the-job-training while others may take some college course work to prepare. The need for laboratory technicians seems to be growing.

Practice

Use the list below to write the correct part of the **microscope** *on the line provided.*

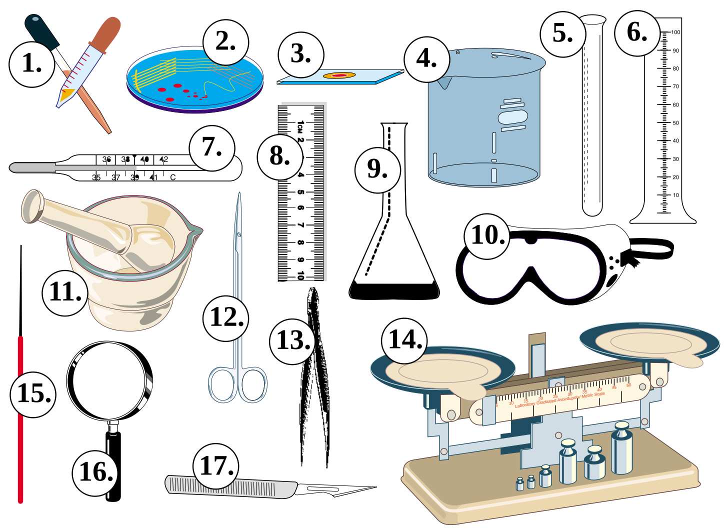
arm	**high-power objective lens**
base	**low-power objective lens**
coarse adjustment knob	**mirror or light**
diaphragm	**stage**
eyepiece	**stage clips**
fine adjustment knob	



Practice

Use the list below to write the correct name of each **apparatus** *pictured on the line next to its corresponding number.*

balance	**graduated cylinder**	**probe**
beaker	**hand lens**	**safety goggles**
dissecting scissors	**metric ruler**	**scalpel**
droppers	**microscope slide**	**test tube**
flask	**mortar and pestle**	**thermometer**
forceps	**petri dish**	



1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

7. ______________________

8. ______________________

9. ______________________

10. ______________________

11. ______________________

12. ______________________

13. ______________________

14. ______________________

15. ______________________

16. ______________________

17. ______________________

Practice

Finish filling out the **accident reports** *below.*

Type of Accident: Chemical Burn

Description: Ashley Allbright burned a hole in the right leg of her new designer jeans. Fortunately, the skin underneath was only slightly irritated. Ashley noticed the hole in math class when she felt her leg begin to burn. Then she remembered she had spilled several drops of acid on her leg in biology lab during the previous period. She had not mentioned this to the biology teacher because she didn't "think much about it at the time."

Cause of Accident: ______________________________

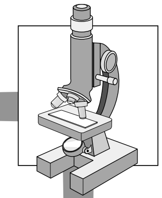
Ways to Prevent This Type of Accident in the Future:

1. ____
2. ____
3. ____
4. ____

Type of Accident: Minor Explosion Resulting in Injury and Fire

Description: Chastain "Chance" Cuthbert lost the tip of his index finger in a small explosion that also led to a fire—here's how. Waiting until the teacher left the room to search for more beakers in the supply closet, Chance attempted to spray a small aerosol can filled with mouth freshener through the flame of his alcohol burner. According to Chance, "I just wanted to see what would happen." The can exploded, blowing off the tip of his index finger and breaking the alcohol burner. The alcohol inside the burner caught fire as it spilled across the table. The teacher was able to put out the fire with a fire extinguisher she grabbed as she emerged from the supply closet.

Cause of Accident: ______________________________



Ways to Prevent This Type of Accident in the Future:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Type of Accident: Burn

Description: Katrina Lamb was scalded on her right cheek after leaning over her boiling test tube to check the contents. According to witnesses, Katrina's lab partner was impatient for the water inside the test tube to boil and urged Katrina to "check out what's going on down there." Hot water and steam burst out of the test tube as Katrina leaned toward it.

Cause of Accident: ______________________________

Ways to Prevent This Type of Accident in the Future:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Practice

Read the **newspaper story** *below, then answer the questions.*

Saturday, April 1, 1998 The Bogie Edition

Martians Kill Farmer's Cows

by I. Donna Believe
Guest Columnist

Reports indicate that aliens from outer space are responsible for the deaths of three cows at the local BBQ Cattle Ranch. Owner Clyde Bingham said that the mysterious deaths followed a night filled with strange lights shining through the woods on the nearby creek gully. He also said that he noticed the next morning that water in this creek had turned green. The water now runs clear, however. "I first noticed those lights early in the evening," said Bingham. "But I got wrapped up in *Wheel of Fortune* and forgot about them. Then, of course *X Files* came on, and I couldn't get up and leave in the middle of that either."

Bingham said he found the dead cows the next morning. They were near the creek where he noticed that the water was green.

"I got to talking to my neighbor Mr. Kloreen about it, and he said that Mars was close to the Earth last night. He also said that Martians oftentimes turn water green and sacrifice a few cows when they visit over here. Mr. Kloreen said visits from outer space are his hobby, so he bought my dead cows as a souvenir," said Bingham.

Malcolm Kloreen, a local businessman, owns the Kloreen Chemical Company and recently purchased this newspaper. He said he was an amateur astronomer interested in extraterrestrial phenomena. He was happy he could contribute his expertise to this case.

"Evidence shows that Martians like to land near a water source," said Kloreen. "It's a good thing Clyde avoided a close encounter! Martians are known to have little mercy for Earthlings."

1. What is your hypothesis for the death of Clyde Bingham's cows? It's possible to have more than one hypothesis. Remember, there may be more factors involved than the ones mentioned in this story.

____

____

____

____

2. If you could get any information you would like to have, how would you test one of your hypotheses? Apply the five steps of the scientific method.

____

____

____

____

____

____

____

____

____

____

____

____

3. Was open discussion of this situation possible? ____________________

Why or why not? ____

____

____

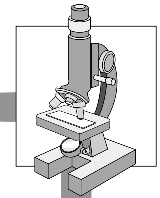
____

____

____

4. If Clyde Bingham's creek were also the water source for your family, how would you feel?

What would you do?



Lab Activity 1: Using the Scientific Method

Facts:

- The scientific method helps us to solve problems.
- Using the scientific method, the problem is identified, observations are made, and a hypothesis is developed.
- The hypothesis is tested by experimenting, observing results, and recording them.
- Conclusions are drawn based on results.

Investigate:

- You will use the scientific method to solve this problem: *Do flasks **A** and **B** contain similar or different liquids?*

Materials:

- 2 flasks labeled **A** and **B** containing liquid
- a clock or watch with a second hand
- 2 stoppers to fit flasks
- beaker

Caution: *Wear eye goggles and wash your hands when you are finished with the lab activities!*

First Observations

1. Examine flasks **A** and **B**. **Do not** remove their stoppers, and **do not** shake them.

2. Record, in the table on the following page, two or three similarities or differences between the two flasks.

Similarities	Differences
1. ____________________	1. ____________________
____________________	____________________
2. ____________________	2. ____________________
____________________	____________________
3. ____________________	3. ____________________
____________________	____________________

3. Do you think both flasks contain the same liquid? ______________

4. Is your answer to Question 1 based on experimenting or guessing?

   ____

5. Do both flasks contain exactly the same amount of liquid? ________

6. What gas might be in the upper half of flask **A** that might not be in flask **B**?

   ____

7. Do you have any evidence for your answer to Question 4? ________

   ____

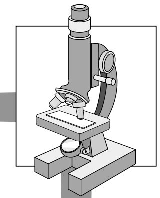
Experimenting

Experiment 1: What happens if you shake the liquids?

Hypothesis: ____

1. Give each flask one hard shake with your hand using an up-and-down motion. Make sure your thumb holds the stopper of the flask so that you won’t spill any of the liquid.

2. Immediately after shaking, observe each flask carefully.



3. Look for similarities and differences between the two flasks, and record your observations in the table below.

Results of Experiment #1	
Similarities	**Differences**
1. ____________________	1. ____________________
____________________	____________________
2. ____________________	2. ____________________
____________________	____________________
3. ____________________	3. ____________________
____________________	____________________
4. ____________________	4. ____________________
____________________	____________________

4. After shaking the flasks, do you think they contain the same or different liquids?

   ____

5. If different, what was present that might have caused the change in the liquid?

   ____

Experiment 2: What happens if you remove some of the liquid in flask **B** so that it has the same amount of space at the top as flask **A**?

Hypothesis: ____

6. Remove the stopper from flask **B**, and pour out half of the liquid into a beaker. Make sure that the amount of liquid in flask **B** is equal to the amount of liquid in flask **A**. Replace the stopper. Give each flask one hard shake as you did before. Remember to hold the stopper in place while shaking.

7. Observe each flask carefully.

8. Look for similarities or differences between the two flasks and record them in the table below.

Results of Experiment #2	
Similarities	**Differences**
1. ______________________	1. ______________________
______________________	______________________
2. ______________________	2. ______________________
______________________	______________________
3. ______________________	3. ______________________
______________________	______________________
4. ______________________	4. ______________________
______________________	______________________

9. Do both flasks now appear to contain the same liquid? ___________

10. What may have been added to flask **B** that wasn't present before?

____

Experiment 3: What happens if you shake the flasks more than once?

Hypothesis: ____

11. Give each flask one hard shake with an up-and-down motion, holding the stopper.

12. Note the exact time in seconds after shaking that it takes for each liquid to return to its original condition. Record the time in the table on the following page.

13. Give each flask two hard shakes in the same manner as before. Record the time.

14. Repeat the procedure with three shakes and record the time.

Results of Experiment #3			
	1 Shake	2 Shakes	3 Shakes
Flask A			
Flask B			

15. After one shake, are the two liquids generally "behaving" in a similar way? That is, is the time that passes before flasks **A** and **B** return to their original condition about the same?

    ____

16. After two and three shakes, are the liquids in flasks **A** and **B** behaving in a similar way?

    ____

17. Look at the data in the table *Results of Experiment #3*. Does flask **A** show an increase or decrease in time needed to return to its original condition as the number of shakes increases from one to three?

    ____

    Does flask **B** show a similar change? ____________________

Interpreting the Data from the Experiment

Answer these questions. They will help you **interpret***, or make sense of, the* **data** *from your observations and experiments.*

1. On the basis of your first observations in Part A, could you decide if both flasks contained the same liquid?

    ____

2. After performing Experiment #1, could you decide if both flasks contained the same liquid?

____

3. Which experiment or experiments may have helped you to decide that the liquids in flasks **A** and **B** were similar or different?

____

Explain: ______________________________________

____

____

4. Besides the liquid itself, what else seems to be needed for the liquid to change color?

____

Forming Conclusions from the Experiment

Answer these questions. They will help you **draw a conclusion** *about your original problem: Do flasks* ***A*** *and* ***B*** *contain* **similar** *or* **different** *liquids?*

1. Why did flask **B** not change color when shaken in Experiment #1?

____

____

2. Why must the liquids in the half-filled flasks be shaken to produce a color change?

____

____

3. Why did more shaking increase the amount of time needed for the liquids in flasks **A** and **B** to change back to their original color?

4. Could you have solved Question 1 in **Experimenting** by guessing?

   Why is *experimenting* a better method of problem solving than *guessing*?

5. What is meant by the phrase "solving a problem by using the scientific method"?

Lab Activity 2: Metric Measurement

Facts:

- All scientific work requires careful and accurate measurement.
- Matter can be measured in terms of length, volume, or weight.
- Scientists use the metric system of measurement.

Investigate:

- You will use metric units to measure the length of given objects, volume of liquids, and mass of common objects.

Materials:

- metric ruler
- balance scale
- graduated cylinder
- water
- various containers and objects

Use your **metric ruler** *to determine the* **length** *of items in your classroom. Write the correct measurement in* **centimeters** *on each line below. Remember that a centimeter is about the width of your little finger!*

__________ 1. your pencil

__________ 2. your desktop

__________ 3. your shoe

__________ 4. the fingernail of your little finger

__________ 5. this sheet of paper

Use a **graduated cylinder** *to determine the* **volume** *of the following. Write the correct measurement in* **milliliters**.

__________ 6. a cup of water

__________ 7. 10 drops of water

__________ 8. a quart of water

Use a **balance** *to determine the* **mass** *of the following objects. Write the correct measurement in* **grams**.

__________ 9. nickel

__________ 10. paper clip

__________ 11. metal bar

__________ 12. beaker

Practice

Use the list below to write the correct term for each definition on the line provided.

biologist	**fact**	**science**
biology	**hypothesis**	**scientific method**
conclusion	**metric system**	**superstition**
control	**microscope**	**theory**
data	**observation**	**variable**
experiment	**problem**	

______________________ 1. an untested or untestable belief upheld by faith in magic or chance

______________________ 2. a condition that can be changed throughout the experiment to test the hypothesis

______________________ 3. an instrument with a series of magnifying lenses for inspecting objects too small to be seen in detail by the unaided eye

______________________ 4. something learned through the senses—sight, hearing, taste, smell, or touch

______________________ 5. a logical, orderly way to solve a problem or answer a question using experimentation

______________________ 6. a statement that may explain a group of related observations

______________________ 7. a question that can be answered through observation and experimentation

________________________ 8. the logical evaluation of a theory as shown by experimentation

________________________ 9. recorded information on all aspects of an experiment

________________________ 10. an activity designed to test a hypothesis

________________________ 11. something known with certainty

________________________ 12. an international system of measurement, based on multiples of 10

________________________ 13. a generalized explanation of the events based on the conclusions of several experiments made by several people over a long period of time

________________________ 14. that part of the experiment where the variable is not changed

________________________ 15. the study of living things; the science of life

________________________ 16. the system by which data is gathered, problems are solved, and theories are developed; it seeks to describe the scope and function of the universe

________________________ 17. a person who studies the science of life

Practice

Use the list below to complete the following statements.

comparing	**old**	**true**
discarded	**predicts**	**truth**
explore	**previous**	**understanding**
large	**small**	

1. When performing a scientific investigation, theories can be supported or disproved, but never proved

   ________________________ .

2. One reason to conduct investigations is to

   ________________________ new problems.

3. Other reasons to investigate include ________________________ theories, checking previous results, and testing how well a theory

   ________________________ .

4. Occasionally, a new theory may predict or describe better than an

   ________________________ theory.

5. When a new theory works better than an old theory, the old theory is

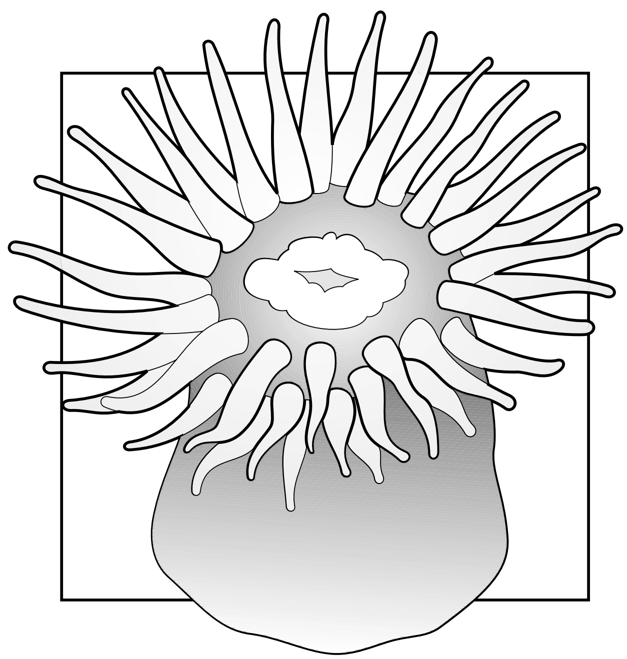
   ________________________ .

6. As theories are developed, tested, and discarded, the result is that we have a better view and ________________________ of the universe.

7. As theories are tested, these investigations usually lead to
_______________________ changes , but sometimes result in
_______________________ changes.

8. The result of the continued publishing, testing, and discarding of theories is an improved view of the world, but not absolute
_______________________ .

Unit 2: Identifying Living Things



Vocabulary

Study the vocabulary words and definitions below.

animal .... a type of organism that is a consumer; can move about to get food; has more than one cell

bacteria .... single-celled organisms that have no cell nucleus; most are consumers; share monera kingdom with blue-green bacteria

blue-green bacteria .... single-celled organisms that have no cell nucleus; are producers; share monera kingdom with bacteria; also called cyanobacteria

cell .... the basic unit of life

chlorophyll .... a green pigment that plants and algae use to make food through photosynthesis

classification .... a way to group things together based on likenesses

common name .... the English name that we have given to a familiar animal or plant; not as precise as the scientific name and does not show the organism's relationship to other living things

consumers .... organisms that must eat other living things to survive

decomposer .... living things that eat dead organisms to survive

fungi .... plantlike types of organisms that are consumers or decomposers; do not move from place to place; have more than one cell (*sing.* fungus)

kingdom .... a large-scale division of all living things

Carolus Linnaeus .... a scientist of the 1700s who started the system of plant and animal classification we use today

monera .... the kingdom of organisms that is microscopic, single-celled, and have no cell nucleus; includes bacteria and blue-green bacteria

organism .... one individual living thing
Example: cat, oak tree, salamander

photosynthesis .... the process plants and algae use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight

plant .... a type of organism that is a producer; does not move from place to place; has more than one cell

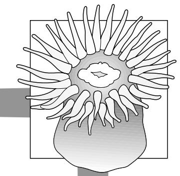
producers .... organisms that can make their own food through photosynthesis

protist .... a single-celled organism that has a cell nucleus

scientific name............................... the name scientists use to identify an organism; gives the organism's genus and species—the two most precise groups by which to classify the organism
Example: humans—*Homo sapiens*

species .... the most precise grouping for an organism; directly identifies one particular type of living thing

virus .... an extremely small infectious agent that only reproduces in living cells

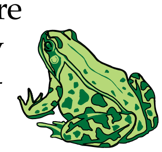


Introduction

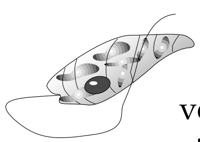
Have you ever awakened in an unfamiliar place—maybe when you were traveling or visiting relatives—and wondered where you were? At first there's a slight feeling of panic as you try to identify your surroundings. But as you identify the things around you—the night table, the lamp, the walls, the windows—you begin to remember where you are and to relax.

For thousands of years, human beings have tried to find their place in the living world. People have discovered that naming the **plants** and **animals** that surround them has been comforting and useful. Over time, we have identified so many plants and animals that we have had to *classify* them, or group them together in certain categories, so that we could keep them straight.

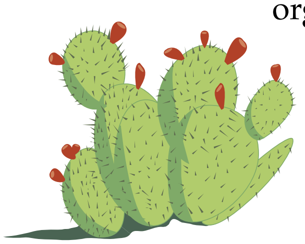
Classifying the things around us is a part of everyday life. When you clean up your room, you put clean clothes in one place, dirty clothes in another, garbage in the garbage can, and books in a stack. This is a process of *identifying* things and *grouping* them together. The grocery store groups types of food. The music store groups kinds of music. In this unit, we will see how biologists have grouped together things in the *living world* according to a system of scientific **classification**.



What Is Life?



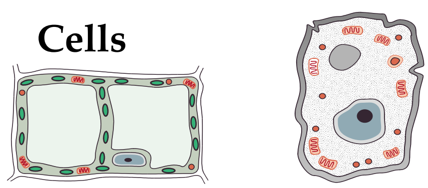
This unit will discuss many of the ways biologists classify life. Before we can advance very far with that, though, we need to ask a question: "What is Life?" Off the top of your head, you can name many living things and probably as many nonliving things. Between all the things you identified, be it tree, bird, or sponge, we could find some common traits. Each living individual thing is an **organism**. An elm tree is an organism, as is a bluebird. No matter what the organisms are, they have traits in common. It is these traits, or characteristics, we will use to define life.



Characteristics of Living Organisms

- Organisms are organized into one or more **cells**. Cells are the smallest part of an organism that can be considered alive. (Cells are discussed in Unit 3.)
- Organisms use energy. It is because of this that a knowledge of energy is fundamental to not only biologists but other scientists.
- Organisms have a particular shape and a limit to their size. A fish can neither look like a tree nor grow to a size larger than the ocean.
- Organisms grow and change. The smallest single cell organism gets larger and changes in some way during its life.
- Organisms can reproduce. Whether they are horses or bacteria, living things can, through one means or more, reproduce more living organisms.
- Organisms die. No living thing has a life span that is without limit.

Cells

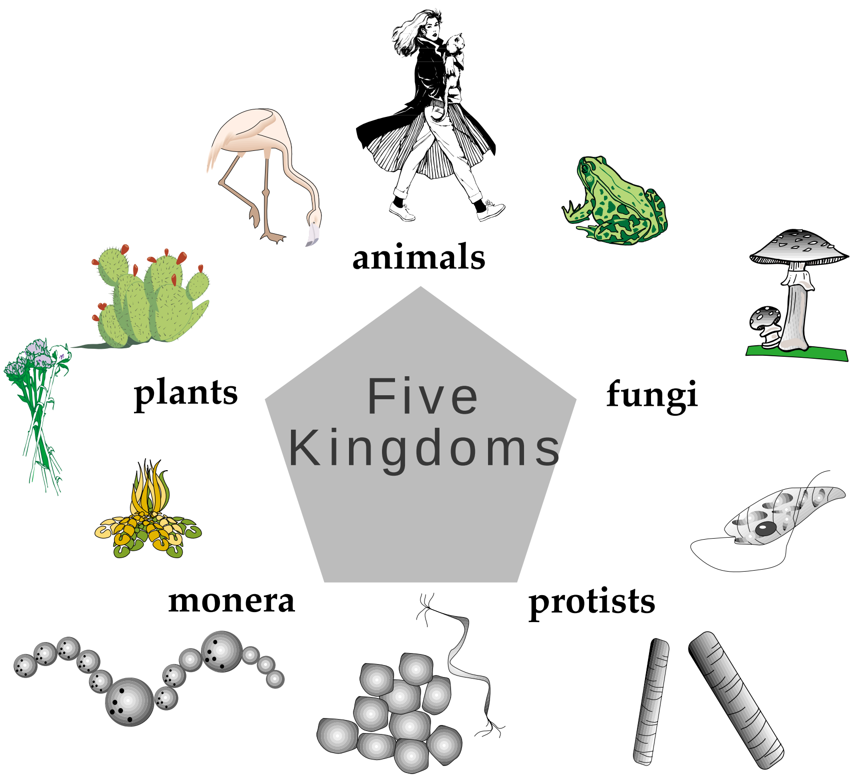


Cells are the smallest part of an organism that can be considered alive.

If you apply these characteristics to any nonliving thing, you may be surprised. A car can move, and it certainly uses energy, but it fails to have most of the characteristics of living organisms. As you can see, the job of deciding if something is alive is really the job of seeing how similar it is to other living things. That's how all of classification works.

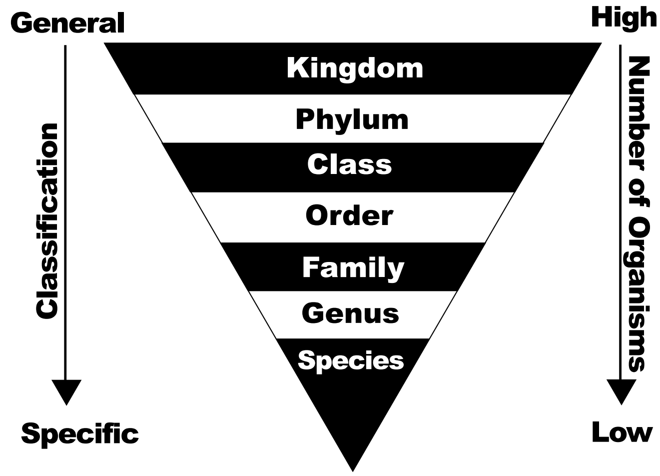
Scientific Classification

In 1735 a scientist named **Carolus Linnaeus** invented a system of classification which is the basis of the one we use today. This system starts out by dividing all organisms into separate **kingdoms**. A kingdom is a very broad, large-scale division of all living things. There are five kingdoms in most modern classification systems: animals, plants, **fungi**, **protists**, and **monera**.



We divided the kingdoms into smaller groups based on structural characteristics of the organisms. Now biologists have developed other means to classify organisms. Each kingdom is divided into several categories. Each level of categories has a unique name and within each are one or more smaller categories. As you move away from the category of kingdom, each group becomes more precise. This means each group is smaller. Within each kingdom are phyla; each phylum is divided into several classes; each class is divided into several orders; each order is divided into several families; each family is divided into several genera (*sing.* genus); and, finally, each genus is divided into several **species**. Species is the most precise grouping of an organism. In a sense, it is the smallest "category" to which it belongs.

Divisions of Classifications



An organism is placed in a group according to a variety of specific traits it possesses. This is easy to see from examples.

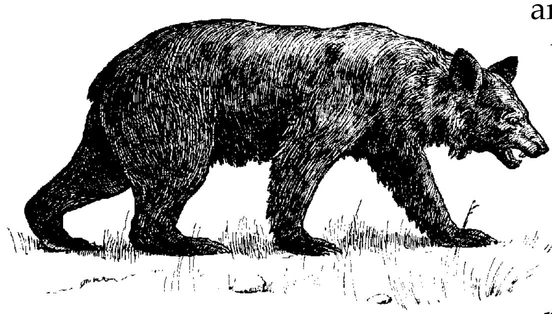
Classification

Group	Group Name		Comparison
	Black Bear	Grizzly Bear	
Kingdom	animal	animal	*same kingdom*
Phylum	chordate	chordate	*same phylum*
Class	mammal	mammal	*same class*
Order	carnivore	carnivore	*same order*
Family	Ursidae	Ursidae	*same family*
Genus	Ursus	Ursus	*same genus*
Species	americanus	horribilis	*different species*

These two organisms are placed in the same groups all the way through to the genus level. This means that they are closely related—that they have many of the same traits. For instance, they are both animals and they are both chordates, which means they have a spinal chord. They are both mammals; that is, they have hair and nurse their young. They are both carnivores, which means they eat meat. Even before we find out what family these organisms are in, we know a lot about them from their classification.

The family name, *Ursidae*, comes form the Latin word for bear, *ursus*. The genus name, *Ursus*, reflects this same word. And finally we come to the species name. The black bear is *americanus*. Its species name tells us it lives in America. The grizzly's species name, *horribilus*, tells us that it is—well—horrible, as in horribly fierce. The fact that these bears are different species shows that they do in fact differ in some traits. The adult grizzly bear is about a foot taller and about 300 pounds heavier than the adult black bear. Grizzlies also have a hump above their shoulders and look a bit dish-faced (that is, they have a short muzzle and a wide face) from the side.

As you can see, we've found out quite a bit about these two organisms just from knowing how they're classified. Their **scientific names** are the key to all this information. The scientific name includes the genus and the species names. Thus the black bear is *Ursus americanus* and the grizzly bear is *Ursus horribilis*. Their **common names**, "black bear" and "grizzly bear," aren't precise enough—for example, there are also black grizzly bears! Also, the common name doesn't show us how these bears are related to all other living things. Finally, the scientific name provides one common, universal term that scientists from all nationalities and cultures use.



The Five Kingdoms of Living Things

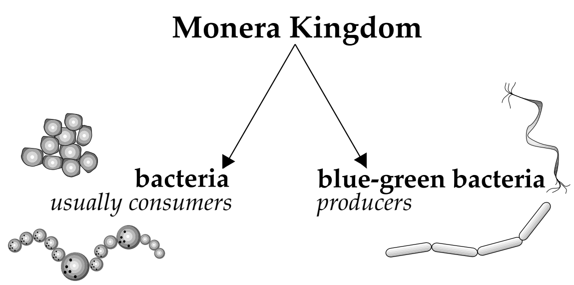
Living things are divided into five major kingdoms: *plants, fungi, animals, protists,* and *monera.* What follows is a description of each kingdom and the traits that place an organism in that kingdom. Some groups of living things are so familiar that they are difficult to define. Have you ever thought of how you would define a plant? An animal? Here are some scientific definitions of the five kingdoms of living things. They have been ordered, as closely as possible, from the simplest to the most complex.

The Monera (Bacteria and Blue-Green Bacteria) Kingdom

Members of the monera (**bacteria** and **blue-green bacteria**) kingdom are the simplest organisms. These are microscopic, single-celled organisms that have *no cell nucleus.* There are two subgroups in this kingdom: bacteria, which are usually **consumers**, and blue-green bacteria, which are *producers*. Producers are organisms that do not have to eat other living organisms to survive. Instead, they use nonliving material to produce the energy they need. Consumers, however, do rely on consuming living organisms. Consumers rely on producers.

Beyond being very, very small—even smaller than members of the protist kingdom, which we will look at next—bacteria lack many cell parts. They are one of three shapes: round, rodlike, or spiral. They are everywhere. When you smell sour milk, you smell the by-products of the bacteria that are feeding on the milk. When you walk past the garbage, you may be nearly knocked down by the stench. This smell is caused by bacteria. People can control bacteria in food by heating or freezing it. We also use preparations called *antiseptics* to protect our cuts and injuries from infection by bacteria.

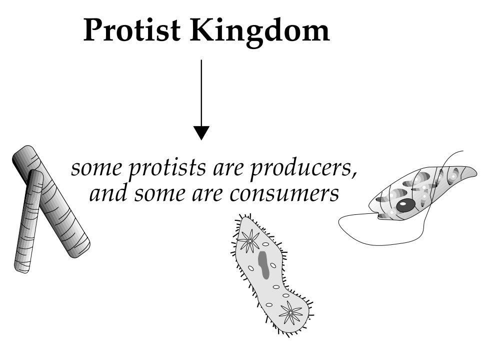
Like bacteria, blue-green algae are very simple and lack many cell parts. They contain the pigment chlorophyll and can feed themselves through photosynthesis. Photosynthesis is the process by which an organism stores the energy of the sun. This is done by combining carbon dioxide (a gas in the atmosphere), water, and the sun's energy to produce sugars. Sometimes they become obvious in polluted lakes where they receive many nutrients for carrying on photosynthesis. They reproduce very quickly and become so plentiful that they form a green scum on the surface of the water.



The Protist Kingdom

The protists are members of a kingdom that exists almost outside our awareness—they are microscopic organisms of fantastic forms and lifestyles. Each is only a single cell large, and each has a cell nucleus. A cell nucleus is a specialized part of a cell. It holds within it the information needed to reproduce the cell. The information also controls the way the cell functions or behaves. Some protists are *producers*, and some are *consumers*. If ever you magnify a drop of pond water with a microscope, you will see these tiny creatures spinning, swimming, and floating about.

Although protists are so small we cannot see them without a microscope, they perform important functions in our world. For one thing, they serve as food for larger organisms, such as fish or snails. Also, some protists are hosts for diseases. Yellow fever and malaria, for example, are spread by mosquitoes that have been infected with disease-carrying protists.



The Fungi Kingdom

The most familiar member of the fungi kingdom is probably the mushroom. Fungi (*sing*. fungus) often look similar to plants. But in fact, they are very different from plants in that they *do not* make their own food. Fungi either feed on living things or on the energy that remains in dead things. When fungi feed on dead things, they decompose or break down the chemical bonds that are still present in these dead organisms. Organisms that rely on energy stored in dead organisms are **decomposers**. For example, mildew feeds on the energy that is still present in the chemical bonds that hold leather together. Mushrooms often grow on cow manure where they can take in the nutrients that managed to pass through the cow. If it weren't for fungi and other types of decomposers, we would live in a world piled high with dead animals, plants, and cow manure. Most fungi are made up of many cells, and each cell has a nucleus.

Fungi Kingdom

fungi often look similar to plants but are very different in that they do not make their own food

The Plant Kingdom

What is the most noticeable difference between plants and other types of living things? Plants are green. They are green for a very important reason: they contain the pigment **chlorophyll**. Plants, like blue-green bacteria, use **photosynthesis**. Chlorophyll makes it possible for plants to produce their own food from sunlight, carbon dioxide, and water. Because plants can produce their own food, they too are known as **producers**. When plants make sugar, they also produce something very important. They produce the gas oxygen. Without oxygen, the members of the next kingdom could not survive.

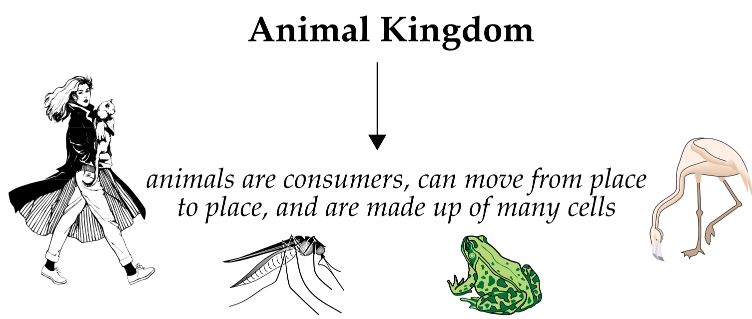
Besides photosynthesis, there are two other traits that define plants: 1) they are stationary—they don't move from place to place on their own; and 2) they are made of many cells.

Plant Kingdom

plants are stationary, are made of many cells, and use photosynthesis

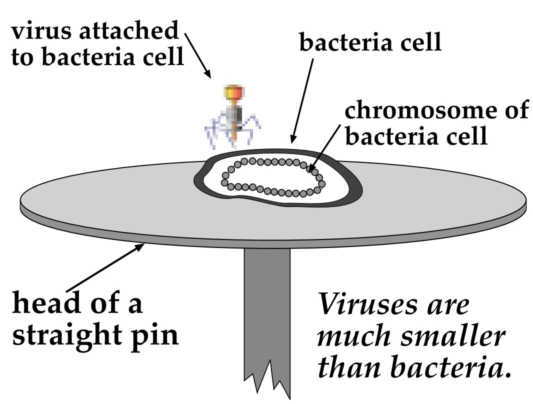
The Animal Kingdom

Think of all the animals you know. They are all so different. What features could they possibly have in common? The most obvious common trait is that animals *cannot* make their own food. They are *consumers*. Another trait you might notice is that most animals can move from place to place. Also, animals show a wide range of shapes and sizes, and most are fairly complex, with many different tissues and organs. Finally, all animals are made up of many cells. We will discuss more features of animals later.



Are Viruses Living Things?

Viruses are strange little things that don't really fall into any category. In fact, scientists have long argued about whether or not viruses are even alive. They are not made of cells, the basic unit of all life. However, they do reproduce. Viruses reproduce by hijacking the equipment of living cells, basically taking over the cell and using its chemicals to make copies of themselves. As they reproduce, they kill the cell they have taken over. Obviously, viruses are *consumers*.



(This illustration is not to scale—the cell and virus are much smaller.)

If viruses aren't made of cells, what are they made of? Mostly, they're a bit of reproductive material inside a protective capsule. They are much smaller than bacteria and can only be seen with very specialized microscopes. A virus operates by somehow tricking a cell into allowing it inside. Then it sabotages the cell by substituting its own reproductive material for the cell's reproductive material. It *tricks* the cell's machinery into making virus copies instead of cell copies.

Viruses are very much in the news these days because of the human immunodeficiency virus (HIV), which attacks immune system cells and causes Acquired Immune Deficiency Syndrome (AIDS). Viruses are also responsible for other familiar sicknesses, such as the common cold. Although scientists have developed vaccines to protect us against some viruses, they have not been able to develop vaccines to keep us safe from all of them.

The Interconnectedness of Life

As we've seen, all living things rely on energy to stay alive. Those that are producers use the sun's energy. Consumers use energy from producers or other consumers. Lastly, decomposers use the energy left in any dead organism. How does this energy do all this? One way of looking at living organisms is to study how energy connects them to other organisms.

All Living Things Rely on Energy

producers	*use the sun's energy*
consumers	*use energy from producers or other consumers*
decomposers	*use the energy left in any dead organism*

The energy that connects the smallest bacteria with you originates in the sun. If we follow all the energy produced by the sun, we find only a small part of it reaches Earth. Much of the energy arrives as light; much of it arrives as heat. Producers use the light energy in photosynthesis. Although algae and plants use this energy, most of the energy from the sun is not used by producers. Where did the remaining energy go?

Living systems—that is, any groups of producers, consumers, and decomposers—obey all physical laws of science. One of these laws states that no matter what happens, we neither destroy or create matter or energy. So, now we know that the sun's energy has not been destroyed. Again we wonder where the energy went. The answer to our question is this: The energy has been changed to heat, another form of energy. Let's see what happens to the energy used by a producer.

A producer that is fairly common is grass. Grass takes a small part of the sun's light energy and makes sugars. The sugars are then consumed by any number of organisms. If a cow happens to be the consumer, the cow will only make use of a small part of the energy. Again, the rest of the energy will become heat. With so much energy being lost as heat, there are some interesting results.

One result is that organisms are very good at finding unused or seldom used sources of energy. This results in a high number of different organisms living together. Consider the example of cows and grass. In reality, many organisms besides the cow and the grass would live together. When a cow eats grass, not all the energy or material in the grass is used by the cow. Some energy is left over. It may be found in the manure produced by the cow. In this case, dung beetles may make use of this energy. Once the dung beetle has finished with the manure, there still may be material useful to some organisms. For instance, minerals may soak back into the ground and promote the growth of new grass or other plants. Alternatively, the cow may spread manure in an area the grass did not grow. Seeds from the grass may sprout and increase the amount of grass in the area.

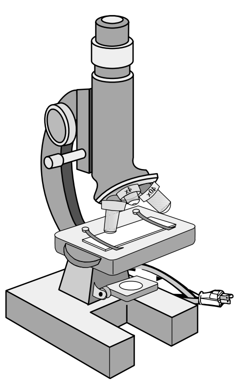
It's easy to see how the cow relies on the grass in its area, but now we see more. We see that the grass relies on the cow (and the dung beetle and other organisms) in order to survive and spread. Such connections are known as interdependence. The interdependence is based on the need for energy, and the result is a high variety of organisms. You've already seen this in our look at the different kingdoms. Later sections of this book will seek to further develop your knowledge of the diversity, complexity, similarities, and interconnectedness of organisms.

Summary

Throughout history, people have identified and named the living things around them. In 1735 the scientist Linnaeus invented a system of classification which is the basis by which we group all living things. The system places all living things in certain categories according to the traits they have. According to this system, each type of organism is identified by its genus and species name. These form its scientific name.

The largest-scale division of living things is division by kingdom. There are five kingdoms of living things: plants, fungi, animals, protists, and monera. Viruses, which are different from living things because they are not made of cells, have not been classified within any kingdom.

All living things share a common set of traits. Within this common pool there is a great diversity and interconnectedness of life. These result from the flow of energy from producers to consumers and to decomposers. Energy and matter are not destroyed in these changes, but energy is lost as unusable heat. A knowledge of the flow of energy is essential to all sciences.



Careers in Biology

Biology Teacher

Biology teachers help students understand important scientific concepts. These concepts relate to biology and science in general, and teachers help students see what relations these concepts have to our lives. Biology teachers prepare for their position by completing the work to earn a bachelor's degree from a college or university. Further, a teacher must be certified by the state in order to actually teach. Florida currently needs science teachers.

Practice

Use other reference materials to complete the chart below. Choose one **organism** *for each of the* **five kingdoms of classification***. Write the names of the* **organisms** *and the names of the* **subgroups** *to which they belong.*

Systems of Classification					
	Organism's Common Name				
Group					
Kingdom	**Plant**	**Animal**	**Fungi**	**Protist**	**Monera**
Phylum					
Class					
Order					
Family					
Genus					
Species					

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

antiseptics	**five**	**interdependence**	**scientific**
common	**freezing**	**kingdom**	**species**
consumers	**genus**	**Linnaeus**	**structural**
decomposers	**heat**	**none**	**vaccines**
diversity	**heating**	**physical**	**viruses**
energy	**HIV virus**	**producers**	

1. A scientist named ________________________ invented the system of classification.

2. The most general grouping in the system of classification is the ________________________ .

3. There are ________________________ kingdoms in the system of classification.

4. The most specific grouping in the system of classification is the ________________________ .

5. One way to group organisms is based on ________________________ characteristics.

6. Organisms have both a ________________________ name and a ________________________ name used by biologists around the world.

7. The scientific name of an organism includes the __________________ and the ________________________ names.

8. ________________________ are infectious agents that reproduce in living cells and have not been classified within any kingdom.

9. The ___________________________ causes AIDS.

10. Scientists have developed ___________________________ to protect us against some viruses.

11. People can control bacteria in food by ___________________________ or by ___________________________ it.

12. We use preparations called ___________________________ to protect our cuts and injuries from infection by bacteria.

13. Because all organisms need ___________________________ to survive, an understanding of energy is essential to biologists and other scientists.

14. Whenever energy or matter is changed, ______________________ is lost.

15. The flow or transfer of energy in living systems takes place between ___________________________ , ___________________________ , and ___________________________ .

16. Whenever energy transfers from one organism to another, none is destroyed but some becomes ___________________________ .

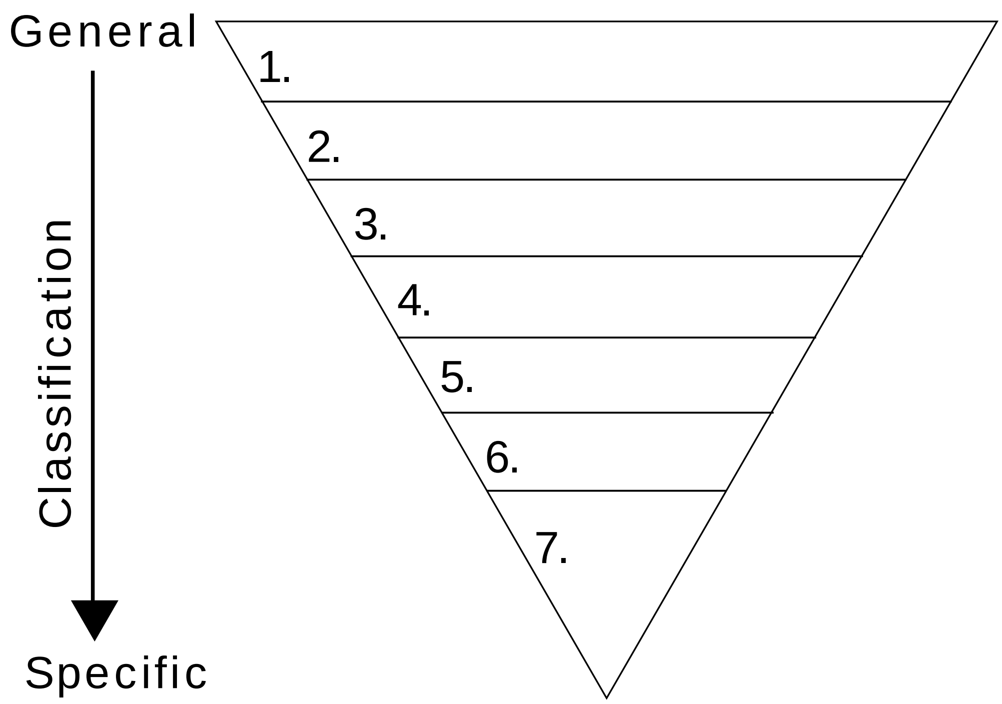
17. Biological systems obey all ____________________ laws of science.

18. The transfer of energy from organisms to others has led to a great ___________________________ and ___________________________ of organisms.

Practice

Use the list below to name each **division** *in the system of classification in* **order of size**. *Begin with the most general division.*

species	**order**	**kingdom**
class	**phylum**	**family**
genus		



Practice

Use pages 45-49 to list the five major groups or **kingdoms of living things** *on the lines below. Give one example of each kingdom and list its characteristics.*

System of Classification		
Kingdom	**Example**	**Characteristics**

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. more than one cell; has cell nucleus; stationary; consumers and decomposers

______ 2. one individual living thing

______ 3. are consumers; can move about; are made of many cells

______ 4. living things that eat dead organisms to survive

______ 5. microscopic; single-celled; no cell nucleus; consumers

______ 6. are producers; are stationary; are made of many cells

______ 7. organisms that can make their own food through photosynthesis

______ 8. microscopic; single-celled; no cell nucleus; producers

______ 9. microscopic; single-celled; has a cell nucleus; found in pond water

______ 10. organisms that must eat living organisms to survive

A. animal

B. bacteria

C. blue-green bacteria

D. consumer

E. decomposer

F. fungi

G. organism

H. plant

I. producer

J. protists

Lab Activity: Classification of Living Things

Facts:

- Scientists divide living things into groups.
- These groups, from larger to smaller, are as follows: kingdom, phylum, class, order, family, genus, species.
- The more similar two living things are, the more groups they share.

Investigate:

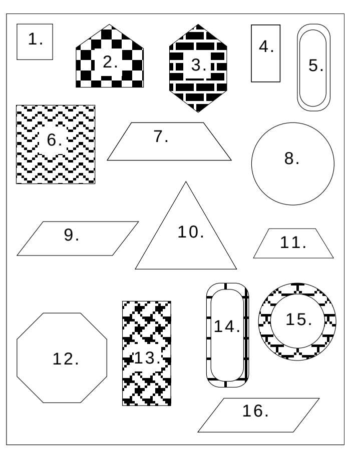
- You will group paper objects.
- You will use the words *kingdom*, *phylum*, and *class* in your classification.
- You will decide what traits were used in the classification.

Materials:

- copy of paper objects
- scissors

1. Get a copy of the paper objects in the figure below from your teacher.

2. Cut out the objects as shown.



3. Place the objects on your desk. Divide them into the two groups described below. Write a descriptive kingdom name for each group in the following chart.

    a. Put objects 1, 4, 6, 7, 9, 11, 13, and 16 into one group. These will represent the classification level of one kingdom.

    b. Put objects 2, 3, 5, 8, 10, 12, 14, and 15 into a second group. These will represent a second kingdom.

Classifying Objects

	Group	Group Name
Kingdom	1, 4, 6, 7, 9, 11, 13, 16	
	2, 3, 5, 8, 10, 12, 14, 15	
Phylum	1, 4, 11, 16	
	6, 7, 9, 13	
	2, 3, 10, 12	
	5, 8, 14, 15	
Class	1, 4	
	11, 16	
	2, 3	
	10, 12	
	6, 13	
	7, 9	
	14, 15	
	5, 8	

4. Divide the objects from the *first* kingdom only as follows. Put objects 1, 4, 11, and 16 into one group. Put objects 6, 7, 9, and 13 into a second group. This represents the next classification level called *phylum*. Write a descriptive phylum name for each group in the chart.

5. Divide the objects from the second kingdom in this way. Put objects 2, 3, 10, and 12 into one group. Put objects 5, 8, 14, and 15 into a second group. Write a descriptive phylum name for each in the chart.

6. Use objects 1, 4, 11, and 16. Separate them into two groups as follows. Put objects 1 and 4 into one group and objects 11 and 16 into a second group. This represents the next classification called *class*. Write the classification level and group names in the chart.

7. Separate out objects 2, 3, 10, and 12. Then group them into two groups. Write the objects' classification level and group names in the chart.

8. Repeat Step 7 for objects 6, 7, 9, and 13. Complete the chart. Repeat Step 7 for objects 5, 8, 14, and 15. Complete the chart.

9. What traits do objects 1, 4, 6, 7, 9, 11, 13, and 16 have in common?

____

____

10. What traits do objects 2, 3, 5, 8, 10, 12, 14, and 15 have in common?

____

____

11. What trait was used to separate the groups with objects 1, 4, 11, and 16, and objects 6, 7, 9, and 13?

____

____

12. What trait was used to separate the groups with objects 2, 3, 10, and 12, and objects 5, 8, 14, and 15?

13. What trait was used to separate the groups with objects 1 and 4 and objects 11 and 16?

14. What traits did you use to separate objects 2, 3, 10, and 12 into two groups?

15. Underline the correct word choice in each of these sentences:

    Objects in the same class also belong to the same (phylum, genus, family).

    Objects in the same phylum also belong to the same (family, order, kingdom).

16. List the classification levels in order from largest to smallest.

17. Classifications are not all alike. Suppose objects 5, 14, and 15 were put in one group. What trait do they have in common?

18. Create a name for each of the groups below.

Objects 1 and 4: ______________________________________

Objects 2 and 3: ______________________________________

Objects 10 and 12: ____________________________________

Objects 8 and 15: _____________________________________

19. What traits are used to determine if living things belong to a particular group?

____

____

____

20. How are compact discs (CDs) and audiocassettes classified in a music store?

____

____

____

21. How are athletic teams grouped? ________________________

____

____

22. What are two reasons for classifying things? _______________

____

____

____

____

Practice

Use the list below to write the correct term for each definition on the line provided.

animal	**fungus**	**producers**
bacteria	**Linneaus**	**protist**
classification	**plant**	**virus**
consumers		

________________________ 1. a type of organism that is a consumer; can move about to get food; has more than one cell

________________________ 2. single-celled organisms that have no cell nucleus; most are consumers; share monera kingdom with blue-green bacteria

________________________ 3. a plantlike type of organism that is a consumer or decomposer; does not move from place to place; has more than one cell

________________________ 4. a scientist of the 1700s who started the system of plant and animal classification we use today

________________________ 5. a single-celled organism that does have a cell nucleus

________________________ 6. a type of organism that is a producer; does not move from place to place; has more than one cell

________________________ 7. an extremely small infectious agent that only reproduces in living cells

________________________ 8. a way to group things together based on likenesses

________________________ 9. organisms that can produce their own food through photosynthesis

________________________ 10. organisms that must eat other living things to survive

Practice

Use the list below to write the correct term for each definition on the line provided.

blue-green bacteria	**decomposers**	**organism**
chlorophyll	**kingdom**	**photosynthesis**
common name	**monera**	**species**

____________________ 1. single-celled organisms that have no cell nucleus; are producers; share their kingdom with bacteria

____________________ 2. the English name given to a familiar animal or plant; not as precise as the scientific name

____________________ 3. the most precise grouping for an organism

____________________ 4. a green pigment that plants and algae use to make food through photosynthesis

____________________ 5. a large-scale division of all living things

____________________ 6. the process plants and algae use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight

____________________ 7. the kingdom of organisms that are microscopic, single-celled, and have no cell nucleus

____________________ 8. living things that eat dead organisms to survive

____________________ 9. one individual living thing

Unit 3: The Cell—The Basic Unit of Life

Vocabulary

Study the vocabulary words and definitions below.

biochemical .... describing those chemical reactions among substances that are specifically involved in life

cell .... the basic unit of life

cell membrane .... a thin outer covering that surrounds the cell and allows molecules to pass into and out of the cell

cellulose .... the fibrous material of cell walls which helps support plants

cell wall .... a hard wall in a plant cell that helps support and protect the cell

chloroplast .... the many green bodies in plant cells where photosynthesis takes place

chromosome .... a twisted and coiled strand of DNA within the nucleus that carries the codes for reproductive traits such as eye and hair color

cytoplasm .... a jellylike, living substance inside the cell membrane but outside the nucleus

DNA .... the strands of genetic material that determine traits of daughter cells (DNA stands for deoxyribonucleic acid)

eukaryotes .... a type of cell that has a clearly defined nucleus with a nuclear membrane as well as organelles—this group includes most cells

Golgi bodies .... organelles that store the chemicals synthesized by ribosomes

membrane .... any thin covering or part used to divide one area of a cell from another; certain substances can cross certain membranes

mitochondria .... organelles that break down food to get energy; sometimes called the "powerhouse" of the cell; (*sing.* mitochondrion)

nuclear membrane .... a thin wall or covering (membrane) that surrounds the nucleus

nucleus .... the control center of the cell; that part of the cell that holds the chromosomes and DNA used for controlling cell activities like reproduction, synthesis, and metabolism (*pl*. nuclei)

organelle .... a cell structure that carries out a specific function for the cell, much like the organs (heart, liver, etc.) that carry out specific functions for human beings

photosynthesis .... the process plants and algae use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight

prokaryotes .... a type of cell that doesn't have a clearly defined nucleus with a nuclear membrane or organelles—this group includes bacteria and certain types of blue-green bacteria

ribosome .... an organelle where other molecules are taken and new molecules are synthesized into proteins

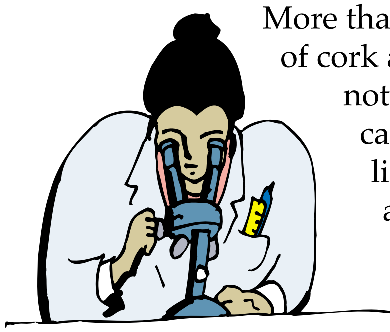
synthesis .... using substances to chemically form new substances

vacuole .... an organelle that stores food or water in the cytoplasm

Introduction

Too tiny for us to see well without a microscope, **cells** are the basic unit of all living things. Though it may be hard to imagine, these little structures constantly carry out all the work necessary for life. They break down food for energy, get rid of garbage, and send messages to each other. And they do all these things chemically. All of the complex work of life is based on the chemical processes that go on in cells.

The Cell Theory



More than 300 years ago, scientists looking at thin slices of cork and other material through microscopes noticed that the material was made of tiny, regular cavities similar to a honeycomb. Because these little cavities were similar to the small rooms in a monastery, the cavities were called cells. Over the next few centuries, scientists continued to develop their idea of what a cell is. Over time, they developed the cell theory.

The cell theory states the following:

- All living things are made of cells.
- The cell is the smallest unit of structure and function of all living things. The cell carries out the processes that are characteristic of all living things.
- Cells are produced only by other cells.

Cell Functions: The Processes That Keep Us Alive

Cells are very busy places. Each cell is a seething laboratory of chemical reactions. All of these chemical reactions are related to each other. The products of one reaction provide the building blocks for the next. All of these reactions are governed by **biochemical** principles. Biochemical principles are those that regulate the way chemicals behave in living organisms. All of these principles are dedicated to one mission: keeping that cell alive. That takes energy. Many cell processes involve taking in and breaking down energy. Again, we see how knowledge of energy is fundamental to all sciences.

Besides those reactions that are devoted to transferring energy, there are lots of other things going on in a cell. As we discussed in the last unit, every living organism must carry out basic functions that are characteristic of all living things. It is these functions that are regulated by the principle of biochemistry. The cell functions and examples are listed below:

Nutrition: Food molecules supply both energy and building materials in cells. Some cells make their own food molecules and others take them in from their environment.
A candy bar becomes energy for a runner.
We fertilize our houseplants regularly.

Digestion: Foods must be broken down into simpler chemicals so that the cell can use them.
A dinner roll becomes sugar if held in your mouth a minute or two.
Yeasts change the taste of flour by partially digesting it.

Absorption: A cell takes in water, food molecules, and other materials from the environment.
The roots of plants take in water.
People who suffer from motion sickness may wear a skin patch from which they absorb medicine to prevent the sickness.

Biosynthesis: Cells make many of the complex materials they need from smaller chemical building blocks they get from their environment.
Plants use carbon dioxide and water to make sugar.
Animals use nutrients to make cell materials.

Respiration: In a cell, the step-by-step breakdown of a food molecule releases energy. In most cells, oxygen is used in this process. The gas

carbon dioxide is usually produced during this process.
Football players must sometimes be given oxygen on the sidelines.
Algae growing in the lake use up the oxygen needed by the fish.

Excretion: During respiration, yeasts give off carbon dioxide and alcohol as by-products. They do not use oxygen. Waste materials pass from inside the cells out into the environment.
Many coastal plants excrete excess salt.
Bread rises and gets fluffy when yeasts excrete carbon dioxide.

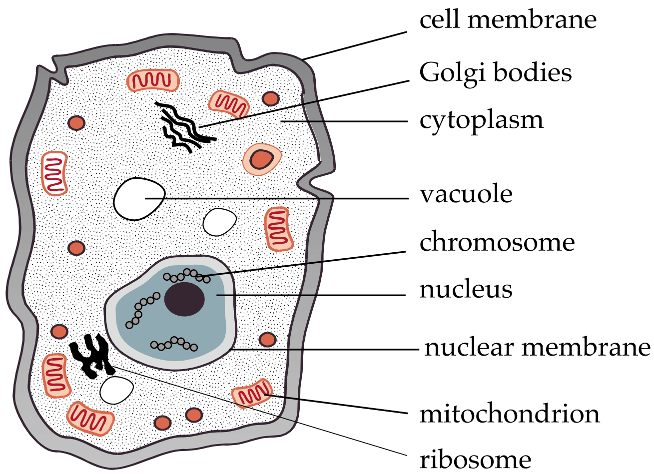
Secretion: Similar to excretion, except in this case the cell passes useful substances, such as vitamins and hormones, into the environment to affect other cells.
The pancreas produces insulin that goes into the blood.
Moths release chemicals (pheromones) into the air which signal other moths that they are ready to mate.

Response: Cell activities change according to influences from outside the cell, such as heat, light, pressure, or chemicals.
Facing the sun may cause you to shield your eyes from the light.
Certain fungi prevent the growth of bacteria by releasing growth-inhibiting chemicals called antibiotics.

Reproduction: Cells multiply in an orderly fashion.
The cat had a litter of kittens.
Acorns produce oak trees.

Cell Structure: The Right Tool to Get the Job Done

Most cells are divided into three parts: the **nucleus**, or the control center; the **cell membrane**, the outer covering of the cell; and the **cytoplasm**, a jellylike substance between the nucleus and the cell membrane. Within the cytoplasm are many **organelles** such as **vacuoles**, the **Golgi bodies**, the **ribosomes**, and **mitochondria**. It is difficult to produce an exact model of a typical cell because there is no typical cell. Each cell is built to accomplish particular tasks.



Typical Animal Cell

Of course, there are broad categories of cells. There are **prokaryotes**—certain bacteria whose nuclei don't have a nuclear membrane. Prokaryotes also lack many of the cell structures that more complex cells have. These more complex cells, which include most cells, are called **eukaryotes**.

Plant cells and animal cells are similar but do have some differences. Plant cells make their own food from light—they *photosynthesize*. The plant cells have some organelles specialized for **photosynthesis** that animal cells don't have.

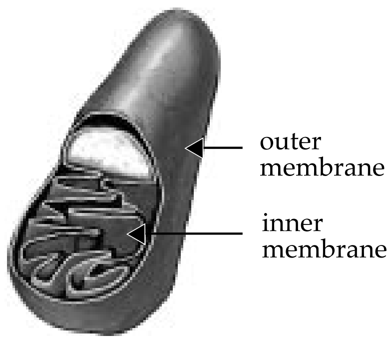
Cell Membranes

The cell membrane separates a cell from other cells and from surrounding fluids. Another **membrane**, the **nuclear membrane,** surrounds the nucleus. These membranes only let certain molecules pass through. This means they are *selectively permeable*—only certain substances can permeate, or soak through, these membranes.

The Organelles

The organelles are cell structures that do various jobs in the cells, much as human organs such as the heart, the liver, or the kidneys carry out different jobs for humans. In a sense, the organelles are "little organs."

Each organelle takes part in a specific chemical activity. These organelles have membranes. It is at the membranes, in fact, that the organelle does its work.



Cutaway of a Mitochondrion

One of the most important jobs for a cell is respiration. Most respiration occurs in the organelle known as the mitochondrion. The mitochondrion actually has two layers of membranes. The inner membrane is folded back and forth many times. The food molecules of the cell come to this membrane and are converted to energy for the cell.

Although we speak of molecules being converted to energy, we must remember that living systems obey physical laws. This means that although the cell produces energy, it must still contend with the leftover molecules. These are often called wastes. Some molecules that are left over are used for other purposes. The cell organelle known as the ribosome is on a membrane. At the ribosome, other molecules are taken and new molecules are synthesized. Again, it is the membrane that allows for energy conversion or chemical **synthesis**.

After these chemicals have been synthesized, they must be stored. Golgi bodies are organelles made of membranes that have been folded into many flat disks. Within the folds, the chemicals synthesized by ribosomes are stored. Besides the chemicals a cell makes, it often stores food and water. The food is usually stored as sugar. Another organelle in the cytoplasm, the vacuole, stores water or sugar.

The Nucleus

The nucleus is the control center of the cell that holds the **chromosomes**. At most times chromosomes are difficult to identify or discern. The nucleus sends out chemical messages to other parts of the cell that tell them what to do. It also controls cell reproduction. When it is time to reproduce, the chromosomes become obvious inside the nucleus. These rod-shaped, twisted, and coiled structures of **DNA** are made of protein. They carry codes that pass on traits from the parent cell to daughter cells. We will look more closely at the functions of proteins and the process of reproduction in Unit 4.

The Cytoplasm

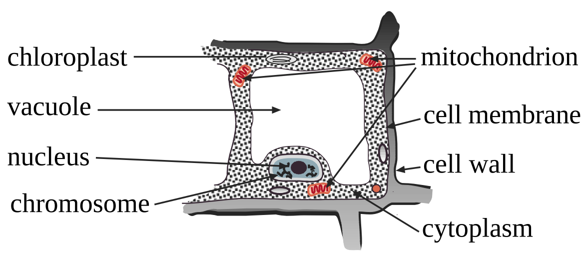
The cytoplasm is the fluid that fills most of the cell. This jellylike fluid provides a substance in which the organelles can float. It also allows the organelles to send chemical messages to one another.

Special Features of Plant Cells

Chloroplasts

The **chloroplast** is a very important cell structure that gives plants the ability to carry out photosynthesis. Chloroplasts make sugars from sunlight, water, and the gas carbon dioxide.

Shaped like a microscopic pea pod, the chloroplast is a photosynthesis factory. It contains the green-colored chemical chlorophyll, which traps the sunlight needed to begin the process of photosynthesis, or sugar making. The chloroplast also contains enzymes, special chemicals that make chemical reactions happen faster and more efficiently.



Typical Plant Cell

As you might expect, many, many chloroplasts are present in leaves, where most photosynthesis takes place. As with mitochondria that turn sugar into energy, chloroplasts are made of membranes. It is at these membranes that energy is used to make the glucose.

Cell Wall

Both plant and animal cells have a plasma membrane bordering their cytoplasm, but plant cells also have a **cell wall**. This is a hard wall made of **cellulose** that separates plant cells from each other.

Depending on the function of a particular plant cell, its cell walls may be thick or thin. For example, the cell walls in leaf cells are pretty flexible. But the cell walls in the stems of plants are thicker and more rigid because they must support the plant.

Part of the cell wall may remain even after plants are long dead. Wood, for instance, is made up of millions of interlocked cell walls. Cork, the substance in which cells were first observed, is made up of the cell walls of dead cells.

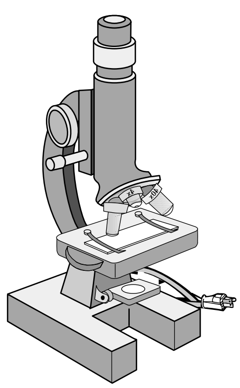
Summary

The cell, so tiny that it is usually invisible to the unaided human eye, is the unit from which all life is built. This idea is stated very clearly in cell theory. Cells carry out all the functions, or work, that living things must do to survive.

Simple cells called *prokaryotes* do not have a cell nucleus or special cell structures, called organelles. More complex cells called *eukaryotes* do have organelles and a nucleus. Most cells are eukaryotes. Eukaryotes also have cytoplasm and a plasma membrane. Plant cells are eukaryotes and have chloroplasts and cell walls.

Membranes are the sites for energy conversion and chemical synthesis. These biochemical reactions are essential for life. The behavior of these reactions is controlled by biochemical principles. The reactions are influenced by molecules from within the organism and from without. Because cells follow all physical laws of energy and matter, it is vital for biologists and others to have a knowledge of energy.

Careers in Biology



Medical Writer

Medical writers keep the public informed of advances and changes in medical knowledge. To do this, they must gather information from such sources as libraries, technical journals, and interviews with scientists and doctors. Some medical writers work on a free-lance basis while others may be employed by newspapers, magazines, or others. To prepare for a career as a medical writer, you should plan on attending college and earning a bachelor's degree in either journalism or the sciences.

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

_________ 1. Most cells are visible to the unaided eye.

_________ 2. The cell carries out all the necessary functions for survival.

_________ 3. Prokaryotes are unique because they have no nucleus.

_________ 4. Eukaryotes are complex cells with organelles but with no nucleus.

_________ 5. Cells have cytoplasm.

_________ 6. The cell membrane prevents some chemicals from entering the cell.

_________ 7. Almost all living things are made of cells.

_________ 8. An organelle called the vacuole breaks down food for energy.

_________ 9. Plants need chloroplasts for photosynthesis.

_________ 10. Animal cells have a cell wall instead of a cell membrane.

_________ 11. The structure that does the work in the cells is the cytoplasm.

_________ 12. The fluid that fills most of the cell is the nucleus.

__________ 13. Unlike physical systems, cells can create and destroy energy.

__________ 14. Organelles perform most of the work in a cell.

__________ 15. A ribosome is a membrane but not an organelle.

__________ 16. Chemical synthesis and energy conversions take place along membranes.

__________ 17. Cells are not affected by chemicals from other organisms.

__________ 18. The chemical reactions that make life possible are controlled by biochemical properties.

__________ 19. Mitochondria are organelles that are responsible for most respiration.

__________ 20. Unlike other scientists, biologists do not need any knowledge of energy.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. A cell takes in water, food molecules, and other materials from the environment.

______ 2. Cell activities change according to influences from outside the cell, such as heat, light, pressure, or chemicals.

______ 3. Cells manufacture, or synthesize, many of the complex materials they need from smaller chemical building blocks they take in from their environment.

______ 4. Cells multiply in an orderly fashion.

______ 5. Food molecules supply both energy and building materials in cells.

______ 6. In a cell, the step-by-step breakdown of a food molecule releases energy.

______ 7. Most foods must be broken down into simpler chemicals so that the cell can use them.

______ 8. Similar to excretion, except in this case the cell passes useful substances, such as vitamins and hormones, into the environment to affect other cells.

______ 9. The cells pass waste materials from inside the cells out into the environment.

A. absorption

B. biosynthesis

C. digestion

D. excretion

E. nutrition

F. respiration

G. response

H. reproduction

I. secretion

Lab Activity 1: Getting Used to the Microscope

Facts:

- The microscope has a set of lenses that work together to magnify what you see. By learning to prepare and view a slide, you increase your powers of observation.
- All living things are made of cells. By magnifying parts of plants, you can see their cells.

Investigate:

- You will cut the letter "e" from the classified ads and prepare it as a wet mount. Then you will view it through your microscope.
- You will prepare plant specimens as wet mounts and observe their cells.

Materials:

- microscope
- pieces of onionskin
- microscope slides
- scissors
- eyedropper
- cover slip
- the classified section of the newspaper
- leaves of the water plant *Elodea* (Anacharis)

1. Watch your teacher demonstrate how to carry a microscope and place it on a solid surface. Your microscope will have a light source to direct the light on the specimen. Adjust the light until you see a bright circle of light.

2. Find a small letter "e" in the classified section of the newspaper and cut it out.

3. Place the letter "e" on the slide, and then add a drop of water over it. Make sure the "e" is right-side up.

4. Take your cover slip and position it on one edge next to the drop of water containing the letter "e." Next, gently lower the top edge of the cover slip and finally drop it flat against the slide.

5. Use the coarse adjustment knob (large knob) to lower the low-power objective lens (marked 4X) all the way down.

6. Place the slide on the stage of the microscope. Center it so that the light passes through it.

7. Look through the eyepiece at the top of the microscope. Use the large knob to raise the tube slowly until you see something. Move the slide until the specimen is where you can see it best. It should just about fill your field of view.

8. Finish focusing with the fine adjustment knob (small knob).

9. If you cannot see it, go back to No. 5 and start again.

10. Slightly move the "e" to left, right, up, and down.

11. In the space below, sketch what the letter "e" looks like under the microscope.

12. What was the position of the "e"? ______________________________

13. Describe how the "e" moves when you move it to the right. _______

____

Looking at Cells under the Microscope

1. Snip or tear off a small piece of *Elodea* and the thin skin from between an onion's layers. Place each one on a separate slide and put a drop of iodine on the specimen. Prepare each separately as a wet mount.

2. Study each specimen, one at a time, under the microscope. Adjust the microscope until you feel you have the best view possible of your specimen.

3. Draw what the cells look like in each specimen:

   a. *Elodea*:

   b. onionskin:

4. Check the cell structures below that you can see in either specimen.

	onionskin	*Elodea*
a. cell walls:	________________	________________
b. the nucleus:	________________	________________
c. the cytoplasm:	________________	________________
d. chloroplasts:	________________	________________

Lab Activity 2: The Living Cell

Facts:

- The cell membrane is a barrier that allows only certain substances to soak through or permeate. It is "selectively permeable."
- *Selective permeability* allows the cell membrane to control what enters and leaves the inside of the cell.

Investigate:

- You will design a model of a cell.
- You will see which substances can pass through its cell membrane and which cannot.

Materials:

- a sealed, numbered jar partly filled with a substance prepared by your teacher
- one resealable, plastic bag
- gelatin solution prepared by your teacher
- one marble

1. The class will be divided into groups. Each group will have a number. Label your jar with your group number.

2. Decide with your group who will be the following: a) the equipment manager; b) the recorder; c) the reporter, who will report to the class; and d) the director, who will make sure that the group follows all directions for this lab activity.

3. Discuss with your group how you could put the plastic bag, marble, and gelatin together to make a model of a cell. The model should include a nucleus, cytoplasm, and a cell membrane. The recorder for the group will record ideas and decide which plan to follow in building the cell model. The recorder will also make a drawing of the proposed cell model and label the cell parts.

4. Now make your cell model.

5. What does your cell model look like? ____________________

____

____

6. What kind of cell does your model represent? ______________

____

____

7. Now your director will place the bag in the jar partly filled with the substance prepared by your teacher. Be sure you replace the lid and number the jar with your group number. What do you think will happen inside the cell…

   by the end of the class period? ______________________

   ____

   after 24 hours? ________________________________

   ____

   after 48 hours? ________________________________

   ____

8. What actually does happen inside the jar…

   by the end of the class period? ______________________

   after 24 hours? ________________________________

   ____

   after 48 hours? ________________________________

   ____

9. Discuss the results with your group members and your class.

Practice

Use the list below to write the correct term for each definition on the line provided.

biochemical	**cytoplasm**	**organelle**
cell	**eukaryote**	**photosynthesis**
cell membrane	**membrane**	**prokaryote**
chloroplasts	**mitochondrion**	**synthesis**
chromosome	**nucleus**	**vacuole**

______________________ 1. a cell structure that carries out a specific function for the cell, much like the organs (heart, liver, etc.) that carry out specific functions for human beings

______________________ 2. a jellylike, living substance inside the cell membrane but outside the nucleus

______________________ 3. a thin outer covering that allows chemicals to pass into and out of the cell

______________________ 4. a type of cell that doesn't have a clearly defined nucleus with a nuclear membrane or organelles; includes bacteria and blue-green bacteria

______________________ 5. a type of cell that has a clearly defined nucleus with a nuclear membrane and organelles; includes most cells

______________________ 6. an organelle that stores food or water in the cytoplasm

______________________ 7. an organelle that breaks down food to get energy; sometimes called the "powerhouse" of the cell

_________________________ 8. using substances to chemically form new substances

_________________________ 9. a twisted and coiled strand of DNA within the nucleus that carries the codes for genetic traits such as eye and hair color

_________________________ 10. the basic unit of which all living things are made

_________________________ 11. the many green bodies in plant cells where photosynthesis takes place

_________________________ 12. the process plants and algae use to make the sugar glucose from water, carbon dioxide, and the energy from sunlight

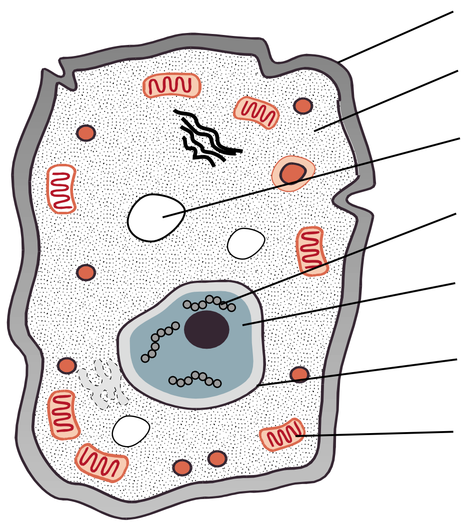
_________________________ 13. the control center of the cell, that part of the cell that holds the chromosomes and DNA needed for controlling cell activities like reproduction, synthesis, and metabolism

_________________________ 14. describing those chemical reactions among substances that are specifically involved in life

_________________________ 15. any thin covering or part used to divide one area of a cell from another; certain substances can cross certain membranes

Practice

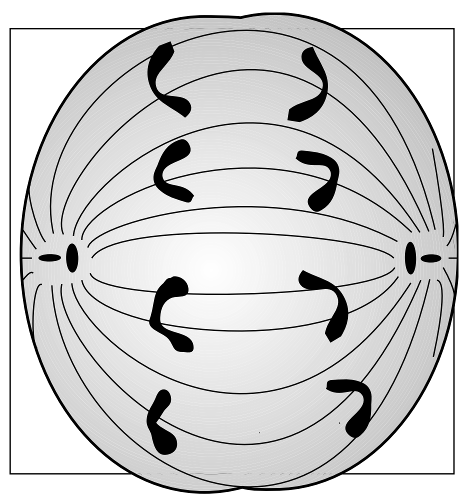
Use the list below to write the correct part of the typical **animal cell** *on the line provided.*

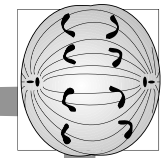


1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

Typical Animal Cell

Unit 4: Cell Growth and Reproduction





Vocabulary

Study the vocabulary words and definitions below.

asexual reproduction .... the creation of a new cell or organism identical to the parent; does not involve the union of sex cells

centriole .... a cell part that organizes the web along which chromosomes move during cell division

chromosome .... a twisted and coiled strand of DNA within the nucleus that carries the codes for reproductive traits such as eye and hair color

cytoplasm .... a jellylike, living substance inside the cell membrane but outside the nucleus

daughter cell .... one of two new cells created when a parent cell divides through mitosis

DNA .... the strands of genetic material that determine traits of daughter cells (DNA stands for deoxyribonucleic acid)

egg .... the sex cell produced by the female

fertilization .... the union of a male sex cell (a sperm) and a female sex cell (an egg)

gene .... a unit of DNA that determines a specific hereditary trait in an organism; genes come in pairs

genetic .... refers to any trait or material that determines characteristics passed on from the parent(s) to the offspring

meiosis .... cell division that results in the formation of four sex cells, each of which has half the number of chromosomes as the parent cell

mitosis .... cell division in which two cells, with the same number of chromosomes identical to the parent, are produced from one cell

nuclear membrane .... a thin wall or covering (membrane) that surrounds the nucleus of the cell

nucleus .... the control center of the cells; that part of the cell that holds the chromosomes and DNA used for controlling all cell activities like reproduction, synthesis, and metabolism (*pl.* nuclei)

parent cell .... the original cell that produces new cells through mitosis or meiosis

protein .... a group of molecules used as both building materials for cell growth and as a control factor for cell behavior

reproduction .... the process through which organisms produce offspring; creation of a new individual

sexual reproduction .... the creation of a new organism through the union of an egg and a sperm

sperm .... the sex cell produced by the male

tetrad .... a group of four chromosomes that takes part in meiosis

Introduction

Believe it or not, you began life as one *cell*. Now your body is made of more than 100 trillion cells. What happened between these two points in time? Cell growth and **reproduction**—that's the answer, and that's what this unit is about.

There are two kinds of cell reproduction: **meiosis** and **mitosis**. Both played a part in your existence. Meiosis results in the formation of sex cells, **eggs** and **sperm**, and two of these sex cells united to make your first cell. Mitosis leads to the production of exact copies of the **parent cell**. Your body has grown bigger thanks largely to mitosis.

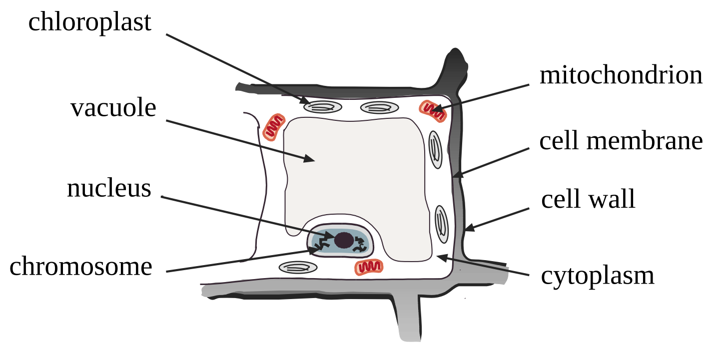
Cell Growth and Cell Division

Cells may fill more space by growing in size or number. For example, the number of cells may stay the same and each cell may just enlarge. Each cell makes more **cytoplasm** and more cell membrane to hold the cytoplasm. But eventually, as a cell enlarges, there's just too much cytoplasm to bring in nutrients from and excrete wastes to the outside world through the limited cell membrane area. This means that the cell volume becomes too large for the cell surface area. Also, the **nucleus**—the cell's control center—has a hard time directing cell activities when the cell grows past a certain point. That's why most cells in most organisms, be they elephants or mice, are about the same size.

How, then, do creatures grow bigger? As we said above, cells may also fill more space by growing in number. Cell number can increase through a process of cell division called mitosis. Each parent cell divides to become two identical **daughter cells**, and these daughter cells each divide into two more daughter cells, and so on and so on.

Besides using cell reproduction to increase the size of their bodies, organisms also count on cell reproduction for repairs to their bodies. If you burn the roof of your mouth on a bite of hot pizza, for example, the burned cells are quickly replaced by new ones. These new cells are produced through mitosis. Starfish have the ability to grow a whole new arm this way.

Some organisms grow whole new individuals simply through the process of cell division by mitosis. When an organism reproduces by generating exact copies of its own cells, which then become separate individuals, this process is called **asexual reproduction**. Asexual reproduction means that the new organism was not created by the union of sex cells.

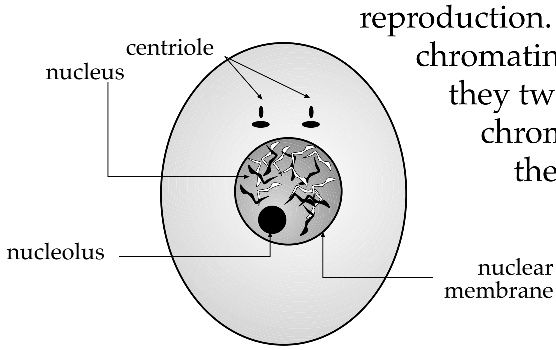


Plants provide many common examples of cell division through mitosis or asexual reproduction. One example is plants that reproduce by budding. A common house plant, the spider plant, creates miniature plants at the end of its stems. When they fall off, they become individual plants. Also, gardeners often create new individual plants by taking a part of a plant, say a root or a leaf, to begin another plant. Even some animals, such as sponges, can reproduce in this manner.

The Stages of Mitosis

Stage One: Resting—Before Mitosis Begins (Interphase)

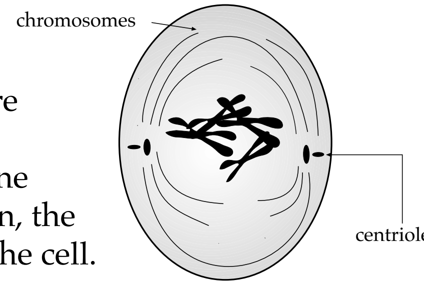
This is the in-between stage, the stage after the cell has been formed and before it divides to make two cells. Many parts of the cell are visible: the nucleus, the **nuclear membrane**, and some important cell division equipment called the **centrioles**. Centrioles help organize the cell during reproduction. Inside the nucleus are the chromatin which are **DNA** strands before they twist into **chromosomes**. The chromosomes are made up of DNA or the material that will determine the traits of the daughter cells. The chromosomes are using the resting stage to make exact copies of themselves. During this stage, the chromosome number doubles, in preparation for cell division.



Stage One—First Step (Early Prophase)

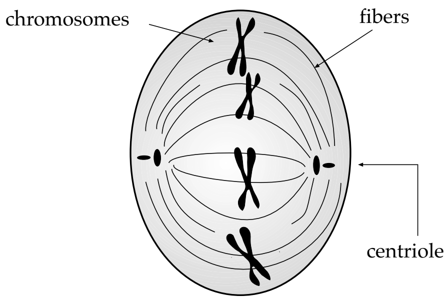
Stage Two: Mitosis Begins (Prophase)

The first sign that mitosis is beginning appears in the nucleus: the chromosomes are thicker, shorter, and easier to see. As they become more obvious, the nuclear membrane disappears. As you can see in the illustration, the centrioles have moved to opposite ends of the cell.



Stage 2 (Prophase)

Stage Three: Mitosis Continues (Metaphase)

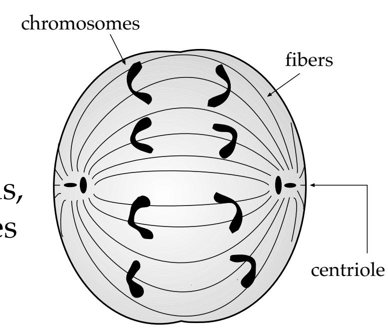


Stage 3 (Metaphase)

The nuclear membrane is now totally gone. The process for mitosis now takes up the whole cell. The spider-like centrioles, each at the opposite ends of the cell, now begin to send out fibers. These fibers make a sort of web that attaches to the chromosomes and arranges them along the middle or equator of the cell.

Stage Four: Mitosis Is Almost Finished (Anaphase)

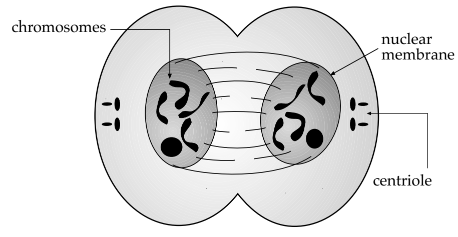
The doubled chromosomes begin to separate, each original and its copy pulling away from each other. They move in opposite directions along the fibers attached to the centrioles, which remain at opposite ends of the cell. Thus, by the end of this step, one set of chromosomes is gathered at one end of the cell, and their duplicates are gathered at the other end of the cell.



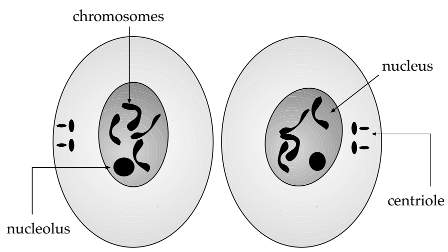
Stage 4 (Anaphase)

Stage Five: Mitosis Finishes (Telophase)

A nuclear membrane begins to form around each set of chromosomes. Also, a new membrane forms to separate the cytoplasm. Two new cells now exist. Each has the same number of chromosomes, all of which are identical to those of the parent cell.



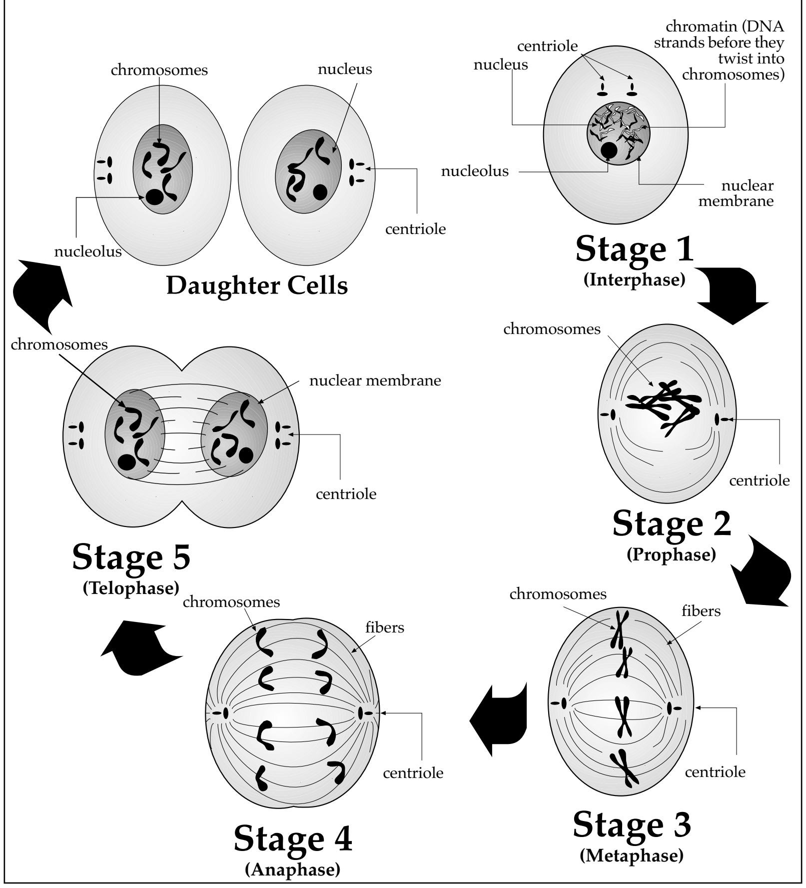
Stage 5 (Telophase)



Daughter Cells

Thus the result of mitosis is two daughter cells, each with the same number of chromosomes as the cell we started with—the mother cell. The chromosomes in the two cells are identical to each other.

The Stages of Mitosis



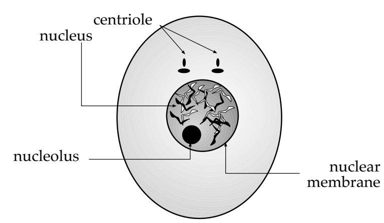
Sex Cells and Special Cell Division

Though some plants, and even animals, may reproduce asexually through mitosis, it's obvious that most creatures are not identical copies of their parents. You certainly did not come out of a **genetic** photocopy machine. You are probably at least a little bit different from either of your parents, and possibly a little bit like both. In fact, most complex plants and animals are products of **sexual reproduction**. Sexual reproduction begins with a special type of cell division—meiosis. Meiosis can be divided into two large units. The first produces two daughter cells. The second divides each daughter cell in two. We end with a total of four daughter cells.

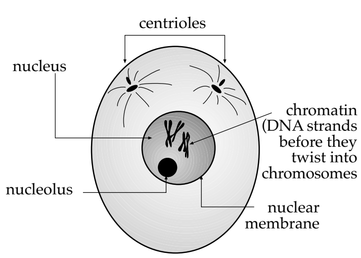
The Stages of Meiosis: First Meiotic Division

Stage One—First Step Resting: Before Meiosis Begins (Early Prophase)

Just as in the resting stage before mitosis, the cell nucleus, nuclear membrane, and centrioles are visible. The chromosomes are making exact copies of themselves.



Stage One—First Step (Early Prophase)



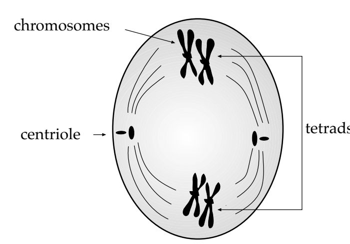
Stage One—Second Step (Late Prophase)

Stage One—Second Step: Meiosis Begins (Late Prophase)

The chromosomes shorten and thicken and thus become more visible—like twisted cables or rope. Each chromosome appears with its copy.

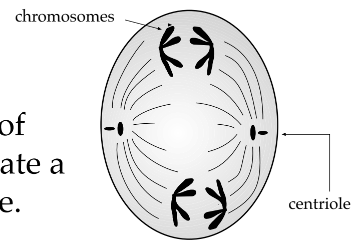
Stage Two: Tetrads Form (Metaphase)

Each double chromosome, or chromosome pair—the original and its copy—snuggles up against another chromosome pair of about the same length. Thus each chromosome is a member of a group of four chromosomes. These four-chromosome groups are called **tetrads**.



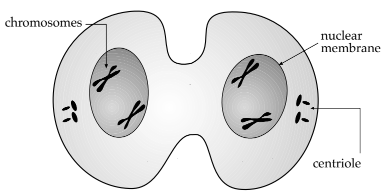
Stage 2 (Metaphase)

Stage Three: Tetrads Line Up at Cell Center (Anaphase)



Stage 3 (Anaphase)

Each tetrad of chromosomes lines up at the center of the cell. As in mitosis, the spider-like centrioles create a web of fibers that pulls the chromosomes into place. While the tetrads are lined up, the chromosomes may exchange and rearrange some of their parts. **Genes** may also be rearranged.



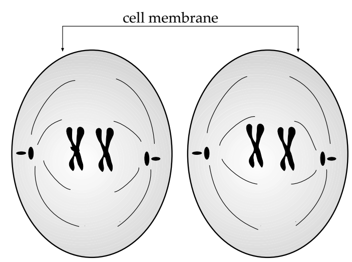
Stage 4 (Telophase)

Stage Four: Tetrads Split (Telophase)

Each tetrad breaks into two pairs again and these chromosome pairs split apart to move to opposite ends of the cell. Note, however, that each chromosome is still paired with its copy.

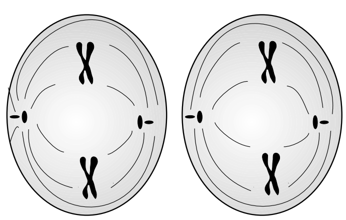
The Stages of Meiosis: Second Meiotic Division (This step divides the two daughters.)

Stage Five: Cell Splits into Two New Cells (Prophase)



Stage 5 (Prophase)

The cell cytoplasm divides as cell membranes form two new cells. Each has the same number of chromosomes as the original parent cell.

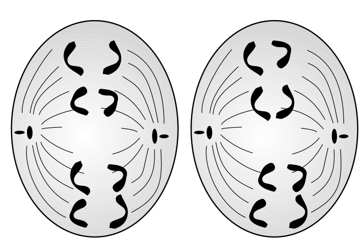

Stage 6 (Metaphase)

Stage Six: Chromosome Pairs Line Up at Cell Center (Metaphase)

Chromosome pairs, each made up of the original chromosome and its copy, line up at cell center.

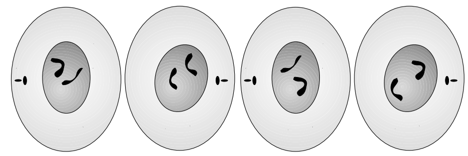
Stage Seven: Chromosome Pairs Split (Anaphase)

The chromosome pairs now pull apart. The original chromosome moves toward one end of the cell while the copy moves toward the other end of the cell.


Stage 7 (Anaphase)

Stage Eight: New Cells Split (Telophase)

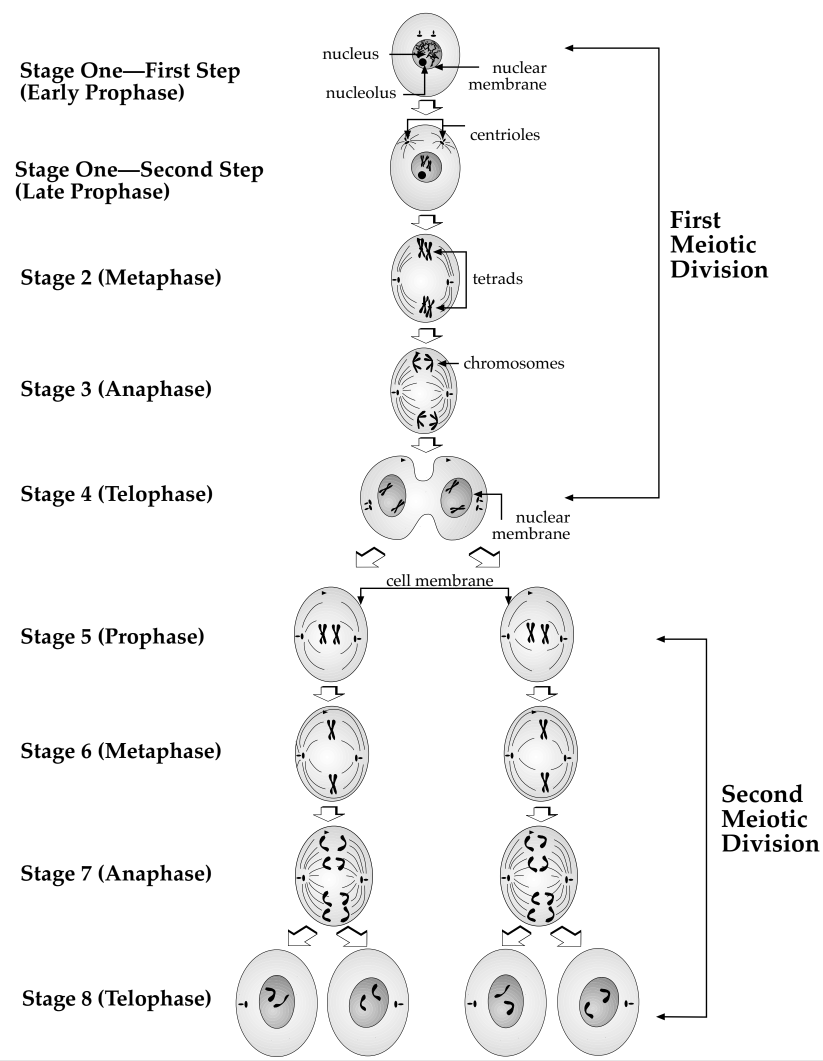
Each cell now splits in two and nuclear membranes form around the chromosomes. Thus four new cells now exist, each with half the number of chromosomes as the parent cell.



Daughter Cells

The result of meiosis is four daughter cells, each with half the number of chromosomes as the parent cell. These are called *sex cells*.

Stages of Meiosis



Fertilization

If sex cells have only half the number of chromosomes as the original parent cell, how do these incomplete cells ever add up to be anything? They must join with another cell with only one half of the needed chromosomes. This is known as **fertilization**. When a male sex cell, a sperm, unites with a female sex cell, an egg, the offspring regains the chromosome number of the parent cell. In this way, organisms maintain a constant number of chromosomes over the generations.

All forms of reproduction and other cell activities are regulated by **proteins**. Protein synthesis is controlled by the DNA molecules within the nucleus. It is these molecules that determine all inherited traits.

Comparing Asexual and Sexual Reproduction

The purpose of this section is to show you what is similar and what is different in meiosis and mitosis. Along the way we will discuss the advantages and disadvantages of both types of reproduction. One similarity between mitosis and meiosis is how they are controlled. We will start there.

Characteristics	Similarities of Mitosis and Meiosis
How is it controlled?	DNA, the molecule that carries all of an organism's inherited traits, triggers certain proteins to be synthesized by the cells. These proteins move throughout the cell and control reproduction.
How does a cell know whether to undergo mitosis and meiosis?	The proteins that control these cycles of reproduction determine what the cell will do.
How does a cell produce protein?	DNA interacts with a variety of molecules in your cells. These molecules interact with other molecules or organelles (such as the ribosome, Unit 3) to produce the proper proteins.
What is the purpose of reproduction?	To make copies of a cell's DNA and pass this inherited material on to new cells.

As you can see, the mechanism that controls reproduction and other cell behavior is DNA. We will discuss DNA and genetics more fully in Unit 5 and Unit 6. For now, we will examine the differences between meiosis and mitosis.

Characteristic	Mitosis	Meiosis
number of daughter cells	2	4
number of chromosomes	same mother cell (diploid)	half of the number in the mother cell (haploid)
purpose	asexual reproduction of certain organisms (bacteria, protists, plants) or growth of an organism (all multicellular life)	sexual reproduction of organisms (protists, plants, animals)
traits of daughter cells	identical to those of the mother cell	may be different because of crossing over and being haploid
Is another organism required to produce a complete offspring?	no	yes

The preceding chart shows some of the advantages of mitosis and meiosis. For instance, very simple, small organisms like bacteria reproduce through mitosis. This explains how one cell of a bacteria can reproduce in your food. Although alone, it makes copies of itself over and over. All the copies are identical. The odds are, one of the bacteria will survive. As we noted before, the purpose of any cell reproduction is to allow DNA to survive.

You may ask yourself if there are any disadvantages to mitosis. There are. If the first bacteria was sensitive to a certain chemical, then all of its copies would have the same sensitivity. Because none of the bacteria were different, they might all die if exposed to that chemical.

In meiosis, however, there is a much greater amount of variability. Because two organisms combine their genetic material, very few offspring are identical. If these offspring are exposed to a certain disease, there is a good chance at least some will survive. Clearly, this variability is an advantage.

For simple organisms, though, sexual reproduction can require a great amount of energy and materials. Also, if no other organism is available, there can be no sexual reproduction. This explains why some simpler organisms (protists, sponges, some plants) can also reproduce asexually.

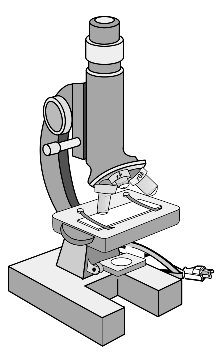
Summary

Organisms grow larger through cell division, called mitosis. Mitosis is a form of asexual reproduction in which a parent cell forms two new cells containing the same number of chromosomes as the parent cell. Chromosomes are identical in number and makeup in parent and daughter cells. Some organisms use mitosis to create new individuals.

Most complex organisms reproduce through sexual reproduction. This involves meiosis, a special type of cell division. Through meiosis, a parent cell yields four daughter cells or sex cells, each with half the number of chromosomes as the parent cell. The chromosomes of daughter cells may be different from those of the parent cells because crossing over may have occurred during meiosis. Genes may have been rearranged, as well.

The offspring regains the chromosome number of the parent cell when fertilization occurs. Two sex cells, an egg and sperm, unite to become the offspring's first cell. All forms of reproduction and other cell activities are regulated by proteins. Protein synthesis is controlled by the DNA molecules within the nucleus. It is these molecules that determine all inherited traits.

Careers in Biology



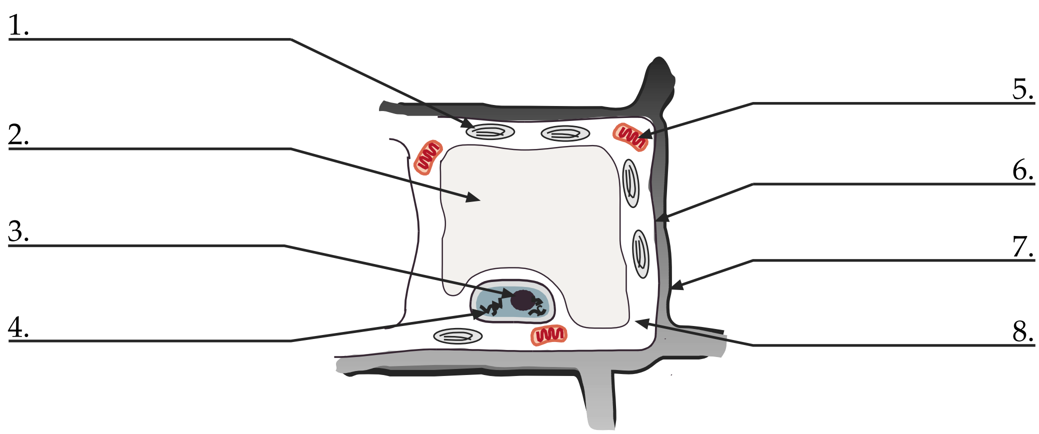
Genetic Counselor

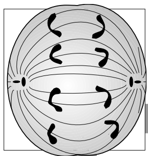
A **genetic counselor** helps couples decide whether or not to have a child when there is a possibility that the child may inherit fatal or disabling traits. Many diseases can be passed on through the chromosomes of one or both parents. Genetic counselors help determine the probability that the child will receive a specific genetic defect. A graduate degree at the masters or doctorate level is usually required for employment in this field.

Practice

Use the list below to write the correct part of the **plant cell** *on the line provided.*

cell membrane	**cytoplasm**
cell wall	**mitochondrion**
chloroplast	**nucleus**
chromosome	**vacuole**

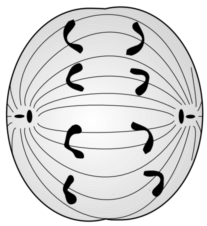




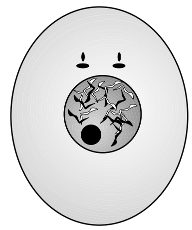
Practice

Number the stages of **mitosis** *shown below. Write the correct number on each line.*

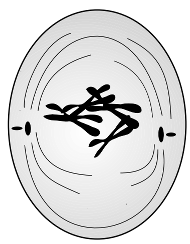
Mitosis



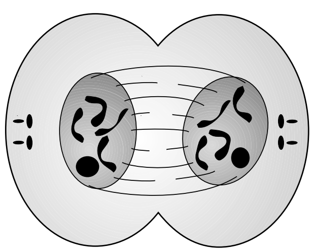
1. Stage ________



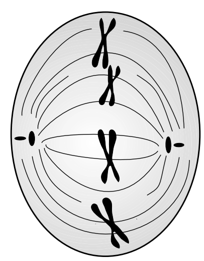
2. Stage ________



3. Stage ________



4. Stage ________



5. Stage ________

Practice

Circle the letter of the correct answer.

1. Cells may fill more space by ____________ .
   a. an enlargement, or increase, of each cell's size
   b. increasing the number through a type of cell division called mitosis
   c. both a. and b.

2. Mitosis is a kind of ____________ .
   a. asexual reproduction
   b. cell enlargement
   c. sexual reproduction

3. The two types of cell division are ____________ .
   a. chromosomes and cytoplasm
   b. tetrads and chloroplasts
   c. mitosis and meiosis

4. Chromosomes ____________ in number in the resting stage.
   a. double
   b. triple
   c. divide

5. Tetrads are ____________ .
   a. new cells
   b. four-chromosome groups
   c. a new kind of bandage

6. Centrioles are ____________ .
   a. the control center of the cell
   b. cell garbage cans
   c. part of the cell's equipment for cell division

7. Meiosis is a kind of ____________ .

   a. chromosome
   b. cell division
   c. asexual reproduction

8. When an egg cell unites with a sperm cell, ____________ occurs.

   a. reproduction
   b. asexual reproduction
   c. fertilization

9. In both mitosis and meiosis there are several ____________ that occur in the process of cell division.

   a. tetrads
   b. cells
   c. stages

10. The result of mitosis is ____________ .

    a. two daughter cells
    b. one parent cell
    c. four chromosomes

11. The result of meiosis is ____________ .

    a. two daughter cells
    b. four daughter cells
    c. one new parent cell

12. Each human body began from ____________ .

    a. one cell
    b. mitosis
    c. three cells

13. The human body contains more than ____________ cells.

    a. 100 trillion
    b. 10 billion
    c. 100 billion

14. All reproduction is controlled by __________ .

    a. centrioles
    b. proteins
    c. mitochondria

15. The types of proteins produced in a cell are governed by __________ .

    a. DNA
    b. ribosomes
    c. mitochondria

16. Mitosis produces new organisms with __________ genetic material as the mother cell.

    a. different
    b. one half
    c. identical

17. Meiosis allows offspring to be genetically __________ .

    a. identical
    b. diverse
    c. neither a. nor b.

18. DNA is found in the __________ of a cell.

    a. chromosomes
    b. nucleus
    c. both a. and b.

Lab Activity: Steps of Mitosis

Facts:

- Cells form new cells by a process called cell division or mitosis.
- It is possible to arrange the events of mitosis into several steps.

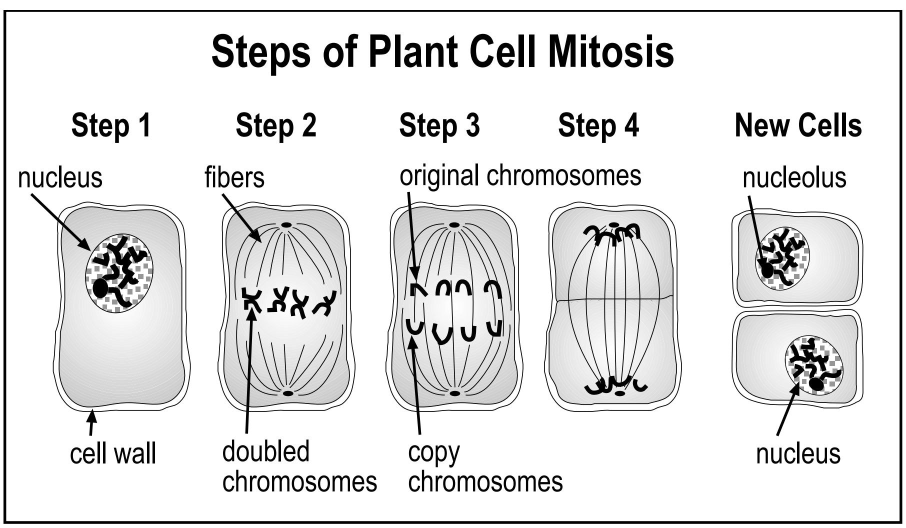
Mission:

- You will build models of the steps of mitosis in a plant cell.
- You will compare your models to diagrams of mitosis taking place in living cells of plants and animals.

Materials:

- scissors
- glue
- 24 toothpicks
- 4 pieces each of two colors of construction paper
- yarn
- thread
- metric ruler

1. Using Figure 1 to review the steps of mitosis.



2. Use the materials listed in the chart below to represent the cell parts. Cut the pieces of paper, yarn, and thread to the sizes given below.

Making Cell Parts			
Cell Parts	**Material to Use**	**Size**	**No. Needed**
cell wall and membrane	dark-colored paper	14 x 8 cm	5
cytoplasm	light-colored paper	13 x 7 cm	5
nucleus	dark-colored paper	5 cm circle	3
nucleolus	light-colored paper	1 cm circle	2
chromosomes	light-colored paper	4 cm long 10 cm long	20 2
fibers	toothpicks	full size	24
cell wall between new cells	dark-colored paper	1/2 x 8 cm	1
nuclei in new cells	thread	1/2 m	2

3. Begin building the models of the cell division steps by gluing each piece of "cytoplasm" paper to the top of a "cell wall and membrane" piece of paper. The cell wall and membrane should show on all four sides of the cytoplasm. Use Figure 2 as a guide.

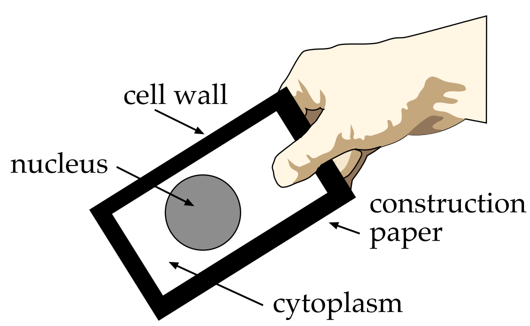


Figure 2

4. Following the diagrams in Figure 1, make a model of each step of mitosis. Use glue to attach the proper parts to the pieces. Study the diagrams carefully so that you get the correct parts in each step.

5. Arrange your models in the order in which mitosis occurs. Note how your models differ from those shown in the illustration of mitosis in an animal cell (see p. 102).

6. Compare your models of the steps of mitosis in a plant cell to those of an animal cell.

7. How are the plant and animal cells different? ____________________

8. How are the plant and animal cells alike? ____________________

Practice

Use the list below to write the correct term for each definition on the line provided.

asexual reproduction	**nuclear membrane**	**reproduction**
chromosome	**nucleus**	**sperm**
daughter cell	**parent cell**	**tetrad**
gene		

_______________ 1. the original cell that produces new cells through mitosis or meiosis

_______________ 2. a group of four chromosomes that takes part in meiosis

_______________ 3. the sex cell produced by the male

_______________ 4. a unit of DNA that determines a specific hereditary trait in an organism; comes in pairs

_______________ 5. a twisted and coiled strand of DNA within the nucleus that carries the codes for reproductive traits such as eye and hair color

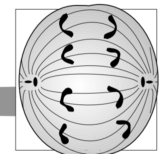
_______________ 6. the process through which organisms produce offspring; creation of a new individual

_______________ 7. the creation of a new cell or organism identical to the parent; does not involve the union of sex cells

_______________ 8. the cell part that holds the chromosomes and DNA that controls all cell activities

__________________________ 9. one of the two cells created when a parent cell divides through mitosis

__________________________ 10. a thin wall or covering that surrounds the nucleus of the cell



Practice

Use the list below to write the correct term for each definition on the line provided.

centriole	**fertilization**	**mitosis**
cytoplasm	**genetic**	**protein**
DNA	**meiosis**	**sexual reproduction**
egg		

______________________ 1. the sex cell produced by the female

______________________ 2. cell division in which two cells, each with the same number of chromosomes identical to the parent, are produced from one cell

______________________ 3. cell division that results in the formation of four sex cells, each of which has half the number of chromosomes as the parent cell

______________________ 4. a cell part that organizes the web along which chromosomes move during cell reproduction

______________________ 5. a jellylike, living substance inside the cell membrane but outside the nucleus

______________________ 6. the creation of a new organism through the union of an egg and a sperm

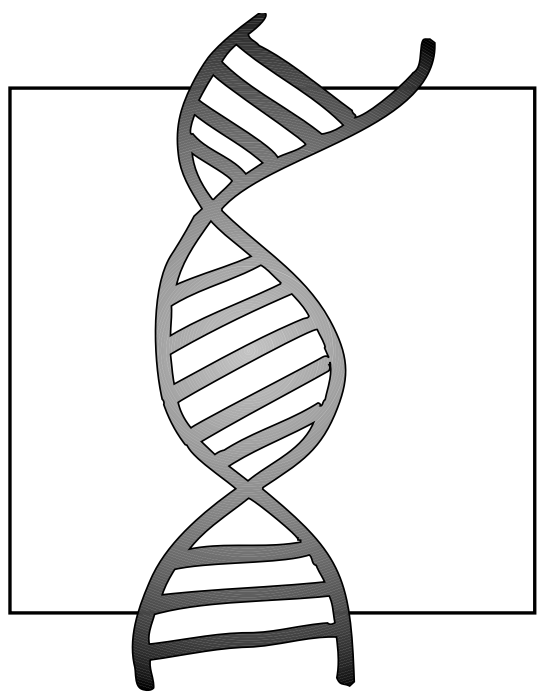
______________________ 7. the union of a male sex cell (a sperm) and a female sex cell (an egg)

______________________ 8. the strands of material that determine traits of daughter cells (stands for deoxyribonucleic acid)

__________________________ 9. refers to any trait or material that determines characteristics passed on from the parent(s)

__________________________ 10. a group of molecules used as both building materials for cell growth and as a control factor for cell behavior

Unit 5: Genetics—The Science of Heredity



Vocabulary

Study the vocabulary words and definitions below.

acquired characteristic .... a characteristic that is not passed from one generation to the next in the genes but instead is acquired during the lifetime of an individual
Example: suntan

base pairs .... a component of DNA; four chemicals form pairs to make up the large molecule DNA; the pairs are adenine-thymine (A-T) and cytosine-guanine (C-G)

chromosome .... a twisted and coiled strand of DNA within the nucleus that carries the codes for reproductive traits such as eye and hair color

cross .... to mate two plants or animals to produce another generation

DNA .... the strands of genetic material that determine traits of daughter cells (DNA stands for deoxyribonucleic acid)

dominant gene .... a gene in a gene pair that is always expressed

environmental effect .... factors in the environment of an organism that limit the full expression of a gene

gene .... the unit of DNA that determines a specific hereditary trait in an organism; genes come in pairs

genetics .... the science of heredity; the study of how traits are passed from parent(s) to the offspring

Gregor Mendel .... an Austrian monk whose work became the basis of genetic theory

heredity .... the transfer of traits from parents to their offspring

heterozygous .... when both genes from a homologous pair are different

homologous pairs .... two similar chromosomes; one from the mother and one from the father

homozygous .... when both genes from a homologous pair are identical

hybrid .... an organism that is the offspring of two similar organisms that are not the same species
Example: a horse and a donkey can breed to produce a mule

Punnett square .... a chart used to predict the proportion of offspring that will have a certain trait when two organisms are crossed

recessive gene .... a gene in a gene pair that is not expressed when paired with a dominant gene

trait .... a characteristic of an organism
Examples: eye color, hair color, height

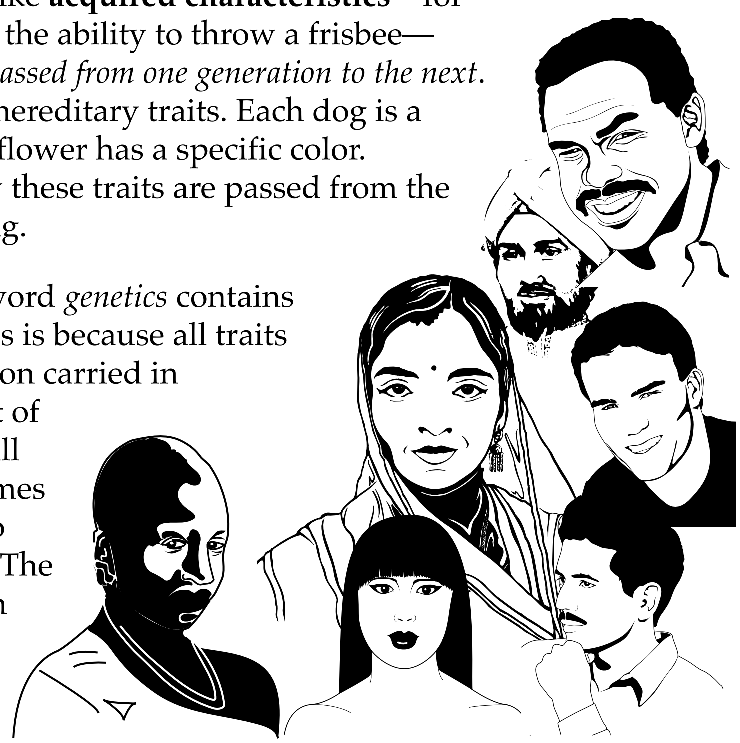
Introduction

In the last chapter, we learned about how cells copy their **chromosomes** and reproduce. Within the chromosomes is the chemical **DNA**. Amazingly, it is DNA that determines all of the **traits** that make each of us a unique human being. These microscopic, threadlike molecules carry **genes** that, in humans, determine eye color, height, the shape of our feet, and millions of other features. Genes also determine traits in other creatures: the color of a flower, smooth or curly fur in dogs, speed in horses. Genes give a unique inheritance to every living thing.

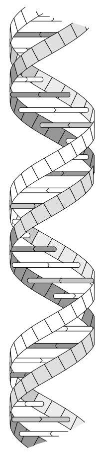
What Is Genetics? How Does It Work?

It's easy to define **genetics** as the science of **heredity**, but what exactly does that mean? Usually, when we think of an inheritance, we think of a sum of money or some valuable possession that a dead person leaves to a live person. But it's easy to see from the world around us that inheritance is also a biological process. Children are born with many things they've inherited from their parents. The color of their skin, the color of their hair, and the shape of their face are some things they inherit. These personal trademarks, the little details that make each person unique, are called hereditary traits. Unlike **acquired characteristics**—for example, a suntan or the ability to throw a frisbee—hereditary traits *are passed from one generation to the next*. All organisms show hereditary traits. Each dog is a particular size. Each flower has a specific color. Genetics studies how these traits are passed from the parent to the offspring.

As you can see, the word *genetics* contains the word "gene." This is because all traits result from information carried in genes. Genes are part of the DNA strands in all cells. The DNA becomes twisted and folded to make chromosomes. The result is that we often speak of genes as being in



chromosomes. As we noted before, chromosomes, genes, and DNA determine hereditary traits. In addition to details like eye color, genes can determine major traits. Genes control much of how a person develops. For example, genes determine not only how big a person's feet might grow but also how that same person's brain works.



DNA model

Each species has its own special number of chromosomes. These chromosomes carry genes that dictate the major and minor characteristics of the organism. Of course, the environment of an organism also has an effect on its development. If someone has a gene for tallness but doesn't get enough food while he's growing up, then he probably won't become very tall. This is called the **environmental effect**. The interaction between genes and the environment is very complex. Scientists spend much time debating which traits of a human are caused by which factors.

A Closer Look at Chromosomes

Since what we know about genetics is based largely on the structure and function of the chromosomes, it's important to understand chromosomes. As we saw in the last chapter, the chromosomes are found in the nucleus, the "control center" of the cell. In body cells, which are products of mitosis, each chromosome comes in a pair. In organisms that reproduce sexually through meiosis, one chromosome comes from the mother and the other from the father. Therefore, the two chromosomes are very similar but not identical. Each chromosome carries its own gene for a specific set of traits. These pairs of chromosomes are called **homologous pairs**. In humans, body cells have 23 homologous pairs. This means the cells have a total of 46 chromosomes.

Not all of your cells have 46 chromosomes, however, because not all reproduce through mitosis. In human sex cells (eggs and sperm) there are only 23 chromosomes. There is only one of each chromosome. The chromosomes do not have homologous pairs.

All creatures have chromosomes in their cells. The number of chromosomes varies with the species. For example, peas have 14 chromosomes, and chickens have 78 chromosomes. Regardless of the number of chromosomes an organism has, certain rules hold true. One of these is that the pattern of homologous pairs appearing in body cells and unpaired chromosomes (half that number) appearing in sex cells holds true. The pollen of a pea has only seven chromosomes, and an unfertilized chicken egg has only 39 chromosomes.

Chromosomes in Living Things		
Organism	**Total Number**	**Number of Pairs**
cat	**38**	**19**
cow	**60**	**30**
dog	**78**	**39**
fruit fly	**8**	**4**
goldfish	**94**	**47**
house fly	**12**	**6**
human	**46**	**23**

Genes and DNA

Each chromosome is a twisted and coiled strand of DNA. DNA is like most other molecules involved in life. Although it is, as a whole, very complex, it is constructed from a set of relatively simple units.

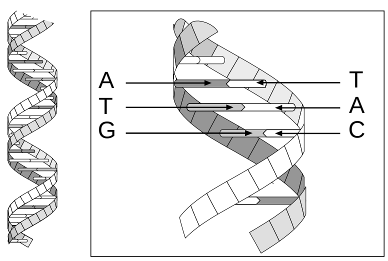
Consider this book. It covers a number of complex topics. Like DNA, it gives instructions. It includes information for you to use now and for you to use later. The book is complex. On another level, though, the book is simple. All the instructions, all the information, all the words are made from only 26 letters.

In a sense, all of your genes—all of your DNA—are made of four letters! Your cells contain many, many times more information than this book. All of this information, though, is based on only four units. A molecule of DNA is made of two twisted and linked groups of simpler molecules. The links that hold the two sides of the molecule together are called **base pairs**. The chemicals that make up base pairs are adenine and thymine, which form one pair, and cytosine and guanine, which form the other pair.

That's it! It's difficult to imagine that something as complex as the shape of a person's face is based on two different pairs.

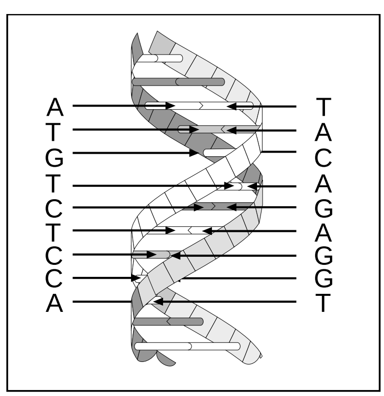
Consider that the shape of your neighbor's face, though very different from your own, is based on the same pairs. How is this possible? As noted earlier, DNA is complex. That complexity is based on how simple units are assembled. In genetics, we refer to the way DNA has been combined or recombined. Regardless of the term we use, the idea is the same. By combining many simple molecules in many different ways, we can create a highly complex molecule, organism, or system.

Let's look at the way DNA is assembled. We will abbreviate each of the base pairs with its first letter. Also, we will always keep the chemicals paired with the proper chemicals. The model below is a sample of real DNA that can be found in all of your cells.



A-T
T-A
G-C

The molecules of DNA are made of thousands more pairs, but this is a small section. This small section tells the cell's molecules to begin producing a protein. Let's look at a longer section:



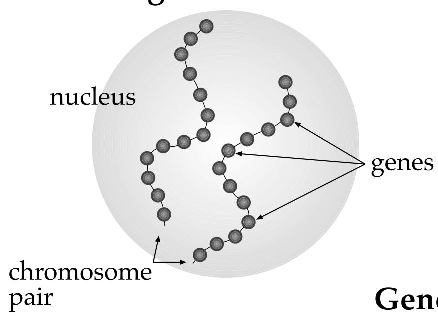
A-T
T-A
G-C
T-A
C-G
T-A
C-G
C-G
A-T
etc.

This longer section is the beginning of a set of instructions. The first three pairs (A-T, T-A, and G-C) tell the cell's molecules that this is the beginning of the instruction. The rest of the strand of DNA tells the cell what protein the cell will make.

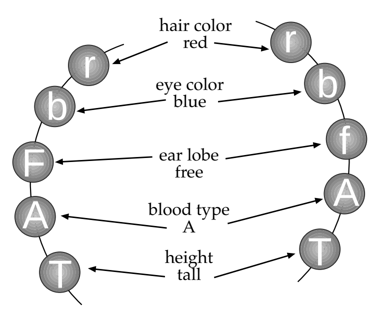
As we learned in Unit 4, it is proteins that control how cells function. The proteins, like DNA, are made of simple units. Like DNA, the units that make up proteins can be assembled in different orders. The result is that DNA includes instructions for making a variety of proteins.

One way of looking at this is that DNA is a string of instructions for making proteins. Because proteins determine what an organism can and will do, there's another way to look at DNA. DNA is a set of instructions for what an organism's traits will be. These instructions are called genes. So, DNA is a string of thousands of genes, each gene in order in its own place on the chromosome. Since chromosomes in body cells are paired, each gene has a pair. The pairs appear opposite each other on the homologous pairs.

Homologous Pairs



Gene Pairs



For example, some pea plants are tall and some are short. Biologists use letters to represent the genes that control height in pea plants. Thus we'll call the gene for the tall plants T and the gene for the short plants t:

tall = T short = t

Each organism has two chromosomes. Therefore, each organism has two genes for the same trait. Any pea plant might have one of three combinations. The possible combinations of tall (T) and short (t) are as follows:

TT	Tt	tt
both genes tall	one gene tall, one gene short	both genes short

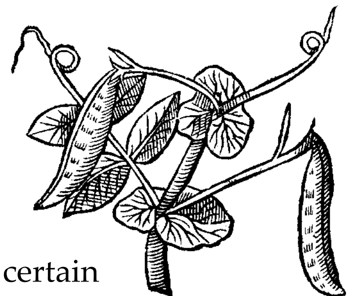
There are different terms to describe these combinations of genes. When an organism has two genes that are identical, this is called **homozygous**. Which of the pairs above is homozygous? Both the TT pair and the tt pair are homozygous. The other pair, Tt, does not have identical genes. This is called **heterozygous**. The pea plant with the Tt genes is our next subject.

Dominant and Recessive Genes

So, would a pea plant with the genes Tt be tall or short? In this case, the plant would be tall because the gene for tallness, T, is a **dominant gene** over the gene for shortness, t. When a gene is dominant, it shows, or is expressed, so that it hides the other gene, which is a **recessive gene**. The recessive genes do not show.

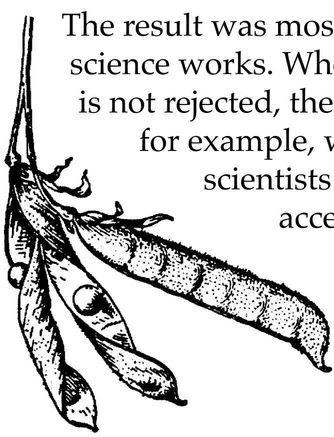
Biologists use capital letters to represent dominant genes (T), and lowercase letters to represent recessive genes (t). The pea plant with the Tt gene combination is heterozygous. The result is that it will be tall. The pea plant with TT is homozygous. Because the gene T (Tall) is dominate, any plant with the TT gene combination is said to be homozygous dominant. The other homozygous set of genes is tt. This is the only combination of traits that makes a pea plant short. This plant would be called homozygous recessive. The only time recessive genes will be seen in the way an organism appears is when they are homozygous recessive. This holds true for all organisms, even pea plants.

Gregor Mendel, the Discoverer of the Basis of Genetic Theory



Pea plants played a special part in the history of genetics. In 1865 an Austrian monk, **Gregor Mendel**, noticed that the pea plants in his garden had certain traits. Some were tall, some were short. Some had white flowers, some had purple flowers. Some had smooth peas, some had wrinkled peas. Not only that, but sometimes a generation of pea plants would come along where certain traits did not appear—for instance, no white flowers. And often, when more than one trait was present, Mendel noticed that it would appear in the same proportion in each generation. That is, white flowers might appear in 25 percent of the offspring, over and over. When Mendel noticed these trends, he became curious.

Remember that in 1865, no one yet knew about chromosomes or DNA. People knew that traits were somehow passed on from one generation to the next, but they didn't know how. Mendel didn't let that bother him. He developed a method for controlling which pea plant produced offspring. When organisms, whether plant, animal, fungi, or protist, reproduce sexually, this is called a **cross**. Although Mendel was working with peas that grew outside, he wanted to know which peas crossed to produce offspring. He began to make experimental crosses so that he could study specific traits. By repeating experiments over and over and painstakingly recording the results, he began to realize that he could predict how many offspring would show a certain trait when he crossed certain parent pea plants. It's worth noting, however, that Mendel's ideas about inheritance did not immediately catch on. Mendel had worked quietly. When he was finished, he published his findings in 1866.



The result was mostly a lack of response, due in part to the way science works. When a new idea is introduced, it is often rejected. If it is not rejected, then over time it may be accepted. Mendel's findings, for example, were nearly forgotten. It was only when other scientists confirmed Mendel's findings that they were accepted in the late 1920s and early 1930s. Since then, the detailed view of genetics has grown. Many scientists from many fields have contributed. The result is a better understanding of heredity.

Solving Genetics Problems

Knowing what we know now, we too can predict the outcome of an experimental cross. It's easier for us than it was for Mendel, because we know about genes and can use a **Punnett square** to figure out the frequency of possible gene combinations.

Punnett Square

		female	
	genes	**T**	**t**
male	**T**		
male	**t**		

		female	
	genes	**T**	**t**
male	**T**	**TT**	**Tt**
male	**t**	**Tt**	**tt**

Crossing Height

Using a Punnett Square to Predict Gene Combinations

1. Draw a box with four squares.

2. Place the genes of one parent across the top, one gene above each box. In this example, we'll cross our heterozygous pea plants, so T will appear above one box and t will appear above the other box.

3. Place the genes of the other parent on the left-hand side, one beside each box. Thus T appears next to one left-hand box, and t appears next to the other left-hand box.

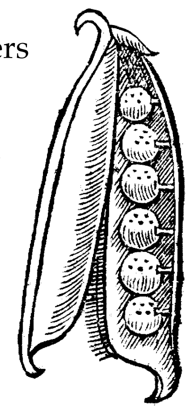
4. Bring each gene at the top of each box down into the squares below. Next, bring each gene to the left of the boxes across into the squares to the right.

5. Now, read the gene combinations appearing in the squares. In this example, we have one out of the four boxes, or one quarter, showing homozygous dominant tall plants, TT. Two out of the four

boxes, or half the boxes, show heterozygous plants which will appear tall, Tt. The other quarter of the boxes shows homozygous recessive plants, tt, which will appear short.

Interpreting the Results of the Punnett Square

The results above are, in fact, the results Mendel got when he crossed pea plants that were heterozygous for height. Out of 816 pea plants produced, 611 grew tall and 205 grew short. If you divide 611 by 816, and 205 by 816, you'll see that these are the very proportions we would have predicted with our Punnett square: three quarters tall pea plants and one quarter short pea plants.



How would one use the Punnett square in a situation where only one offspring is produced? In exactly the same way we used the Punnett square to determine the height of pea plants. If you use it to find out possible gene combinations for a cross of two parents who are heterozygous for eye color, Bb, with B standing for the dominant brown eye color and b for the recessive blue, you will find that only one square out of the four will show a possible gene combination having blue eyes, bb. This means that there is a one out of four chance, or a 25 percent chance, that the baby of these parents will have blue eyes. With pea plants, which have hundreds of offspring, you can actually see the frequencies of different gene combinations. However, in crossing for a single offspring, such as human, it is only possible to know which gene combinations are possible and which are more and less probable.

Often, we have to interpret the Punnett square backwards. For example, the parents above may not know whether or not they are heterozygous for eye color. Perhaps all they know is that they each have brown eyes. However, when their baby turns out to have blue eyes, the parents will realize that they must each be carrying a recessive gene for blue eyes. Otherwise, it would not have been possible for them to have had a blue-eyed child.

Genetic Variation and Hybridization

So far, we have discussed genetics with regard to sexual reproduction. There are a few factors that we still need to consider. One of these is what animals can cross? A mature male and female of the same species can successfully cross. In most cases, the male and female will have significantly different genes. Most of their offsprings' genes will likely be heterozygous.

If the male and female, however, are closely related, there may be problems. If they both have a recessive trait that is harmful, there is a high likelihood their offspring will show that trait. Let's look at an example.

The condition known as sickle-cell anemia can be deadly. With this disease, some of a human's blood cells are malformed. The result is that they do not work properly. We will call the dominant trait of normal blood cells, "C." The recessive trait we will call "c." If two unrelated people who are heterozygous for this trait mate, a Punnett square would look like this:

Female

Male		C	c
	C	CC	Cc
	c	Cc	cc

As you can see, the homozygous recessive trait (cc) shows up one fourth of the time. Now, let's compare that to two people, closely related, who are both homozygous recessive.

Female

Male		c	c
	c	cc	cc
	c	cc	cc

As you can see, all of their offspring have sickle-cell anemia. These children would be born with a serious disease.

Punnett squares are predictions in probability. In the case above, the prediction is 100 percent that the children would have the homozygous recessive trait for sickle-cell anemia. In our first Punnett square, we predicted only 25 percent of the children would have this gene pair. Remember, these are predictions. For the predictions to work well, we need large numbers of crosses and offspring.

Notice also that when there is variety in the genes of the parents, the offspring tend to not have homozygous recessive traits. One way to introduce high variety in the parents is to make a **hybrid** cross. Hybrids are offspring of parents that are similar, but not of the same species. In days past, a common hybrid animal was the mule. Mules are the offspring of a horse and a donkey. The horse and donkey are similar (and have similar genes) but are not the same species. They have genes with a fair amount of variety. When they breed (cross), they produce mules. Mules are neither horses nor donkeys. Mules tend to be stronger and healthier than either horses or donkeys.

As hybrids, mules are incapable of creating their own offspring. This is one reason there is not an overabundance of mules. One other factor we must keep in mind in genetics is this: If the organisms are too different, not closely related, they will not produce offspring. Thus, a cat and a dog cannot breed. On the other hand, closely related species can breed. The hybrid is usually stronger in some way. This is called hybrid vigor. The downside of hybrid vigor is that with a few exceptions, hybrids cannot reproduce.

We've seen that diversity leads to strong, vigorous organisms. Consider organisms that reproduce asexually. Can they have offspring with genes different from the parent? In most cases, the answer is that they cannot. Again we see that though asexual reproduction is simpler, it does have its drawbacks. The lack of genetic diversity is one of the greatest.

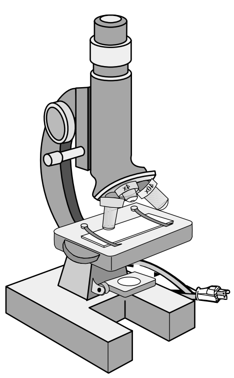
Summary

Genetics is the study of how hereditary traits are passed from parents to offspring. Traits are passed on in genes, which are instructions contained in DNA. Sex cells have only one copy of each gene, but when sex cells unite to form a new organism, all of the new organism's body cells have two versions of each gene. Body cells have homologous chromosomes pairs. Offspring may be heterozygous, having two different genes for a trait, or it may be homozygous, having the same genes for a trait. If the organism is heterozygous, it's possible that one gene will be dominant over the other. The dominant gene will be expressed, but the recessive gene will be hidden—recessive genes are not expressed unless they are homozygous. The two forms of reproduction (sexual and asexual) have different genetic advantages.

Gregor Mendel, the discoverer of the basis of genetic theory, found that he could cross two pea plants having a certain trait and predict the number of offspring that would also have that trait. We also can predict the probability of possible gene combinations by using a Punnett square. Although Mendel's work was slow to gain acceptance, the genetic theory has since grown based on the input of many scientists.

DNA is like many other chemicals involved in life. It is made of simple units that are arranged in various ways to make a complex molecule. The genes contained in DNA determine what proteins a cell will make and control its behavior.

Careers in Biology



Biogeneticist

Biogeneticists study the way genes affect organisms. They may seek to understand how one gene influences a variety of traits, or they may see how a sequence of genes interacts with one another. Some biogeneticists (genetic engineers) work to alter the genes in an organism. Biogeneticists work in laboratories. The labs may be housed at universities, at private research centers, or at corporations. A graduate degree at the masters or doctorate level in biogenetics is usually required for employment in this field.

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

46	**genes**	**Punnett square**
cross	**genetics**	**recessive**
DNA	**heredity**	**sex**
dominant	**hybrid**	**tall**
expressed	**Mendel**	**traits**

1. __________________________ is the study of heredity.

2. In all living things, __________________________ determine the traits and make each creature unique.

3. An organism that has a homozygous gene pair will always have two __________________________ genes or two __________________________ genes for a particular trait.

4. In the Punnett square, letters represent __________________________ in a chromosome.

5. Capital letters represent __________________________ traits; lower case letters represent __________________________ traits.

6. __________________________ is considered to be the discoverer of the basis of genetic theory.

7. Hair color and eye color are known as characteristics or inherited __________________________ .

8. Dominant genes are ________________________ , whereas ________________________ genes do not always show.

9. ________________________ is the transfer of traits from parents to their offspring.

10. Human body cells have ________________________ chromosomes in homozygous pairs, whereas human ________________________ cells have only 23 chromosomes.

11. A ________________________ is when two plants or animals are mated.

12. When a homozygous tall plant is crossed with a homozygous short, all the offspring will be ________________________ .

13. A ________________________ organism is one that is the offspring of two closely related organisms that are not from the same species.

14. ________________________ determines what proteins a cell will produce.

15. The ________________________ is a chart used to predict the traits for the offspring from a cross.

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Gregor Mendel worked with the fruit fly.

__________ 2. Blue eyes are an acquired characteristic.

__________ 3. Gregor Mendel was the discoverer of the basis of genetic theory.

__________ 4. The dominant gene is always expressed.

__________ 5. A genetic trait such as height can be changed by environmental effects.

__________ 6. TT would be a homozygous recessive tall pea plant.

__________ 7. Chromosomes are found in the nucleus.

__________ 8. During mitosis, sperm and eggs are formed.

__________ 9. *Environmental effect* is the study of how traits are passed from parents to offspring.

__________ 10. A hybrid is an organism with two different genes for a specific trait.

__________ 11. DNA is a simple molecule made of complex units.

__________ 12. The behavior of cells is controlled by proteins.

__________ 13. One disadvantage of asexual reproduction is that it creates high genetic diversity.

_________ 14. One advantage of sexual reproduction is the mixing of genes to prevent genetic diseases.

_________ 15. DNA is made of chromosomes.

Lab Activity: The Punnett Square

Facts:

- Sex cells receive only one copy of each chromosome; therefore, sex cells combine to make a number of possible combinations.
- The outcome of experimental genetic crosses can be predicted by using the Punnett square.

Investigate:

- You will collect and display genetic data using biological symbols.
- You will use the Punnett square to determine possible gene combinations of the genetic data collected.

Materials:

- pencil
- paper
- copies of Punnett squares
- collected data

1. Use the following record sheet to record genetic information about your parents.

2. Using one Punnett square for each genetic trait in the information gathered about your parents, determine the possible genetic combinations.

3. Under each combination below the dotted line, in the space provided, write the name of the offspring with that trait (if the trait applies).

	Parental Genetic Information			
	eye color	**hair color**	**ear lobes**	**tongue rolling**
Mother				
Father				
	eye color brown - BB, Bb blue - bb green - gg	**hair color** brown - RR, Rr blonde - bb red - ii black - ll	**ear lobes** free - FF, Ff attached - ff	**tongue roll** roll - RR, Rr cannot roll - rr

		Mother	
	genes		
Father			

Eye Color

		Mother	
	genes		
Father			

Hair Color

		Mother	
	genes		
Father			

Ear Lobe

		Mother	
	genes		
Father			

Tongue Roll

Practice

Use the list below to write the correct term for each definition on the line provided.

acquired characteristic	**environmental effect**	**homozygous**
base pairs	**gene**	**hybrid**
chromosomes	**genetics**	**Mendel**
cross	**heredity**	**Punnett square**
DNA	**heterozygous**	**recessive**
dominant	**homologous pairs**	**trait**

________________________ 1. a characteristic that is not passed from one generation to the next in the genes but instead is acquired during the lifetime of an individual

________________________ 2. to mate two plants or animals to produce another generation

________________________ 3. a unit of DNA that determines a specific trait in an organism

________________________ 4. the transfer of traits from parents to their offspring

________________________ 5. a chart used to predict the proportion of offspring that will have a certain trait when two organisms are crossed

________________________ 6. a gene in a gene pair that is not expressed when paired with a dominant gene

________________________ 7. an organism that is the offspring of two similar organisms that are not the same species

________________________ 8. a gene in a gene pair that is always expressed

________________________ 9. a characteristic of an organism; for example, eye color, hair color, or height

________________________ 10. the science of heredity; the study of how traits are passed from parent(s) to offspring

________________________ 11. the discoverer of the basis of genetic theory

________________________ 12. when both genes from a homologous pair are identical

________________________ 13. factors in the environment of an organism that limit the full expression of a gene

________________________ 14. a twisted and coiled strand of DNA within the nucleus that carries the codes for reproductive traits such as eye and hair color

________________________ 15. a component of DNA; four chemicals form pairs to make up the large molecule DNA; the pairs are adenine-thymine (A-T) and cytosine-guanine (C-G)

________________________ 16. the strands of genetic material that determine traits of daughter cells (stands for deoxyribonucleic acid)

________________________ 17. when both genes from a homologous pair are different

________________________ 18. two similar chromosomes; one from the mother and one from the father

Practice

Answer the following using complete sentences.

1. For each base, what is the letter of base that would be found paired in each strand of DNA?

   T: ______________________________

   C: ______________________________

   A: ______________________________

   G: ______________________________

2. How did Mendel's work gradually gain acceptance? ____________

   ____

   ____

   ____

   ____

3. Describe how a cross between two closely related organisms may result in genetic problems.

   ____

   ____

   ____

   ____

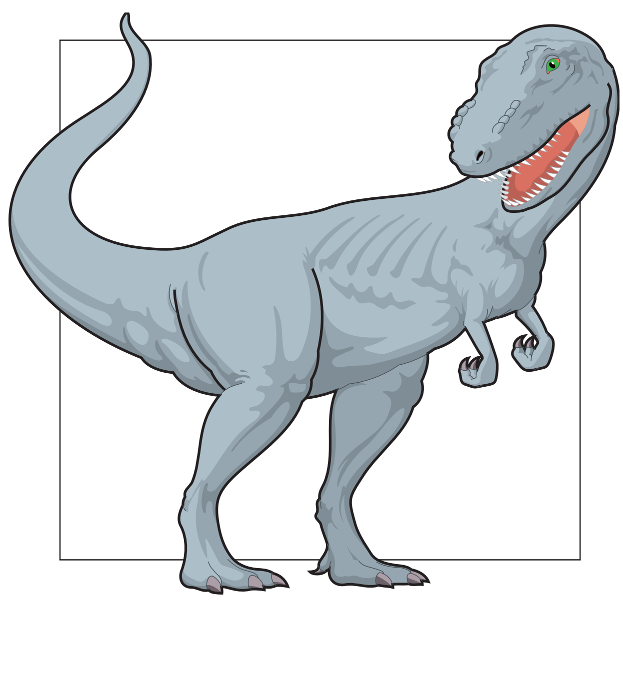
   ____

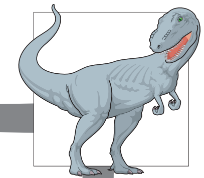
   ____

   ____

4. What advantage, if any, is there to breeding organisms from closely related species? Explain.

Unit 6: The Changing Nature of Life





Vocabulary

Study the vocabulary words and definitions below.

adaptation .... a trait that a species develops over generations which helps it to survive

bias .... a preference that can hinder impartial judgement

Charles Darwin .... the biologist who developed and offered evidence of the theory of natural selection—he showed how living things had changed over long periods of time

evolution .... changes in living things over time

extinct .... describes a species that no longer has any living representatives

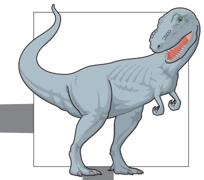
fittest .... best suited to survive in its environment

fossil .... remains of organisms that lived in the past

gene .... unit of DNA that determines a specific trait in the organism; genes come in pairs

mutation .... a change in genes that causes a change in a particular trait

natural selection .... the survival of organisms best fit for the environment

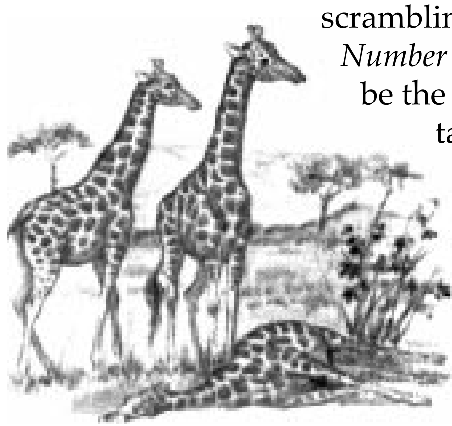


Introduction

Some people may look at a forest and see a peaceful, green landscape where the birds twitter and the rabbits hop. However, the forest is, in fact, an ever-changing setting where animals and plants must struggle every day to survive. That is what this unit is about: how living things must either meet the demands of their environment or die. As Earth has changed over billions of years, living things have also had to change.

Survival of the Fittest

Have you ever heard the expression, "survival of the **fittest**"? What do you think it means? Does it bring to mind teams of brawny football players, butting heads and crunching bones, scrambling to make a touchdown, struggling to be *Number One*? Which team will triumph? Will it be the team that can adapt its game strategy to take advantage of the other team's weaknesses? Will it be the team that has developed a startling new offensive play that no other team is prepared for?



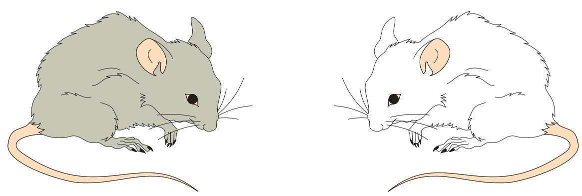
Biological playoffs are going on every day, constantly, without end. Animals and plants compete against each other for food and habitat, or shelter. They struggle against natural forces, such as drought and hurricanes, to survive just one more day. Much like a winning football team, it's those organisms who can make **adaptations**—changes that help them survive—who make it. But these adaptations may be much different than those you'd expect from a football team. Let's take a look at the world of mice.

Adapting to Survive

The oldfield mouse is widespread throughout northern and central Florida. It feeds on seeds and berries and makes its home in burrows. It digs in sand beaches and sandy fields. In most places, this mouse is the color of pale cinnamon. However, in Florida's Gulf Coast sand dunes, biologists discovered that some of these mice are white! How did this come about?

Oldfield mice differ in how light or dark their fur is. That is, oldfield mice show differences in the color of their fur. Biologists suggest that on sand dunes mice with lighter fur have a higher rate of survival. Why? Mice with light-colored fur are better able to blend in with the sugar-white sand and sneak past the foxes and hawks that hunt them. Mice with dark fur would be seen, caught, and eaten. Over time, more individuals with lighter fur have survived and have had more offspring, thereby passing on **genes** for lighter and lighter fur. It's even possible that some mice have had genetic **mutations—**changes in their chromosomes—that allowed them to have whiter fur.

Natural Selection

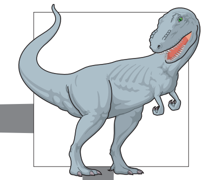


oldfield mouse
pale cinnamon color

oldfield mouse
white color

So, as generations passed, oldfield mice living in Florida's Gulf Coast sand dunes adapted to their surroundings. The higher survival rate of mice with light fur illustrates the process of **natural selection**. In a sense, nature "selected" their traits. Lighter fur made these mice more fit—more capable of survival—in their environment than the dark fur. In this case, *survival of the fittest* didn't mean survival of the strongest. It simply meant a change of uniform.

The change was an adaptation. Was it something the mice meant to do? The mice did not control the change. Consider what would have happened if some of the mice weren't able to have white fur. If this had been the case, the mice would not have survived on the white sand. Adaptations are not changes that happen to one organism. Adaptations are changes that nature causes in a group of organisms. When a species of organism is able to undergo changes to survive, it is usually fit. The species has adapted.



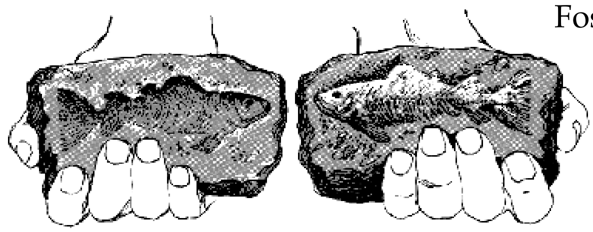
Nature's Heap: The Fossil Record

What's the flip side of survival of the fittest? What happens to animal and plant species that fail to adapt? You've probably heard the word *extinction*. When a species fails to adapt to the problems it faces and all living examples of this organism die out, then it is said to be **extinct**.

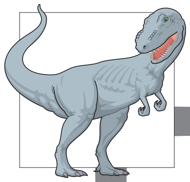
When people dig deep into the earth or look at cliff faces where old rivers have cut deep down through stone, they often find traces of animals and plants that went extinct thousands or millions of years ago. These signs of earlier life forms are called **fossils**. Fossils usually appear in layers in the earth. The most recent fossils are close to the surface, while older fossils lie deeper. Thus biologists can observe changes in animals and plants over time by looking at this fossil record.

Florida Fossils

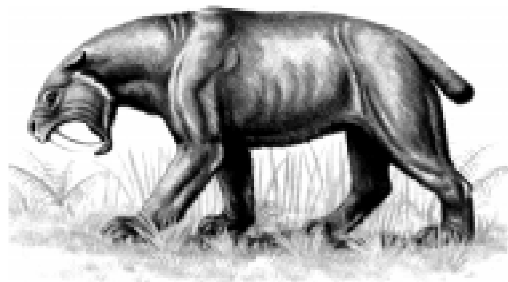
Florida is full of fossils. Since much of Florida was once underwater, you can often find fossils of ancient sea life, such as shark's teeth and petrified sea urchins, simply by looking carefully as you walk down sandy roads.



Fossils of creatures that lived on land are also plentiful in Florida. Many have been found in phosphate pits in central Florida, but they're also common in springs and spring-fed rivers in other parts of the state. During an Ice Age, millions of years ago, Florida was sort of a warm-weather resort for mammals. These were not the sort of mammals we know today. Many were huge, bizarre creatures. The saber-toothed tiger lived in Florida at this time. So did the giant sloth, which was 20 feet long, weighed 12,000 pounds, and could uproot the trees it fed on. Glyptodonts—giant, armadillo-like animals with spikes on their tails—could grow to as much as 12 feet in length. And there were many, many other types of animals here: horses, camels, rhinoceroses, and mammoths.



Most of these animals became extinct. There are no longer any saber-toothed tigers or truck-sized ground sloths trotting around the "Sunshine State." Imagine the trouble drivers would have if glyptodonts were still trying to cross the highways. "Road kill" would take on a whole new meaning. As the environment in which the animals lived changed, new abilities, features, or size became important. The animals that could not change did not survive. In biology, the inability to change with changing surroundings often leads to death. Biologists suggest that the saber-toothed tiger's famous teeth were so big that the cat finally couldn't compete with other types of big cats for food. Of course, this is just a hypothesis. No one really knows specifically why many of these ancient animals died out.

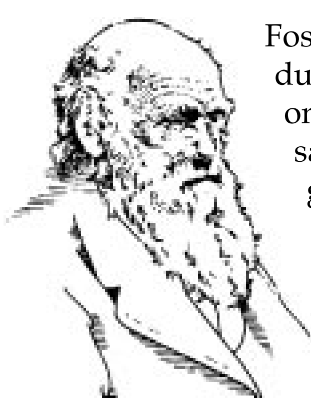


saber-toothed tiger

Then there are those animals like the early rhinoceros. Though it died out in Florida, it managed to survive in Africa and become the rhino we know today. Of course, many other animals did survive in Florida to become present-day natives: alligators, manatees, bats, and panthers are just a few. These animals were able to change with Florida's changing environment through *adaptation*.

Though the Pleistocene ice ages ended about twenty-thousand years ago, traces of this era are still evident in Florida. Not only does Florida boast a very rich fossil record, but our state has more different kinds of living plants and animals than any other state besides California or Texas.

Darwin's Theory of Evolution



Charles Darwin

Fossils fascinated **Charles Darwin**, a biologist who lived during the 1800s. Darwin was a great collector. He not only collected fossils of all kinds, he also collected samples of living plants and animals. One of his greatest opportunities for collecting came when he signed on as ship's naturalist on the HMS (HMS stands for His/Her Majesty's Ship) *Beagle*. In 1831 the ship started a five-year journey. During this time, Darwin was able to collect and observe many organisms. Darwin was struck by the similarities and differences of the things in his collections. As he puzzled over how some specimens were very similar but had developed differences in small traits, he realized that living things change over time. These changes may take hundreds or thousands or millions of years. He called this process **evolution**. He wrote a book about it, *The Origin of Species,* in 1859. There he offered hundreds of pages of evidence from the fossil record and the living world to support his theory of the way evolution proceeds through natural selection.

These are the basic points Darwin made.

1. Organisms produce more offspring than the environment can support.

2. The offspring are different from each other—there is *variation*.

3. The offspring struggle to survive: they struggle against each other, against other creatures, and against elements of nature such as weather.

4. *Natural selection* occurs, and only the offspring who are most *fit*—best suited to their environment—survive.

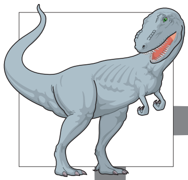
Genetics and Evolution

wooly mammoth

When Darwin published *The Origin of Species*, it would still be six years until Gregor Mendel published his work on genetics. While Darwin had some of the story, he was still missing large portions. Over time, other scientists have added details to our views.

Genetics are both the cause and result of evolution. Anytime an organism undergoes a mutation, evolution may result. A mutation in genetic material happens when base pairs (Unit 5) become rearranged. This results in the organism doing one of the following: producing a new protein or not producing a protein it previously used.

Changes often result in the organism's death. In some cases, the change doesn't seem to matter. Occasionally, the change—the mutation—makes the organism more fit.



Being fit increases an organism's chances to reproduce. This means that the number of offspring with the trait increases. These organisms are still the same species, but they are a little different.

If the environment changes, there are a number of organisms with a wide variety of genes. As a result, the likelihood that some will survive is much higher. Less fit organisms do not survive. This keeps the number of organisms at a level the environment can support. It also means that the amount of food and other materials is higher for the more fit organisms.

With the constant changing of conditions, life becomes diverse. The competition for resources (food, water, etc.) can be intense. To be most fit, a species must be very adaptable. With the findings of Darwin and Mendel, scientists are seeing how these adaptations are made.

The Controversy over Evolution

Everything in science is based on observation. For example, imagine if a scientist came up with this theory:

> Life arose from cotton balls.

Immediately, other scientists would demand evidence. If the given evidence didn't match other theories or things known, there would be problems. Scientists around the world would criticize the theory. They would judge the "cotton-ball" theory based on the following:

Judge the "Cotton-Ball Theory"

- how it fits with other theories
- how well it explains observed data
- how broad a variety of observations it explains
- how effectively it predicts new findings

Very likely, the "cotton-ball" theory would not last. At some point, someone might wonder who came up with the "cotton ball" theory. Imagine if you learned this:

> The "cotton-ball" theory was created by a group of scientists that work for a cotton ball company.

Would this explain why they came up with the theory? A preference that hinders or prevents impartial judgement is known as **bias**. To avoid problems like the one we described, scientists are supposed to seek out their own biases. Once they know what the biases are, they can design their research to avoid faulty conclusions. Apparently, the cotton-ball scientists did not do this.

Many people believe that Darwin and other scientists working on evolution have reached faulty conclusions. The conclusions of science, however, are based on observation. They are based on testing, review by other scientists, and reexamination. So far, evolution appears far more sturdy than any "cotton-ball" theory. Does this mean the controversy will go away? Probably it will not. In science, however, criticism leads to stronger theories, better understanding, and more knowledge.

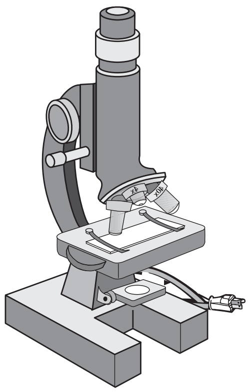
Summary

The living world is an ever-changing place where only the fittest survive. Here, *fittest* describes the species that are best suited to their environment. Mutations can lead to changes in genetic material. The changes are the result of the rearrangement of chemicals within DNA. These changes affect an organism's fitness and ability to survive. Those organisms who are well suited to their environment increase through natural selection. In a sense, nature *selects* them for survival because they have useful traits. The fossil record gives many examples of animal and plant species that have become extinct because they did not develop useful *adaptations* quickly enough.

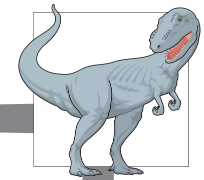
Charles Darwin studied the fossil record and the living world to develop the *theory of evolution* in the 1850s. The changes that come about in living things over time are known as *evolution*. Evolution, like other theories, receives much criticism. In all research, bias must be examined to insure reliable conclusions.

Careers in Biology

Museum Curator



Museum curators take care of museum collections. They decide on a system by which to organize the collection, catalog each item, store it according to the category to which it belongs, and then make sure that each item remains well preserved. Natural history museum collections, such as those at the Smithsonian Institution, may contain thousands of animals and plants. Curators of natural history collections either have graduate degrees or extensive experience in identifying and gathering collections.



Practice

Use the list below to complete the following statements.

adapt	**extinct**	**mutation**
adaptations	**fittest**	**natural selection**
criticism	**fossil**	**saber-tooth tiger**
Darwin	**giant sloth**	**survival**
evolution	**glyptodont**	**variation**

1. The term ______________________________ describes living things that are best suited to their environment.

2. Species that survive are the ones that make ______________________________ or meet changes.

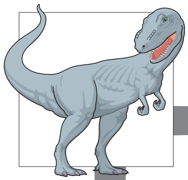
3. Florida has a rich ______________________________ record.

4. Two examples of land animal fossils found in Florida are the ______________________________ and the ______________________________ .

5. Some animals unable to adapt to the changing environment became ______________________________ .

6. Living things ______________________________ over time to meet their changing environment.

7. The biologist ______________________________ studied evolution in the 1800s.



8. The ______________________________ was a giant, armadillo-like animal with a spiked tail that once lived in Florida.

9. *The Origin of Species* is a book written in 1859 about ______________________________ .

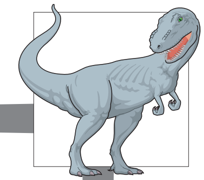
10. Nature selects the fittest for ______________________________ because they have useful traits.

11. Changes may occur in animals due to changes in the sequence of base pairs in their DNA, and this is known as a ______________________________ .

12. Oldfield mice show ______________________________ in the color of their fur.

13. The survival of the light-colored oldfield mice on Florida's Gulf Coast is an example of the process called ______________________________ .

14. Evolution is a controversial theory that has survived much ______________________________ .



Practice

Explain each term using complete sentences.

1. "Survival of the fittest": ______________________________

2. Adaptation: ______________________________

3. Evolution: ______________________________

4. Bias: ______________________________

Lab Activity: Coloration

Facts:

- Through evolution, some organisms have developed changes in color that allow them to blend in with their natural background.
- Those animals that blend in with their natural background are less obvious to predators.

Investigate:

- Using different-colored toothpicks as prey, you will act as predator and see how color plays a part in whether or not prey survive.

Materials:

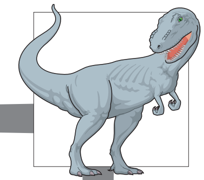
- 100 green toothpicks
- 100 red toothpicks
- a grassy area about 10 meters square

1. Scatter 100 red and 100 green toothpicks in a grassy area about 10 meters square. The toothpicks represent insects.

2. Pretend you are a bird. Put one hand behind your back and use your other hand as a beak to gather food.

3. Pick up as many toothpicks as you can in 30 seconds.

4. Count the toothpicks to see how many green ones and how many red ones you have collected. Record your findings on the following chart.



The Coloration Game		
Number of 30-Second Trials	**Red Toothpicks Collected**	**Green Toothpicks Collected**
1		
2		
3		
4		

5. Repeat your 30-second "hunting" sessions for a total of four trials, and record all results on the chart.

6. Which color toothpicks could you see most easily? ________________

7. In the first trial, how may red toothpicks did you pick up? ________

   How many green toothpicks? ________________________________

8. How many trials did it take to pick up 75 red toothpicks? _________

   How many trials did it take to pick up 75 green toothpicks? _______

9. Which color of insect (remember, the toothpicks represented insects) has a better chance of survival? Why?

   ____

   ____

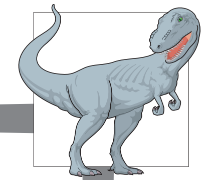
   ____

   ____

   ____

10. If these were real insects, what do you think would happen to the red insects after a long period of time?

11. What do you think would happen if you tried the same investigation in a dirt area rather than a grassy area?



Practice

Use the list below to write the correct term for each definition on the line provided.

adaptation	**extinct**	**gene**
Darwin	**fittest**	**mutation**
evolution	**fossils**	**natural selection**

________________________ 1. a change in genes that causes a change in a particular trait

________________________ 2. describes a species that no longer has any living representatives

________________________ 3. a trait that a species develops over generations which helps it to survive

________________________ 4. a unit of DNA that determines a specific trait in the organism

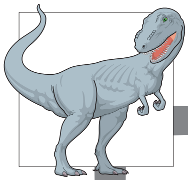
________________________ 5. the survival of organisms best fit for the environment

________________________ 6. changes in living things over time

________________________ 7. remains of organisms that lived in the past

________________________ 8. best suited to survive in its environment

________________________ 9. the biologist who developed and offered evidence of the theory of natural selection



Practice

Answer the following using complete sentences.

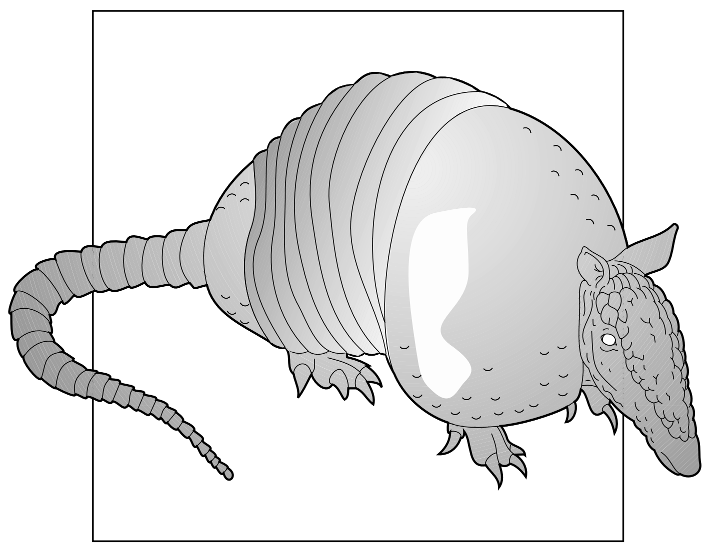
1. How does genetic variation create new species over time?

2. How does changing the proteins produced in a cell alter what an organism does?

3. In terms of evolution, why do animals that are preyed upon (eaten) likely to have a high number of offspring?

4. Why is it vital that scientists recognize their own biases and that they be open to criticism?

Unit 7: The Diversity of Living Things



Vocabulary

Study the vocabulary words and definitions below.

algae (brown, red, or green) .... a nonvascular plant that reproduces by spores; makes it own food

amphibian .... a thin-skinned, scaleless, cold-blooded vertebrate; many spend part of their life in the water and part on land, and lay eggs in water
Examples: frog, salamander

annelid worm .... a segmented worm with a well-defined body cavity as well as a system of blood vessels and nerves
Example: earthworm

arthropod .... an animal with a segmented body and an exoskeleton
Examples: all insects, spider, crab, lobster, shrimp

bird .... a warm-blooded vertebrate that has feathers and wings
Examples: eagle, robin

chordate .... an animal that has a nerve cord in its back at some point in its life

cnidarian .... a bag-shaped animal with only two cell layers that is armed with stinging cells, and often has tentacles
Examples: jellyfish, sea anemone

cold-blooded .... having a body temperature that is determined by the temperature of the surroundings

conifers .... a vascular plant that has needlelike leaves and reproduces by seeds in cones

echinoderm .... a spiny-skinned animal whose parts are arranged in a pattern of five rays
Examples: starfish, sea urchin

endoskeleton .... a skeleton that appears on the inside of the body

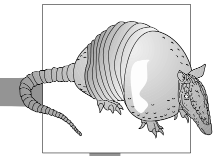
exoskeleton .... a skeleton that appears on the outside of the body

fern.. a vascular plant that reproduces by spores as well as sperm and eggs

fish .... a cold-blooded vertebrate that lives in the water and breathes through gills; most have scaly skin
Examples: grouper, bass

flatworm .... a ribbon-shaped worm with no body cavity
Example: tapeworm

flowering plant.............................. a vascular plant that reproduces with flowers
Examples: azalea, camellia



invertebrate .... an animal without a backbone

mammal .... a warm-blooded vertebrate that has hair and whose females feed the young with milk glands
Examples: human, bear

mollusk .... a soft-bodied animal with a muscular foot or feet; may or may not have a shell
Examples: oyster, octopus

moss .... a nonvascular plant that reproduces by spores

nonvascular .... plants without tubelike cells

photosynthesis .... the process plants and algae use to make the sugar glucose, from water, carbon dioxide, and the energy in sunlight

phylum .... the largest, most general group of a kingdom (*pl.* phyla)

reptile .... a dry, scaly, thick-skinned, cold-blooded vertebrate that lays eggs on land
*Examples: s*nake, alligator

roundworm .... a round worm with a tubelike body cavity
Example: hookworm

seed .... a part formed by a flower or cone that contains a new plant and stored food

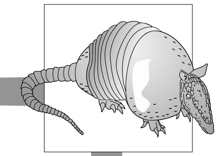
sponge .... a simple animal with two layers of unspecialized cells that gets food by filtering water through its pores

spore .... a specialized cell that can grow into a new plant

vascular .... plants having tubelike cells for transporting liquids

vertebrate .... an animal that has a nerve cord in its back and a backbone

warm-blooded .... having a constant body temperature regardless of the temperature of the surroundings; only birds and mammals are warm-blooded



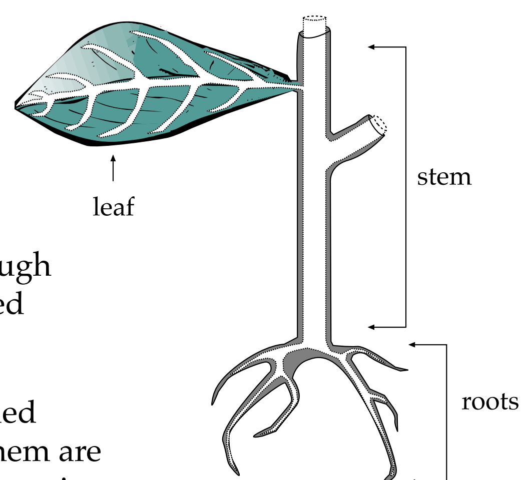
Introduction

Have you ever taken a moment to think how many different forms of life there are on Earth? Study a forest or field sometime and count how many different animals and plants you see. Now think about all those little organisms you can't see: tiny insects, protists, and bacteria. These are the organisms of our familiar landscapes. How about those that live on the seashore, in the ocean, and in the rain forests? If you ever have a chance to search the Florida seashore at low tide, you might be amazed at all the different animals you will find: jellyfish, sea worms, sea cucumbers, and starfish. These are animals whose strategy for living is as mind-boggling as anything you'll see in a science fiction movie.

The word *diversity* means a wide variety or a wide range of differences. In this unit we will look at the diversity of organisms that share our world with us. Some may be stranger than you ever imagined. This unit will examine how scientists use knowledge of organisms' ancestors, behavior, and shape to classify them.

A Survey of the Plant Kingdom

Have you ever wondered how trees get water from their roots all the way up to their topmost leaves? The answer is a system of tubelike cells that work sort of like elevators. This elevator system of tubelike cells goes down as well as up. It moves food made in the leaves down to the roots. The roots can't make food through **photosynthesis** because they're buried underground and receive no light.



Plants that have tubelike cells are called **vascular**, and those that don't have them are called **nonvascular**. These are the two main divisions in the green kingdom of plants.

Nonvascular Plants

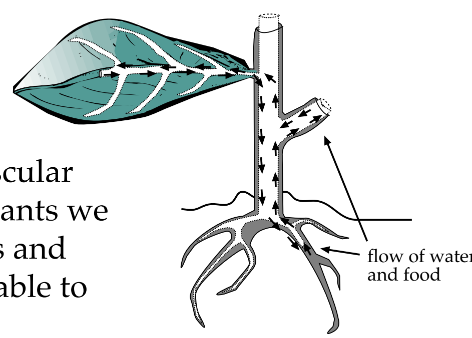
As you might imagine, nonvascular plants can't grow very tall. Without tubelike cells to move water and food around, each cell must be close to a water source, and each cell must be able to make its own food. Thus they don't have as many different parts—leaves, flowers, stems, roots—as vascular plants. Essentially, they are just clumps of green cells. Plants in this group include things like green **mosses**, liverworts, and green, red, and brown **algae**.

If these plants don't have **seeds**, how do they reproduce? The answer is **spores**. Spores are very fine particles—each a very small cell—that can develop into a new plant. When spores are ready for release into a plant's surroundings, they burst like a puff of powder out of capsules on the tips of the plants.

Vascular Plants

Most of the plants we're familiar with are vascular. Trees, grass, bushes, and vines are all vascular. Tube cells carry water to different parts of the plant. Vascular plants can grow very tall. In vascular plants we see specialized structures such as leaves and roots because the plant cells have been able to adapt to different tasks.

Vascular Plant



Ferns

Ferns are common around the world. They live in a variety of areas. Usually, they are found low, near the ground. Some are small, but others are quite large. Among the largest in Florida is the leather fern, common in South Florida's swamps.

Ferns, along with other lesser-known plants like horsetails and club mosses, are members of an in-between category: vascular plants that reproduce by spores. Although they have the tubelike cells that allow them to move food and water around through their larger bodies, they still develop powder-like spores that they release through capsules. The spore capsules on ferns are very obvious: rows of raised, brown dots on the bottom of leaves.

Conifers

Conifers are trees that have cones. They are very common in Florida. Most of us are familiar with pine cones. You may have noticed cones on cypress trees. Conifers are often called evergreens. This means they have needlelike leaves that stay green all year; Florida's cypress is notable as a conifer because it loses its needles in the winter.

You may have wondered what purpose the cone serves. Remember that one characteristic of living things is that they reproduce. Cones help these trees reproduce. The cones' prickly scales cover seeds. The seeds of conifers are like other seeds. They contain a cell that will grow into a new tree. They also contain some food for that cell to use. Lastly, the seed includes a covering to protect the food and cell. When conditions are right, the cone releases the seeds. The seeds may then become new trees.

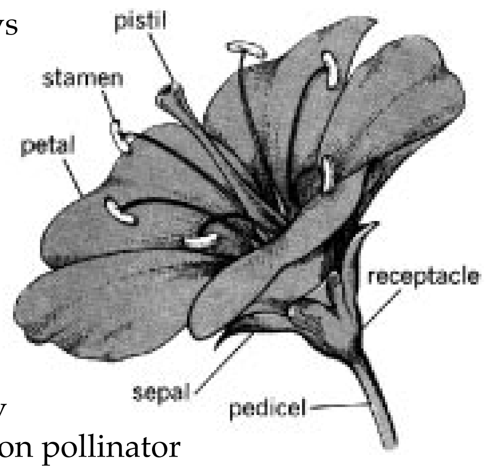
Flowering Plants

This group contains the plants that most of us know best: those that have leaves and flowers. In this plant group it is very easy to see how plant parts have specialized—taken on special qualities—to carry out different jobs.

Plant Parts and Their Specialized Jobs

Plant Part	Job	Special Qualities
Leaf	photosynthesis	• most are broad and flat with large surface to capture sunlight • filled with chlorophyll, which is needed in photosynthesis
Stem	support, movement	• has cells with hard cell walls for support • has many tubelike cells
Root	anchors plant	• has root hairs that help it absorb water and nutrients • takes in water and nutrients from the soil • has special cells for storing starches and holding water • has slimy root tip with cells that divide quickly and push through the soil
Flower	produces male and female sex cells; attracts pollinators	• contains plant's sexual parts • sometimes has showy parts that attract pollinators

The flower is one of the most remarkable parts of these plants. People have long appreciated flowers for their beauty. In fact, the flower is dedicated to the process of sexual reproduction. All of the sexual parts of **flowering plants** are right there inside the flower. Every aspect of the flower is designed to encourage the union between male and female sex cells.



Look at the drawing to the right. It shows the way parts of a flower are arranged. The petals and sepals are often the most obvious part of the flower. This is because their function is to attract animals and insects that can help move pollen—the male sex cells. These animals and insects are called *pollinators*. Since plants can't move to other individuals to reproduce sexually, they rely on pollinators to carry male sex cells around for them. A common pollinator is the bee. When a bee arrives at a flower, it noses around looking for nectar—another attraction device the plant has perfected. Nectar is often a sweet, fragrant liquid which bees eat and use to make honey. As the bee moves around, it brushes the *stamen*, the male part of the flower, which is coated with pollen. The pollen sticks to the bee. Then, at the next flower the bee visits, it rubs its back against the *pistil*, the female part of the flower. Pollen grains stick to the pistil and grow down inside of it to fertilize the female sex cells. Thus one plant has managed to fertilize another—with a little help from a nectar-hungry bee.

When pollen from one plant manages to fertilize another plant, the process is called *cross-pollination*. However, it's easy to see how a plant might fertilize itself using a process called *self-pollination*. Some plants don't depend on pollinators to spread their pollen but instead wait for the wind to blow their pollen about. As you might imagine, wind-pollinated plants have no need for big, showy flowers. In fact, their flowers are often almost invisible—to the eye. Each year, pollen from ragweed, pecan trees, and other wind-pollinated plants bothers sensitive noses, bringing on the miseries of hay fever.

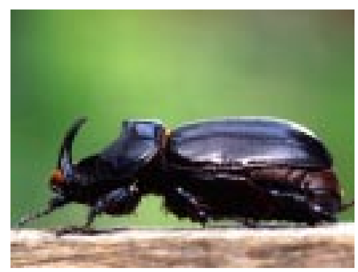
Remember, also, that some plants can reproduce without all the flowery fuss of sexual reproduction. Many plants can reproduce asexually; a whole new plant can grow from a leaf, a stem, or a root. Plant nurseries often use this technique, called *propagation*, to grow new individuals.

A Survey of the Animal Kingdom

domestic cat

The animal kingdom is generally divided into 30 major phyla, although the majority of animals are found in nine phyla which we will study. The most familiar of these phyla is the **chordates**. As you can tell from the name, chordates are animals that have a nerve cord in their back at some point in their development. Most animals that have this nerve cord also have a backbone. The pieces of this backbone are called vertebrae, so animals with backbones are called **vertebrates**. Vertebrates are only one part of the chordate **phylum**. But since vertebrates are large, and since human beings are vertebrates, we tend to pay the most attention to this group.

We shouldn't allow our strong interest in vertebrates, however, to distract us from the **invertebrates**—animals without backbones. In fact, most of the world's different sorts of animals fall into these phyla. For example, insects are members of the **arthropod** phylum. Insects are invertebrates, and there are 800,000 species of them in the world. Invertebrates also include some of the weirdest animals you'd ever want to meet. You might expect space creatures to be all head and legs or to spend their lives chewing up and spitting out dirt. But don't be surprised if this description fits many of our fellow earthlings—invertebrate earthlings.



beetle

Invertebrates

The invertebrates are often thought of as being more "primitive"—less complex—than vertebrates. Level of complexity is a trait scientists use to group animals. You will notice that the invertebrate animal phyla below are arranged according to whether or not they have certain types of physical equipment. We move from **sponges**, which resemble living baskets, to worms, arthropods, and **mollusks**, which have blood vessels, muscles, and digestive systems.

In many ways, however, "complexity" is a matter of personal judgment. It would be misleading to say these animals are simple. Invertebrates are marvels of physical design and have developed startling techniques for surviving in their environment. For instance, the octopus can squirt ink from its mouth, and the spider can shoot silk from its bottom. The starfish can turn its stomach inside-out. Who could belittle such abilities?

Here, we will look at eight phyla of invertebrates—those that contain at least one member that would seem familiar to most people. We will describe the major traits of these invertebrate phyla and present one or two members that you might know.

Sponges. The sponge is an animal with a basket-shaped body made up of two layers of cells that have pores, or holes. The sponge has special cells that set up a current to draw water inside. As the water passes back out of the sponge, the sponge filters out tiny animals that it uses for food. Sponges cannot move about and must be anchored to some surface. They have a flexible form, a sort of "skeleton," made up of particles of silicon or calcium or fibers of spongin.

sponge

The sponges we normally see are just skeletons of the living animals. Live sponges are still common in the waters near Tarpon Springs, Florida.

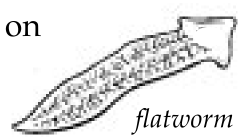
Example: any natural sponge used for bathing or cleaning is a familiar example—that is, a familiar example of a *dead* sponge.

Cnidarians. Cnidarians are mostly free-swimming animals with a bag-like body made up of two cell layers. They have a stomach cavity, or space, with one opening. Most have tentacles and all are armed with tiny, stinging darts.

coral

Examples: jellyfish, coral, sea anemone.

Flatworms. Flatworms are just what they sound like: flat, ribbonlike worms with no body cavity. Each flatworm is both male and female. Many are parasites on vertebrates.



flatworm

Examples: tapeworm, planarian.

Roundworms. Roundworms differ from tapeworms in that they are indeed round. This is partly because they do have a body cavity, a sort of long inner tube for digesting food. They have muscles. Roundworms are either male or female—not both. Many are parasites and cause health problems.

roundworm

> **Examples:** hookworm, pinworm, and *Ascaris*, a parasite found in uncooked pork.

earthworm

Annelid worms. Annelid worms have bodies that are very obviously divided into segments. They have a body cavity, they have hearts (several!), and blood vessels. They also have nerve cells, a nerve cord, and two openings to their digestive system.

> **Examples:** earthworm, leech.

clam

Mollusks. Mollusks are soft-bodied animals that may or may not have shells. They have well-developed systems of blood vessels, nerves, muscles, and food digestion. Most mollusks are equipped with a large, muscular foot.

> **Examples:** snail, oyster, clam, octopus (divided foot).

crab

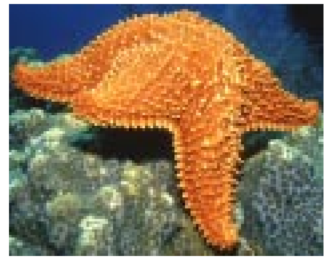
Arthropods. Arthropods are segmented animals with a hard outer shell called an **exoskeleton**. They have jointed legs attached to their segments. They have well-developed systems of blood vessels, nerves, muscles, and food digestion.

> **Examples:** all insects, spider, lobster, horseshoe crab, other crabs, shrimp.

Echinoderms. *Echino-* means "spiny," and *-derm* means "skin." So the name of these animals tells you they are spiny-skinned. Most have a body of five parts arranged in a circular design. Most also have tiny, fingerlike suction cups called *tube feet*. Echinoderms move by taking in water through their tube feet and forcing it through their bodies along a system of tubes and canals. They use this system instead of muscles.

Otherwise, echinoderms have well-developed systems of nerves and food digestion. They also have the unusual ability to pass their stomachs through tiny openings—into the crack between the two shells of an oyster—and to turn their stomachs inside-out to digest their prey.

Examples: starfish, sand dollar, sea urchin.



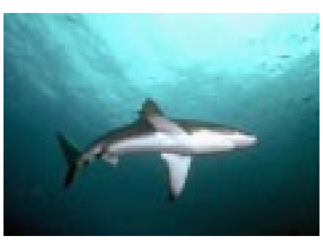
starfish

Chordate Phylum, Including Vertebrates

Out of the nine major phyla of animals in our world, people are most familiar with the chordates. One common trait of this phylum of animals is that they have a cord of nerves in their back at some point in their life. One subphylum, which includes most chordates, has backbones, or vertebrae. Thus they bear the name *vertebrates*. Another common trait vertebrates share is that their skeleton is on the inside of their body—they have an **endoskeleton**.

Fish, **amphibians, reptiles**, **birds**, and **mammals** are all classes of the vertebrate phylum. They all have backbones and endoskeletons, but as you will see, in other ways they are very different from each other.

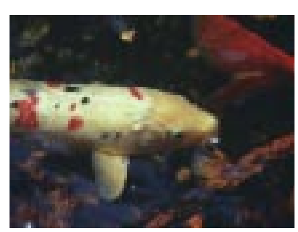
Fish. Fish fall into three classes: jawless fish, cartilage fish, and bony fish. One jawless fish, the lamprey looks and lives much like a leech. Slimy and scaleless, the lamprey, is basically a muscular tube with a mouth full of sharp teeth and a razor-edged tongue. It makes its living by latching onto other fish, tearing a hole in them, and sucking out their blood and body fluids.



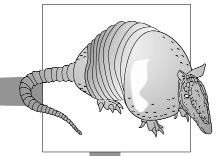
shark

Cartilage fish are fish that have flexible skeletons made of cartilage, a substance in the body similar to bone. Cartilage is soft and light and not as strong as bone. Fish that have such skeletons have fine, toothlike scales. Sharks and sting rays are familiar cartilage fish.

Bony fish include all other fish: goldfish, mullet, flounder, and bass, just to name a few examples. As their name tells you, their skeletons are made of bone. They usually have flat, broad scales.



goldfish



Amphibians and Reptiles. Amphibians are vertebrates that often live both in water and on land. Although some can spend long periods on land, they must live near a water source where they can lay eggs. Otherwise, the eggs dry out. Frogs, toads, and salamanders are all amphibians. As you can see from tadpoles, the earliest stage in the development of frogs, young amphibians usually look much different from adults.

lizard

Reptiles have thicker skin than amphibians. Their skin does not dry out as easily, so they are not as dependent on water. Reptiles, including turtles, lay their eggs on land. Most can live entirely on land. Reptiles include snakes, lizards, alligators, and turtles. Young reptiles look much like adults.

A **cold-blooded** animal's body temperature changes with the temperature of its surroundings. Most animals are cold-blooded. Only birds and mammals—the next two classes of vertebrates we'll look at—are **warm-blooded**.

bird

Birds. How would you define a bird? Easy: birds are vertebrates with feathers. Also, birds are the first animals we've studied that are warm-blooded. A warm-blooded animal keeps the same body temperature—within a few degrees—regardless of how hot or cold its surroundings. All birds also have wings, whether or not they use them to fly. Penguins use them to swim! Also, birds have a very lightweight, bone skeleton.

dog

Mammals. Human beings are mammals. So are monkeys, cows, dogs, cats—most of the animals we know best. But even in our own group, there are many mammals that surprise us with their strangeness. The blue whale—the largest creature ever known—weighs in at 150 tons and measures 100 feet long. Another unusual mammal is the naked mole rat, an almost hairless creature, who lives in underground colonies. But despite all our differences, mammals share these traits: all are warm-blooded and have hair, and females have milk glands to nurse their young.

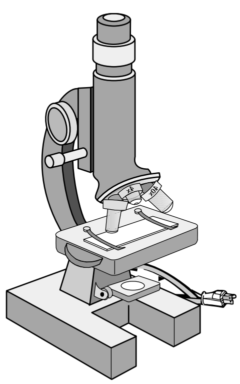
Summary

In this unit we have made a survey of the plant and animal kingdoms. We have studied the diversity, or the wide range of differences, among these organisms.

The plant kingdom is divided into nonvascular and vascular plants. Nonvascular plants include mosses and liverworts. Vascular plants include ferns, conifers, and flowering plants. Vascular plants have specialized parts, such as roots, stems, and leaves, for carrying out different functions. Flowering plants have developed a specialized part for carrying out sex—the flower. Male sex cells are found in the stamen of the flower, and female sex cells are found in the pistil.

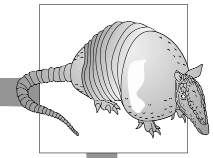
In the animal kingdom, we looked at nine of the phyla: sponges, cnidarians, flatworms, roundworms, annelid worms, arthropods, mollusks, echinoderms, and chordates. Chordates include vertebrates: animals that have backbones. Animals without backbones are invertebrates. Vertebrates include fish, amphibians, reptiles, birds, and mammals.

Careers in Biology



Science Illustrator

A **science illustrator** is a graphic artist who specializes in scientific topics. These topics are diverse. They include the physical and life sciences as well as everything between. Science illustrators often prepare for their career by studying science as well as attaining a degree in the graphic arts, such as BFA (bachelor of fine arts). Science illustrators may use a variety of media for their work, including computers, painting techniques, and line drawing.



Practice

Use the list below to complete the following statements.

asexually	**evergreens**	**pollinators**	**spores**
attract	**flower**	**propagation**	**stamen**
conifers	**nonvascular**	**seeds**	**vascular**
cross-pollination	**pistil**	**self-pollination**	**wind**
cypress			

1. Plants that have tubelike cells are called ________________ .

2. Plants that do **not** have tubelike cells are called ________________ .

3. Vascular plants reproduce by their ________________ or ________________ .

4. Nonvascular plants reproduce through their ________________ .

5. ________________ are trees that make cones.

6. Conifers are often known as ________________ .

7. A Florida ________________ is an unusual conifer because it loses its needles in winter.

8. The sexual parts of flowering plants are all located in the ________________ .

9. One function of the petals and sepals of flowers is to __________________________ animals and insects.

10. The male part of the flower is the __________________________ .

11. The female part of the flower is the __________________________ .

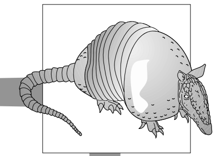
12. Animals and insects that help move pollen are called __________________________ .

13. When pollen moves from one plant to another plant and fertilizes that plant, the process is called __________________________ .

14. When a plant fertilizes itself, the process is called __________________________ .

15. Some plants depend on pollinators; others depend on the __________________________ to pollinate.

16. In a process called __________________________ , many plants reproduce another plant from a leaf, stem, or root.



Practice

List the terms below under the correct heading: **Vascular Plants** *or* **Nonvascular Plants.** *One or more terms will be used more than once.*

cypress tree	**green moss**	**not very tall**
division of labor	**liverworts**	**red algae**
ferns	**many different parts**	**spores**
flowers or cones	**no division of labor**	**tall**

Vascular Plants	**Nonvascular Plants**
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

Practice

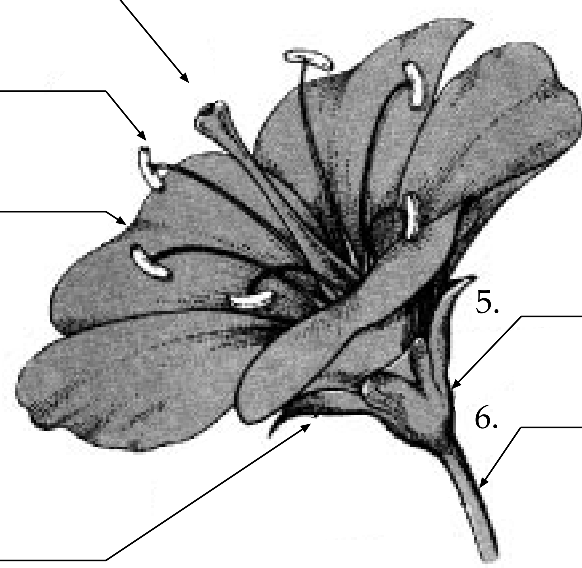
Use the list below to write the correct **part of the flower** *on the line provided.*

pedicel	**receptacle**
petal	**sepal**
pistil	**stamen**

1. ____________________

2. ____________________

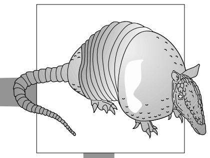
3. ____________________



4. ____________________

5. ____________________

6. ____________________



Lab Activity 1: Constructing Plant Models

Facts:

- Vascular plants have tubelike structures to carry food and water.
- Vascular plants have specialized plant structures such as roots, stems, and leaves.
- Nonvascular plants do not have tubelike structures.
- Nonvascular plants do not have roots, stems, and leaves.

Investigate:

- You will use models to determine the differences between vascular and nonvascular plants.
- You will examine and compare vascular and nonvascular plants under the microscope.

Materials:

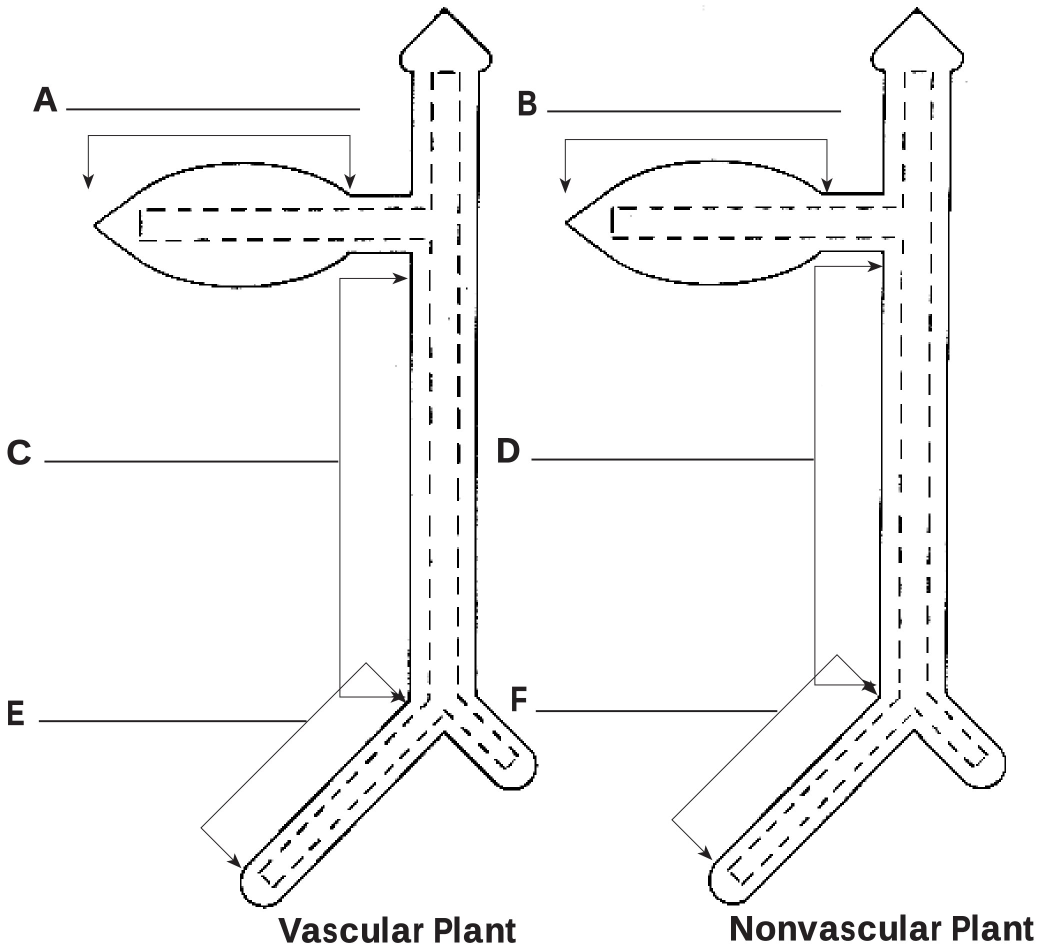
- green crayon
- razor blade
- 2 drinking straws
- sea lettuce
- 2 microscope slides
- scissors
- lettuce
- celery
- microscope

1. The diagrams in Figure 1 are outlined models of two plants. One is marked "vascular plant" and one is marked "nonvascular plant." Color parts **A** and **B** green. These are the parts that contain chlorophyll.

2. Cut and tape straws along the dashed lines on **only one model**. The straws represent tubelike cells. Review the definitions of *vascular* and *nonvascular* plants in order to determine on which model to place the straws.

3. Plant parts that appear to be leaves but lack the tubelike cells are said to be *leaflike*. Label parts **A** and **B** as either *leaf* or *leaflike*.

Figure 1



4. Plant parts that appear to be stems but lack the tubelike cells are said to be *stemlike*. Label parts **C** and **D** as either *stem* or *stemlike*.

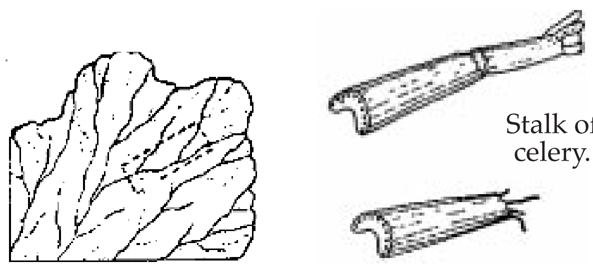
5. Plant parts that appear to be roots but lack the tubelike cells are said to be *rootlike*. Label parts **E** and **F** as either a *root* or *rootlike*. These leaflike, stemlike, and rootlike parts are features of *nonvascular* plants.

Lab Activity 1: Part 2: Examination of Vascular and Nonvascular Plants

1. Obtain a piece of lettuce. Use a razor blade to cut out a small section. See Figure 2.

Figure 2

Preparing Lettuce and Celery

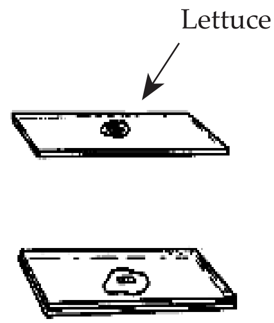


Remove a small section as shown here.

Pull apart pieces. This will expose tubelike structures (strings).

Figure 3

Slide Preparation



Place a small piece of lettuce or celery in the middle of a slide. Then place a slide cover over the lettuce or celery.

2. Place the section on a microscope slide. Add two or three drops of water.

3. Place a second "cover" slide over the first slide. Gently press the slides together. (See Figure 3.)

4. Examine the lettuce under low-power magnification only.

5. Look for long, tubelike cells. They may look like spirals or train tracks. Draw a diagram of what you see in the appropriate place in the chart on the following page.

6. Obtain a piece of sea lettuce from your teacher. Repeat steps 1 through 5. Draw a diagram in the chart of what you see.

7. What does the green color used in coloring the plant models represent?

____

8. What do the straws used in the model represent? ________________

____

9. Obtain a piece of celery from your teacher. Prepare the celery as shown in Figure 2. Cut off a 1 cm piece of the celery "string." Repeat steps 2 through 5. Draw a diagram in the chart.

10. Complete the last two columns in the chart.

Comparison of Vascular and Nonvascular Plants

Plant	Diagram	Tubelike Cells Present or Absent	Vascular or Nonvascular
Lettuce			
Sea Lettuce			
Celery			

11. List one way in which vascular and nonvascular plants are alike.

____

12. List three ways in which vascular and nonvascular plants are different. Use your model labels for help.

____

____

____

____

13. Explain how tubelike cells in vascular plants are used.

____

____

____

____

14. Explain the difference between stems and stemlike parts. __________

____

____

____

____

15. Explain the difference between roots and rootlike parts. __________

____

____

____

16. Consult the models. Are tubelike cells continuous throughout the plant if the plant is vascular?

____

How is this helpful to the plant? ____________________________

____

____

____

17. Would you expect to find roots, stems, and leaves in lettuce, sea lettuce, and celery?

____

Why? ____

____

____

____

____

____

____

____

____

____

Practice

Circle the letter of the correct answer.

1. Animals with backbones are known as __________ .

   a. vertebrates
   b. mammals
   c. invertebrates
   d. vascular

2. Animals without backbones are known as __________ .

   a. chordates
   b. nonvascular
   c. vertebrates
   d. invertebrates

3. A __________ is an example of an invertebrate.

   a. cnidarian
   b. sponge
   c. flatworm
   d. all of the above

4. Fish, amphibians, reptiles, birds, and mammals are all __________ .

   a. warm-blooded
   b. cold-blooded
   c. chordates
   d. invertebrates

5. Walking along the beach you might see a large number of echinoderms such as __________ .

   a. starfish
   b. jellyfish
   c. shrimp
   d. crabs

6. Fish, amphibians, and reptiles are all ____________ .

   a. invertebrates
   b. arthropods
   c. vertebrates
   d. endoskeletons

7. Vertebrates that often live both in water and on land but must lay eggs in water are ____________ .

   a. fish
   b. reptiles
   c. amphibians
   d. mammals

8. A ____________ animal's body temperature changes with the surroundings.

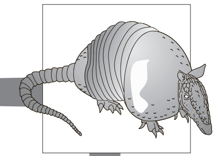
   a. warm-blooded
   b. cold-blooded
   c. reptile
   d. mammal

9. A ____________ is an example of a cnidarian.

   a. sea urchin
   b. jelly fish
   c. lobster
   d. sponge

10. Birds are defined as ____________ .

   a. mammals with wings
   b. chordates with beaks
   c. vertebrates with feathers
   d. invertebrates that fly



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Nonvascular plants grow very tall.

__________ 2. Vascular plants have many different kinds of cells.

__________ 3. The largest number of animals are vertebrates.

__________ 4. You might use an annelid to catch a fish.

__________ 5. A spider is a mollusk.

__________ 6. Some arthropods are common food for humans.

__________ 7. Vertebrates have an endoskeleton.

__________ 8. A cold-blooded animal keeps the same body temperature regardless of the surroundings.

__________ 9. Birds are cold-blooded.

__________ 10. All birds have feathers and wings.

__________ 11. All birds fly.

__________ 12. Human beings are mammals.

Practice

Write an example for each **group** *listed below.*

Sponges: ______________________________

Cnidarians: ______________________________

Flatworms: ______________________________

Roundworms: ______________________________

Annelids: ______________________________

Mollusks: ______________________________

Arthropods: ______________________________

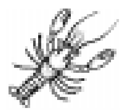
Echinoderms: ______________________________

Vertebrates: ______________________________

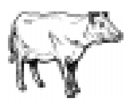
Practice

Match each **picture** *with the correct* **animal group**. *Write the letter on the line provided.*

____ 1. 

____ 2. 

____ 3. 

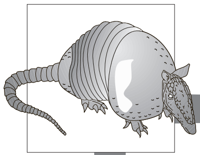
____ 4. 

A. arthropods

B. mollusks

C. chordates

D. flatworms

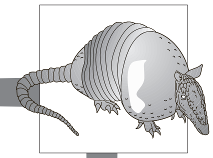


Practice

Use the list below to complete the following statements.

amphibians	**mammals**	**roundworms**	**warm-blooded**
arthropods	**mollusk**	**tapeworm/planarian**	
endoskeleton	**reptiles**	**vertebrates**	

1. Animals with backbones are in a subphylum of chordates called ____________________ .
2. Vertebrates have a skeleton inside their body called an ____________________ .
3. Insects, spiders, crabs, and shrimp are all ____________________ .
4. Frogs and salamanders are ____________________ .
5. A ____________________ animal's body temperature stays about the same regardless of the temperature of its environment.
6. When you eat an oyster, you eat a ____________________ .
7. ____________________ are not as dependent on water as are amphibians.
8. A human and a bear are both ____________________ .
9. A ____________________ is a flatworm.
10. Hookworms and pinworms are ____________________ .



Lab Activity 2: Animals

Facts:

- The chordate phylum, which includes vertebrates, contains only a small fraction of the world's animal species.
- The diagram in Figure 4 shows how many species are in each of the nine phyla we discussed in Unit 7.

Investigate:

- You will determine which phylum contains the most and the fewest species.
- You will construct graphs showing how many animal species are in each phylum.

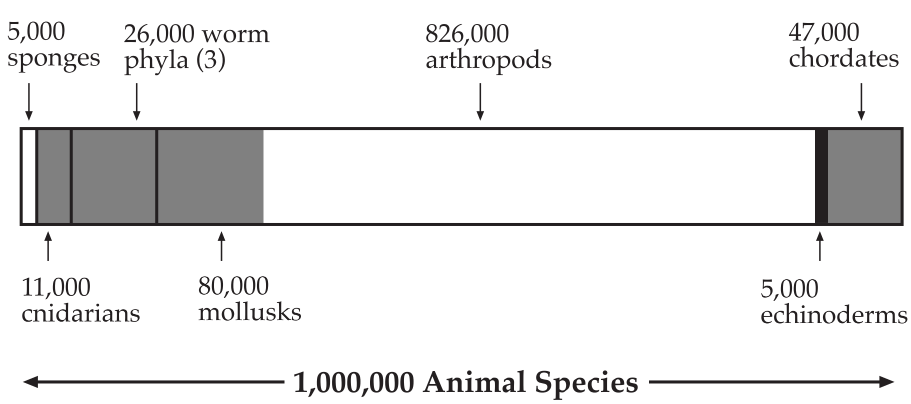
Materials:

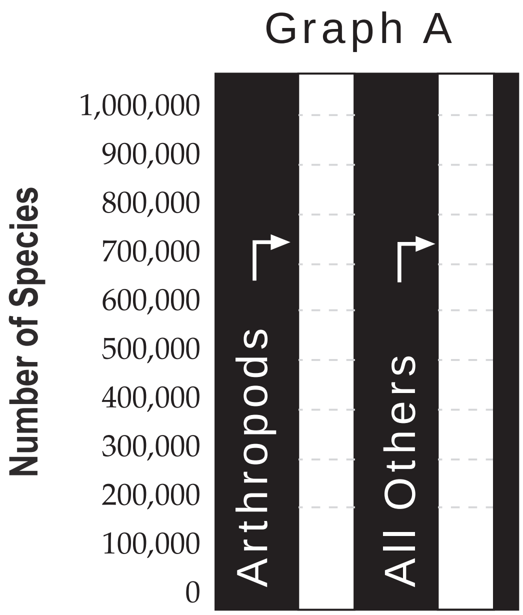
- pencil
- graph recording paper

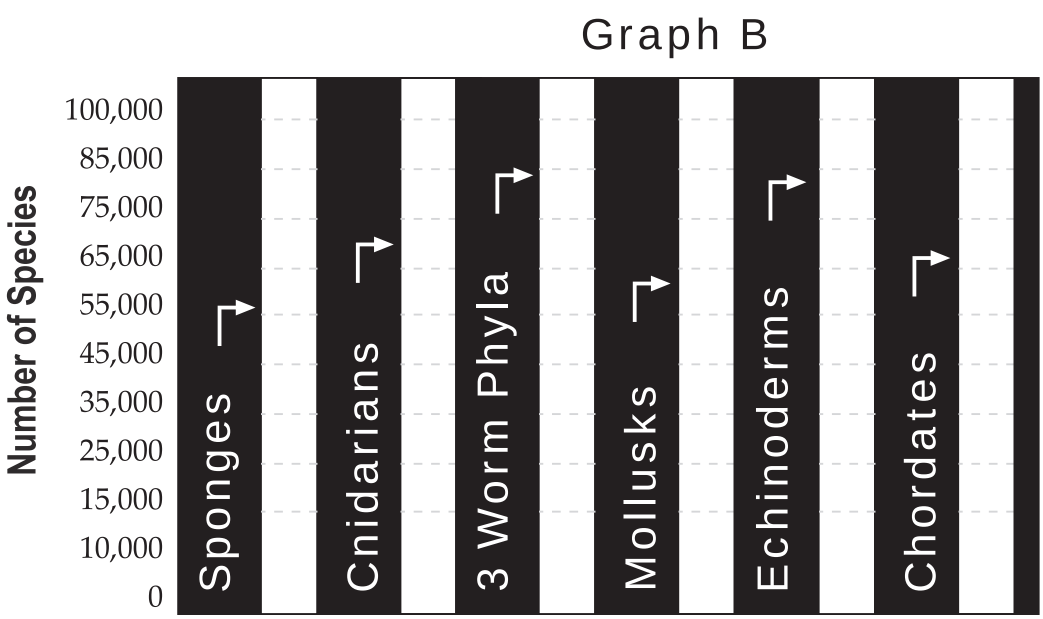
1. Using the data in Figure 4, complete Graph A by shading in the bars.

2. Using the data in Figure 4, complete Graph B by shading in the bars.

Figure 4

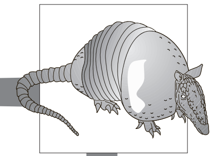






3. According to Figure 4, what is the total number of animal species?

____



4. According to Figure 4, what is the total number of animal species **not** counting the arthropods?

   ____

5. Which phylum has the largest number of species? ____________

   Which is the second largest phylum? ______________

   Which two phyla are the smallest? ________________

   ____

   Of all the animals in the world, which are the most numerous?

   ____

Practice

Use the list below to write the correct term for each definition on the line provided.

algae	**flowering plant**	**seed**
conifer	**nonvascular**	**spore**
fern	**photosynthesis**	**vascular**

____________________ 1. a part formed by a flower or cone that contains a new plant and stored food

____________________ 2. plants having tubelike cells for transporting liquids

____________________ 3. a vascular plant that has needlelike leaves and reproduces by seeds in cones

____________________ 4. a vascular plant that reproduces by spores as well as sperm and eggs

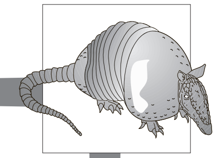
____________________ 5. a specialized cell that can grow into a new plant

____________________ 6. plants without tubelike cells

____________________ 7. the process by which plants and algae make glucose, a form of sugar, using chlorophyll to combine sunlight, carbon dioxide, and water

____________________ 8. a nonvascular plant that reproduces by spores

____________________ 9. a vascular plant that reproduces with flowers



Practice

Use the list below to write the correct term for each definition on the line provided.

amphibian	**cnidarian**	**flatworm**	**roundworm**
annelid	**cold-blooded**	**invertebrate**	**sponge**
arthropod	**echinoderm**	**mammal**	**vertebrate**
bird	**exoskeleton**	**mollusk**	**warm-blooded**
chordate	**fish**	**reptile**	

________________________ 1. an animal that has a nerve cord in its back and a backbone

________________________ 2. having a constant body temperature regardless of the temperature of the surroundings

________________________ 3. a simple animal with two layers of cells that gets food by filtering water through its pores

________________________ 4. an animal with a segmented body and an exoskeleton

________________________ 5. a round worm with a tubelike body cavity

________________________ 6. a spiny-skinned animal whose parts are arranged in a circular pattern

________________________ 7. a dry, scaly, thick-skinned, cold-blooded vertebrate that lays eggs on land

________________________ 8. a warm-blooded vertebrate that has feathers and wings

________________________ 9. an animal that has a nerve cord in its back at some point in its life

______________________ 10. a soft-bodied animal with a muscular foot or feet; may or may not have a shell

______________________ 11. a cold-blooded vertebrate that lives in the water and breathes through gills; most have scaly skin

______________________ 12. a segmented worm with a well-defined body cavity as well as a system of blood vessels and nerves

______________________ 13. a warm-blooded vertebrate that has hair and whose females feed the young with milk glands

______________________ 14. a skeleton that appears on the outside of the body

______________________ 15. a thin-skinned, scaleless, cold-blooded vertebrate; many spend part of their life in the water and part on land, and lay eggs in water

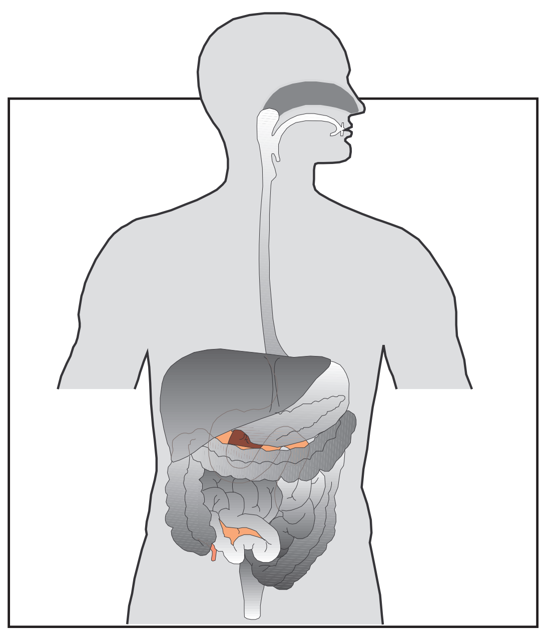
______________________ 16. a ribbon-shaped worm with no body cavity

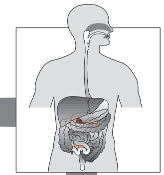
______________________ 17. a bag-shaped animal with two cell layers that is armed with stinging cells

______________________ 18. an animal without a backbone

______________________ 19. having a body temperature that is determined by the surroundings

Unit 8: Systems of the Body





Vocabulary

Study the vocabulary words and definitions below.

arteries .... blood vessels that contain blood traveling away from the heart

atrium .... the top chamber of both sides of the heart (*pl.* atria)

bile .... a substance produced in the liver and stored in the gall bladder that works specifically to dissolve fat in the small intestine

bones .... sections of the skeleton; serve as the framework for the body, anchors for the muscles, factories for blood cells, and storage places for calcium

bronchi .... the two branches of the windpipe that descend to the right and left lungs (*sing.* bronchus)

capillaries .... tiny blood vessels where pickup of wastes and delivery of oxygen and food takes place; connect arteries to veins

cardiac muscle .... tightly woven involuntary muscle that makes up heart muscle

cartilage .... a soft, flexible substance that sometimes hardens into bone as it ages

diaphragm .... the dome-shaped muscle at the base of the chest cavity that contracts and lowers to draw oxygen into the lungs, then relaxes and rises to push carbon dioxide out

enzymes .... proteins that speed up the breakdown of food into molecules in the digestive system; also speed up chemical reactions

epiglottis .... a little flap of tissue in the throat that protects the opening to the windpipe

esophagus .... the tube that carries food to the stomach

hemoglobin .... the protein that colors red blood cells and allows them to carry oxygen to the tissues

involuntary muscles .... muscles that operate completely outside of conscious thought, whether we want them to do so or not

larynx .... also known as the voice box; a structure in the windpipe in which the vocal cords vibrate with passing air to make sound

ligaments .... tough fibers that help hold bones together

nephrons .... tiny filtering units in the kidneys

organ .... a body structure made up of a number of cell tissues that works as a unit to perform a specific function
Example: heart, lungs, brain

periosteum .... a tough layer of tissue covering the outside of the bone

plasma .... the liquid part of the blood

platelets .... pieces of larger cells formed in the bone marrow that have no nuclei and are even smaller than red blood cells; they work with proteins in the plasma to clot the blood

red blood cells .... small, disk-shaped cells containing hemoglobin; they deliver oxygen to body cells and pick up carbon dioxide

saliva .... a fluid released from glands in the mouth that soaks into food and helps in chewing, swallowing, and digesting

skeletal muscles .... voluntary muscles that move the bones of the skeleton
Example: muscles found in arms and legs

smooth muscle .... involuntary muscle contained in many parts of the body
Example: muscles found in walls of stomach, intestines, and blood vessels

solid bone .... very dense and strong; a storage place for calcium; usually found around the edges of bones

spongy bone .... has many small holes; strong, like solid bone, but more lightweight; usually found at the end of bones

tendons .... strong fibers that attach muscles to bone

urea .... a waste product that is made up of leftover parts of used proteins and is high in nitrogen

urethra .... the passageway out of the body for urine

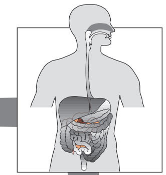
urine .... urea and other waste substances that are collected in the bladder

veins .... blood vessels that contain blood traveling back to the heart

ventricle .... the bottom chamber of both sides of the heart

voluntary muscles .... muscles you choose to use at will

white blood cells .... cells that surround and destroy microorganisms that invade the body; larger than red blood cells

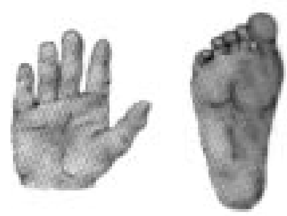


Introduction

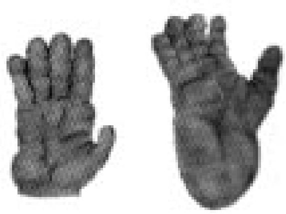
Every moment, waking or sleeping, we depend on biological systems built into our bodies to keep us alive. We define life itself by the signs that these systems are working. For example, our respiratory system allows us to breathe; our circulatory system gives us a pulse. Our respiratory and circulatory systems—along with many other systems—allow us to have the experience we call *life*. Most healthy people are lucky enough never to have to think about the processes that keep them going. They put a hamburger into their digestive systems and forget about it. Their nervous systems help them dodge a bad driver in a parking lot, and they don't think twice. In this unit we will see how all of our body systems operate and interact to help us survive.

The Human Body—A General Overview

Remembering our lessons in biological classification, how would we classify *human beings*? Humans are in the *Animal* Kingdom, Phylum *Chordata*, Class *Mammalia*, Order *Primates*, Family *Hominidae*, Genus *Homo*, Species *sapiens*. Although humans are the only living representatives of their family, genus, and species, the Order Primates includes many animals besides humans. The Order Primates includes "erect mammals," those that stand straight and walk on two legs. Can you guess which animals share the Order Primates with humans? Which animals on Earth look the most like us?



human hand and foot



ape hand and foot

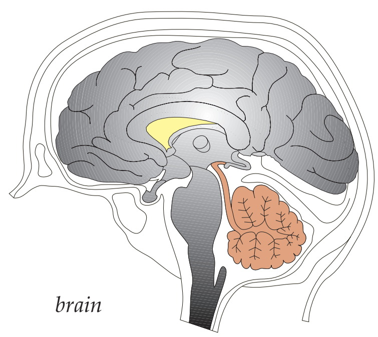
If you've ever looked at a monkey and seen a resemblance to yourself, the similarity was more than your imagination. Monkeys, as well as lemurs, baboons, orangutans, and gorillas, are all in the Order Primates with humans. Besides sharing the ability to walk upright, primates are alike in that they have large brains, very complex and efficient nervous systems, and most have hands with five fingers each and feet with five toes each. Hands (and feet, in other primates) are adapted for grasping things. Many primates have what is called an "opposable thumb," a thumb that can be pinched to the fingers to hold something. If you've never before considered the great value of your thumbs, try to pick a dime up off the floor without using them.

Internal structures are much the same in all mammals. The heart and blood vessels, the digestive and excretory equipment, and the lungs and glands are all similar. Yet primates have body systems that are the most like ours: similar skeletons, muscles, stomachs, livers, hearts, and kidneys. In fact, in 1992, a human received a liver transplant from a baboon in an effort to extend his life until an appropriate human liver was available. The patient lived two months with the transplanted baboon liver but unfortunately died awaiting a human donor.

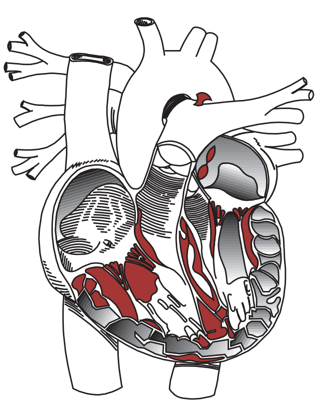
Major Organs

If we're going to survey the biological systems that run the human body, perhaps we should take some time to get our bearings. What are the really important pieces of the human body?

People usually refer to these important pieces as "major organs." An **organ** is a body structure made up of a number of cell tissues that work as a unit to perform a specific function. Some major organs are easy to think of and locate. For example, the brain is in the head and directs the nervous system. The heart is in the chest and serves as the main pump for the circulatory system. The function and location of other major organs are less obvious. On the following page is a table that lists some major organs, gives a rough idea of their locations in the human body, and describes which body system depends on them.



brain



heart

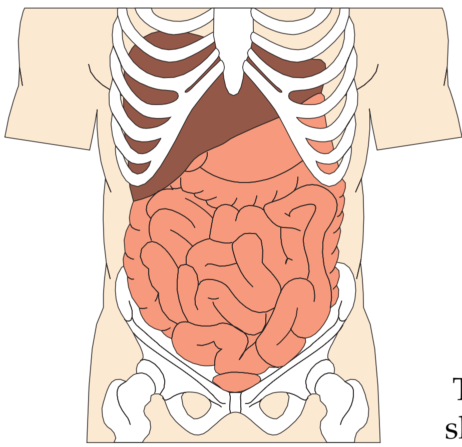
Major Organs of the Body

	Location	Function
brain	head	analyzes signals from the sensory organs and directs the central *nervous system*
heart	chest, slightly left of the center	pumps blood; is the central structure of the *circulatory system*
lungs	both sides of the chest	provide a place for blood to take in oxygen and give up carbon dioxide; are the central structures of the *respiratory system*
liver	upper right abdomen	secretes bile to dissolve fats as food is broken down; filters out some toxins taken in with food and drink before nutrients are distributed throughout the body; part of the *digestive systems*
stomach	upper left midsection	carries out rough breakdown of food; central structure of the *digestive system*
intestines	central and lower abdomen	finish the breakdown of food and absorb the nutrients; part of the *digestive system*
kidneys	lower back, each side of the spine	remove waste materials and toxins from the blood; central structures of the *excretory system*

Body Systems

What exactly is a *body system*? We have learned that an organ is a body structure that performs a specific function. A body system also performs a specific function, but it is made up of one or more organs plus all of their support structures. For example, the circulatory system is made up of the heart plus all of the veins, capillaries, and arteries.

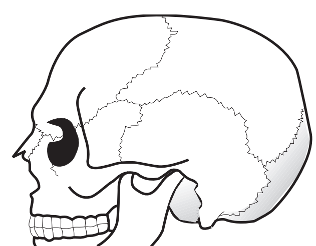
Since there are so many body systems, this book uses two units to cover them. But there really is no neat dividing line for grouping body systems into two categories. All human body systems maintain life; all of them enable us to survive. Otherwise we wouldn't have them. Also, all of our body systems function together. Though we'll study them one by one, it's important to remember—and impossible to ignore—how they are all intertwined with one another.



The systems included in this unit are the skeletal, muscular, circulatory, respiratory, excretory, and digestive systems.

Skeletal System

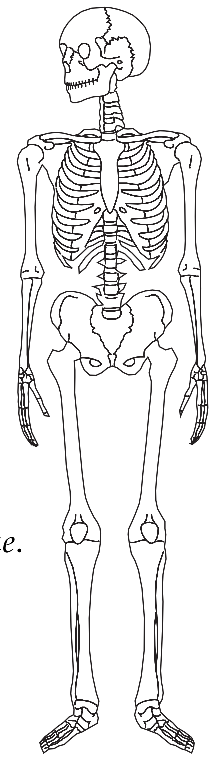
The human skeleton is familiar to most of us from Halloween costumes, if for no other reason. Most people even know the common names of some of their **bones**: for example, the skull, ribs, and backbone. Yet the adult human skeleton is more complex than it might first appear. There are 206 bones, in all—22 in the skull alone! While most of us realize that the skeleton is the framework that supports the rest of the body, it's important to realize that it serves other functions as well.



human skull

Functions of the Skeleton

1. Acts as framework for the body.
2. Anchors the muscles by providing places for attachment.
3. Makes blood cells.
4. Stores calcium.


human skeleton

Along with acting as a framework for the body, the bones serve as anchors for the muscles. Because the ends of our muscles are attached to bones by tendons, the contraction, or shortening, moves the bones.

You might think of bones as just a bunch of brittle, white pipes buried deep in our bodies. In fact, bone is *living tissue*. Bone cells produce and store many products the body needs. The soft center of the bones, marrow, makes blood cells. The bones also store calcium, a mineral that makes bones strong and also helps the body in other ways.

Bone Structure

Bone first develops in humans as **cartilage**, a softer, more flexible substance. As humans grow older, most of the cartilage hardens into bone. Some parts of our bodies remain cartilage throughout our lives, such as the tip of the nose and the outside of the ears. Cartilage is also found at the ends of bones at joints. There it acts as a cushion, or shock absorber, between the bones. At moveable joints, such as the elbow and the knee, you'll also find **ligaments**, tough fibers that help hold bones together.

Covering the outside of the bone is a tough layer of tissue called the **periosteum**. It provides a place for muscles to attach to the bone. It also contains nerves as well as blood vessels that supply the bone with blood. These blood vessels and nerves penetrate to the inside of the bone through tiny channels that pass through the bone.

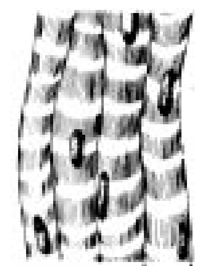
Bones are made up of two types of bone: **solid bone** and **spongy bone**. As the storage place for calcium, solid bone is very dense and strong. It is usually found around the edges of bones. Spongy bone, as its name would lead you to believe, has many small holes. Though it's strong, like solid bone, it is much more lightweight. Spongy bone is usually found at the end of bones. At the middle of the bone is a central cavity filled with marrow. It also contains nerves and blood vessels.

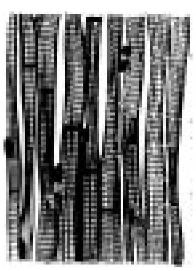
Muscular System

Every moment of our lives we're using muscle. We rub our eyes or scratch our backs and dozens of muscles act in concert to achieve these motions. Even as you read these words, muscles are moving your eyes from left to right and back again. In fact, the muscles involved in the movements mentioned up to now are examples of just the **voluntary muscles**—you could choose not to rub your eyes, scratch your back, or move your eyes to read. We have not even begun to consider **involuntary muscles**—those that operate completely outside of our conscious thought. Involuntary muscles include muscles that run the heart, the stomach, the intestines, and the blood vessels—constantly, every moment of our lives.

Three Kinds of Muscle

Skeletal muscles are the muscles that move the bones of the skeleton. We move our arms, legs, and neck, for example, with skeletal muscles. These are *voluntary* muscles. When seen under a microscope, skeletal muscle seems striped with light and dark bands.


skeletal


cardiac muscle

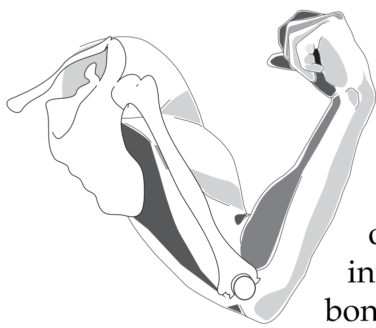
Cardiac muscle makes up our most tireless muscle, the heart. It also appears striped under magnification. But in cardiac muscle, the striping is finer and closer together so that the muscle looks sort of like a tightly woven basket. The heart is the only muscle made of cardiac muscle. This muscle is *involuntary*.

Smooth muscle can be found in many parts of the body. It does not appear at all striped but does, in fact, look smooth. This type of muscle is also involuntary. The stomach, intestines, and blood vessels are examples of body parts that contain smooth muscle.


smooth

How Muscles Work

Muscles move by shortening or contracting. This happens when the long, slender cells that make up muscle are supplied with energy and activated by a nerve impulse. The process of how these cells actually shorten themselves still isn't clear to biologists. However, the most common theory to explain muscle contraction is that fibers in the muscle cells slide over one another and thus cause the cell to shorten. As the fibers return to their original position, the contractions subside.



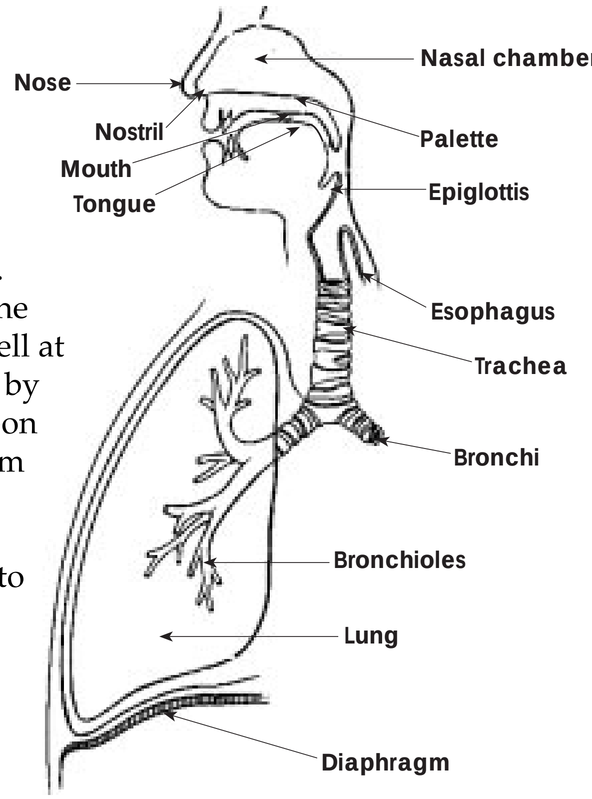
Skeletal muscles move the bones in the body much like a pulley and hinge system. For instance, to bend the knee, the rear thigh muscle, which is attached to both the thigh bone and upper shin bone, shortens. This brings the shin and thigh bones closer together, thus bending the hinge of the knee. Each major hinge in the body is usually operated by a pair of muscles, one that controls its bend and one that straightens it again. The muscles involved in these systems are attached to the bones by strong fibers called **tendons**.

Respiratory System

As you know, human beings must breathe oxygen to survive. This is because oxygen is an element that is crucial to burning the energy we have taken in as food and stored as fats and sugars in our bodies. The chemical process that changes food to energy for our bodies takes place in the cells. However, many of our cells are buried deep inside our bodies far from any oxygen source. So how can each cell in the body receive oxygen?

One part of the answer is the respiratory system. This system is as familiar to us as the noses on our faces, but obviously there is much more to it that we can't see. We take in oxygen through the mouth or nose, which filters and warms it. From there the oxygen travels down the windpipe. The windpipe descends from the back of the throat and is protected by a little flap of tissue called the **epiglottis.** Just inside the epiglottis is the voice box or **larynx**. The vocal cords of the larynx vibrate with passing air to make sound.

Below this point, at the top of the chest, the windpipe divides into two branches. These branches are called **bronchi** (*sing*. bronchus). One of the bronchi leads to the right lung and one leads to the left lung. From there the bronchi branch into millions of smaller tubes, each of which leads to a small air sac. Each air sac is surrounded by tiny, tiny veins through which the blood passes. These veins are so narrow that the blood can only pass one blood cell at a time. As these blood cells pass by the air sac, they give up the carbon dioxide they have picked up from body cells as a waste product in exchange for a fresh load of oxygen. Then the blood returns to the heart, which pumps it back out to the body to deliver oxygen to waiting body cells.



How We Breathe

By breathing, we draw oxygen into our lungs and push carbon dioxide out. How does this work? In many ways, our breathing equipment functions like a big syringe, with the plunger moving out and in, out and in.

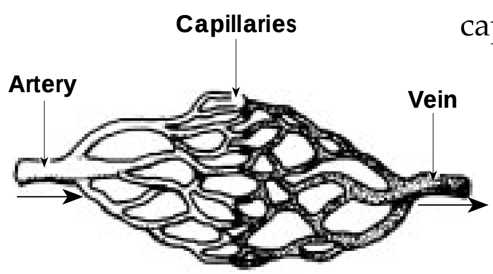
As we take in a breath, the muscles of the ribs contract, pulling the ribs up and out. Then the **diaphragm,** the dome-shaped muscle at the base of the chest cavity, contracts and lowers. The diaphragm functions like the plunger in a syringe. As it lowers, the area of the lungs increases, and oxygen moves in to fill up the space. Then, as the diaphragm relaxes and returns to its original position, the area in the lungs decreases again. The diaphragm—plunger—goes in and pushes carbon dioxide and other gases out of the lungs.

Circulatory System

One way to imagine the circulatory system is as a vast highway system with little delivery trucks traveling around on it. The highway system is *blood vessels*. The delivery trucks are *red blood cells*. The delivery trucks do not move by their own power but are pushed along in small bursts of speed. The power behind them is the *pumping of the heart*.

In studying the respiratory system, we saw how red blood cells picked up carbon dioxide—a waste product from burning food—from the body cells. In the lungs, the red blood cells exchanged their load of carbon dioxide for a load of oxygen. The blood cells also pick up other wastes from body cells and leave them in the kidneys, which filter blood. They move on to other pickup points to load up with products of the digestive system—food nutrients—to deliver to the body cells.

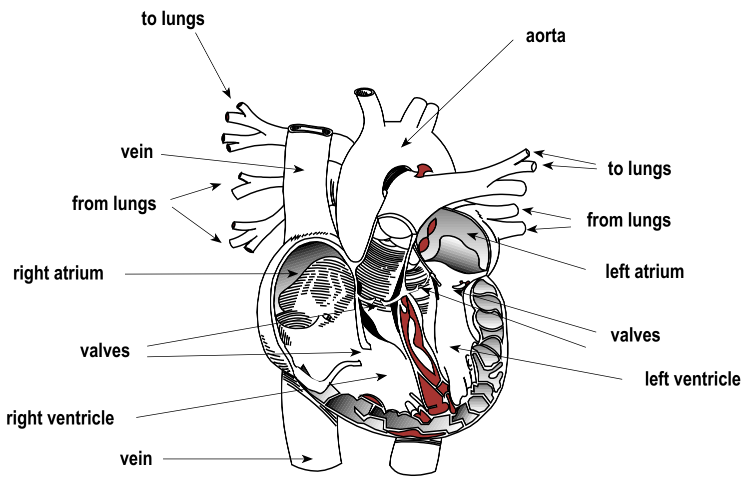
Blood vessels are divided into three types. **Arteries** are blood vessels leading away from the heart. **Capillaries** are tiny blood vessels where pickup of wastes and delivery of oxygen and food takes place. And **veins** are blood vessels that connect with the capillaries to take blood back to the heart.



This pickup and delivery system would not work without the powerful pumping of the heart, which pushes blood cells through the blood vessels. How does the heart work?

The Heart—A Two-Sided Pump

The heart is a muscle with two sides completely walled off from one another. Each side has a top chamber, the **atrium** (*pl.* atria) and a bottom chamber, the **ventricle**. First the top chambers contract, squeezing blood into the bottom chambers. Then the bottom chambers contract, squeezing blood out of the heart into the arteries that lead out of the bottom chambers. After each contraction empties one set of chambers, the heart relaxes pressure on the other set of chambers. This increases the space inside, and new blood is sucked in to fill the space. Thus the two sets of chambers take turns being filled and emptied with blood—one set fills as the other set empties. Valves at the out-gates of the atria and ventricles prevent the backflow of the blood. It's these two sets of valves closing—first one set, then the other—that we hear as a heartbeat.



Heart

Each side of the heart has a special job. The right side of the heart pumps blood only to the lungs. Receiving blood from the body that contains lots of carbon dioxide and little oxygen, the right side of the heart pumps this blood to the lungs for gas exchange. The blood returns to the left side of the heart from the lungs. There it gets a new push to make its trip back out into the blood vessels of the body.

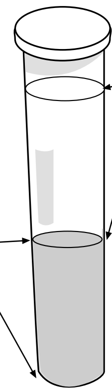
The Structure of Blood

We tend to think of blood as liquid, but in fact blood is made up of a liquid part and a solid part. The liquid part of the blood, called **plasma**, makes up about 55 percent of the total volume. The solid part, blood *solids*, makes up about 45 percent of the total volume.

Plasma is 90 percent water. Otherwise, it contains the substances listed on the chart on page 223. Proteins in plasma give blood the ability to clot and form scabs, which are necessary to stop bleeding. Proteins also give blood the ability to regulate the amount of fluid contained in cells and the ability to recognize and fight disease. Digested foods float around in the plasma in the form of glucose and fats. Wastes (such as urea, which ultimately exits the body in the form of urine) are also found in the blood.

Blood

blood settled and separated



Blood Plasma

nonliving part of blood
yellow in color
liquid part of blood
contains:

- water
- proteins
- digested foods
- mineral salts
- cell waste products
- dissolved gases (O_2 and CO_2)
- vitamins (regulate cell functions)
- hormones (chemical messengers)

Blood Solids

living part of blood
red in color
contains:

- red blood cells
  - disk-shaped
  - very small
  - contain hemoglobin
- white blood cells
  - destroy invading microorganisms
  - fight infection
- platelets
  - pieces of larger cells
  - found in bone marrow
  - help clot the blood

Blood solids fall into three categories. **Red blood cells** are disk-shaped and very small. They contain the protein **hemoglobin,** which combines easily with oxygen and carbon dioxide. This is what makes red blood cells such good pickup and delivery trucks for these gases throughout the body and in the lungs. **White blood cells** are larger than red blood cells. Their most important function is to surround and destroy microorganisms that invade the body. Thus, when there is an infection in the body, the number of white blood cells increases to fight it off. **Platelets** are not really whole cells. They're pieces of larger cells formed in the bone marrow. They have no nuclei and are even smaller than red blood cells. Platelets work with proteins in the plasma to clot the blood.

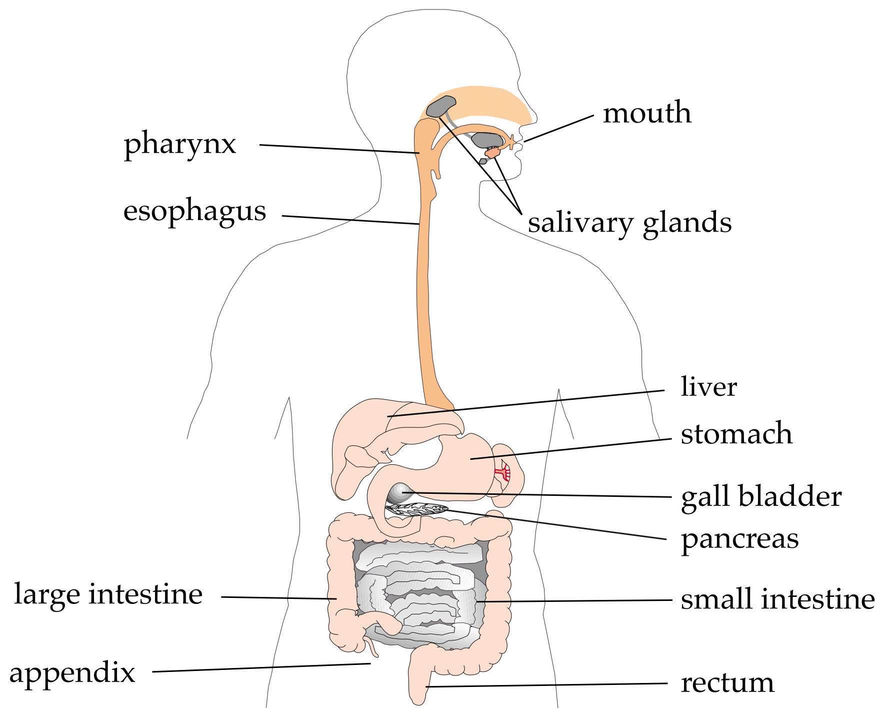
Digestive System

Oxygen and food are the two main things body cells need to carry out their many varied missions, whether they're muscle cells contracting to move bones or white blood cells fighting off invading microorganisms or any other type of cell. We've seen how the respiratory system provides oxygen to cells. But how is raisin bread, a pork chop, or a chocolate bar processed into the tiny molecules that cells need to burn for energy? And how do these molecules reach cells all over the body?

These are the jobs of the digestive system: breaking down food into a form cells can use and aiding or getting this refined food to the cells.

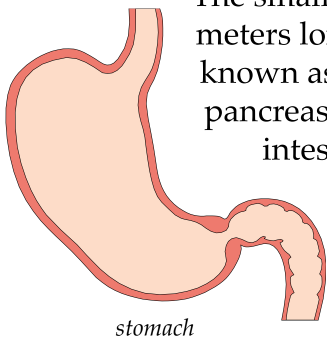
Physical and Chemical Changes That Break Down Food

Our bodies begin to break down food the minute we put it in our mouths. Not only do we change food physically, grinding it into smaller pieces with our teeth, but we also change it chemically with our **saliva**. Saliva, a fluid released from glands in the mouth, soaks into the food and helps turn it into a paste. If the food is a carbohydrate, such as raisin bread, saliva begins to change the chemical makeup of the bread with an enzyme. **Enzymes** are proteins that speed up the breakdown of food into molecules. Enzymes are very specific to the type of food they affect. In the human digestive system there are enzymes specific to carbohydrates, such as raisin bread; proteins, such as pork chops; or fat (one of the primary ingredients in chocolate bars).



When we swallow, muscles in the throat push the bite of food into the **esophagus**. This is the tube that carries food to the stomach. The esophagus also has muscles that push the food down toward the stomach.

The stomach is a muscular bag that holds and works on food for about four hours. Cells inside the stomach make chemicals which include hydrochloric acid and enzymes. After the stomach is finished with the food, it pushes it into the small intestine.



stomach

The small intestine is a tube-shaped organ that's about seven meters long. This is where most of the food processing known as *digestion* occurs. Enzymes from the liver and pancreas work with enzymes produced by the small intestine to break down foods from all three food groups—carbohydrates, proteins, and fat. **Bile**, a substance produced in the liver and stored in the gall bladder, works specifically on fat. The small intestine may handle food for as long as 10 hours before the remnants of what's left pass through.

The large intestine is a larger tube whose main job is to remove water from the undigested remains of the food that entered the mouth. By this point, all of the usable nutrients in the food have been removed. Undigested food and wastes pass from the large intestine out of the body through the rectum.

How the Body Absorbs Food

The small intestine breaks food down into molecules that cells can use. But how do these molecules get from the small intestine to the cells?

Food molecules are absorbed through the very thin lining of the small intestine into blood passing through underlying capillaries. From there the blood travels to the liver for filtering before it circulates throughout the body. But even seven meters worth of small intestine would not provide enough space to absorb all of the available food molecules if the lining of the intestine were not constructed in a way that maximizes absorption area. The inside of the small intestine is not smooth. It is puckered up into millions of fingerlike knobs called *villi*. This puckering or knobby wrinkling of the small intestine lining increases the amount of area with which food comes into contact.

Excretory System

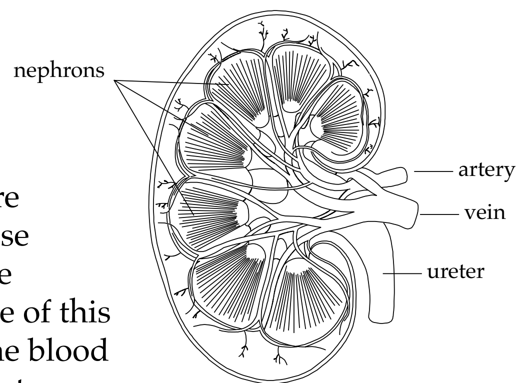
The excretory system is the body's garbage service. Through the excretory organs, the human body gets rid of waste products that could slow down and even poison its other systems. One of these waste products is **urea**, a substance that is made up of leftover parts of used proteins and is high in nitrogen. Another waste product is carbon dioxide.

Though we think of lungs as part of the respiratory system, they're an excretory organ in that they remove carbon dioxide from the body. The skin also excretes some urea with water and salt when we perspire, although the main purpose of perspiration is to cool the body.

Kidneys—The Major Excretory Organs

The kidneys are the major excretory organs. They are found on either side of the spine in the small of the back, looking like a pair of giant kidney beans.

Each kidney is made up of many tiny filtering units called **nephrons**. Each nephron is made up of a cuplike structure mounted on a tube that leads out of the kidney. The cup holds a tightly coiled capillary. Pressure inside this capillary is very high because the heart pumps blood directly into the arteries that lead to the kidney. Because of this pressure, everything is forced out of the blood except the blood cells. This includes water, mineral salts, food, and urea—much of which the blood needs to keep. But not to worry: all of these things run down into the nephron tube, which the capillary wraps around. The capillary reabsorbs the food as well as the proper amounts of water and mineral salts. The urea and everything else continues down the nephron tube. Eventually they leave the kidney, are gathered in the bladder as **urine**, and leave the body through the **urethra**.



Kidney

Summary

The human body depends on many biological systems to function and survive. All of these systems interact and overlap with one another. Humans are most like primates in the structure of their bodies.

Major organs include the brain, heart, lungs, liver, stomach, intestines, and kidneys. All of these organs play central roles in the systems that run the human body.

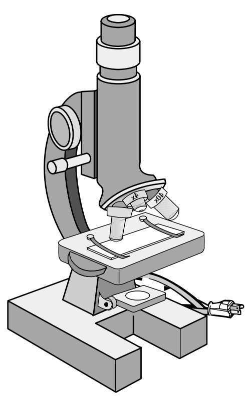
The skeleton provides a framework for the body and also accomplishes other important jobs. The muscles move the bones of the skeleton and contribute to the make up and function of most major organs.

The respiratory system provides a place for blood to take up oxygen and give off carbon dioxide: the lungs. The circulatory system allows blood to deliver oxygen and food molecules to body cells and to pick up waste products. The heart pushes blood through the body so that it can accomplish these tasks.

The digestive system breaks down food into molecules that cells can use. The liver and pancreas contribute enzymes to this process. The small intestine is the place where the blood absorbs these molecules.

The excretory system is the human body’s garbage service. The kidneys are the main excretory organs. They remove waste products from the blood and regulate the amount of water and mineral salts that blood contains.

Careers in Biology



Physicians’ Assistant

Physicians’ assistants work in a variety of settings. They may work in clinics, doctors’ private offices, or hospitals. A physicians’ assistant may work directly with patients or be in a laboratory setting. The educational background for such positions varies, but completion of a high school diploma and some college is generally desirable. The recent expansion of the medical profession and related fields seems to indicate that the desire for physicians’ assistants will continue.

Practice

Complete the following outline.

A. Skeletal system

1. Functions of the skeleton

   a. ______________________________

   b. ______________________________

   c. Makes blood cells

   d. Stores calcium

2. Bone structure

   a. ______________________________ —soft, flexible substance

   b. ______________________________ —holds bones together

   c. Periosteum—covers outside of bone

B. Muscular system

1. Two types of muscles

   a. Voluntary—*examples:* ______________________________

   b. ______________________________ —heart, stomach, intestines

2. Three kinds of muscle

   a. Skeletal
   b. ______________________________—*examples:* stomach, intestines

   c. Cardiac

3. How muscles work

   a. Move by ________________________

   b. Move the ________________________ which are

      attached by ________________________

C. Respiratory system

1. Function: ________________________

2. Parts of the system:

   a. ________________________—filters and warms the air

   b. Windpipe covered by the ________________________

   c. Voice box or ________________________

   d. ________________________ or branches of the windpipe

   e. Red blood cells—pick up ________________________ and give up carbon dioxide

   f. ________________________—a large muscle that helps us breathe

D. Circulatory system

1. Power supply: ____________________

2. Function of red blood cells

   a. Pick up wastes; take to kidneys

   b. Pick up food energy to deliver to ____________________

3. Three types of blood vessels

   a. ____________________—lead away from the heart

   b. ____________________—where pickup and delivery takes place

   c. ____________________—take blood back to the heart

4. The heart—a two-sided pump

   a. Structure

      (1) ____________________—top chamber

      (2) Ventricle—____________________ chamber

   b. Function

      (1) Right side—pumps blood to the ____________________

      (2) ____________________ side—receives blood from the lungs and sends it out to the ____________________

5. Blood

   a. Liquid part—________________________

   b. Solids

      (1) Red blood cells contain ________________________

      (2) ________________________ help fight off infection

      (3) ________________________ help clot the blood

E. Digestive system

1. Jobs of the system

   a. ________________________

   b. Getting the food to the cells

2. Breakdown of food

   a. Mouth—teeth and ________________________ (enzymes)

   b. Esophagus—carries food to

      the ________________________

   c. Stomach chemicals: ________________________ and

      ____

d. Small intestine

(1) Structure

(a) Length: ______________________ meters

(b) Lining composed of ______________________ to increase absorption area

(2) Description

(a) Uses enzymes from the liver,

______________________ , and small intestine

(b) Process time: ______________________ hours

e. ______________________ intestine—sends undigested food out of the body

F. Excretory system

1. Function: ______________________

2. Waste products—______________________

   and ______________________

3. ______________________—central organs located in the small of the back on either side of the spine

4. Nephrons filter ______________________ from the blood

5. Urea goes to the bladder as urine, leaves the body

   through the ______________________

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

4	**cardiac**	**ligaments**	**skeletal**
206	**diaphragm**	**lungs**	**skeleton**
arteries	**digestive**	**mouth**	**smooth**
atria	**excretory**	**muscles**	**tendons**
bile	**involuntary**	**plasma**	**veins**
capillaries	**kidneys**	**saliva**	**ventricles**

1. The circulatory system is made up of the heart plus all of the

   ______________________ , ______________________ , and

   ______________________ .

2. The human skeleton has ______________________ bones in all.

3. Our ______________________ is the framework for our body.

4. Our ______________________ are attached to our skeleton.

5. ______________________ help hold our bones together.

6. ______________________ muscles run the heart, stomach, and intestines.

7. The three kinds of muscle are ______________________ ,

   ______________________ , and ______________________ .

8. Muscles are attached to the bones by strong fibers called

   ______________________ .

9. When we breathe, a large muscle called the ____________________ helps us draw oxygen into our lungs.

10. The ____________________ filter our blood.

11. The right side of the heart pumps blood only to the ____________________ .

12. The human heart has ____________________ chambers.

13. The top chambers of the heart are each called the ____________________ .

14. The bottom chambers of the heart are each called the ____________________ .

15. The liquid part of the blood is called ____________________ .

16. The ____________________ system breaks down food for the body's cells.

17. Digestion begins in the ____________________ with the teeth and ____________________ .

18. The liver produces ____________________ , which acts on fat.

19. The ____________________ system is the body's garbage service.

20. The ____________________ are the main excretory organs.

Lab Activity: Part 1: The Skeletal and Muscular Systems

Facts:

- Some injuries involve the skeletal system or the muscular system.
- These injuries may result from sports or everyday activities.

Investigate:

- You will learn the difference between ligaments and tendons.
- You will relate sprains, torn tendons, and tendinitis to certain injuries.
- You will learn the names of certain body muscles, bones, and tendons.

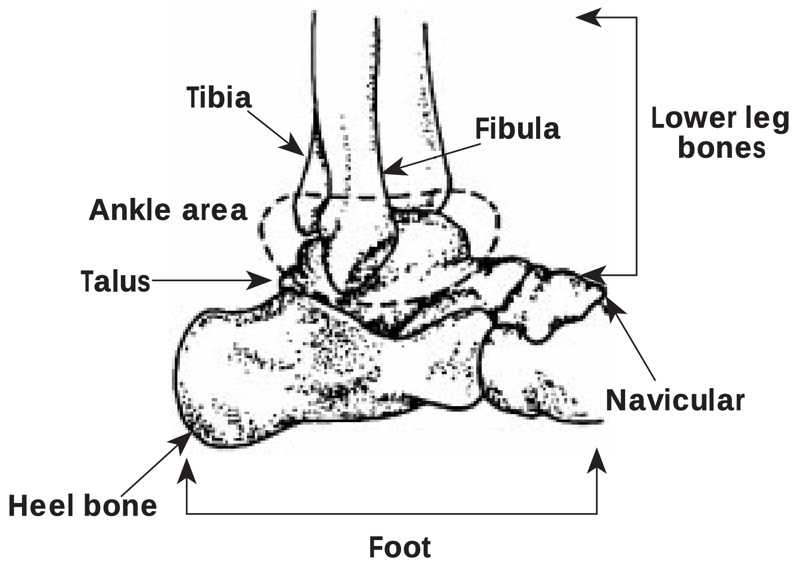
Materials:

- a #2 pencil
- colored pencils: blue and red

1. Examine Figure 1 on the next page. This is a drawing of the bones that are a part of the human ankle.

Figure 1

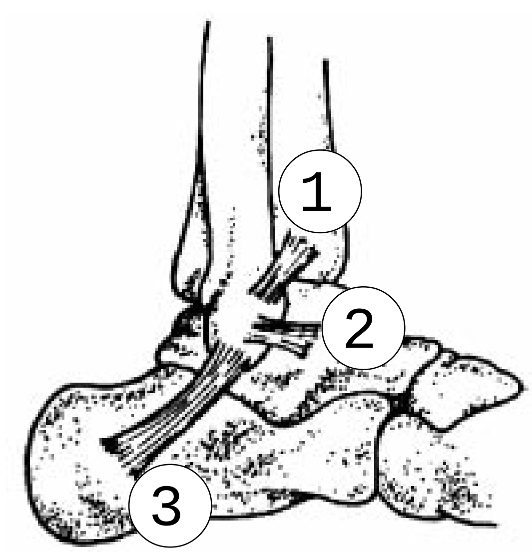
Bones of the Ankle



2. Examine Figure 2. This is a similar drawing of the ankle except that three ligaments have been added. They are marked 1, 2, and 3.

Figure 2

Ligaments of the Ankle



3. Using your collected materials:

    a. color all leg bones in Figure 2 gray.

    b. color all foot bones in Figure 2 blue.

    c. color all ligaments in Figure 2 red.

4. On Figure 2:

    a. label the two bones held together by ligament 1.

    b. label the two bones held together by ligament 2.

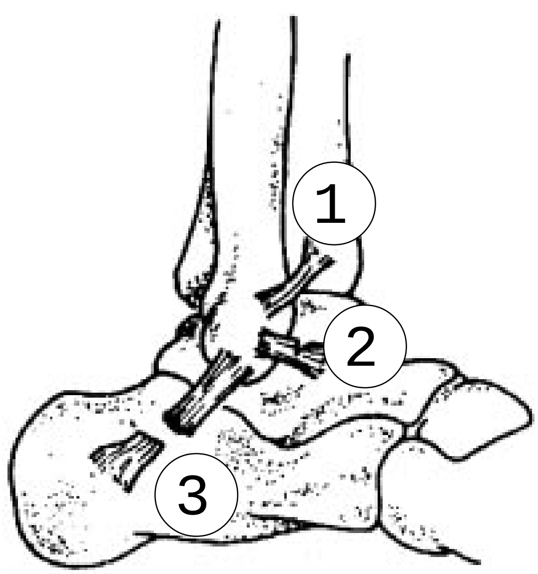
    c. label the two bones held together by ligament 3.

5. Examine Figure 3 showing the three types of sprains. They are as follows:

    first-degree sprain—ligaments are only stretched.
    second-degree sprain—ligaments are only partly torn.
    third-degree sprain—ligaments are torn completely.

Figure 3

Sprained Ankle Ligament



6. Using your materials and Figure 3:

   a. color the first-degree sprain gray.

   b. color the second-degree sprain blue.

   c. color the third-degree sprain red.

7. Examine Figure 4. This is a drawing of the bones and ligaments of the shoulder. Using your materials:

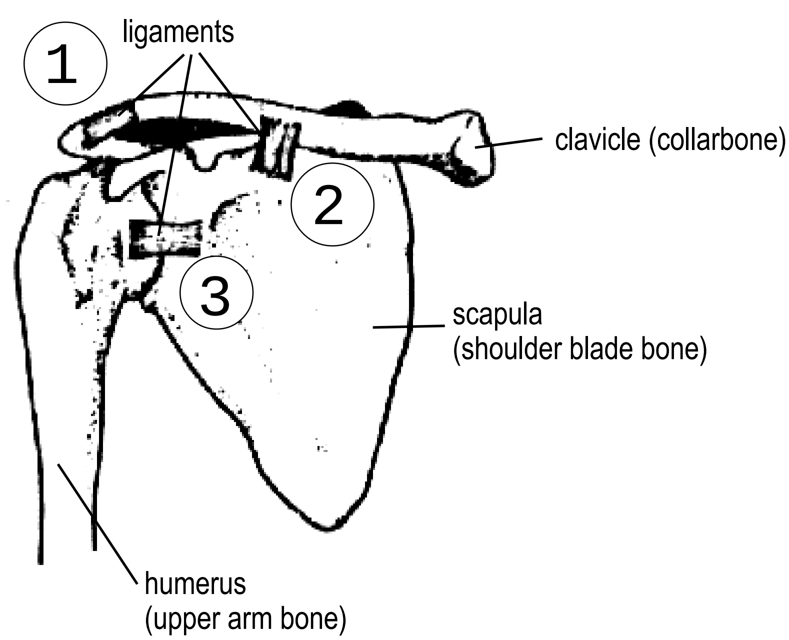
   a. color all shoulder bones gray.

   b. color all upper arm bones blue.

   c. color all ligaments red.

Figure 4

Ligaments of the Shoulder



8. Circle the two bones held together by ligament 1 in red. Circle the two bones held together by ligament 2 in blue.

9. Examine the incomplete drawing of the shoulder in Figure 5. Finish the drawing by doing the following:

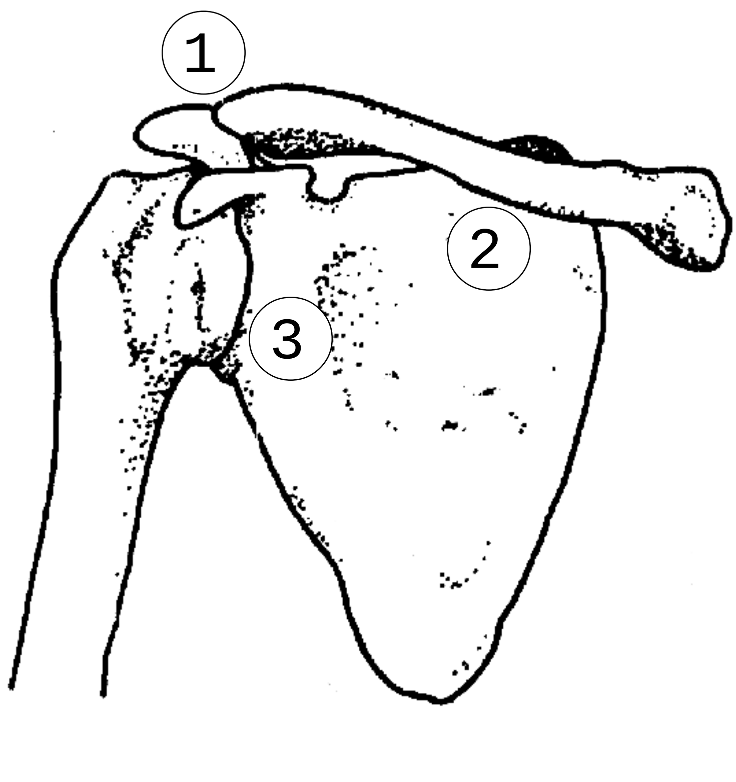
    a. drawing in a second-degree sprain of ligament 1.

    b. drawing in a third-degree sprain of ligament 2.

    c. drawing in a normal ligament holding the humerus to the scapula.

Figure 5

Sprains of the Shoulder



Lab Activity: Part 2: Totally Torn Tendons—Tendonitis

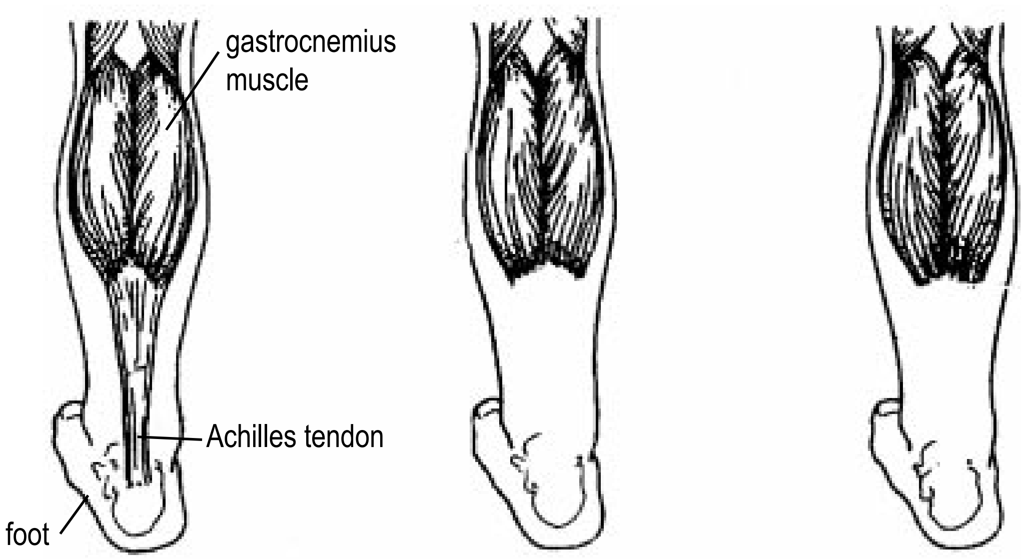
1. Locate your calf muscle—your *gastrocnemius* muscle. Run your hand down your calf until you nearly reach the back of your heel. You should now be able to feel a thick cord at the back of your heel. This cord is a tendon—your *Achilles* tendon.

2. Examine Figure 6a. This drawing shows an actual view of the back of a person's leg. The skin has been removed.

Figure 6

The Calf Muscle

6a **6b** **6c**



3. Finish Figure 6b by showing what a totally torn Achilles tendon would look like. Draw an arrow pointing to the torn area and label it.

4. Finish Figure 6c by showing what tendonitis of the Achilles tendon would look like. Tendonitis is a soreness of the tendon. It is caused by small tears that occur along the tendon. Draw an arrow pointing to the tears and label them.

5. What body parts are held together by ligaments?

6. Are ligaments a part of the muscular system or the skeletal system?

7. What type of sprain probably takes the least time to heal?

8. What type of sprain takes the most time to heal?

9. Describe what one might have to do to cause a sprain.

Practice

Use the list below to write the correct term for each definition on the line provided.

arteries	**larynx**	**saliva**
bile	**organ**	**spongy bone**
bones	**periosteum**	**veins**
cartilage	**platelets**	**voluntary muscles**
enzymes	**red blood cells**	**white blood cells**
epiglottis		

________________________ 1. a body structure made up of a number of cell tissues that works as a unit to perform a specific function

________________________ 2. a fluid released from glands in the mouth that soaks into food and helps in chewing, swallowing, and digesting

________________________ 3. a soft, flexible substance that sometimes hardens into bone as it ages

________________________ 4. a substance produced in the liver and stored in the gall bladder that works specifically to dissolve fat in the small intestine

________________________ 5. a tough layer of tissue covering the outside of the bone

________________________ 6. also known as the voice box; a structure in the windpipe in which the vocal cords vibrate with passing air to make sound

________________________ 7. blood vessels that contain blood traveling away from the heart

____________________ 8. blood vessels that contain blood traveling back to the heart

____________________ 9. proteins that speed up chemical reactions; speed up the breakdown of food into molecules

____________________ 10. larger than red blood cells, their most important function is to surround and destroy microorganisms that invade the body

____________________ 11. little flap of tissue in the throat that protects the opening to the windpipe

____________________ 12. muscles you choose to use at will

____________________ 13. pieces of larger cells formed in the bone marrow that have no nuclei and are even smaller than red blood cells; they work with proteins in the plasma to clot the blood

____________________ 14. sections of the skeleton; serve as framework for the body, anchors for the muscles, factories for blood cells, storage places for calcium

____________________ 15. small, disk-shaped cells containing hemoglobin; they deliver oxygen to body cells and pick up carbon dioxide

____________________ 16. has many small holes; strong, like solid bone, but more lightweight; found at the end of bones

Practice

Use the list below to write the correct term for each definition on the line provided.

atria	**involuntary muscles**	**tendons**
bronchi	**ligaments**	**urea**
capillaries	**nephrons**	**urethra**
diaphragm	**plasma**	**urine**
esophagus	**solid bone**	**ventricle**
hemoglobin		

______________________________ 1. strong fibers that attach muscles to bone

______________________________ 2. the bottom chamber of both sides of the heart

______________________________ 3. the dome-shaped muscle at the base of the chest cavity that contracts and lowers to draw oxygen into the lungs, then relaxes and lowers to push carbon dioxide out

______________________________ 4. the liquid part of the blood

______________________________ 5. the protein that colors red blood cells and allows them to carry oxygen to the tissues

______________________________ 6. the passageway out of the body for urine

______________________________ 7. the top chamber of both sides of the heart

______________________________ 8. the tube that carries food to the stomach

_______________________ 9. the two branches of the windpipe that descend to the right and left lungs

_______________________ 10. muscles that operate completely outside of conscious thought, whether we want them to do so or not

_______________________ 11. tiny blood vessels where pickup of wastes and delivery of oxygen and food takes place; connect arteries to veins

_______________________ 12. tiny filtering units in the kidneys

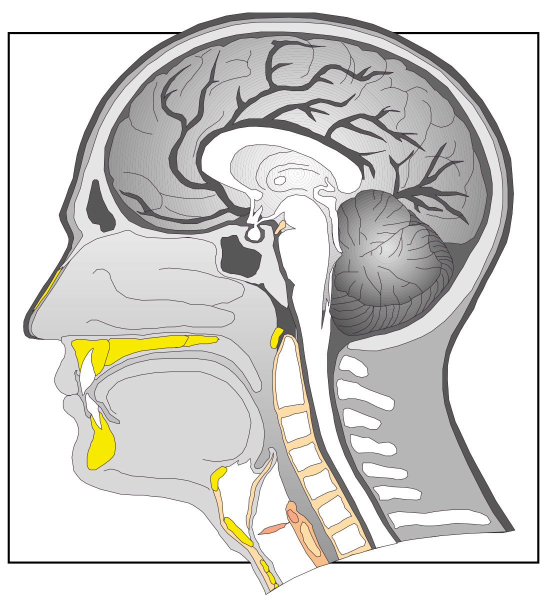
_______________________ 13. tough fibers that help hold bones together

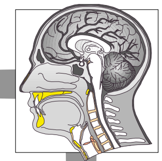
_______________________ 14. a waste product that is made up of leftover parts of used proteins and is high in nitrogen

_______________________ 15. urea and other waste substances that are collected in the bladder

_______________________ 16. very dense and strong; a storage place for calcium; usually found around the edges of bones

Unit 9: More Human Body Systems





Vocabulary

Study the vocabulary words and definitions below.

antibodies .... proteins that stick to pathogens and make them harmless

auditory nerve .... the nerve that sends information from the ear to the brain

cerebellum .... the middle part of the brain; coordinates motor impulses

cerebrum .... the uppermost and largest part of the brain; responsible for complex thought processes

cervix .... the opening of the uterus

cochlea .... a spiral-shaped tube deep inside the ear whose neurons react to sound wave patterns

embryo .... the developing individual inside the uterus

Fallopian tubes .... tubes that connect the ovaries to the uterus

glands .... structures in the endocrine system that produce hormones

hormones .... biochemical messengers in the endocrine system

immunization .... a small amount of a dead or weakened pathogen that is introduced to the body so that lymph cells can produce specific antibodies to disable the pathogen in its stronger, more dangerous form

lymph nodes .... special structures in the body that produce antibodies

medulla .... the lowermost part of the brain; maintains the involuntary function of vital organs, such as the heart, the intestines, and endocrine glands

menstruation .... a monthly discharge released from the uterus when the lining decays after the egg is not fertilized

neurons .... long, thin cells that make up the nervous system

olfactory nerve .... the nerve that sends information from the nose to the brain

optic nerve .... the nerve that sends information from the eye to the brain

ovaries .... female sex organs that produce female sex hormones and female sex cells, or eggs

pathogens .... disease-causing agents that invade the body

penis .... the sex organ by which the male ejects sperm into the female reproductive system

phagocytes .... white blood cells that surround and swallow pathogens

placenta .... a special organ that provides the embryo with oxygen and nutrients and disposes of its waste products

retina .... a surface at the back of the eye that contains neurons that pass on information about the light patterns it receives

scrotum .... the sack of skin that houses the testes

semen .... a mixture of sperm and other fluids that help the sperm survive

taste buds .... little, flask-shaped structures in the tongue containing neurons that react to different tastes

testes .... male sex organs that produce male hormones and male sex cells known as sperm (*sing.* testis)

uterus .... the sex organ in which the fertilized egg will develop

vagina .... a muscle-lined canal connecting the opening of the uterus to the outside of the body

Introduction

In Unit 8, we began our inspection of the human body and the many biological systems that make it work. With Unit 9, we will finish that inspection by looking at the *nervous* system, the *endocrine* system, the *reproductive* system, and the *immune* system. We will also consider the many different types of disease that disrupt or slow down a particular body system or perhaps bring all of the interacting systems to a grinding halt. Once again, it's important to keep in mind how each system overlaps and contributes to the others.

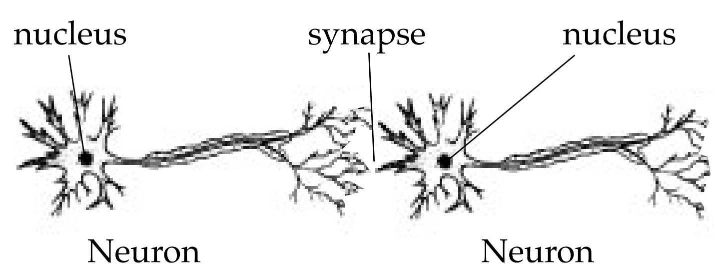
The Nervous System

The nervous system is involved in every movement of every muscle. Nerves are a part of voluntary movements, such as seeing a luscious brownie and reaching for it. They also cause the motion of involuntary muscles, such as the heart's beating or the intestines' pulsing.

The cells that make up the nervous system are called **neurons**. Neurons are like parts of an electrical wiring system that carry messages from the sense organs—for example, the eyes, ears, or nose—to the "master control center," the brain. The brain analyzes all of the information it receives and determines what action the body should take. Thus the nervous system can bring about anything from a tiny quiver to a great thought.

Neuron Structure

Like any other cell in the body, the neuron has a nucleus and organelles. Yet the neuron is special in that it has a long, thin shape with branching ends. This shape helps the neuron act as a message pathway—a sort of telephone wire—for the body. Neurons are often bunched together like a cable of wires. These bunches of neurons are known as *nerves*.



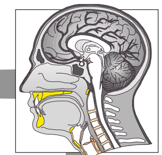
Messages travel along neurons as tiny surges of electricity. Electrically charged atoms of sodium and potassium, called *ions*, are concentrated on opposite sides of the cell membrane of the long neuron fiber. As an electrical impulse moves along the neuron, the cell membrane suddenly allows these ions to change sides—sodium ions rush inside the fiber and potassium ions rush out. Thus the nerve impulse moves down the fiber like a wave. It is a wave of chemicals that produce electricity. After the impulse passes a given spot, the concentration of ions returns to its pre-impulse condition. All of this happens in less than one millisecond (one-thousandth of a second)!

The Sense Organs

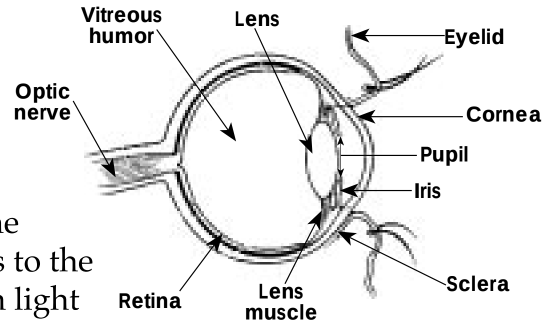
When we think of senses, we usually think of the big five: sight, hearing, smell, taste, and touch. Sense organs take in information from the world around us through neurons and send it to the brain to be processed. The brain then sends back a message along a separate nerve pathway to tell the sense organs what to do next.

The Human Senses

Sense	Sense Organs	Function
sight	**eyes**	pick up patterns of light; lens forms image on *retina*; impulses from *optic nerve* go to the brain; the brain interprets and decodes the image
hearing	**ears**	the outer ear directs sound waves through ear canal; sound waves vibrate through the middle and inner ear systems; information travels via the *auditory nerve* to the brain where it is interpreted and decoded
smell	**nose and nasal cavities**	chemicals in the form of a gas are detected by *neurons*; neurons line the top of the nasal chamber; the *olfactory nerve* carries the message of smell to the brain where it is interpreted as smoke, perfume, or some other odor
taste	**tongue and nose**	small bumps on the surface of the tongue called *taste buds* cause sense of taste; special nerve cells detect chemicals and send signals to the brain; taste buds sense only sour, sweet, salty, and bitter; our nose and the smell of food helps our appreciation
touch	**skin**	five types of nerve cells detect pain, pressure, touch, heat, and cold; signals sent to the brain for decoding; most nerve cells found in the *dermis* (thick inner layer); only nerve cells which detect pain found in the dermis and *epidermis* (thin outer layer)



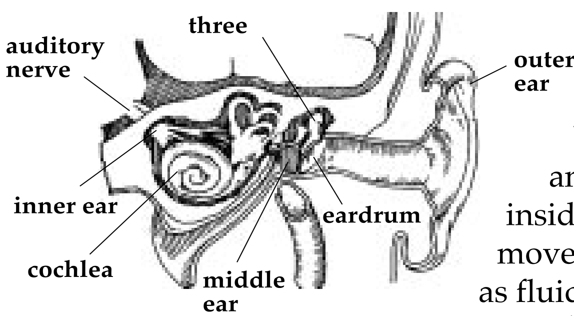
The Eyes



The eye allows us to see by picking up patterns of light, which pass through the lens of the eye to form an image on the **retina,** which lies at the back of the eye. The neurons of the retina send impulses to the **optic nerve** according to how much light they take in. From there, the nerve impulses go to the brain, which interprets the signals from the optic nerve and, finally, shows us what we perceive as a vision of the outside world.

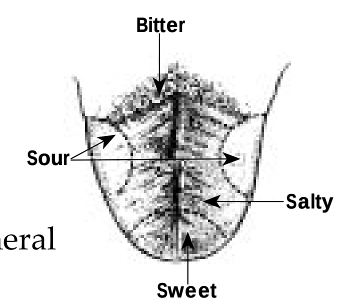
The Ears

The ears perceive sound as air molecules that are set in motion. We call these vibrating air molecules *sound waves*. Sound waves hit the whole body, thus people can sometimes "feel" sounds even if their ears don't work. In healthy working ears, the outer ear structure channels the sound wave down the ear canal to the eardrum. The eardrum picks up the vibration and passes it on to tiny bones inside the ear. These bones pass the vibration on to another membrane that causes fluid inside the spiral-shaped **cochlea** to move. Neurons inside the cochlea react as fluid moves past them. The **auditory nerve** gathers this information and sends it to the brain, which interprets the specific patterns of the vibrations as specific sounds. The inner ear also contains tiny hairs that detect gravity and help us keep our balance.



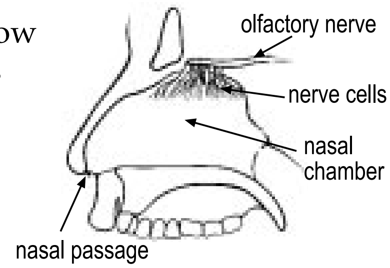
The Tongue

The tongue gives us the sense of taste through its tiny **taste buds**. These are little, flask-shaped structures with pores in the top. Food dissolved in saliva enters these pores. Then hairlike nerve endings inside react, sending signals to the brain. Research shows taste buds can sense only four general flavors: sour, sweet, salty, and bitter. Much of our appreciation of food stems from its smell.



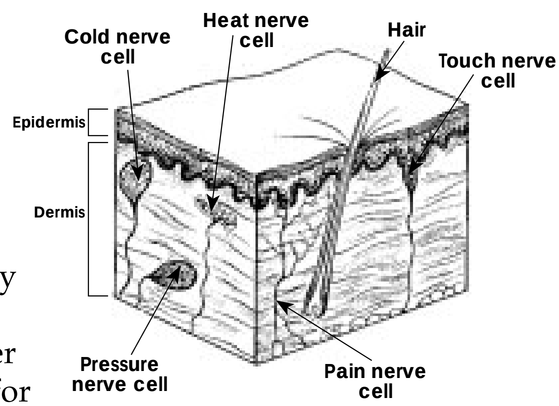
The Nose and Nasal Cavities

Neurons inside the nose and nasal cavities allow us to smell. Smells enter the nose as chemicals floating in the air. Different groups of nasal neurons are sensitive to particular types of chemicals. They send signals that travel through the **olfactory nerve** to the brain where they are interpreted as odors.



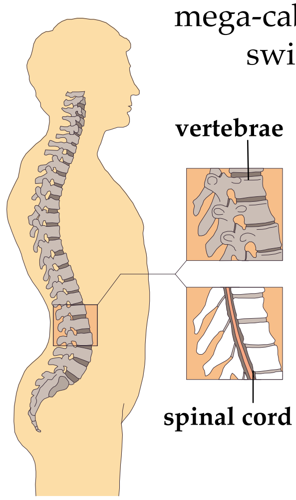
The Skin

Besides the sense of touch, the skin can feel several other conditions: pain, pressure, heat, and cold. Different neurons in the skin are responsible for sensing each of these conditions. According to their job, the neurons are either very close to the skin surface, as with neurons for pain or touch, or deeper in the skin tissue, as with neurons for pressure.

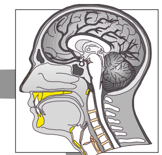


The Spinal Cord

If you think of a nerve—a bundle of neurons—as a telephone cable filled with telephone wires, then you can think of the spinal cord as the mega-cable for the body's nervous system, leading to the main switchboard, the brain. The spinal cord carries sensory messages from the body to the brain, and motor impulses from the brain to the body.

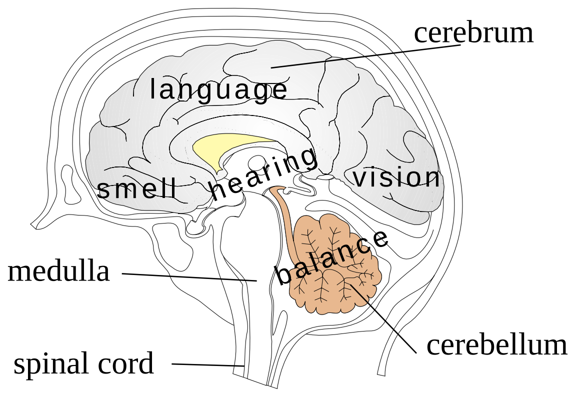


The spinal cord leads directly from the brain and descends about two-thirds of the way down the back. It is protected by the bones of the spinal column, called *vertebrae*. The inner part of the spinal cord is made up of "gray matter," the same tissue of densely packed neurons of which the brain is made. The outer part is made of nerve fibers. Many spinal nerves branch off from the spinal cord between the bones of the spine.



The Brain

The brain is divided into three major parts: the **cerebrum**, the **cerebellum**, and the **medulla**. Nerves carry electrical impulses which may have been caused by external or internal factors to the brain. For example, we respond by eating the food that smells good to us. However, pain in our stomach caused by eating spoiled food may cause us to vomit. As we examine how the three parts of the brain function, we will see how the different organs and parts of the body communicate.



brain

The upper part of the brain, the cerebrum, is the largest part of the brain. It's the cerebrum most people picture when they think of the brain—gray and ridged with deep wrinkles and furrows. The cerebrum is responsible for *complex thought processes* such as language, reasoning, and artistic efforts. It stores information as memories. It also receives and interprets information from the sense organs and sends impulses to the muscles for voluntary motions. The cerebrum is made up of two halves: the right half controls the left side of the body and the left half controls the right side.

The cerebellum helps the cerebrum to control *muscular activity*. It coordinates impulses sent to the muscles so that motion is smooth, not jerky. The operation of the cerebellum is involuntary. The cerebellum lies beneath the cerebrum.

The medulla is the bottom part of the brain, lying at the base of the skull and at the top of the spinal cord. The medulla controls *vital involuntary motions*, such as the activities of all internal organs. These activities include respiration and the actions of the heart and digestive organs. The medulla also controls the actions of **glands** that release the biochemical messengers of the endocrine system, which we'll look at next.

The Endocrine System

The nervous system isn't the only means by which our bodies can send messages from one part to another. The endocrine system is a network of organs that produce chemical messengers known as **hormones**. These organs are known as glands and are located in many different places in the body. They travel from place to place in the bloodstream. Some hormones are complex proteins, and others are not. Specific hormones cause specific changes to take place in certain body parts or organs.

Glands: Their Location and Function		
	Location	**Function**
Pituitary	brain	controls growth and regulates sex organs
Thyroid	throat	regulates use of food in body cells
Parathyroid	throat	controls calcium levels in body
Adrenal	near kidney in central back	produces adrenaline which allows bursts of energy; controls salt levels
Pancreas	near kidney in central back	produces insulin, which controls the amount of sugar in the blood and helps sugar enter cells
Ovary	lower abdomen	controls female sex characteristics in females
Testis	testicles	controls male sex characteristics in males

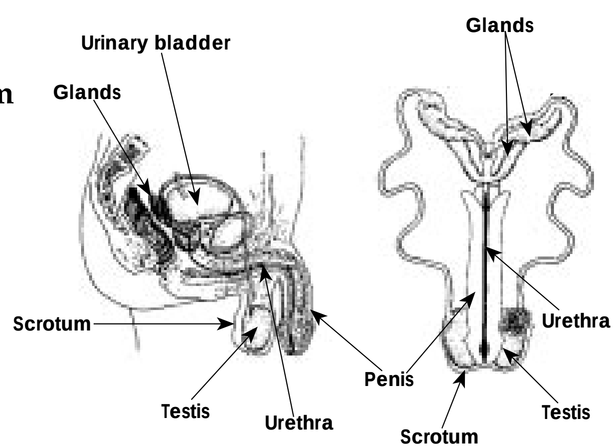
All of these glands, and the hormones they produce, play important roles in the body. No doubt you've heard of some of them. For example, the pancreas produces insulin. Insulin acts as a gatekeeper for cells, allowing sugar to move from the bloodstream into the cell, where it is used as food. A lack of insulin or the body's inability to use insulin properly causes *diabetes*. People with diabetes do not have or cannot use their own insulin to let sugar into their body cells. Thus there's a high level of sugar in the blood and urine, yet the cells are starving. This condition can now be corrected by injecting insulin produced from pigs, cows, or sheep.

The Reproductive System

Hormones play a big part in bringing the sexual organs of men and women to maturity. Hormones also play a big part in making the reproductive system work. One of their main functions is to make males and females attractive to each other so that they will mate and bear offspring. As we've seen through our study of other body systems, each system is designed to achieve its goal as efficiently as possible, and the goal of the reproductive system is to reproduce. Humans, however, unlike most other animals, have the ability to rise above the hormonal urges of their reproductive systems. Humans are able to think about what they want for themselves.

In some ways it seems odd to discuss the structure and operation of the human reproductive system as just another biological topic. For most of us, the reproductive system is associated with ideas of love, romance, desire, and commitment. In many ways, however, it is especially important to be objective and knowledgeable about how the reproductive system works. Knowing the facts means that you can control when or if you have children and whether or not you become infected with serious or even deadly diseases.

The Male Reproductive System

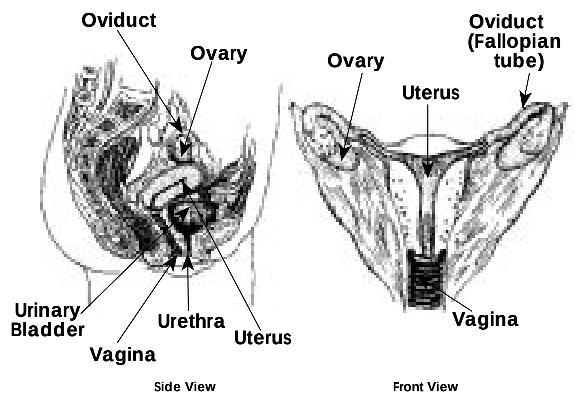


The **testes** (*sing.* testis) are the male sex organs that produce male sex cells, known as *sperm*. The testes also produce testosterone, a hormone that helps create and maintain male sex characteristics. These characteristics include the sex organs themselves as well as other traits such as body hair, muscular development, and a deeper voice. The testes are housed in a sack of skin called the **scrotum**.

Sperm develop from special cells in the testes. These cells divide by meiosis. If you'll recall the cell division described in Unit 4, meiosis gives each sex cell only half the number of chromosomes as the parent cell. When the male sex cell unites with the female sex cell, the egg, the offspring has the same number of chromosomes as the parents.

After the sperm leave the testes, they mix with several fluids from other glands. This gives them energy and more resistance to acidity. The resulting mixture is called **semen**. During sexual intercourse, semen is ejected into the female reproductive system through a sex organ called the **penis**. As many as 130 million sperm may be ejected at a time.

The Female Reproductive System

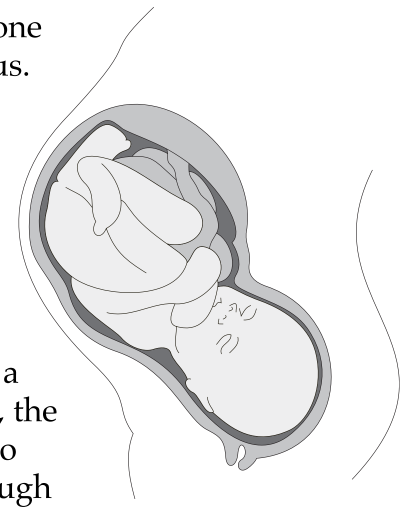


The **ovaries** are the female sex organs that produce female sex hormones and female sex cells, or eggs. Like sperm, eggs are produced through meiosis and contain only half the chromosome number of the parent.

In humans, the ovaries usually release one egg each month. The egg moves from the ovaries into the **Fallopian tubes**, which are tubes that connect the ovaries to the **uterus**. The uterus is the sex organ in which the egg will develop if it is fertilized. Each month, hormones in the body prepare the uterus for the possibility of nurturing a fertilized egg as it develops into another individual. These hormones give the uterus a soft, spongy lining with lots of blood vessels to deliver nutrients. If the egg is not fertilized, this lining decays and drains out of the uterus at the end of the monthly cycle. This discharge is known as **menstruation**. It leaves the uterus through an opening called the **cervix** and exits the body through a canal called the **vagina**. The vagina serves as an entry point for sperm during sexual intercourse and also as the birth canal.

Fertilization and Development

Following sexual intercourse, fertilization normally occurs as an egg is floating down one of the Fallopian tubes on its way to the uterus. A sperm must swim up the vagina, through the cervix, across the uterus, and up the Fallopian tube to reach the egg. As soon as the sperm penetrates the membrane of the egg, the egg begins to develop into a multicellular individual. Even before it reaches the lining of the uterus, where it attaches itself, the fertilized egg has become a tiny ball of hundreds of cells. Once attached, the developing individual, the **embryo**, begins to receive blood, nutrients, and hormones through the **placenta**. The placenta is a special organ that is made of tissue from both the mother and the embryo.



After about 40 weeks of development, the child is born. The membranes surrounding the baby break. The tissues of the mother's cervix and uterus relax. The cervix enlarges so that the baby can pass through. Strong muscles in the uterus force the baby out and down the vagina. Moments later, the uterus pushes out the placenta, to which the baby is still attached. Soon after birth, the cord that connects the baby to the placenta is cut. The cord stump attached to the baby withers and falls off after several days, leaving what we know as a navel.

Disease and the Immune System

As we have reviewed the various systems of the human body, we have studied how they are supposed to work under ideal conditions. Obviously, life is not always ideal. Many people's bodies are damaged by disease. Disease can slow down and stop any of the body's marvelous systems. Thanks to medical research, doctors are often able to prescribe lifestyle changes, drugs, or surgery to help ailing body systems. However, a particular system can be so badly diseased that it cannot function at all. Even if it's propped up by medical means, it's possible that the entire body will shut down and die. Every system supports and interacts with every other system. So if one stops, another is likely to falter.

Example Classification of Diseases		
Hereditary	**Degenerative**	**Deficiency**
hemophilia	arthritis	kidney disease
cystic fibrosis	arteriosclerosis	cirrhosis of the liver
diabetes	Alzheimer's disease	congestive heart failure
sickle cell anemia	cancer	lung disease
muscular dystrophy	retinitis pigmentosa	osteoporosis

Diseases that afflict humans fall into several different categories. *Hereditary* disease is disease that people *inherit* from their parents, usually through a defect in their genes. Hereditary diseases include hemophilia and sickle cell anemia (Unit 5). *Degenerative* disease is disease that results from *aging*; parts of the body simply wear out. Arthritis and hardening of the arteries, or arteriosclerosis, which often causes heart problems, are examples of degenerative diseases. Deficiency diseases include problems with body systems that simply *don't work* at the required capacity. For instance, some people's kidneys do not efficiently filter out and excrete impurities from the blood. These people must often rely on dialysis machines to increase the filtering capacity of their kidneys.

Examples of Contagious Diseases	
• influenza	• mumps
• pneumonia	• measles
• chicken pox	• AIDS
• rabies	• trichinosis
• salmonella	• dysentery
• malaria	• hepatitis

Contagious diseases are diseases that one person can *catch* from another. These diseases are usually passed on in bacteria or viruses. The body has several defenses against such invaders.

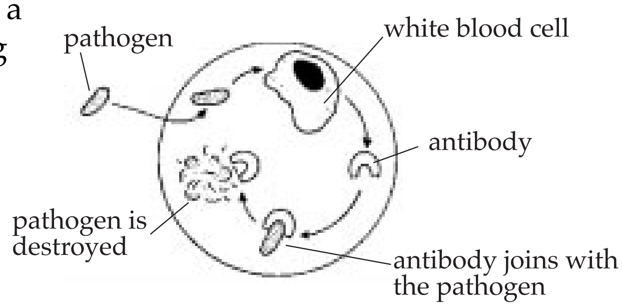
How the Body Protects Itself from Contagious Diseases

The first line of defense against contagious disease-causing agents, or **pathogens**, prevents them from entering body tissues. This line of defense includes the skin, tears, mucus, and stomach acid.

The second line of defense against pathogens involves white blood cells called **phagocytes**. Scientists think that phagocytes find their way to sites of infection by sensing chemicals. These chemicals may be released either from the injured tissue or by the pathogens themselves. The phagocytes surround and swallow the invaders. Certain phagocytes can enlarge to take in as many as 100 or more bacteria.

The third line of defense is what we call the *immune system*. When people are immune to a disease, that means that they cannot become infected with it. Immunity may be natural—present at birth—or acquired since birth.

The body becomes immune to a particular disease by acquiring **antibodies** for it. Antibodies are produced in the **lymph nodes**, special immune system structures. Antibodies are proteins that stick to pathogens and make them harmless. Antibodies usually act specifically on certain pathogens.

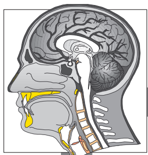


The normal response of the immune system to disease-causing organisms.

People can acquire antibodies to a pathogen in several ways. Antibodies may be passed on from mother to child, or antibodies may be injected into a person. However, these sorts of immunity, where someone passively accepts antibodies from someone else, may soon wear off. Active immunity, where a person's own body develops antibodies to a pathogen, lasts longer. Active immunity involves exposure to the pathogen. This is the sort of immunity we receive through **immunizations**. The substance we receive in an immunization is usually a *dead* or *weakened form* of a pathogen. Exposure to this pathogen allows the lymph nodes to develop antibodies that are specific for the pathogen even in its stronger, more dangerous form. Thus the immunization gives the benefits of exposure—antibodies and immunity—while avoiding the risks of major infection.

Summary

In this unit, we finished our inspection of the many body systems that keep us alive. The nervous system is made up of special cells called neurons which carry tiny electrical messages throughout the body. Sense organs take in information and send it to the brain for processing. The spinal cord is a major nerve pathway that allows the brain to communicate with other parts of the body. The brain is made up of three main parts, the cerebrum, cerebellum, and medulla, each of which controls different nervous system functions. The brain and other body systems respond to internal and external conditions.



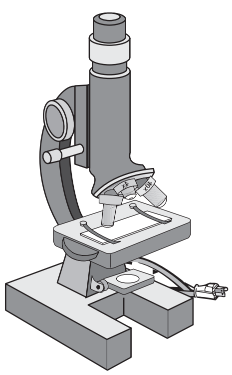
The endocrine system uses another means of sending messages throughout the body: biochemicals known as hormones. These are produced in glands located in many different places. Hormones control many important functions such as sugar levels in the blood, rate of growth, and the development and function of sex organs.

The reproductive system is largely controlled by hormones. Both males and females have special sex organs that allow them to produce sex cells. Union of sex cells and development of the resulting embryo takes place inside the female. Knowledge of how fertilization occurs, as well as the many diseases that can be passed on during sex, is useful for those who wish to control those events in their lives.

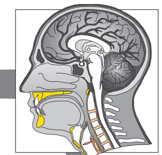
Hereditary, degenerative, deficiency, and contagious diseases are all threats to the efficient operation of body systems. The body has several lines of defense against contagious diseases, including the antibodies of the immune system.

Careers in Biology

Anthropologist



Anthropologists study human beings—their sociology, culture, evolution, and physical characteristics. The field of anthropology has many areas of specialization. Cultural anthropology involves the study of customs. Archaeology focuses on the study of artifacts. Linguistics is the study of how language develops. Physical anthropology is the study of human evolution. Anthropologists usually work in a university setting as teachers and researchers. Anthropologists may also seek funding through grants from their state, the federal government, or national associations. A graduate degree at the masters or doctorate level is usually required for employment in this field.



Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

brain	**hearing**	**sensory**	**taste**
cerebellum	**medulla**	**smell**	**taste buds**
cerebrum	**nerves**	**sight**	**touch**
eye	**neurons**	**spinal cord**	

Nervous System

1. ______________________ cause the motion of involuntary muscles such as the heart's beating.

2. The cells that make up the nervous system are called ______________________ .

3. Neurons carry messages from the sense organs to the "master control center," the ______________________ .

4. Bundles of neurons are called ______________________ .

5. Our ______________________ organs take in information from the world around us.

6. The five senses are ______________________ , ______________________ , ______________________ , ______________________ , and ______________________ .

7. The retina and optic nerve are part of the ______________________ .

8. The spiral-shaped cochlea helps us with the sense of ________________________ .

9. The ________________________ on the tongue give us the sense of taste.

10. The sense of smell comes from ________________________ inside the nose.

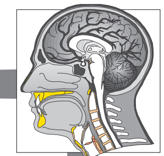
11. Neurons in the skin are responsible for the sense of ________________________ and other conditions such as pain, pressure, and temperature.

12. The primary "cable" for the body's nervous system is the ________________________ .

13. The brain is divided into three major parts: ________________________ , ________________________ , and ________________________ .

14. The largest part of the brain is the ________________________ .

15. The part of the brain that controls muscular activity is the ________________________ .



Practice

Circle the letter of the correct answer.

Endocrine and Reproductive Systems

1. The endocrine system is made up of ________ .

   a. brain and neurons
   b. glands and hormones
   c. thyroid and pancreas
   d. nerves and chemicals

2. The endocrine system's chemical messengers are called ________ .

   a. cells
   b. neurons
   c. ions
   d. hormones

3. The ________ gland, located in the brain, controls growth.

   a. pituitary
   b. thyroid
   c. pancreas
   d. adrenal

4. The pancreas produces ________ , which controls the amount of sugar in the blood.

   a. calcium
   b. adrenaline
   c. insulin
   d. hormones

5. People with ________ do not have or cannot use their body's insulin.

   a. diabetes
   b. testicles
   c. ovaries
   d. hormones

6. __________ are chemicals that play a big part in making the reproductive system work.

   a. Glands
   b. Hormones
   c. Chromosomes
   d. Organs

7. The testes, male sex organs, produce __________ .

   a. hormones
   b. sexual intercourse
   c. sperm and testosterone
   d. glands

8. Sperm travel from the penis in a fluid known as __________ .

   a. testosterone
   b. testes
   c. scrotum
   d. semen

9. The female sex organs that produce eggs and female sex hormones are the __________ .

   a. glands
   b. embryo
   c. ovaries
   d. uterus

10. Sperm and egg cells are produced through __________ .

   a. mitosis
   b. meiosis
   c. intercourse
   d. chromosomes

11. The __________ connect the ovaries to the uterus.

   a. Fallopian tubes
   b. vagina
   c. cervix
   d. embryo

12. __________ occurs when the sperm and egg unite.

a. Menstruation
b. Fertilization
c. Intercourse
d. Fallopian

13. The embryo receives nutrients through the __________ .

a. vagina
b. cervix
c. uterus
d. placenta

14. Our __________ is a feature that shows we were attached to the placenta.

a. uterus
b. cervix
c. navel
d. membrane

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

Disease and the Immune System

__________ 1. Disease can slow down or stop the body's systems.

__________ 2. One body system affected by disease will not affect another.

__________ 3. A hereditary disease is a disease that people inherit.

__________ 4. Hemophilia is a degenerative disease.

__________ 5. Sickle cell anemia is a hereditary disease.

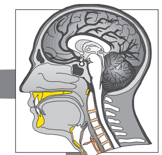
__________ 6. An example of a degenerative disease is arthritis.

__________ 7. Deficiency diseases result from body systems that don't work to capacity.

__________ 8. Deficiency diseases can be caught from another person.

__________ 9. Bacteria or viruses cause degenerative diseases.

__________ 10. The body has no natural defense against disease.



Practice

Use the list below to write the correct term for each definition on the line provided.

acquired immunity	**immunization**	**natural immunity**
antibodies	**lymph nodes**	**pathogens**
immune	**mucus and tears**	**phagocytes**

________________________ 1. disease-causing agents

________________________ 2. white blood cells that fight bacteria

________________________ 3. cannot become infected

________________________ 4. an immunity present at birth

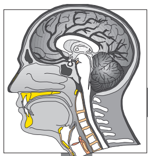
________________________ 5. a condition developed after birth to resist disease

________________________ 6. help prevent disease from entering the body

________________________ 7. produce antibodies

________________________ 8. a form of pathogen injected into the body to produce an active immunity

________________________ 9. enable the body to become immune to disease



Lab Activity: The Human Brain

Facts:

- The human brain is divided into a right and a left side.
- The right side is thought to control creativity, and the left side is thought to control the ability to analyze problems.
- The right side of the brain controls the left side of the body; the left side of the brain controls the right side of the body.
- In most people, one side of the brain is dominant.

Investigate:

- You will check to see which hand you use most often in certain activities.
- You will check to see which foot you use most often in certain activities.
- You will find out if you see or draw objects more to the right or the left side.
- You will find out if the left side or the right side of your brain is dominant.

Materials:

- paper
- red pencil

1. Place a check mark in the proper column in the table on the next page to show which hand you usually use to do the following tasks. *Note: If you use either hand just as often, then check both columns.*

2. Place a check mark in the proper column in the table to show which foot you usually use to do the following tasks. *Note—if you use either foot just as often, check both columns.*

Finding Your Dominant Side		
Task	**Left**	**Right**
write name		
wave "hello"		
bat		
thumb position		
hold spoon		
walk down stairs		
walk up stairs		
catch from falling		
skipping		
standing		
start to run		
dog drawing		
circle drawing		
dominant eye		
Totals		

3. Draw, in the space provided, a simple side view of a dog. Place a check mark in the column of the table that shows the direction your drawing faces **away** from.

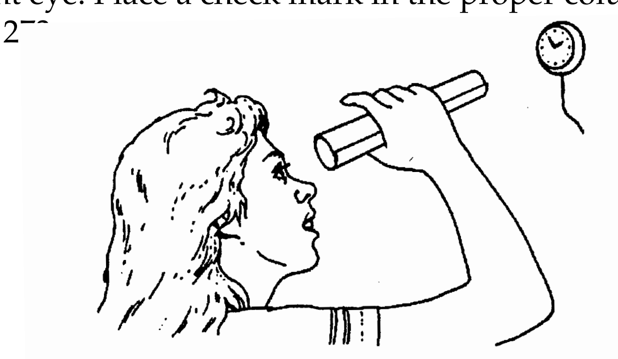
dog drawing

left hand

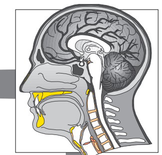
right hand

4. Draw a circle with your **right** hand in the space provided. Note the direction in which you made this circle. Now draw a circle with your left hand. Note the direction in which you made this circle. If both circles were drawn clockwise, mark the right column in the table on page 273. If both circles were drawn counterclockwise, mark the left column in the table. If you drew one circle in each direction, check both columns.

5. Roll a sheet of paper into a tube. Hold the tube a couple of inches in front of your eyes. Look through the tube at some distant object with both eyes open as shown in the figure below. Then, while looking through the tube at the distant object, close one eye and then the other. The eye that sees the object through the tube is your dominant eye. Place a check mark in the proper column in the table on page 273.



6. Total up the check marks for each column of the table on page 273 and place the total at the bottom of the columns.



Practice

Use the list below to write the correct term for each definition on the line provided.

auditory nerve	**hormones**	**optic nerve**
cerebellum	**immunization**	**pathogens**
cerebrum	**lymph nodes**	**retina**
cochlea	**medulla**	**taste buds**
glands	**neurons**	

________________________ 1. a small amount of a dead or weakened pathogen that is introduced to the body so that lymph cells can produce specific antibodies to disable the pathogen in its stronger, more dangerous form

________________________ 2. biochemical messengers in the endocrine system

________________________ 3. a spiral-shaped tube deep inside the ear whose neurons react to sound wave patterns

________________________ 4. a surface at the back of the eye that contains neurons that pass on information about the light patterns it receives

________________________ 5. disease-causing agents that invade the body

________________________ 6. little, flask-shaped structures in the tongue containing neurons that react to different tastes

________________________ 7. long, thin cells that make up the nervous system

__________ 8. special structures in the body that produce antibodies

__________ 9. structures in the endocrine system that produce hormones

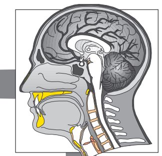
__________ 10. the lowermost part of the brain; maintains the involuntary function of vital organs, such as the heart, the intestines, and endocrine glands

__________ 11. the middle part of the brain; coordinates motor impulses

__________ 12. the nerve that sends information from the ear to the brain

__________ 13. the nerve that sends information from the eye to the brain

__________ 14. the uppermost and largest part of the brain; responsible for complex thought processes



Practice

Use the list below to write the correct term for each definition on the line provided.

antibodies	**menstruation**	**placenta**	**testes**
cervix	**ovaries**	**scrotum**	**uterus**
embryo	**penis**	**semen**	**vagina**
Fallopian tubes	**phagocytes**		

________________________ 1. white blood cells that surround and swallow pathogens

________________________ 2. male sex organs that produce male hormones and male sex cells known as sperm

________________________ 3. a monthly discharge released from the uterus when the lining decays after the egg is not fertilized

________________________ 4. female sex organs that produce female sex hormones and female sex cells, or eggs

________________________ 5. the developing individual inside the uterus

________________________ 6. the opening of the uterus

________________________ 7. the sex organ by which the male ejects sperm into the female reproductive system

________________________ 8. tubes that connect the ovaries to the uterus

________________________ 9. a mixture of sperm and other fluids that help the sperm survive

________________________ 10. a muscle-lined canal connecting the opening of uterus to the outside of the body

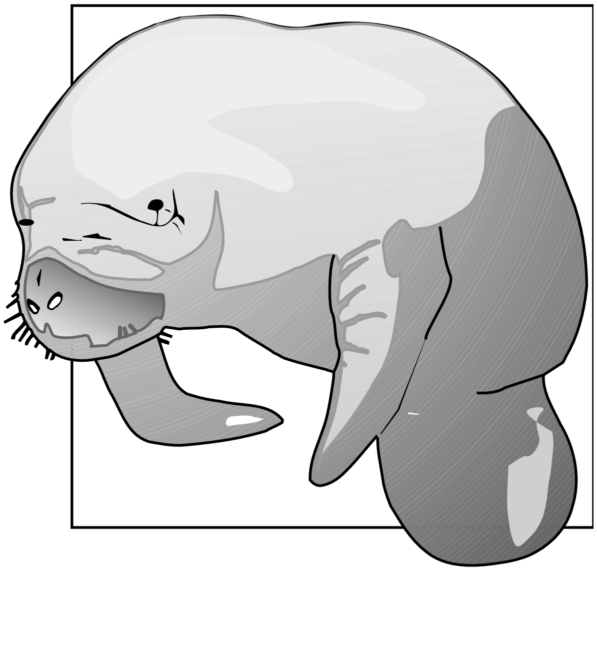
________________________ 11. the sack of skin that houses the testes

________________________ 12. a special organ that provides the embryo with oxygen and nutrients and disposes of its waste products

________________________ 13. the sex organ in which the fertilized egg develops

________________________ 14. proteins that stick to pathogens and make them harmless

Unit 10: Florida's Living Treasures



Vocabulary

Study the vocabulary words and definitions below.

biodiversity .... the variety of species of organisms

carnivore .... an animal that eats only meat

community .... all the interacting organisms of different species living in the same area

ecology .... the study of habitat in interaction with the community of organisms that live there

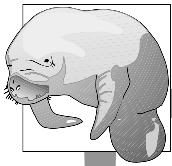
ecosystem .... a distinct, self-supporting unit of interacting organisms and their environment

environment .... the biological and physical things that surround and affect an organism

extinct .... describes a species that no longer has any living representatives

food chain .... a way of viewing the transfer of energy from one living thing to another; a chain of living things in which each organism eats the one before it and is eaten by the one after it

food web .... a way of viewing organisms as being in a network of interacting food chains



habitats .... places to live

herbivore .... an animal that eats only plants

native .... natural resident of an area

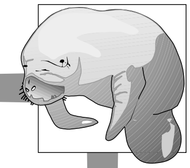
omnivore .... an animal that eats both plants and animals

peninsula .... a strip of land surrounded by water on three sides and connected to a larger land mass on the fourth
Example: Florida

physical geology .... the structure and composition of Earth's crust and the forces of change affecting them

subtropical .... nearly tropical; pertaining to a region between tropical and temperate
Example: northern Mexico

temperate .... moderate in respect to temperature
Example: North America



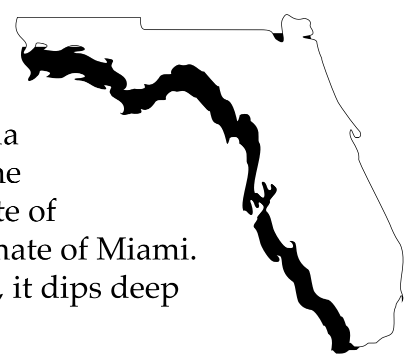
Introduction

In earlier units, we have examined how individual organisms live and how they perform the functions of all living things. Now we will look at things on a much larger scale, we will look at Florida.

Florida is a treasure house of nature. Blessed with hundreds of thousands of species, Florida has more different kinds of animals and plants than any other state in the continental United States except for Texas and California. Some Florida species are not found anywhere else in the world. Yet the warm climate that makes Florida so suitable for all of these plants and animals also attracts humans who settle as new residents. The challenge Floridians face is to protect their natural heritage, which makes Florida so beautiful and exotic, and at the same time deal with the 1,000 or so new people who move to Florida each day.

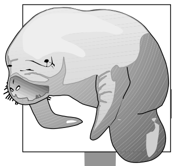
Florida: A Treasure House of Nature

Why does Florida have such a wide variety of plants and animals? What makes it different from Georgia, for example, or Louisiana—southern states that have many fewer species?



Unlike any other state, Florida is a long **peninsula**, a strip of land that is surrounded by water on three sides and connected to a larger land mass on its fourth side. The Florida peninsula stretches hundreds of miles from the occasionally harsh-wintered **temperate** climate of Tallahassee to the ever-warm **subtropical** climate of Miami. Hanging from the southeastern United States, it dips deep into the warm seas of the West Indies.

Because of its shape and location, Florida has acted as a funnel trap for all those species of animals and plants spreading south from the United States and North America. But it has also acted as a long-handled spoon, scooping in species of the West Indies that flew or floated past. Thus Florida contains the southernmost representatives of more northern species, such as the American skunk and the sugar maple. But it also



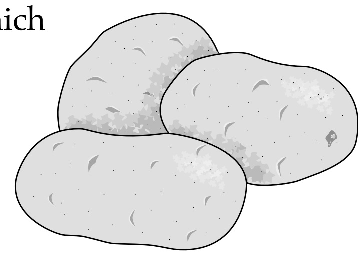
contains the northernmost representatives of some tropical species, such as the American crocodile and mangrove trees.

Another reason that Florida hosts so many different species is that Florida is made up of many different landscapes. The **physical geology** of an area, the soil and rock that make up the land, changes greatly from place to place. At the backbone of Florida are 25-million-year-old sand dunes. At the edges are 3,000-year-old barrier islands. In between are springs and rivers carved from limestone, and flat, wet pinelands sitting on clay. These different landscapes offer animals and plants many different **habitats**, or places to live. Most animals and plants survive best in a particular kind of habitat. The more different habitats that are available, the more different species that will come to live in those habitats.

Thus because of its shape and location, and because of the many habitats it contains, Florida is very rich in the variety of life it supports. This variety of life is called **biodiversity** (bio=life, diversity=difference). Over time, biologists have come to appreciate the great value of biodiversity.

Why Is Biodiversity Important?

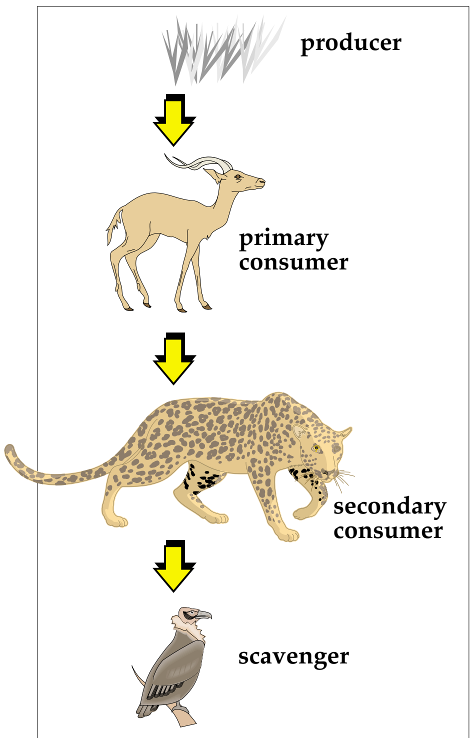
During the 1800s and early 1900s, millions of Irish people emigrated to the United States. This was because of a crisis in Ireland known as the Great Potato Famine. Potatoes, which were the mainstay of the Irish diet at that time, were stricken with a blight. The potatoes rotted before they could be eaten. Thousands of poor people who depended on potatoes for food starved to death. Totally dependent on the potato as their main source of nutrition, these poor Irish people could find little else to eat.



How does this story relate to the importance of biodiversity? It is important to remember that all living things are interdependent. Every organism on Earth is involved in a **food chain**. All energy for life comes from the sun, and all life relies on energy. As our look at food chains will show, a knowledge and understanding of energy is important to science and survival.

A food chain is a way to show the *transfer of energy* from the sun to producers such as plants, which produce their own food, and on to consumers such as people. There may be many steps in a food chain.

In an **ecosystem**, the relationship between what an organism eats and what it is eaten by determines its feeding level. We will examine the feeding levels of producers, consumers, and decomposers. Producers, or the lowest feeding level, use light energy and photosynthesis to produce food. Grass and plants are two examples of producers.



A Natural Food Chain

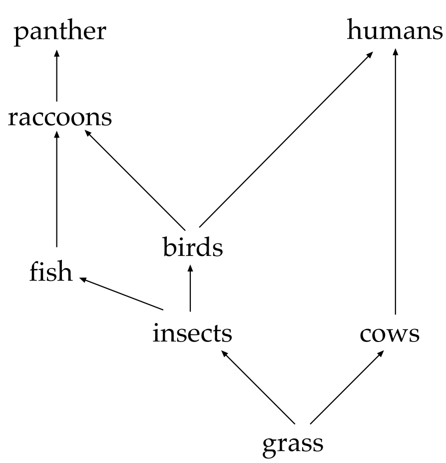
Consumers are classified according to the type of food they eat. At the second feeding level are consumers called **herbivores** who eat the producers. Among these consumers are grass-eating antelopes, cows, and sheep. Next on the food chain are **carnivores**, consumers who eat other consumers. These include lions, eagles, cobras, and praying mantises. Another consumer is the **omnivore** who eats producers and consumers. Grizzly bears and humans are omnivores. Scavengers are consumers who feed on organisms who have recently died. Vultures and crows are two such consumers.

Our food chain may also include decomposers such as fungi, organisms that break down dead tissues and wastes. These tissues and wastes become chemical wastes making them available to producers once again. This cycle is repeated over and over in the same ecosystem. Although the food chain models how energy moves and is recycled, some energy becomes heat. This heat energy is usually not used to produce life. The amount of energy stays the same but is less useful.

Since there is a limit to the amount of energy available, diversity is also important in an ecosystem's food chain. The potato blight affected the amount of energy or food available to the poor farmers of Ireland. The example of the Great Potato Famine is simple: the producers were potatoes, and the consumers were people. The amount of energy or food available to the top-level consumers was much lower than the amount produced. Obviously, the potato blight would not have had such drastic consequences if the Irish had had different things to eat—more *diversity* in their diet. But since they did rely only on the potato, and the potatoes had all rotted, the food chain crashed. The consumers at the top of the chain starved.

An organism has a greater chance of survival if there is more diversity in its food chain—more kinds of producers at the bottom, more kinds of herbivores at the second level, and many different kinds of omnivores and carnivores at the third level. Then the food chain is more like a **food web**. Because there are more connections between the different levels, a diverse food web is not as likely to break down. Food webs, like chains, are not just tools. They help us understand how energy is used by living systems. The illustration below shows a sample food web. Through it you get a better idea of how energy moves to different organisms. The web describes a system.

It is important to understand what scientists mean by "system." A system is a group of interrelated objects and energy. It can be large or small. On the large scale, scientists view the entire universe as a system with energy and objects (matter). The universe is a complex system, so the rules that describe it range from simple to complex. Science, through careful study, tries to find these rules. A food web can be one way of describing rules for a smaller system, and these rules may work for only one ecosystem.



Grass is the basis for this simple food web.
Are real systems this simple?

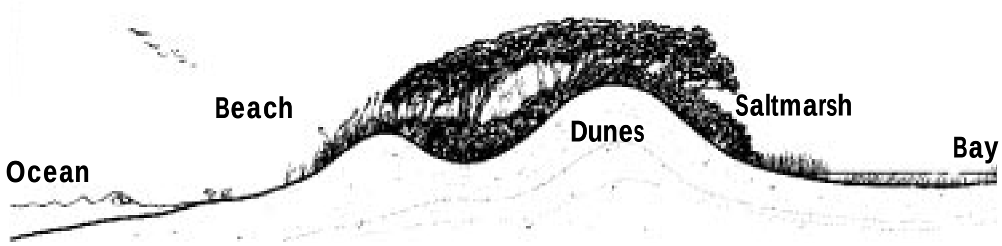
An ecosystem is the particular place organisms live—the habitat—in interaction with all of the organisms that choose to live there—the **community**. It is the biodiversity of ecosystems that makes them healthy. The study of how the habitat and the community affect each other, and how the ecosystem works, is called **ecology**. In many ways, an ecosystem itself functions like a huge creature: it has its own special and recognizable character traits that make it different from other ecosystems. All of its parts must function together to support it. If its supply of energy or water suddenly changes, it can go into shock. If its internal systems are badly injured, an ecosystem can die. As with any living being, though, changes to systems are usually met by efforts to avoid death. Changes can cause unpredictable results. Biodiversity helps make it possible for the ecosystem to return to its original condition.

Florida Ecosystems

This is just a short list of some of Florida's most common ecosystems. It by no means covers all of Florida's ecosystems. Part of Florida's charm is that its natural areas are so different and unique that no short, simple list can do them justice.

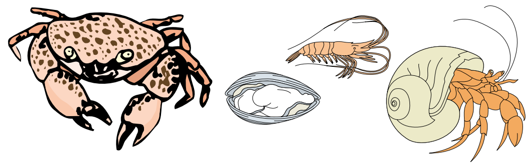
Coastal Areas

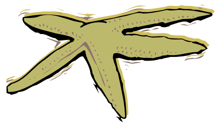
Life on the coast can be harsh. Plants that live there are battered by the waves and wind and constantly exposed to salt spray. Many have *developed* special protective features. For example, the seaside golden aster has a woolly covering on its leaves to keep them from drying out.



Sea oats have strong, wide-branching roots to keep them from blowing away. These roots help stabilize the dunes. Sand live oaks that live on the coast often look as though they've been over pruned and stunted. Growing small near the water and taller farther from shore, these hardy little trees take on a sturdy, bush-like form that can withstand high wind.

sea oats

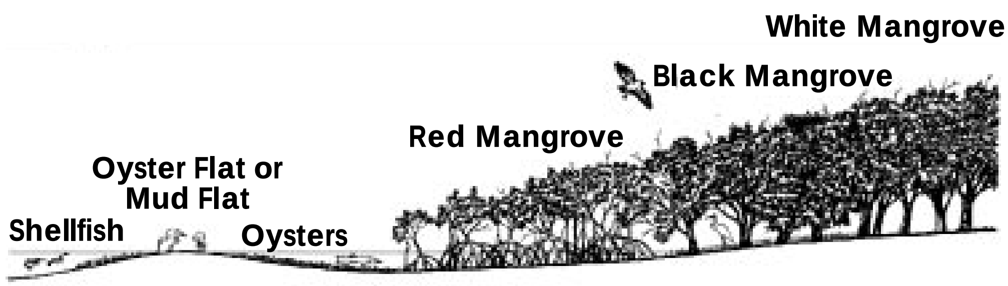




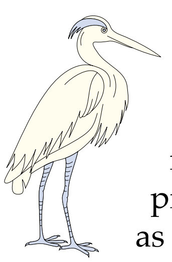
In many coastal areas there are vast salt marshes. These shallow waters provide food and shelter for ocean animals. Salt marshes serve as a "nursery" for many of these animals, such as scallops, shrimp, and oysters, in the early stages of their lives.

Coastal areas are a wonderland of invertebrates. Most beachcombers have seen ghost crabs scurrying sideways on their tiptoes or found hermit crabs peeping out of shells. There are many other invertebrates that also make their livings in the tidal zone: sea worms, sand dollars, starfish, and horseshoe crabs. A simple investigation can turn up bizarre animals that can expand your idea of what makes up life.

Mangrove Swamps

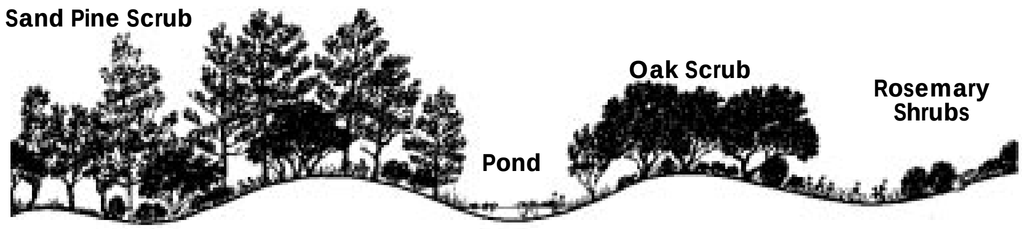


Mangroves are tropical plants that grow along Florida's south coast and halfway up the peninsula. They grow in areas protected from strong waves. Red mangroves have prop roots that grow down from larger branches. Black mangroves have hundreds of roots that look like pencils poking up out of the sand. Tall white mangroves usually grow upland of the red and black mangroves.


egret

Many birds nest in mangroves, including herons, egrets, and pelicans. People once considered mangroves trash trees and cleared large areas of them. However, mangroves are now legally protected because Floridians realized that they provide protection from storm damage. Mangroves also serve as nursery grounds for young fish, crab, and shrimp.

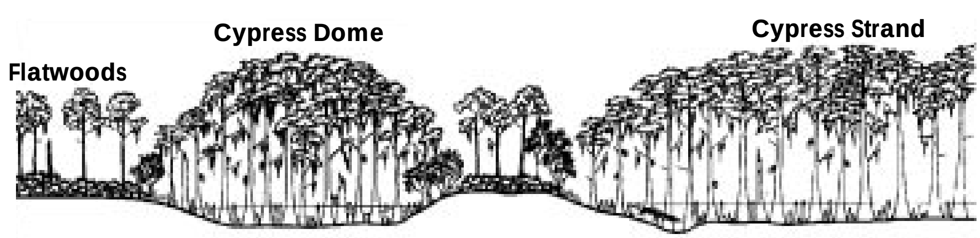
Scrub



Scrub areas resemble coastal areas in many ways. In fact, you could say scrub is a coastal area that the ocean left behind long, long ago. The oldest scrub in Florida runs along the center of the southern peninsula. This area is in fact a group of ancient sand dunes, the first part of the Florida peninsula to emerge from the ocean. This happened 25 million years ago. Scrub is one of the oldest ecosystems in Florida.

Because sand dunes tend to form ridges, areas of scrub are often isolated, like islands, within other types of ecosystems that are lower and wetter. Scrub is recognizable by its fine, white sugar sand, a type of soil that holds little moisture. In many ways, scrub is Florida's version of the desert. Scrub plants include prickly pear cactus and rosemary shrubs, as well as trees such as sand live oak and sand pines. Animals include desert-like animals such as the scrub lizard, which literally swims through the sand, and the gopher tortoise. The scrub jay, cousin to the blue jay, lives only in scrub.

Freshwater Swamps and Marshes

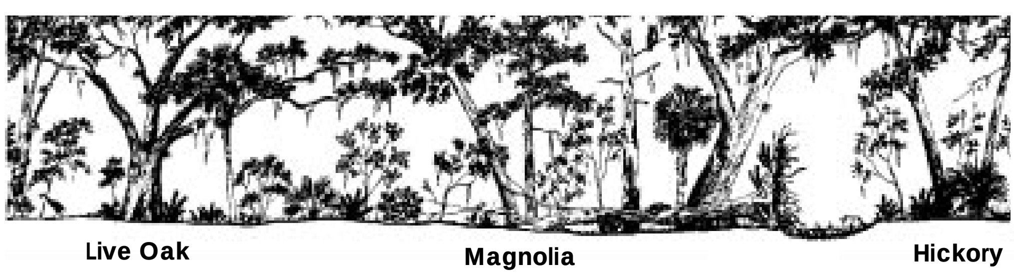


Freshwater swamps are common in Florida. These are low, wet areas that often have scattered mounds of higher ground. In many places they appear as "cypress domes." These are wet lowlands, circular in shape, that have tall cypress trees growing in the center and shorter cypress trees around the edges. This gives the swamp a dome-like look. The Okefenokee is a large collection of cypress domes and open water in

Georgia, near the Florida border. Other freshwater swamps, particularly swamps in central and north Florida, support trees of the bay family—magnolias, red bays, and sweet bays. These swamps are often called *bayheads*. Still other freshwater swamps are filled with black gum, maple, and elm trees. The Everglades, Florida's most famous area of freshwater submerging ground, is a marsh. It is filled with millions of acres of saw grass.

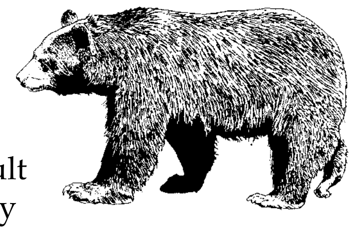
Though freshwater swamps and marshes vary in the types of plants that live there, they are all the same in that they are havens and watering spots for wildlife. Since these spots aren't favored by human residents, many are still available for other Florida species. Florida's few remaining panthers live deep in the freshwater swamps of extreme southwest Florida. Black bears survive better in the remote wilderness of large swamps. Wood ducks, wood storks, and other birds often shelter and feed there. A freshwater swamp or marsh is also a good habitat for alligators.

Hardwood Forests and Hammocks



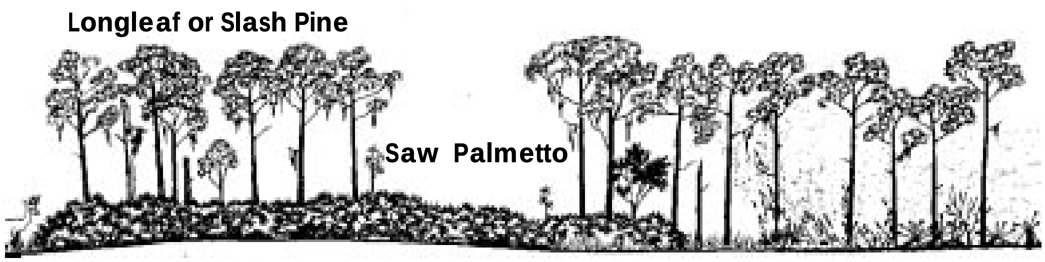
Hardwoods are broad-leaved trees that usually shed their leaves at some point during the year. They are flowering plants, but many have flowers that are so small they aren't noticeable. Southern live oak, magnolia, holly, hickory, and dogwood are common hardwoods that grow in Florida forests. The state tree, cabbage palm, is also abundant in southern and coastal areas. Hardwood forests are often called *hammocks*. Hardwood hammocks in the extreme south contain many rare tropical species, such as mahogany. Hammocks are mixed together with numerous freshwater swamps in many parts of Florida.

Turkey and white-tailed deer are probably the most well-known residents of hardwood forests. Bears forage there if the area is free from human disturbance. Bobcats are common in hardwood forests but are so quiet and cunning that it's difficult to sight them. The loud, Woody-Woodpeckerish cry of the pileated woodpecker often resounds through the trees.



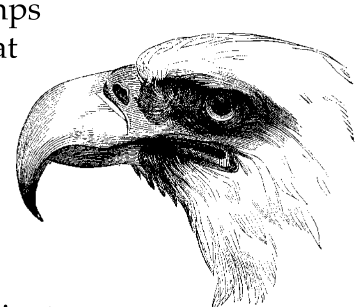
black bear

Pine Flatwoods



Pine flatwoods cover more area in Florida than any other ecosystem. These are flat, low pinelands covered with longleaf pine, slash pine, and low-growing saw palmetto. They are frequently flooded by summer rains. Before human settlements divided the pine flatwoods, they burned naturally about every second spring, from low fires set by lightning storms that spread for miles. Mature pines are protected from fire by their thick bark, while other plants resprout with fresh, green shoots that are good for wildlife. Fire is an important force in this ecosystem, keeping its wide, open spaces free of brush. Land managers now purposefully set fires to maintain the flatwoods. These fires are called controlled burns.

Pine flatwoods have high biodiversity of 50 to 75 species of plants per acre. They are often interrupted by cypress swamps or hardwood hammocks. Most of the animals that live in swamps and hammocks also use the flatwoods at least part of the year. Three notable animals that live in pine flatwoods are the bald eagle, selected as our national symbol in 1782 ; the fox squirrel, a large, brushy-tailed squirrel fond of pine nuts; and the red-cockaded woodpecker, which nests only in the heart of ancient longleaf pines.



bald eagle

What distinguishes each ecosystem from another is its physical setting. A cypress tree cannot survive on the beach. This is because it is in the wrong setting. Yet ecosystems in Florida, though they are unique, share traits with ecosystems elsewhere. They rely on the soil, water, temperature, and other physical factors to determine what organisms can survive in an area. This creates the unique ecosystems we have just described.

Habitat Destruction

panther

The Florida ecosystems described above sound like scenes from a nature movie, filled with the music of birds and the passage of fat, happy animals. Unfortunately, that is not the case. More and more, humans are pushing back these ecosystems to make room for subdivisions, shopping centers, agriculture, tree farming, new highways, and phosphate mining. More and more, the description of ecosystems as thriving worlds cut off from human activity is not accurate or realistic.

Coastal areas are threatened with overdevelopment—wall-to-wall houses and marinas—which in turn threatens offshore water quality. Scrub has become hard to find; most of it has been planted with citrus groves. Many freshwater swamps have been drained for agriculture. Efforts were underway to drain most of the Everglades until experts showed that much of it wouldn't support crops. Hardwood forests are highly prized by land developers as potential sites for new neighborhoods. Much of what used to be pine flatwoods has now been drained and planted with neat little rows of slash pine destined for the paper mill. Roads and fences crisscross all of these ecosystems, breaking them into small pieces, or fragments.

Not surprisingly, many of the animals and plants that once lived in Florida's natural ecosystems have lost their homes. Their habitats have been drastically changed, even destroyed. In some cases, the change is very obvious.

alligator

For example, drainage turns wetlands into dry habitats. The lawns of a subdivision are much different than the hardwood forest that used to exist on the same site.

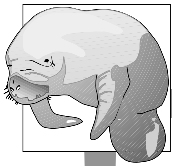
Each of these ecosystems can support a limited amount of life. Human actions such as road building, dredging, and other development can alter the ecosystem, causing changes in how energy moves through the system. This change in energy movement reduces the amount of life that can be supported.

Sometimes, the destructive change in a habitat is not so obvious. Pine flatwoods can become choked with hardwoods if they are not burned frequently, and all of the plants adapted to live in pine flatwoods then die off. Pesticides and fertilizer can run off farmlands into rivers to pollute the salt marshes far away at the river's mouth. Here are some activities that lead to destruction of the **environment**—the biological and physical setting that all living things share.

Some Activities That Harm the Natural Environment

- draining and filling of wetlands
- clearing **native** plants—plants that are natural residents of the site—for construction
- clearing native plants for farming
- allowing uncontrolled runoff of pesticides and fertilizer
- fragmentation—dividing ecosystems into smaller pieces with roads or other man-made construction

At least 34 species of Florida animals have become **extinct** since European settlement. *Extinct* means that there are no longer any living individuals of these species in Florida. The list below shows some of these animals as well as some that are now on the brink of extinction—very few individuals are left. Those animals that went extinct before 1900 were victims of overhunting. Those that have gone extinct since then, however, and those that are now in danger of extinction, are victims of *environmental change and destruction*. With every species that goes extinct, Florida loses another precious part of its biodiversity.



Extinct/Endangered Florida Animals	
1987-Present Endangered	• Florida panther • Florida Key deer • West Indian manatee • Florida black bear • Red-cockaded woodpecker • American crocodile
1900-1987 Extinct	• Ivory-billed woodpecker • Dusky seaside sparrow • Pallid beach mouse • Goff's pocket gopher
<1900 Extinct	• Florida red wolf • Plains bison • Carolina parakeet • Passenger pigeon

What You Can Do for Florida Wildlife

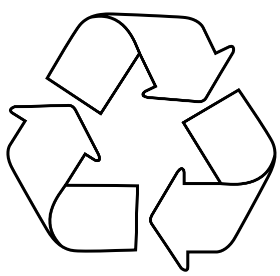
Often, when someone tells you what you can do for the environment, it involves writing to your legislator to encourage him or her to protect it. This certainly is a responsible, worthwhile effort, and it is important to know how to reach your state and federal representatives and senators. There are many other ways to help wildlife, many of which are just plain fun.

Plant native species in your yard. One way to make up for taking land from wildlife for our own homes is to replant species of plants that might have lived there before. Try to figure out what type of habitat used to be in your yard. Then figure out what native plants used to live there. Some local nurseries specialize in native plants and can help you decide what to buy to plant in your yard.

cinnamon fern

Build and install nesting boxes for cavity nesters. By cutting down forests, people have removed hollow trees that many animals depend on for shelter. Bluebirds, woodpeckers, flying squirrels, and bats all use cavities in old or dead trees for their homes. Nesting boxes are easy to build from plans you can find in the library, at local nurseries, or at state wildlife agencies such as the Florida Game and Freshwater Fish Commission.

Install and maintain a bird feeder and bird bath. A safe, clean bird feeder, regularly filled with birdseed, is a joy for both the birds and those who watch them. Bird feeders can bring birds into your life—near a window or a sun deck—where you can watch them every day. Sources of clean water are sometimes difficult for birds to find, and they need a safe place to drink and bathe.



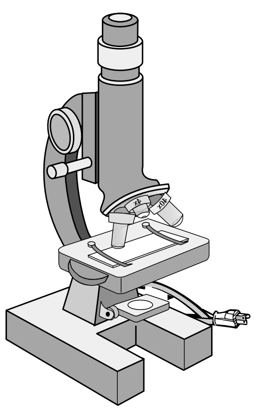
Reduce, Reuse, Recycle. If you recycle disposable materials, reduce the amount of materials you use in the first place, and reuse items instead of buying new ones, these actions will lessen your negative impact on the environment. If there is less demand for consumer goods, fewer resources will be destroyed to make them. If there is less garbage, less land will be used for dumps and landfills. Remember the 3 R's—reduce, reuse, and recycle.

Summary

Florida is a treasure house of nature, containing a large number of different species. Because it contains so many different species, Florida is said to have a high biodiversity. The shape and location of Florida, as well as its many different habitats, contribute to this biodiversity.

Biodiversity contributes to the health of Florida's ecosystems by adding more ways for energy to be transferred so that all animals have a variety of things on which to feed. At the base of the food web are plant producers; above them are herbivores; above them are omnivores and carnivores. Decomposers break down organisms. At each level of the food web, more energy is lost as heat. Organisms at each level of the food web are essential to healthy ecosystems. Food webs and chains are another tool to aid scientists in understanding the universe.

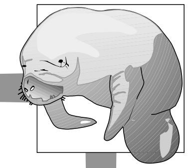
Florida has many types of ecosystems. Coastal areas, mangrove swamps, scrub, freshwater swamps, hardwood hammocks, and pine flatwoods are just a few examples of Florida ecosystems. But Florida ecosystems are being destroyed by clearing for farming and construction as well as by other activities. Changes in an ecosystem can destroy it or have unpredicted results. Ecosystems tend to return to their original condition, though. This condition is based on many physical factors. It's up to Floridians to protect the treasures of nature with which Florida is so richly blessed.



Careers in Biology

Ecologist

An **ecologist** studies the interactions between organisms and their environment. Ecologists often specialize in certain types of environments such as deserts, rain forests, or marine and freshwater environments. Some ecologists specialize in the ways humans affect the environment, and others study how energy is distributed within a system. Most ecologists study biology or a closely related field to receive a bachelor's degree and then specialize in ecology.



Practice

Answer the following using complete sentences.

1. Why does Florida have such a wide variety of plants and animals?

2. What is a food chain?

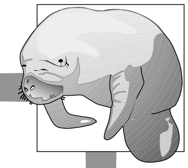
3. Having more than one source of food may help keep species from becoming extinct. Why?

4. What was the Great Potato Famine?

5. What is an ecosystem?

6. In what ways is our natural environment being destroyed?

7. What can you do to help preserve our wildlife?



Practice

Complete the chart below. Choose two different **Florida ecosystems** *or* **natural areas**. *Describe each system and the characteristics as listed below.*

Florida's Ecosystems			
Ecosystem	**Description**	**Plant Life**	**Animal Life**

Practice

Use the list below to write the correct name of the **Florida ecosystem** *where you might be most likely to find each* **animal** *or* **plant**. *Write the name on the line provided. If the animal is now extinct, write "***extinct***" on the line.*

coastal areas	**pine flatwoods**
extinct	**scrub**
hardwood forests and hammocks	**swamps and marshes**
mangrove swamps	

__________________________ 1. ivory-billed woodpecker

__________________________ 2. fox squirrel

__________________________ 3. Florida panther

__________________________ 4. turkey and white-tailed deer

__________________________ 5. pallid beach mouse

__________________________ 6. black bear

__________________________ 7. passenger pigeon

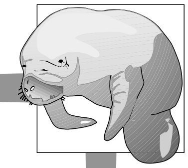
__________________________ 8. young crab and shrimp

__________________________ 9. scrub lizard, gopher tortoise, and scrub jay

__________________________ 10. scallops, shrimp, oysters, sand dollars, starfish, and horseshoe crabs

__________________________ 11. bear, bobcats, and pileated woodpecker

__________________________ 12. Florida red wolf



Lab Activity: Water Pollution

Facts:

- Phosphates are a major source of water pollution.
- Detergents and fertilizers are the most common sources of phosphates.
- Overabundance of phosphate—a nutrient—allows algae to overproduce and use up all the oxygen in the water. This leads to fish kills.
- This process of phosphate pollution leading to oxygen-poor water is called *eutrophication*.

Investigate:

- You will create an experimental system to investigate the effects of detergent as a pollutant.

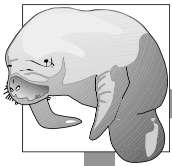
Materials:

- 3 aquariums
- pond water
- wax pencil
- paper towels
- balance
- plastic wrap
- fluorescent lamp
- *Spirogyra*, a stock culture of algae
- detergent with phosphate, 2 g
- detergent without phosphate, 2 g

1. Fill each aquarium two-thirds full of pond water. Label the aquariums #1, #2, and #3. To aquarium #1, add 2 g of detergent with phosphates. To aquarium #2, add 2 g of detergent without phosphates. To aquarium #3, add no detergent.

2. Remove the *Spirogyra* from the culture container and place it briefly on a folded paper towel to absorb the excess water. Make three 25 g samples of *Spirogyra*, and add one sample to each of the aquariums. This procedure must be done quickly to keep the *Spirogyra* from drying out.

3. Cover each aquarium with a sheet of plastic wrap and place all of them 20 cm from a fluorescent lamp.



4. Observe the aquariums twice each week and record your observations in chart form. The observations should include color of the *Spirogyra*, odor of the aquariums, position of the *Spirogyra* in the aquariums, presence of bubbles, relative number of *Spirogyra* present, and any other details you notice.

The Effects of Detergent as a Pollutant						
		Color of Spirogyra	**Odor of the Aquarium**	**Position of Spirogyra**	**Presence of Bubbles**	**Number of Spirogyra**
Aquariums	**1.**					
	2.					
	3.					

5. After three weeks, remove the *Spirogyra*, and briefly place it on a folded paper towel to absorb the excess water. Clump the *Spirogyra* found in each aquarium and find the mass of each clump in the balance.

6. Calculate the increase in mass in each aquarium by subtracting the original mass from the final mass.

7. What is the purpose of aquarium #3? ____________________________

   ____

8. What is the reason for massing each sample that is placed in the aquariums?

   ____

   ____

9. What is the purpose of the lamp? ______________________________

10. Which aquarium had the greatest increase in the mass of *Spirogyra*?

11. How did the color differ in each aquarium? ____________________

12. In what part of the aquariums did you find the *Spirogyra*?

13. Why do you think the *Spirogyra* was in that part of the aquariums?

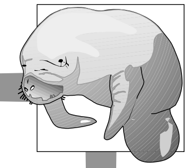
14. If the *Spirogyra* grew very quickly in a lake, pond, or river, what effect do you think it would have on the other organisms in the aquatic ecosystem?

15. In which aquarium did the *Spirogyra* show this rapid type of growth?

16. How can you account for the rapid growth?

17. What are the signs that *eutrophication* or the process of phosphate pollution leading to oxygen-poor water is occurring in an aquatic ecosystem?

18. If you were in charge of the health and well-being of this aquatic ecosystem, what action would you suggest?



Practice

Use the list below to write the correct term for each definition on the line provided.

biodiversity	**environment**	**habitats**	**peninsula**
carnivore	**extinct**	**herbivore**	**physical geology**
community	**food chain**	**native**	**subtropical**
ecology	**food web**	**omnivore**	**temperate**
ecosystems			

________________________ 1. a strip of land surrounded by water on three sides and connected to a larger land mass on the fourth

________________________ 2. an animal that eats both plants and animals

________________________ 3. an animal that eats only meat

________________________ 4. natural resident of an area

________________________ 5. a species that no longer exists

________________________ 6. all the interacting organisms of different species living in the same area

________________________ 7. places to live

________________________ 8. an animal that eats only plants

________________________ 9. moderate in respect to temperature

________________________ 10. a way of viewing the transfer of energy from one living thing to another; a chain of living things in which each organism eats the one before it and is eaten by the one after it

_________________________ 11. the biological and physical things that surround an organism and affect it

_________________________ 12. the study of the habitat in interaction with the community of organisms that live there

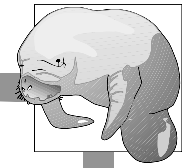
_________________________ 13. a distinct, self-supporting unit of interacting organisms and their environment

_________________________ 14. a way of viewing organisms as being in a network of interacting food chains

_________________________ 15. the variety of species of organisms

_________________________ 16. nearly tropical; pertaining to a region between tropical and temperate

_________________________ 17. the structure and composition of Earth’s crust and the forces of change affecting them



Practice

Use the list below to complete the following statements.

consumers	**draining**	**life**	**physical**
decomposers	**heat**	**native**	**reduce**
destruction	**interdependence**	**original**	**understand**

1. A food web shows the diversity of food sources and the ______________________ of organisms on one another.

2. Energy in an ecosystem flows through producers, ______________________ , and ______________________ .

3. Although changing one part of an ecosystem can have unpredictable results, the tendency is for the ecosystem to return to its ______________________ condition.

4. One thing that divides ecosystems are their ______________________ factors such as water, soil type, and climate.

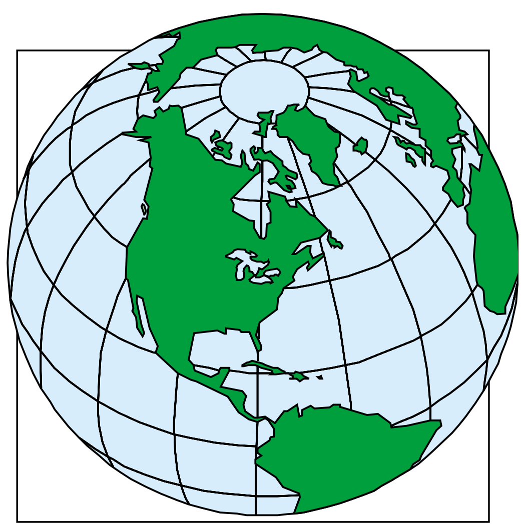
5. There is a limit to the amount of ______________________ an ecosystem can support, and humans can ______________________ this amount through their actions.

6. Examples of ways humans are endangering different ecosystems include: habitat ______________________ , the ______________________ and filling of wetlands, and clearing ______________________ plants.

7. Scientists believe that by carefully studying the universe and its systems, like ecosystems, they can ______________________ how the universe works.

8. As with physical systems and sciences, the amount of usable energy in an ecosystem is always being reduced by the loss of energy as ______________________ .

Unit 11: Science and the Environment



Vocabulary

Study the vocabulary words and definitions below.

analogous system .... a research model that studies objects which are similar in function or design

computer model .... a program that allows a computer to quickly and with detail mimic or predict the behavior of real objects or systems

greenhouse gases .... chemicals emitted into the atmosphere that add to the overall increase in Earth's temperatures

habitat fragmentation .... when roads cross a habitat; they expose animals within the habitat to death due to encounters with vehicles

pollutants....................................... substances which lower the amount of life within a system

runoff .... water that travels over the surface of the land during and after rain

scale model .... a miniaturized but proportional version of an object

technology .... the knowledge and tools we use to do difficult tasks

Introduction

In Unit 10 we discussed ecosystems. We included some of the ways man may change ecosystems. In this unit we will expand on that topic and look at ways that man's tools impact ecosystems. Specifically, we will examine how science and **technology** affect the quality of our lives, our environments, and our future.

Protecting the Environment

The environment is very delicate. Special care must be taken of the environment if it is going to continue to provide an atmosphere that will support life and all of the natural resources people need to live. Some of these resources, such as minerals, ores, and fossil fuels, cannot be replaced. They are said to be nonrenewable. Others, such as the forests, soil, air, and water, are renewable and can be used over and over again. People must learn to use resources wisely and conserve or preserve natural resources for future use without inhibiting progress.

Pollution is a change in the air, water, or land that can be harmful or unpleasant to living things and the environment. Pollution upsets the balance of nature, and if not controlled, could cause severe environmental problems.

There are several measures society can take to help preserve the balance of nature and at the same time allow for technological advancement. One way is to make people aware of the problems of pollution and the need for conservation. Society can help create laws which protect the environment. Conducting scientific research to help keep nature in balance is another way to protect the environment. Some of the projects scientists are working on to accomplish this are as follows:

- finding new food sources
- looking for ways to get usable minerals and other natural resources from the ocean
- trying to find easier and less expensive ways to turn ocean water into fresh water
- looking for new energy sources
- looking for new ways to combat the harmful effects of pollution
- exploring space to possibly find new resources, answers to problems on Earth, and perhaps a new place for people to live

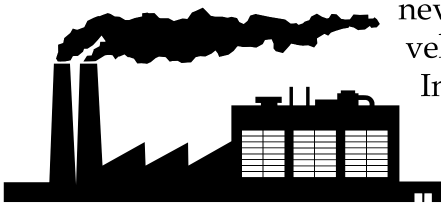
Environmental Impact of Technology

Self-propelled vehicles have been around now for over 100 years and are a form of technology that most of us know well. Even if you don't know how a car works, its technology lets you use it to get around town. One of the goals of any technology is to solve problems or make life easier. Unfortunately, technology is not perfect. While vehicles make it easier for humans to travel great distances, they also can create problems. Let's look at just three of the problems: **runoff, greenhouse gases**, and **habitat fragmentation**.

Runoff

Runoff is water that travels over the surface of the land during and after rain. It can carry **pollutants** and nutrients to waterways and disturb ecosystems.

Think about the many vehicles that are driven each day on a road. As the miles go by, the tires wear down, leaving rubber on the road. The next time it rains, that rubber, and all the spilled oil, gas, and other materials left on the highway wash downstream, causing water pollution. This problem can be traced back to a technology most of us take for granted,



never thinking of the devastating effect vehicles have on lakes, ponds, and wetlands. In response, scientists have been conducting research and looking for other energy sources. One of these is the electric vehicle.

One benefit of research is that you never know what you will learn. While we seek a solution to the problem of runoff and alternative energy sources, we may find solutions to other problems. Any effort to solve a problem advances science; that is, research increases our knowledge and understanding of the universe. In the case of runoff, there is much research being conducted. Because it is not possible or plausible to test all roads and conditions, scientists make some compromises. When a hypothesis is prepared and ready for testing, they may make use of a variety of models. Some models are like the **scale models** many people build as hobbies. They show a miniaturized version of objects and factors.

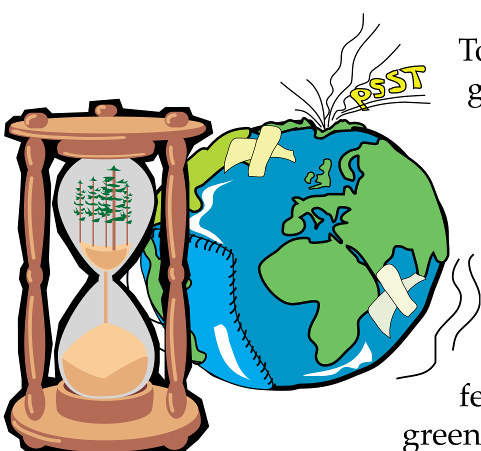
Some models may be **computer models**. These are programs that allow a computer to quickly and with detail mimic or predict the behavior of real objects or systems. For instance, we know that adding phosphate to water will increase the amount of algae. To predict how a large lake will be affected, we do not want to add the phosphate, motor oil, or other pollutants. Instead, we might create a computer program that would use known information to predict what could happen to the lake. This would be a far safer and faster way to examine the effects of runoff.

In researching runoff, we might look at another model, an **analogous system**. A small ditch in your yard is not the Apalachicola River. Still, there are similarities. Objects which are similar in function or design are analogs. We could determine how runoff effects the organisms that live in your ditch. From this, we might be able to reach conclusions about a stream, brook, or river. Runoff poses a threat to many Florida waters, so research is being conducted to determine ways to solve and prevent this problem.

Greenhouse Effect

The greenhouse effect is a condition of increased heat resulting from the reflection of the sun's heat back to Earth from the atmosphere. Higher levels of carbon dioxide in the atmosphere cause an increase in the ability of the atmosphere to trap heat. This trapped heat may cause an overall increase in Earth's temperatures. Chemicals called greenhouse gases are emitted into the atmosphere and add to the greenhouse effect. These gases are the result of burning fossil fuels in vehicles and using these fuels in homes and factories. Fossil fuels are created when living things die and form layers within the earth. Some of these organic materials do not fully decompose and so they maintain a high level of energy. Eventually, given great time and pressure, these energy-rich organic materials may turn into coal or oil deposits which are then burned by humans. This produces much-needed heat, but at the same time creates a variety of greenhouse gases such as carbon dioxide. These greenhouse gases coupled with the destruction of the world's rain forests have created a slow but steady increase in atmospheric carbon dioxide levels. This increase may have an adverse effect on life on Earth.

Burning fossil fuels releases carbon dioxide into the atmosphere. In order to remove these dangerous levels of carbon dioxide from the air, we rely on green plants to use carbon dioxide in photosynthesis. This process produces food for the plants and other organisms and at the same time releases oxygen. Without plants, our lives would not be possible. One effect of building roads and making the world accessible to vehicles, though, is a reduction in the amount of plant life. As the amount of plant life decreases and the quantity of greenhouse gases increases, Earth's climate may change. The result may be the loss of species or whole ecosystems.



To help solve the problem of greenhouse gases, scientists and engineers have recently made changes in vehicles by installing pollution-control devices. These changes have contributed to a reduction in the amount of greenhouse gases produced. The improvements may continue to come; however, they will be controlled by a few factors. If a vehicle produced no greenhouse gases but cost one million dollars, would many people buy it? This solution would not be practical. At the same time, it may not be practical to ask everyone to start walking. Some people would be unable and others unwilling.

The value one person places on something may be different from the value another person places on it. Think about the importance of plant life to different people. Persons who rely on herbal medicines may want to save the rain forests and improve their health and quality of life. Others may want cheap lumber and beef grown on land that used to be forest. The same is true for technology. One person may rely on a cellular phone or pager and see no way to do without them. Someone else though, when faced with the destruction of plants, trees, or an entire ecosystem to install a transmitter tower, may see that technology as unnecessary.

Every individual can do his or her part to help reduce the effect of greenhouse gases. Actions such as car pooling, using public transportation, riding bicycles, making sure that vehicles are in good working order, and planting trees and greenery can help solve this problem.

Habitat Fragmentation

Florida panther

Habit fragmentation occurs when roads cross a habitat and expose animals within the habitat to fatal encounters with vehicles. Imagine a young Florida panther on a dark road who knows nothing of automobiles, trucks, or headlights. The panther is only concerned with getting across the road. Often, the panther would attempt to cross and would die. The resulting loss of life was caused by a culprit called habitat fragmentation.

Habitat fragmentation creates isolated pockets of creatures and most likely contributes to the threatened and endangered status of the Florida panther. The public has become concerned with the dwindling number of panthers in the wild. State and federal governments, private foundations, and industries all offer money for research to determine what can be done to save the panther. Scientists have begun to research the panther and its habitat and have discovered that panthers need large, unbroken habitats. A male panther will also need his home range to cross that of several females.

Scientists, however, cannot take away the roads. Instead, scientists have offered an experiment. A series of low, hidden tunnels have been built under roads. The tunnels are monitored for signs of use. The tunnels have reduced the number of panthers killed and have also provided crossings for other animals as well. In this case, a technological answer to a technological problem does seem to be producing some benefits. In order to learn this and other information about panthers, scientists perform research. Scientists have some information to offer and their insights point the way to the solution. The case is similar whenever scientists are asked to offer solutions or explanations of matters of public concern.

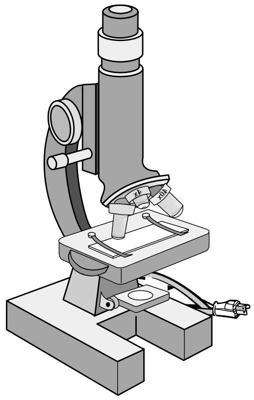
Summary

There is an interconnectedness of Earth's systems and the quality of life. To improve their quality of life, many use technology. This technology allows humans to do many things but may adversely affect their environments. Such problems may create an opportunity for new technology, but the value of this technology differs for different people. No technology is successful if it is not practical for humans and does not meet their needs or values.

In testing technologies and other scientific situations, scientists use a variety of models. These include scale models, computers models, and analogous systems. The research conducted allows scientists to address areas of public research and offer knowledge and insight. Money for such research comes from a variety of sources including state and federal governments as well as private industry and foundations. This money can control the areas of research.

Florida is threatened by a variety of technological problems. These include runoff into lakes and wetlands, the greenhouse effect, and habitat fragmentation. One culprit in these threats is vehicles. Vehicles contribute to the production of greenhouse gases through the burning of fossil fuels. Scientists are currently seeking the technological solutions to these technological problems. Protecting our environment, while at the same time allowing for technological progress, is an extremely important and difficult task. Controlling the pollution of air, land, and water is one way to help solve this problem.

Careers in Biology



Environmental Engineer

Environmental engineers apply knowledge of ecology and engineering to promote a safe environment for humans and other organisms. The work done by individual engineers varies widely. Some work in laboratories or offices while others inspect building sites and structures. Environmental engineers usually seek to prevent humans from damaging environmental systems or find ways to minimize such damage. Many engineers work on protecting clean drinking water. A bachelor's degree is the minimum college work needed and most environmental engineers have higher degrees.

Practice

Answer the following using complete sentences.

1. Give an example of a situation or problem that would be difficult to test without a model and describe the model you would use.

2. Describe a situation from the news or recent history where scientists were called upon to provide explanations of events and offer possible solutions to problems.

3. Choose an industry or business. Decide what areas of scientific study they should support and state why you think so.

4. Describe one way in which the quality of human life is based on the quality of a natural ecosystem.

5. Give an example of a technology or problem that has recently become widespread. Discuss the impact of this technology or problem and contrast that to the way you think others may view the technology or problem.

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

Florida panther	**rain**	**temperature**
fossils	**runoff**	**tunnels**
pollutants	**technology**	**vehicles**
radios	**telephones**	**wetlands**

1. ____________________ is the knowledge and tools we use to do difficult tasks.

2. ____________________ , ____________________ , and ____________________ are all examples of technology we use daily.

3. ____________________ is water that travels over the surface of the land during and after rain. It can carry ____________________ and nutrients to waterways and disturb ecosystems.

4. When vehicles roll down the roads, the rubber that wears off the tires may run downhill during the next ____________________ .

5. Oil, gas, and other pollutants may pose a threat to Florida's lakes and ____________________ .

6. Greenhouse gases are chemicals emitted into the atmosphere that add to the overall increase in Earth's ____________________ .

7. Greenhouse gases are produced by burning ____________________ fuels, which are the remains of living organisms.

8. When roads cross a habitat, they expose animals within the habitat to increased rates of death due to encounters with ________________________ .

9. It is believed that the creation of isolated pockets of animals has likely contributed to the endangerment of the ________________________ .

10. By creating ________________________ under roads, the number of panthers struck and killed seems to have been reduced.

Lab Activity: Carbon Dioxide in the Atmosphere

Facts:

- Oxygen is used by many organisms to release energy from food.
- Carbon dioxide is a product of combustion as well as the metabolism of food.
- Without oxygen, many organisms cannot survive.
- Flames will not burn without the presence of oxygen.

Investigate:

- You will use a burning candle to model a living system and show how its production of carbon dioxide can be used to extinguish the flame.

Materials:

- 1 candle
- 2 beakers or jars to cover the candle, 1 smaller and 1 larger
- matches or lighter
- a stopwatch

1. Place the candle in the center of your workspace. Light the candle and allow it to burn until the flame is steady. Did you see any smoke or other material given off by the flame?

   ____

2. Set the stopwatch to zero. Set the smaller beaker down over the flame. Record the time before the flame extinguishes. What happened to the flame before it went out?

   ____

3. Remove the smaller beaker. Light the candle and allow it to burn until the flame is steady. Set the larger beaker down over the flame. Record the time before the flame extinguishes.

   ____

4. What accounts for the difference (if any) in the times between the larger and smaller beakers?

____

5. What gas was produced by the candle that caused it to go out?

____

6. What gas was used by the candle before it went out? ____________

7. What does the candle represent in this experiment? ____________

8. What type of model is the candle? ________________________

   Why? ____

9. If it were possible to put living plants within the beakers that used the carbon dioxide for photosynthesis, what might happen to the flame?

____

10. Describe a real-life situation that is similar to that described in question #3.

____

____

____

11. What implication does this experiment have for the burning of fossil fuels?

____

____

____

____

Practice

Use the list below to write the correct term for each definition on the line provided.

analagous system	**habitat fragmentation**	**scale model**
computer model	**pollutants**	**technology**
greenhouse gases	**runoff**	

______________________ 1. chemicals emitted into the atmosphere that add to the overall increase in Earth's temperatures

______________________ 2. when roads cross a habitat; they expose animals within the habitat to death due to encounters with vehicles

______________________ 3. substances which lower the amount of life within a system

______________________ 4. the knowledge and tools we use to do difficult tasks

______________________ 5. a research model that studies objects which are similar in function or design

______________________ 6. water that travels over the surface of the land during and after rain

______________________ 7. a miniaturized but proportional version of an object

______________________ 8. a program that allows a computer to quickly and with detail mimic or predict the behavior of real objects or systems

Appendices

Metric Equivalents

Measurements			
	EQUIVALENTS	ABBREVIATIONS AND SYMBOLS	
LENGTH	**meter**		
	1 meter = 10 decimeters	meter = m	
	1 meter = 100 centimeters	decimeter = dm	
	1 meter = 1000 millimeters	centimeter = cm	
	1000 meter = 1 kilometer	millimeter = mm	
		kilometer = km	
VOLUME AND CAPACITY	**liter**		
	1 liter = 10 deciliters	liter = L	
	1 liter = 100 centiliters	deciliter = dL	
	1 liter = 1000 milliliters	centiliter = cL	
	1000 liter = 1 kiloliter	milliliter = mL	
	1 cubic centimeter = 1 milliliter	kiloliter = kL	
	1000 cubic centimeters = 1 liter	cubic centimeter = cc	
WEIGHT	**gram**		
	1 gram = 10 decigrams	gram = g	
	1 gram = 100 centigrams	decigram = dg	
	1 gram = 1000 milligrams	centigram = cg	
	1000 gram = 1 kilogram	milligram = mg	
		kilogram = kg	
TEMPERATURE	**degree**		
		F	**C**
	boiling point of water	212°	100°
	normal body temperature	98.6°	37°
	freezing point of water	32°	0°
	degree = °		
	Celsius = C		
	Fahrenheit = F		

Metric Conversions

÷ 1000	÷ 100	÷ 10	← →	x 10	x 100	x 1000
1 kiloliter **(kL)**	1 hectoliter **(hL)**	1 dekaliter **(daL)**	**1 liter L**	1 deciliter **(dL)**	1 centiliter **(cL)**	1 milliliter **(mL)**
1 kilometer **(km)**	1 hectometer **(hm)**	1 dekameter **(dam)**	**1 meter M**	1 decimeter **(dm)**	1 centimeter **(cm)**	1 millimeter **(mm)**
1 kilogram **(kg)**	1 hectogram **(hg)**	1 dekagram **(dag)**	**1 gram G**	1 decigram **(dg)**	1 centigram **(cg)**	1 milligram **(mg)**

Index

R

S

T

U

V

W

References

Alexander, Peter, et al. *Biology*. Morristown, NJ: Silver, Burdett, and Ginn, 1986.

Biggs, Alton, et al. *Biology: The Dynamics of Life*. Westerville, OH: Glencoe Division of Macmillan/McGraw-Hill, 1998.

Bledsoe, Lucy Jane. *Biology*. Paramus, NJ: Globe Fearon Educational Publisher, 1994.

Bledsoe, Lucy Jane. *General Science*. Paramus, NJ: Globe Fearon Educational Publisher, 1994.

Clewell, André F. *Common Florida Natural Areas*. Winter Park, FL: Florida Conservation Foundation, 1989.

Florida Department of Education. *Florida Course Descriptions.* Tallahassee, FL: State of Florida, 1998.

Florida Department of Education. *Florida Curriculum Framework: Science.* Tallahassee, FL: State of Florida, 1996.

Goodman, Harvey D., et al. *Biology.* Orlando, FL: Harcourt Brace Jovanovich, 1986.

Goodman, Harvey D., et al. *Laboratory Investigations Biology.* Orlando, FL: Harcourt Brace Jovanovich, 1986.

Johnson, George B. and Peter H. Raven. *Biology: Principles and Explorations*. NY: Holt, Rinehart, and Winston, 1998.

Kaskel, Albert, Paul J. Hummer, Jr., and Lucy Daniel. *Biology: An Everyday Experience*. Teacher Resource Book. Columbus, OH: Merrill, 1988.

LaRue, Charles. *Basic Biology: The Science of Living Things*. Circle Pines MN: American Guidance Service, 1986.

Petras, Kathryn, et al. *Jobs '98*. New York: Fireside, 1997.

Richardson, Bradley G. *JobSmarts: 50 Top Careers*. New York: Harper Collins, 1997.

Schraer, William D. and Herbert J. Stoltze. *Biology: The Study of Life*. Needham, MA: Prentice-Hall, 1993.

Starr, Cecile. *Biology: Concepts and Applications*. Albany, NY: Wadsworth Publishing Company, 1997.

Stevenson, L. Harold and Bruce Wyman, eds. *The Facts on File Dictionary of Environmental Science*. New York: Facts on File, 1991.

Tebo, Mary. *Fundamentals of Biology*. Tallahassee, FL: Florida Department of Education, 1993.

Towle, Albert. *Modern Biology.* Orlando, FL: Holt, Rinehart, and Winston, 1993.

White, Jo Ann, ed. *The New American Desk Encyclopedia*. New York: Penguin Putnam, 1997.

Production Software

Adobe PageMaker 6.5. Mountain View, CA: Adobe Systems.

Adobe Photoshop 3.0. Mountain View, CA: Adobe Systems.

Macromedia Freehand 8.0. San Francisco: Macromedia.

Microsoft Word 5.0. Redmond, WA: Microsoft.