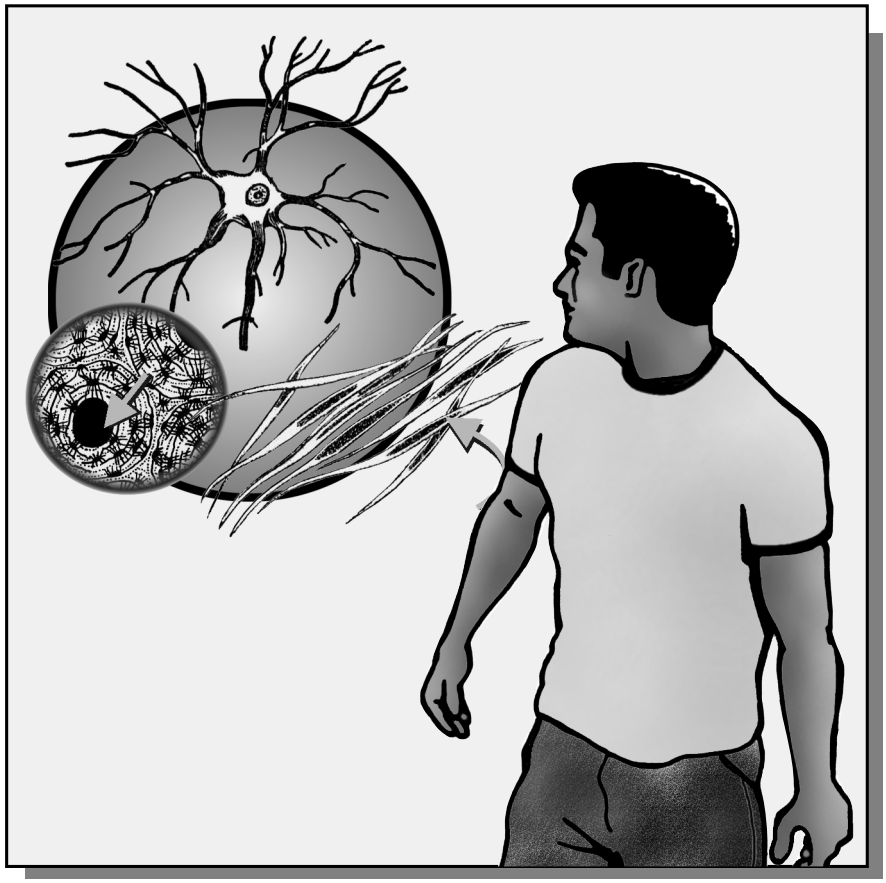
Natural Science Mysteries



Chapter 4

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Chapter 4

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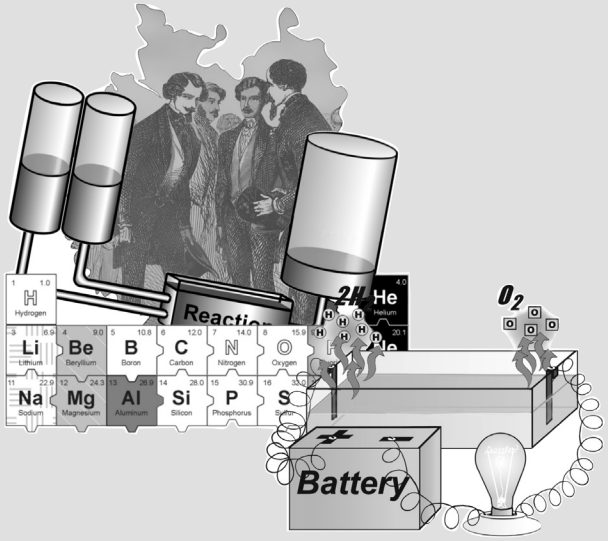
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"By knowledge, understanding and wisdom the true mysteries of life unfold as they are studied line by line and precept upon precept." —Ronald E. Johnson, C.Ph.D.



Lesson 1
Biology

Chapter 4

Structure and Function of Plant and Animal Cells

Section 1

Lessons 1-5

CELLS



Bryan and Tom were spending their summer vacation working on Danger Island, a nature preserve. By Friday afternoon, the boys had finished their assigned duties for that week. They had worked extra hours to earn the next Monday off, giving them a long weekend. The boys planned to spend the time in Cadey, a small resort town on the mainland.

Tom said, "I would like to leave this green world behind for three days and see some brick and asphalt! We'll have a great time with not a single mystery in sight!"

Bryan continued to be puzzled by what they had experienced on the island. He said, "When we first hiked to the twisted tree, we saw a village on Shell Island. The next time we were there, the village had disappeared! How can an entire village disappear? What important discovery did Mr. Murphy make before he disappeared 25 years ago?"

"I want to go to Cadey, too!" Del interrupted. "The main street has been closed for a fair. I can go over by myself, only if my mother meets me when the ferry lands. She works tomorrow, so I'll have to stay here unless you guys take me."

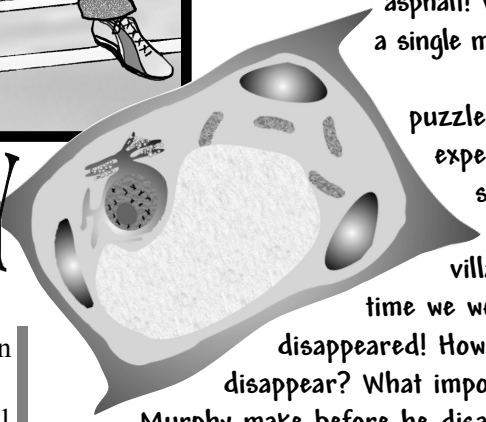
Tom asked, "You want us to let you tag along?"

"Yes!" Del petitioned. "Please!"

Tom looked right in her face and said "Look Del, we really didn't plan on taking care of a girl while we were in town."

Del pleaded, "Next week you'll wish I was with you! Your work schedule calls for planting seedlings on the bald hill where the fire destroyed the natural stand of timber. You'll have to carry in 500 seedlings and camp out the four days you work next week!"

"How could you help with that?" Tom asked.



VOCABULARY

Chloroplasts: green colored structures in plant cells that contain chlorophyll

Chlorophyll: a complex chemical that enables plant cells to combine minerals, water and sunlight to make food

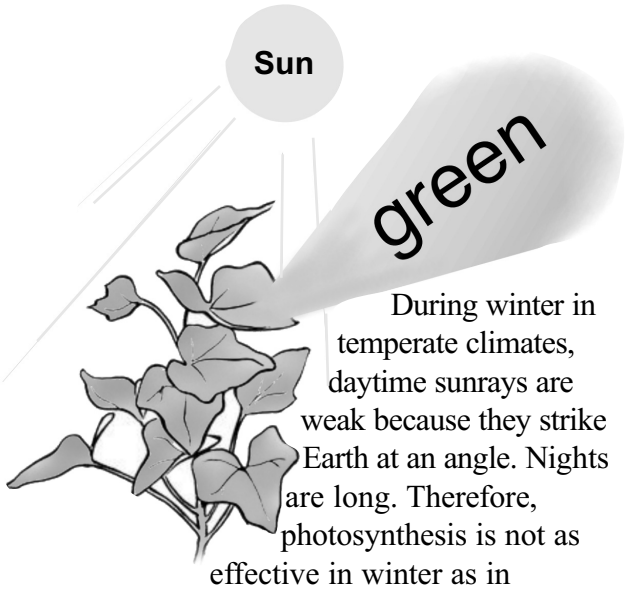
Photosynthesis: the production of food by green plants through the use of light, usually sunlight, as a source of energy; water and carbon dioxide are combined to produce simple sugars

Cells: basic structural units of all organisms; composed of nuclei and cytoplasmic materials enclosed by cell membrane or cell wall

When Tom spoke about the green world, he referred to the grass, leaves and other green vegetation on Danger Island. Plants look green because they contain structures known as ***chloroplasts***. Chloroplasts are found only in plants. Chloroplasts contain ***chlorophyll***. Chlorophyll absorbs most of the colors of sunlight except for green. Because chlorophyll reflects green, plants and the leaves of trees have a green color.

VOCABULARY

Monastery: a type of church building with dormitory space where priests live and study
Cell walls: give plant cells their structure and are made of cellulose
Micrometers: millionths of a meter; also called *microns*
Protoplasm: the chemical substance that makes up living tissue; the living material of a cell
Translucent: transmitting light but diffusing it so that objects beyond are not clearly visible
Cell membrane: the outer covering of a cell that controls the passage of chemicals into and out of the cell
Hormones: chemical messengers that regulate development in plant or animal cells
Semipermeable: allowing some compounds to pass but acting as a barrier to others
Cytoplasm: all of the protoplasm of a cell except for the nucleus
Vacuoles: storage areas of cells that contain water, food or wastes
Ribosomes: small structures in the cytoplasm of cells that produce protein
Mitochondria: a structure in the cytoplasm of a cell that converts food into useable energy
Nucleus: the command center of a cell that controls the production of energy, growth and reproduction; the nucleus is enclosed in a membrane
Deoxyribonucleic acid (DNA): a compound in the nucleus that carries information about the growth and reproduction of a cell; capable of making copies of itself and producing ribonucleic acid
Ribonucleic acid (RNA): a chemical produced by DNA that can pass through the membrane of the nucleus and carries the pattern for the production of protein in the cell



During winter in temperate climates, daytime sunrays are weak because they strike Earth at an angle. Nights are long. Therefore, photosynthesis is not as effective in winter as in summer. As winter approaches, trees shut down photosynthesis. Leaves loose their green color to reveal their natural browns and reds. The leaves no longer receive food from the tree during this time and fall to the ground.

Chlorophyll is a large, complex molecule. It is made mostly of carbon, hydrogen, oxygen and nitrogen. However, at its center is an atom of magnesium (Mg). The chemical formula for chlorophyll is $C_{55}H_{72}MgN_4O_5$. It has 55 carbon atoms, 72 hydrogen atoms, four nitrogen atoms, five oxygen atoms and a single magnesium atom. Atoms which compose chlorophyll and most other compounds which make up living things are more complex than atoms found in non-living matter.

Chlorophyll has a long hydrocarbon chain that extends into the chloroplast. When the chlorophyll absorbs sunlight, the electrons gain energy; and this begins a series of chemical reactions that result in the production of the

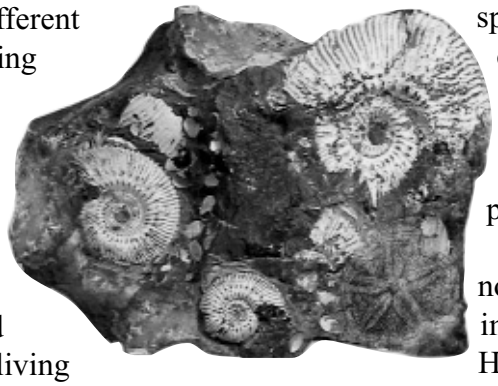
sugar, glucose. Glucose ($C_6H_{12}O_6$) provides the energy for cells to carry out their functions. ***Photosynthesis*** is the process of using light, usually sunlight, to combine carbon dioxide with water to produce glucose.

About two hundred years ago, chemists realized that all matter was made of atoms. All chemical compounds in the air, water or soil are made of a limited number of different types of atoms. Elements in the non-living portion of the environment were also found in living organisms. Carbon, oxygen, nitrogen and hydrogen are the chief ingredients that make up (compose) living tissue.

The understanding that atoms are the building blocks of matter helped chemists in their understanding of non-living compounds. A similar discovery showed that ***cells*** are the building blocks of living organisms. This discovery helped chemists and biologists understand living plants and animals.

Robert Hooke, an English scientist, gave the name to cells in 1665. He wrote a book about his discoveries with the use of a microscope. The book contained some of the best drawings of microscopic subjects ever made. He noticed that thin slices of cork seemed to be made of tiny chambers. He named the chambers after the rooms in a ***monastery***. The small rooms were called *cells*. The cells that Hooke saw in cork were open spaces. They were the ***cell walls*** left behind after the plant cells died.

The people of England marveled at the beautiful, complex designs found in the tiniest of creatures. Robert Hooke was a religious man who credited God as the creator of these tiny living organisms. Hooke made the first study of fossils. A fossil is the remains or imprint of past life. During the late 1600s, many biologists believed a natural force gave rise to stones that looked like living organisms. Robert Hooke was the first scientist to examine fossils with a microscope. In his study of petrified wood, Hooke saw cells similar to the ones he saw in cork. He also found fossils that were not like any living form of life. Hooke reasoned that the fossils must have once lived, then died. He said, "There have been many other species of creatures in former ages, of which we can find none at present."



Biologists did not understand the importance of Hooke's discovery of cells until the 1800s. Then biologists realized that a cell is the basic unit of life. It is the smallest structure capable of performing life functions independently. Life functions of each cell include responding to external conditions, taking energy from nutrients, removing waste, growing and reproducing. All living things (plants, animals and microorganisms) are made of cells that work together to perform life functions.

Modern technology reveals that the human body consist of about 10 million of these tiny building blocks. Each cell in turn contains about 100,000 times as many molecules as there are stars in the Milky Way, (which has at least 100,000 stars) — truly mind boggling complexity. Cells vary in size but average about 40 ***micrometers*** in length. If the cells of one person were laid end to end, they would reach 100 times around the earth at the equator.

The living material of a cell is ***protoplasm***. Protoplasm is a semifluid, ***translucent*** substance. It is very complex and is made of proteins, fats and other molecules suspended in water. All life on earth, whether

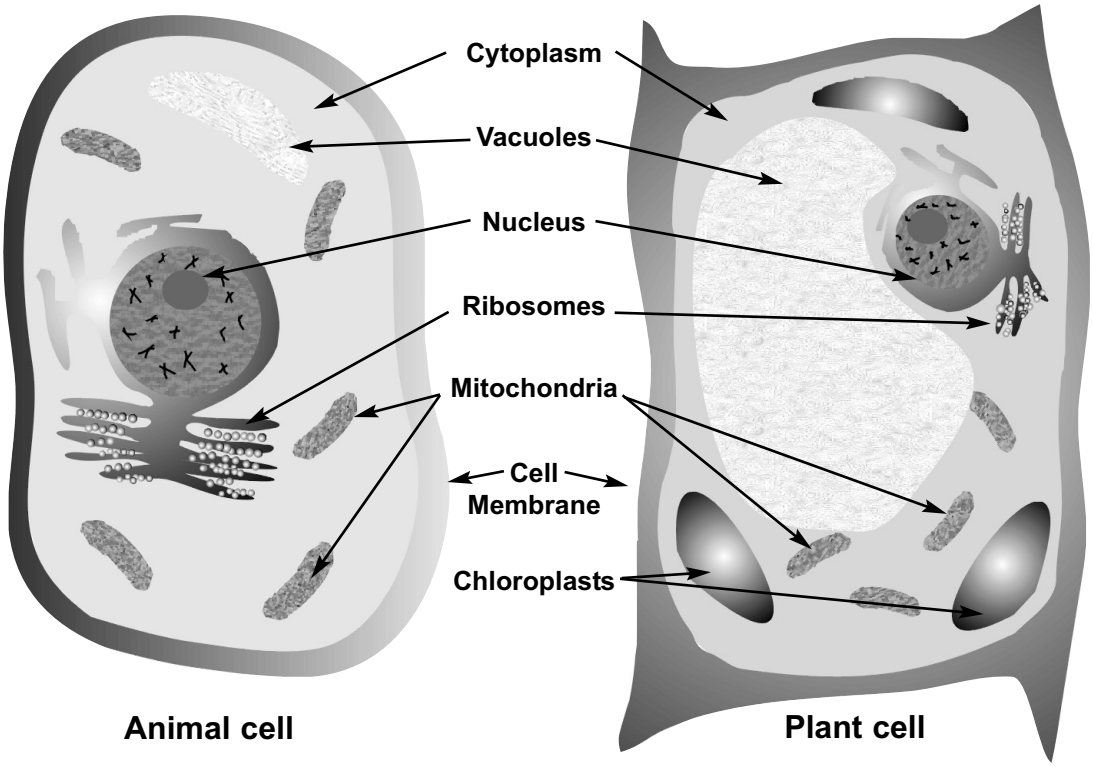
plant or animal or one-celled microorganisms, is made of protoplasm.

A ***cell membrane*** is the outer covering of the cell. The membrane controls what enters and leaves the cell. A cell needs nutrients and water from the outside. In addition, if the cell is part of a specialized tissue, then it must react to messages from other organs in the body. Chemicals known as ***hormones*** carry the messages. A hormone is a protein that is produced by one group of cells to tell another group of cells what to do. The hormone enters the bloodstream and is carried throughout the body. After passing through the cell membrane, the hormone stimulates the cell into taking a particular action. The proteins that are hormones must be able to get into the cell.

At the same time, the cell membrane must protect the cell from outside invaders. Unwanted chemicals and dangerous invaders such as viruses that can destroy the cell are kept out by the membrane. Other compounds such as waste products must leave the cell. The cell membrane is ***semipermeable***, therefore it can control what enters and leaves the cell.

The ***cytoplasm*** is inside the cell membrane. Cytoplasm is protoplasm that makes up the part of the cell that does not include the nucleus. A microscope reveals that the cytoplasm is not uniform. It has structures inside it.

Vacuoles are small pockets in cytoplasm that act as storage areas. They hold water, food or waste. Vacuoles are found in both plant and animal cells. In plant cells a central vacuole can be huge and take up most of the space in the cell. In animal cells, however, they are small. A cell may have more than one vacuole.



Ribosomes are small bodies that produce proteins. Proteins are important chemicals in the body. They make enzymes that help chemical reactions go faster, such as digestion of food. A special type of enzyme (also known as hormones) are the chemical

messengers of the body. Proteins are also the antibodies that fight bacteria that invade the body and cause disease. Proteins, enzymes and hormones are made by ribosomes.

Mitochondria are the powerhouses of the cell. Mitochondria combine oxygen with nutrients to produce energy for use by the cell. Without the mitochondria, we would not be able to move a muscle or think a thought.

Also present in the cytoplasm are structures for a variety of other tasks including giving the cell an internal structure and transporting substances between parts of the cell.

The ***nucleus*** is the control center of the cell. The nucleus is separated from the rest of the cell by a membrane. The nucleus contains ***deoxyribonucleic acid*** (***DNA***.) DNA is the master chemical of the cell. It carries all the information about the cell so that an exact copy of the cell is made whenever it divides and reproduces. DNA also carries information about the production of protein in the cell.

However, DNA cannot act alone. To send messages to other parts of the cell, DNA produces ***ribonucleic acid*** (***RNA***). Ribonucleic acid is a long and complex molecule that acts as a messenger between the nucleus and structures in the cytoplasm. DNA makes RNA as a chemical pattern to be followed in the manufacture of proteins or other chemicals. The RNA passes through the nucleus membrane. The pattern it carries instructs the cell how to construct other compounds.

A few types of algae and bacteria have a cell membrane and cytoplasm, but they have no nucleus. They have DNA but it is not in a separate nucleus.

Plant and animal cells are alike in that they are each made of a cell membrane, cytoplasm and a nucleus. Plant and animal cells have vacuoles, ribosomes and mitochondria. However, some features such as chloroplasts and cellulose are found in plants alone. As you can see, living organisms are intricately and wonderfully designed to carry out life functions in an orderly and predictable way.

Del explained how she could help with the tree planting so the boys would take her to Cadey. "Suppose I loaned you my horse, Major, to pack in the seedlings —"

"No," Tom protested.

Del continued, "— and brought you a home cooked meal each day."

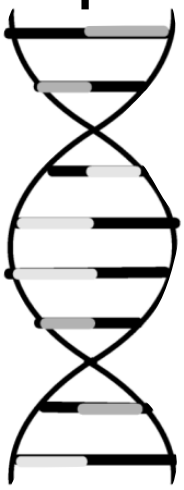
Tom hesitated.

Bryan knew that the 500 trees made a substantial load to carry halfway across the island. Major would be a help. Bryan said, "Okay, we'll do it. We'll meet you at the ferry tomorrow."

Life Principle

"Definiteness of purpose is the starting point of all achievement."

—Clement Stone



Lesson 2
Biology

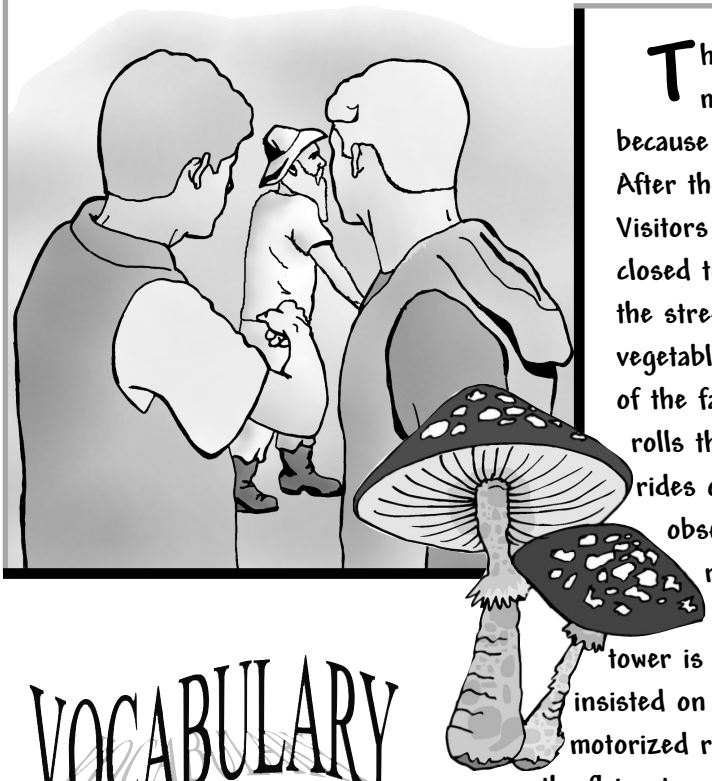
Chapter 4

Pasteur's Experiments, Components of Fungi Kingdom

Section 1

Lessons 1-5

FUNGI KINGDOM



The ferry ride to Cadey took half of the morning. Del was anxious to arrive early because she didn't want to miss any excitement. After the ferry landed, the teens hurried into town. Visitors filled the streets. Main Street had been closed to vehicles. Booths occupied both sides of the street. Local people sold crafts, food, fruits, vegetables, honey and farm-raised produce. Some of the farm women had made pastries and yeast rolls that released wonderful aromas. Carnival rides occupied the north end of the street. An observation tower stood on a hill behind the rides.

Del explained, "The observation tower is where the lighthouse used to be." Del insisted on seeing every booth and experiencing every motorized ride. The day passed quickly. While Del rode the flying teacups one more time, Bryan and Tom watched from a nearby food booth. They ordered ice cream.

"Let's get her a cone," Bryan said. "What flavor do you think she would like?"

Tom grinned, "Pick something with a really disgusting color! Try pink and purple marshmallow lime!"

Del came down from the ride and took the ice cream. She laughed and asked, "How did you know that this is my favorite flavor?"

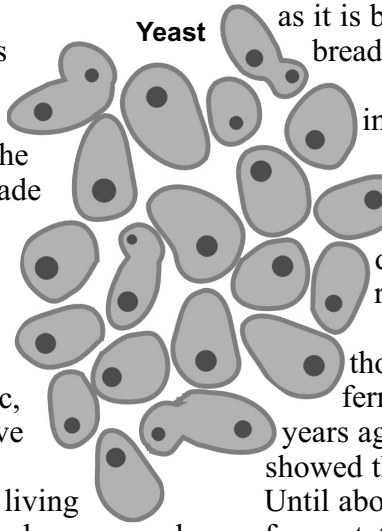
Suddenly, Bryan noticed a person walking purposely through the crowd. The man ignored the swirl of activity and seemed determined to reach a specific location. The man wore all white clothes and had a beard. Bryan whispered urgently to Tom, "That's the man we saw trespassing at the Barnett mill and home site on the island! Let's follow him!"

VOCABULARY

Pasteurization: gentle heating to kill unwanted microorganisms in food products such as milk
Yeasts: one-celled fungi that release enzymes that change sugar into alcohol and carbon dioxide
Fungi: fungi can be one-celled such as yeast, of multicellular such as mushrooms; singular of fungi is *fungus*
Asexual: non-sexual
Spontaneous generation: the theory that life can evolve from non-living matter

One of the pleasant aromas at the fair was the distinctive smell of fresh baked bread. The smell is due to the presence of yeast, tiny one celled life. Bakers provide the right conditions that allow yeast to multiply in the bread dough. Bakers want the yeast to grow and reproduce.

Some microorganisms are harmful and should not be eaten or absorbed by the human body. The ice cream the boys bought was probably made from pasteurized cream. The intent of ***pasteurization*** is to destroy harmful microorganisms that cause cream to spoil.


Yeast

Yeasts are microscopic, one-celled ***fungi***. Yeast receive their nutrition directly from chemicals produced by other living organisms. As they feed, yeast change complex chemicals into simpler substances. For instance, yeast can change the carbohydrates of bread into alcohol and carbon dioxide. Yeast causes bread to rise by releasing carbon dioxide gas. The gas produces tiny pockets in the dough. The alcohol in bread is driven off as it is baked. The alcohol gives the baking bread a pleasant aroma.

The fermentation of grape juice into wine is done by the action of yeast, too. Yeast changes sugar into alcohol and carbon dioxide. In fermentation of wine, the carbon dioxide is released and the alcohol is retained.

Yeasts were used for thousands of years to make bread and ferment wine. However, about 125 years ago, French chemist Louis Pasteur showed that yeasts were living organisms. Until about 1825, scientists believed that fermentation was solely a non-living chemical process.

Louis Pasteur observed fermentation of yeast through a microscope. He knew that living things need energy and food to reproduce. Pasteur saw that yeast grew and reproduced by budding. A small bud formed on the surface of a parent cell. The daughter cell enlarged, matured, and detached from the parent. Pasteur concluded that fermentation involved living organisms. Reproduction from a single parent, as observed by Pasteur, is called ***asexual*** reproduction, because the genetic material comes from only one parent. The daughter cell of yeast is identical to the parent cell.

Louis Pasteur proved the role of microorganisms in causing butter to spoil, milk to go sour and wine to go bad. Pasteur developed the process of gentle heating to control the growth of undesirable organisms in milk,


Louis Pasteur

VOCABULARY

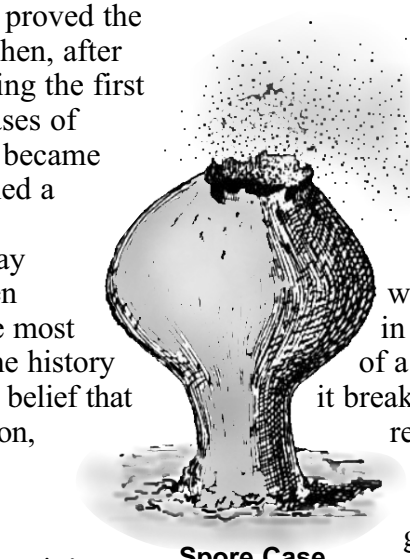
Molds: small clumps of "fuzzy" or slimy appearing types of fungi visible to the unaided eyes; grows on bread, fruit and other foods
Spores: tough, single-celled reproductive bodies released by fungi
Spore case: the structure of a fungus that ripens to produce the reproductive spores
Athlete's foot: a fungus infection of the skin, usually on feet bottoms or between the toes
Kingdom: the largest category of living things
Animal kingdom: composed of multicellular living organisms that can move about; members have sense organs and nervous systems, can respond to external conditions, but must get their food from plants or other animals
Plant kingdom: composed of multicellular living organisms that cannot move about; members do not have nervous systems; plants can make their own food from nonliving minerals by the process of photosynthesis

cheese and other food products. This process became known as *pasteurization*.

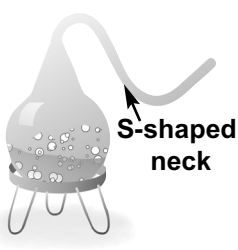
Pasteur also showed that tiny life is the cause of some diseases in animals and humans. Until Pasteur's discoveries, scientists ignored or scoffed at the idea that microscopic life could cause disease. Many doctors ridiculed Pasteur's germ theories and called him a 'quack' because he had no medical degree. But, against much opposition from his scientist peers, Louis Pasteur proved the Germ Theory of Disease. Then, after developing and demonstrating the first vaccines for the killer diseases of anthrax and rabies, Pasteur became world famous, yet maintained a humble bearing.

Louis Pasteur is today considered one of the top ten scientists of all time and the most important single figure in the history of medicine. He held a firm belief that life began as a special creation, and he began each day with prayer and Bible reading.

Many scientists of Pasteur's time embraced Darwin's new Theory of Evolution. The first step of that theory was the belief that smaller life forms such as yeast could spring into existence where no life had existed previously. Because he believed that life could not arise from non-life, Pasteur became the first European scientist to reject the Theory of Evolution on scientific grounds. In one of his most dramatic experiments, Louis Pasteur proved ***spontaneous generation*** to be a myth. Pasteur put beef broth in a container with an "*S*-shaped" neck. The opening allowed air to enter but kept microorganisms from falling into the broth from the air. He boiled the beef broth to kill the microorganisms in it, then he set aside the container to see if life would develop. The beef broth stayed completely devoid of life. The flasks are still in existence at the Pasteur Institute in Paris. The broth still has nothing living in it.



Spore Case



Molds are also classified as fungi. Although small, molds are visible to the human eye. Mold often grows on bread that is moist and warm. The mold appears as small balls on tiny stalks. Molds have thread-like structures that cover the surface of the food and extend below the surface. In humid climates, mold will grow on almost any surface made of once living material such as clothes made from natural fibers like cotton, and leather goods.

Molds reproduce by ***spores***. A spore is a tough little bit of protoplasm that can withstand long periods without water or warmth. Spores grow in the knob-like ***spore case*** at the top of a mold. After the knob becomes ripe, it breaks open and releases the spores. The released spores are light and drift along on air currents. Millions are released, but only a few find the right growing conditions. However, a single spore is capable of growing into a new individual. The *airborne* spores fall on fresh fruit or bread and start growing.

Bread is temporarily protected from mold by keeping the bread in plastic wrap, by adding chemicals (or nutrients such as vitamin C or raisins) to retard the growth of fungi, and by refrigeration or freezing. Mold that grows on the surface of bread needs warmth and moisture to thrive. In the past, bread was toasted to remove the moisture. Roman soldiers toasted bread so they could carry it with them as they marched. Without moisture, bread is less likely to spoil, even without refrigeration.

Some fungi can be harmful. Once they start growing, molds and fungi can be very persistent and difficult to destroy. For instance, ***athlete's foot*** is a condition in humans caused by fungi growing under the skin. Once it is well established, destroying the fungus is difficult. Sometimes the fungus has to be treated by exposure to x-rays or

ultraviolet light. More often, special anti-fungus nutrients or medicines are taken internally or applied topically on the affected area.

Because of the special characteristics of fungi, a separate ***kingdom*** was created for them. Until about the third quarter of the 1900s, all living things were classified as belonging to one of two kingdoms. One was the ***animal kingdom***. Animals are capable of moving. They have sense organs to see and hear. However, they cannot make food energy directly from non-living minerals.

The other division was the ***plant kingdom***. Plants have no organs designed to help them move. In general, they are rooted in the soil or float around in water. Although they can respond to external stimulation such as sunlight, they do not have well-developed sense organs for seeing or hearing. They have no nervous system. Plants have cell walls of cellulose. They have chlorophyll and derive their food energy almost entirely by photosynthesis. Plants use the energy of sunlight to combine water and carbon dioxide to produce simple sugars.



Classification is the process of putting similar subjects together. Placing plants and animals into two kingdoms makes easier the work of a biologist. The division of life into plant and animal kingdoms allows the biologist to understand the broad outline of living organisms. However, biologists found exceptions to the two kingdoms of plants and animals. For an organism to be a member of the plant kingdom, it must contain chlorophyll and be ***multicellular***. To be a member of the animal kingdom, an organism must have all of the characteristics of an animal and also be multicellular.

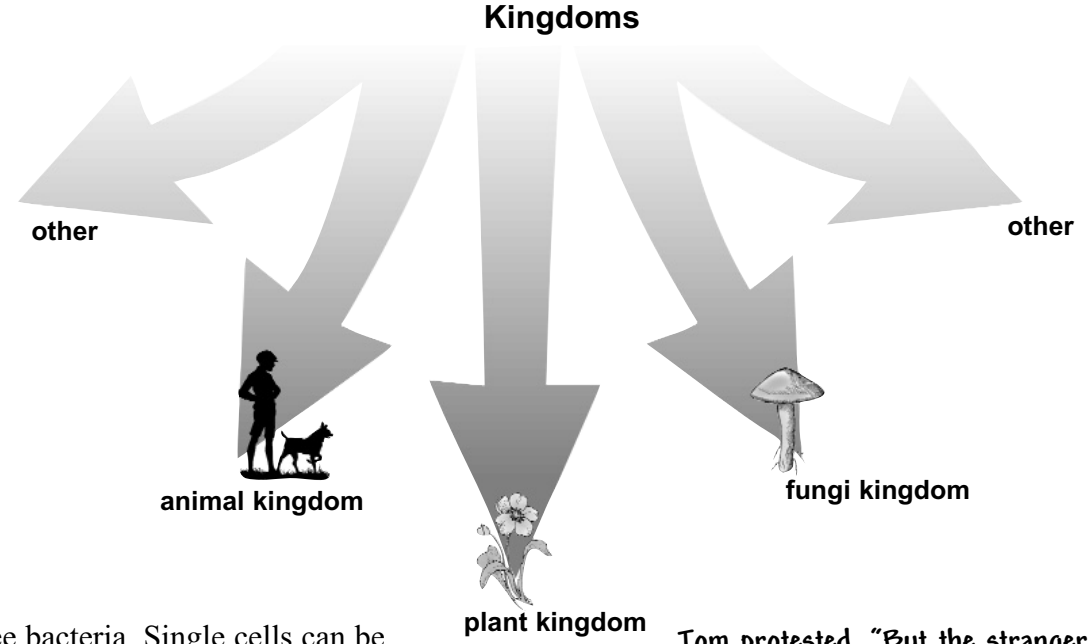
The definitions of plant and animal kingdoms left fungi without a home. Fungi include yeast that makes bread rise, and mold that grows on the surface of fruit and other foods, causing them to spoil. Fungi cells have nuclei like plants and animals; but fungi cannot be classified as plants because they have no chlorophyll. Fungi are types of ***parasites*** that get their nutrition by decomposing and absorbing organic (plant and animal) matter. Fungi cannot be put in the animal kingdom because they have no sense organs, no central nervous system, and no organs for transport.

Biologists classified fungi as a separate kingdom because fungi are neither plant nor animal. Yeasts and molds are members of the ***fungi kingdom***.

Living things are made of cells. Cells vary considerably in size. Some, like ***bacteria,*** are very tiny. Each bacterium is made of a single cell that is microscopic. You would need a microscope that magnifies 200 times

VOCABULARY

Classification: the process of grouping objects based on their similarities
Multicellular: made of many cells
Parasites: organisms that grow on or in a plant or animal of a different species; gain nutrients but contribute nothing to the host organism; result in sickness or death of host
Fungi kingdom: composed of single or multicelled organisms; neither plant nor animal; members are types of parasites that exist by decomposing organic matter
Bacteria: single celled, microscopic organisms each without a separate nucleus; singular form of bacteria is *bacterium*
Tissue: similar cells that act together for a specialized task; skin is an example of a tissue
Organs: tissues that work together for a particular propose; the stomach is an organ that is made of several different types of tissue
Systems: several related organs that work together to accomplish a broad range of related functions; examples include the digestive system, the respiratory system, and the nervous system
Unicellular: consists of a single cell



to see bacteria. Single cells can be large, too. Nerve cells are the longest. The land animal with the longest single cell is a giraffe. It has a nerve cell about three feet long in its neck.

The human body, like many plants and animals, is made of more than one cell. A multicellular organism has cells which perform specific tasks. A ***tissue*** is a group of similar cells that work together to do a particular task. Your skin is an example of tissue, as is the lining in your stomach. Tissues in turn form ***organs***. Examples of organs include the heart, lungs, arteries, stomach, intestines, eyes and brain. Organs are grouped in ***systems***. An example of one of these systems is the circulatory system that includes the heart, lungs and arteries. The digestive system includes the stomach, intestines and other organs. The nervous system includes sense organs such as the eyes and the brain.

Microorganisms such as bacteria and protozoa are each made of a single cell. They are ***unicellular***. Despite being so tiny, the single-celled life carries out an amazing range of chemical reactions. These reactions are necessary for the cell to respond to light and heat, digest food, grow and reproduce. Some single cell microorganisms can move about. A so called "simple cell" is amazing in its complexity of design and capability.

Tom protested, "But the stranger would recognize us; he saw us on the island!"

"I'll go!" Del instantly volunteered.

Tom said, "Absolutely not! We are not letting you out of our sight!"

Del looked thoughtful, "Why is the man wearing white?" she asked. Then she speculated, "Maybe he's a painter, you know — like a house painter. They always wear white."

Tom said, "I thought he was a sailor."

Bryan countered, "I don't think so. Maybe he runs an ice cream truck. One of the ice cream companies dresses its employees in white uniforms."

Impatiently, Del said, "While you guys discuss the color of his clothes, you are going to lose him! Do something!"

Life Principle

"The laws of nature work consistently and without complication."

—Lise Meitner



Lesson 3
Biology

Chapter 4

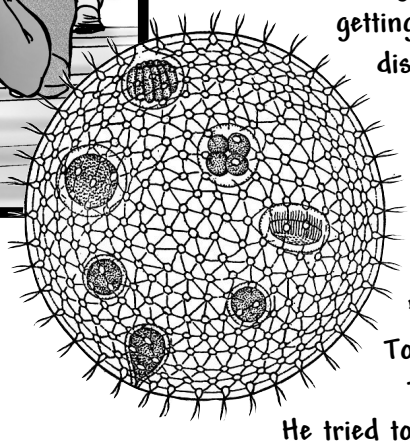
Discovery of Penicillin; Edible Fungi; Protista Kingdom

Section 1

Lessons 1-5

FUNGI AND ALGAE





As the man in white walked further away, Bryan turned and raced up the steps to the observation tower. Tom and Del followed. From the higher viewpoint, the youth again had the man in sight. He continued striding along as if he had a particular destination in mind. He quickly covered the distance despite the press of the crowd. Tom said, "He is walking straight down Main Street. He is getting too far away. He is about to disappear into the crowd!" 1

Del had moved to one of the observation tower telescopes. She called out, "I can see him clearly! Quick, put in another quarter before my time runs out!" 2

Bryan cried, "I'm out of change! Tom, do you have any quarters?" 3

Tom fed money into the machine. He tried to push Del aside. "Let me see!" 4

Del insisted, "I can't look up or I'll lose him! Now he is walking past the city park. The brick building on the other side is the Cadey Historical Museum. He's carrying a package. It's a shoebox. Quick, put in another quarter!" 5

Tom did as Del instructed. He warned, "I'm running out of change!" 6

Del reported, "He's walking across the museum grounds. Now he is at the entrance to the museum. It's not open this late. He's going around to the side door. He's knocking. Yes, someone opened it for him! He went inside. What do we do now?" 7

Bryan instructed, "Let's hurry up and get over there before he comes out! We'll find a place to watch without being seen! Why did he go to the historical museum?" 8

VOCABULARY

Catalyst: a chemical that hastens chemical reactions without being changed by the reaction

Enzymes: chemicals produced by living organisms that promote chemical reactions; organic catalysts

Penicillin: an antibiotic drug produced by the penicillium mold

Death cup: highly poisonous fungus; named because of its cup-shaped base

Toxin: a poisonous substance; most cause chemical reactions that damage cells

9 Sighting the man in white caused Bryan, Tom and Del to spring into action. Rather than strolling through the fair at their usual speed, they raced much more quickly to the observation tower. Sometimes a person is described as a ***catalyst*** because he or she causes other people to take action. In chemistry, a catalyst has a specific meaning. It is a chemical that hastens chemical reactions without being changed by the reaction. Many life processes depend on catalysts.

10 Fungi grow on dead organic matter and release ***enzymes*** to dissolve their food. Enzymes are chemical catalysts that hasten chemical reactions and break down complex compounds into simpler ones. The nutrients are then absorbed through the thin cell walls of the fungi.

VOCABULARY

Euglena: a single-celled algae that has chlorophyll and can move by means of a flagellum

Flagellum: a whip-like extension from a cell that can be waved back and forth to give the cell a means of motion

Protista kingdom: the kingdom made of algae and protozoa

Diatoms: single celled algae that have a hard outer coating of silicon dioxide

Volvox: freshwater green algae that form a hollow, spherical colony

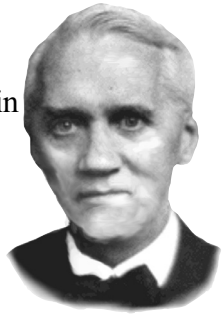
Aquatic: capable of living and growing in water

Kelp: a type of brown algae seaweed that can reach lengths of several hundred feet

Weathering: the process that changes rock into smaller particles by the action of wind, water, temperature changes and the action of living organisms such as lichens

11 Fungi such as mold attack crops and spoil food. Although not always poisonous, the mold makes the food taste bad. The action of fungi tends to soften or break down the organic matter. Mold on fruit breaks down the sugar and causes the fruit to become soft and mushy. When a tree dies, fungi help return the decomposed tree to the soil. In this way, fungi are beneficial because they help reuse the chemicals of life.

12 ***Penicillin*** is another beneficial fungus. It fights bacteria that cause infections. Alexander Fleming, a Scottish physician and medical researcher, discovered penicillin in 1929. He had left some dishes containing colonies of staphylococcus bacteria on a table by an open window. Staphylococcus bacteria cause staph infections, which can be deadly in humans.



Alexander Fleming

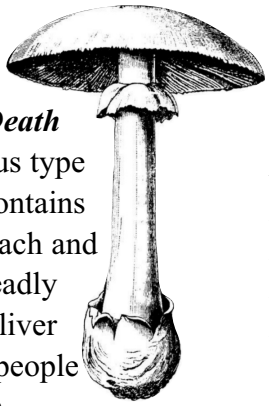
A type of bread mold known as *penicillium mold* fell into the dishes and dissolved some of the deadly bacteria. Tests showed that a chemical produced by the mold would kill germs but not damage human cells. Fleming named the chemical *penicillin*.

13 Penicillin came into widespread use during World War II. Since then, several other molds have been found to have the ability to destroy bacteria that cause diseases. The design of nature is so bountiful that many surprising secrets remain to be revealed. Biologists cannot help but be excited at prospects of finding healing agents provided in nature.

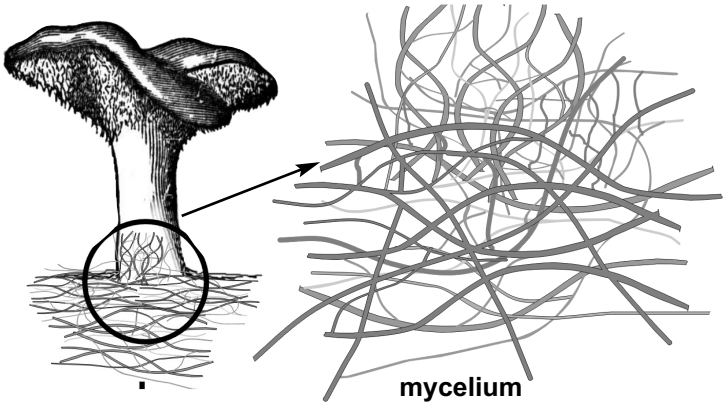
14 Humans eat some types of fungi as food. Both Roquefort and Blue cheese contain a blue-green mold that produces a sharp flavor. *Truffles* are the most highly prized form of fungi for food. They grow underground. In Europe, truffles are hunted with specially trained pigs. They sniff out the distinctive odor and uproot the fungi.

15 Mushrooms are another common type of fungi. The vast majority of mushrooms are tough, bitter or otherwise not suitable as food. Some are poisonous. ***Death cup*** is an extremely poisonous type of mushroom. The ***toxin*** it contains causes the lining of the stomach and intestines to dissolve. The deadly mushroom also destroys the liver and kidneys. About half the people who eat *death cup* die within twenty-four hours. The popular name for umbrella-shaped fungi that cannot be eaten is "toadstools." However, *toadstool* is not a scientific term. Toadstools have no special features that set them apart from edible (eatable) mushrooms.

Death Cup Mushroom



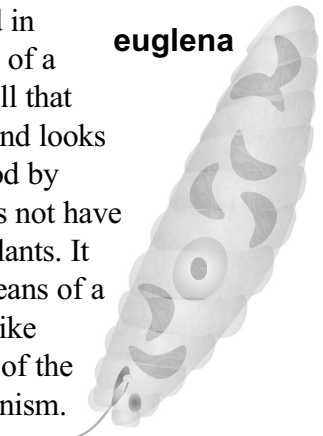
16 Unless a person knows what he or she is doing and can positively identify a mushroom, the only safe procedure is to eat mushrooms grown commercially. Commercial mushrooms are grown in caves or cellars. The temperature and humidity are controlled. The mushrooms thrive in a bed of rotted manure. To ensure that only the edible variety grows, the mushrooms are grown from the *mycelium*, a mass of thread-like structures that absorb the nutrients. Edible mushrooms are harvested and taken to market while still fresh.



17 The primary part of the mushroom that is eaten is the stalk and umbrella shaped body that holds the spores. A typical mushroom can release millions of spores. The champion at releasing spores is the *puffball* mushroom. The puffball can be three inches or more in diameter. When it matures, the surface becomes brown and powdery. Inside are trillions of spores. A single raindrop striking the spore case causes millions of the spores to pop out. A person or animal that steps on the puffball releases a great cloud of the spores that are carried away by the wind.

18 In addition to fungi, the microscope revealed other organisms that did not fit well in either the plant or animal kingdoms. ***Euglena*** is a type of alga found in fresh water. It is made of a single, microscopic cell that contains chlorophyll and looks green. It can make food by photosynthesis. It does not have a rigid cell wall like plants. It can move about by means of a ***flagellum***. The whip-like flagellum extends out of the front of the microorganism. By rapidly thrashing the flagellum back and forth, the euglena can move through the water. A flagellum is a highly complex water-cooled device that requires about 50 complex genes to create. Its mechanisms include a reversible engine, a drive shaft and a u-joint in addition to its whip-like propeller. The design of, this microscopic outboard motor enables it to scoot around at about 17,000 rpm (revolutions per minute).

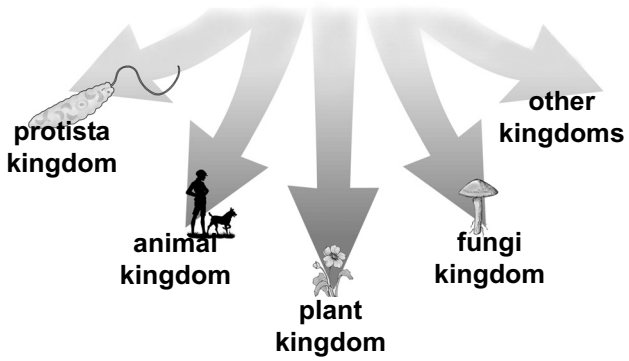
euglena



19 Euglena and other algae were originally classified as plants because they contained chlorophyll for photosynthesis. Despite being

plant-like because of the chlorophyll, algae have no roots, stems or leaves. They do not have the well-developed reproductive organs of true plants. They do not have vascular systems to transport sap. Algae are today placed in the ***protista kingdom***.

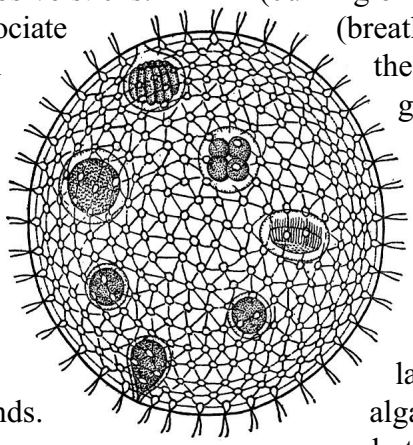
Kingdoms



20 Some algae are single cells that live independently. Examples include the euglena and ***diatoms***. Diatoms are single-celled algae whose cell walls are surrounded with a coating of silicon dioxide, a glass-like material. When the diatoms die, their microscopic hollow shells are left behind. In some places, remains of diatoms have accumulated in deep layers. The hollow diatoms serve as filtering material, as insulation, as a non-toxic insecticide and in sticks of dynamite. The diatom shells in dynamite absorb the oily nitroglycerin to give a paste that is formed into explosive sticks.

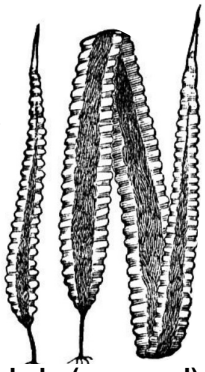
21 Some types of algae associate together to form a colony. Pond scum, for instance, is made of cells that cluster together in a colony called *spirogyra*. Despite being so small, they are so numerous they form a visible layer on ponds and stagnant streams.

22 Another example is the ***volvox*** found in fresh water ponds. It is made of hundreds of cells. Each cell is independent, but they team together as a hollow spherical colony. In the proper light, a volvox is just visible to the unaided eye. Some biologists consider the volvox to be multicellular, because not all cells that make the colony are identical. Some are specialized cells for reproduction. The daughter cells are kept inside the sphere and are released when the colony dies.


volvox

23 Algae can live floating free in the sea. Organisms such as algae that thrive floating in water are described as ***aquatic***. Many creatures that live in ponds, streams, lakes and oceans depend on algae for food.

24 The largest algae are ***kelp*** and seaweed. They are multicellular algae that can become very large. Kelp may reach a length of two hundred feet. Although all algae contain chlorophyll, not all algae are green. Some algae have pigments that give them other colors. They may be green, blue-green, brown or red. The Red Sea got its name from the high concentration of red algae.

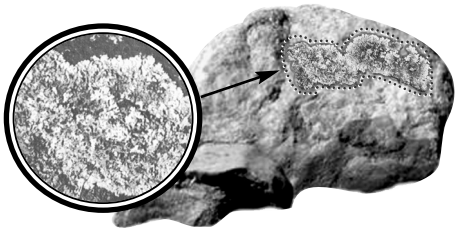

kelp (seaweed)

25 Algae have a major role in keeping oxygen in the atmosphere. Oxygen is an active chemical that quickly forms compounds by oxidation with other elements. Combustion (burning or rapid oxidation) and respiration (breathing) also remove oxygen from the air. During photosynthesis green plants and algae produce oxygen gas and restore it to the atmosphere. Worldwide, algae account for at least half (50 percent) of all oxygen production.

26 Some algae can live on land. Moss is a type of green alga that lives on rocks and trees, but has a tendency to dry out and

die in direct sunlight. For that reason, moss is found as a thin, green covering on the moist, shaded northern sides of trees and rocks. Hikers, hunters, trappers and Native Americans use moss as a direction finder. The side of a tree where moss grows best faces north.

27 Lichens are unusual organisms. They are a curious union of a type of fungus and a type of alga growing together. Lichens are seen as crust-like growths on bare rocks and release an acid that gradually dissolves the rock. Lichens are effective in the ***weathering*** process that reduces large stones to finer grains of minerals.



Tom made a path through the crowd, and Bryan and Del followed. They hurried as fast as they could. As they reached the city park, the side door of the museum opened. The man in white stepped out. Bryan and Tom ducked under cover behind the band gazebo. Del stepped out and strolled by the man. He brushed past her without taking notice. He quickly walked down the hill and turned into a side street. 28

Del told the boys, "The man looked at his watch. He appeared to be late for an appointment. I think I know him! He is Jory Barnett, the grandson of Ed Barnett who ran the mill on Danger Island." 29

Bryan observed, "He was not carrying the shoebox! He must have left it inside. We will check out the museum tomorrow afternoon when it opens." 30

Life Principle



"A positive attitude can produce a chain reaction of positive thoughts, events and outcomes."

—Anonymous

Lesson 4
Biology

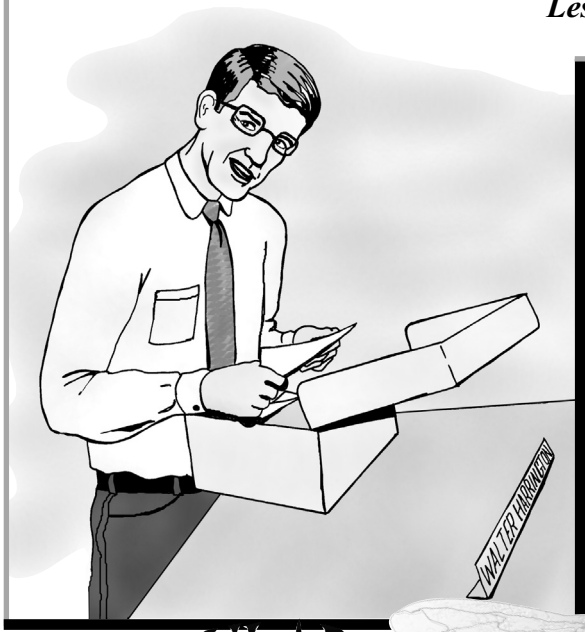
Chapter 4

Amoebas, Parameciums, and Diseases caused by Protozoa

Section 1

Lessons 1-5

PROTOZOA



On Sunday afternoon, Bryan and Tom visited the historical museum. Admission to the museum was free, although a box with a slot in the top pointedly suggested a donation. The museum was cool and quiet inside. Despite the number of people at the fair, the museum was nearly deserted.

The boys stopped at a display for hikers. The display showed some of the nearby hiking trails and gave information of interest to hikers. A sign read, "Warning: Water from fresh water streams in the back country must be properly treated before drinking. Microscopic parasites in the water can cause *giardiasis*, an illness whose symptoms include diarrhea, nausea, and abdominal cramps. Bringing water to a vigorous boil for at least one minute kills these microbes. Other methods include using ceramic filters and treatment with iodine."



The boys walked by an office. Through the partially open door, they saw a man unpacking snapshot photographs from a shoebox. The nameplate on his desk identified him as Walter Harrington, Museum Director. He was a thin man, with intense eyes behind thick glasses. He saw the boys and said, "What can I do for you?"

Bryan boldly asked, "Are those photographs from the Barnett place on Danger Island?"

"Yes," Mr. Harrington said happily. "They have practically no monetary value, but they are valuable from a historical standpoint. I'm going to sort them out and scan in copies of the

VOCABULARY

Giardiasis (je-ar-di-a-sis)***:*** an infection of the small intestine of human beings caused by a particular type of parasitic protozoa

Protozoa: organisms of the protista kingdom that have many of the features of animals except they are unicellular and mostly microscopic; singular form is *protozoan*

Cysts: small, tough capsule-like enclosures unto which protozoa retreat for defense

Amoebas: protozoa without definite form; have flexible cell membranes that move by means of pseudopodia

important ones. When I finish, I'll send the originals to Jory in Phoenix where he lives. Why do you ask?"

Bryan explained, "Strange things are happening on Danger Island. We thought Jory Barnett might have some information to help us. Where is he now?"

VOCABULARY

Pseudopodia (su-do-pod-ia)***:*** "false feet;" temporary extensions of an amoeba or other protozoan for locomotion and to engulf food particles or other microorganisms and bacteria; *pseudo* means "false", while *pod* means "feet"
Paramecium: protozoan with the shape of a shoe sole that can move about by tiny hair-like projections (cilia) from the surface of the cell membrane
Cilia: hair-like extensions from the surface of a unicellular organism that propel the cell in water
Anus: an opening through which waste products are eliminated from a body
Trichocysts: stinging, bristle-like darts along the cell membranes of protozoa that can be discharged as a means of defense, like a porcupine shoots its quills
Binary fission: asexual reproduction in which a parent cell splits into two identical daughter cells
Sleeping sickness: an infectious disease of human beings and animals in tropical Africa caused by an infection of a particular type of parasitic protozoa and transmitted by the tsetse fly; the victim experiences extreme weakness, sleepiness and eventually falls into a coma and dies
Malaria: an infectious disease of human beings, usually found in the tropics; caused by an infection of a particular type of parasitic protozoa; the victim experiences chills, fevers, and sweating; symptoms often leave to reappear at a later date
Monera Kingdom: composed primarily of bacteria; one of five major classifications of living things; members are composed of cells with no separate nuclei

The director said, "He had to leave yesterday afternoon to catch his flight home. He should be in Phoenix by now."

Bryan inquired, "What is his interest in the island?"

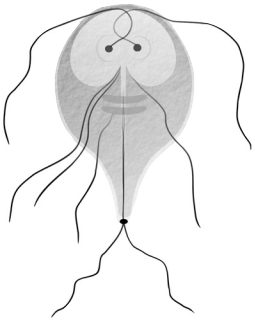
The museum director said, "He has absolutely no interest. He came back to take care of his grandfather's affairs. I had to insist that Jory go to the island and recover the photographs. He reluctantly agreed."

The director was pleased to have someone interested in his work. He let the boys look through the photographs with him.

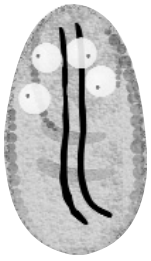
For people in the United States, giardiasis is one of the most common protozoa infections. *Giardiasis* is an infection of the small intestine that causes diarrhea, nausea and cramps. Hikers and backpackers can get the disease from unsanitary water in creeks and rivers.

Giardiasis, is caused by a type of ***protozoa***, a form of single-celled microscopic life. They each have a well-defined nucleus and most can move on their own. They have no chlorophyll. About 30,000 different types of protozoa are known. They inhabit both land and water and can be found in all regions of the Earth, even in cold climates at the North and South Poles.

giardiasis



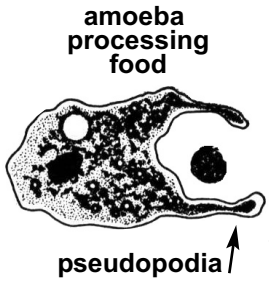
cyst



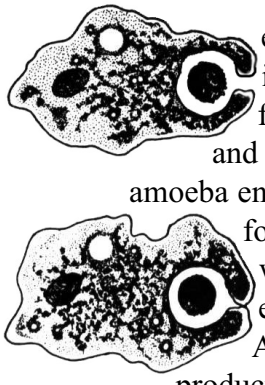
The protozoa that cause giardiasis are transmitted as ***cysts***, tough, little containers that protozoa draw into when adverse conditions strike. Once drawn into their cysts, protozoa can survive for up to three months outside the body.

Other protozoa use this trick of forming cysts to survive harsh conditions. For instance, protozoa in the soil actually live in the film of water that clings to soil particles. Should the soil become dry, the protozoa secrete a cyst with a thick, tough wall. The protozoa pull into the cyst and power down. They live at a reduced rate similar to hibernation. When the rains come, the protozoa pop out of the cyst and become fully active again.

Amoebas are another common type of protozoa. They live in soil and water. Amoebas have no particular shape but change form depending on the environment. While changing shape, a complex activity takes place in the amoeba. Cells have a structure given by a network of protein fibers. As the amoeba changes shape, it takes apart its internal structure and rebuilds it in the direction the amoeba wants to move.



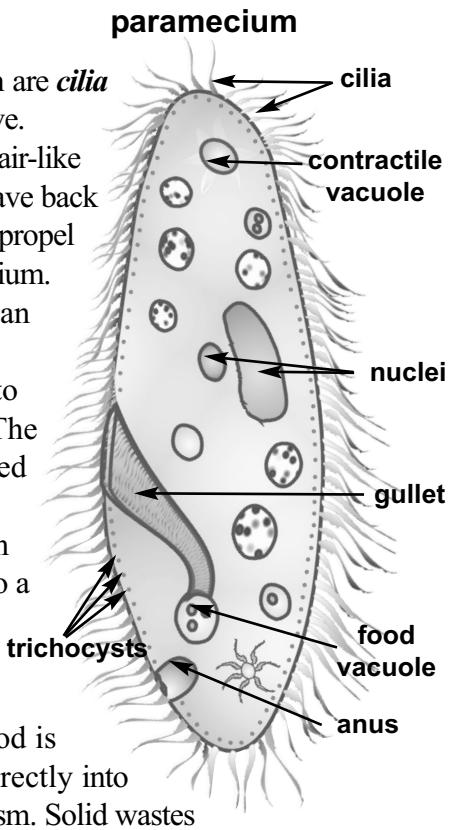
When the amoeba encounters food, it immediately forms "false feet" called ***pseudopodia*** and encircles the food. The amoeba enfolds the food particle, forming a vacuole into which the amoeba secretes enzymes to digest the food. After digestion, solid waste products are left behind as the amoeba moves along. Liquid waste is collected in a special vacuole that squirts the waste through a temporary hole in the cell membrane.



The larger amoebas are about 1/40th of an inch long. When a drop of water is illuminated from the side, amoebas are just barely visible to the unaided eye.

Although sometimes called a primitive life form, the amoeba is instead a complex cell. The amoeba can attack other microorganisms. Remember that it can put out long, curving pseudopodia that surround an unsuspecting microorganism. Once it is within the amoebas grasp, the victim is swept into a vacuole for digestion. Despite its small size, all of the life processes of a larger organism take place in the amoeba. To describe it as "primitive" fails to recognize its marvelous design and complexity.

A ***paramecium*** is a protozoan that has a shape like a shoe sole. A paramecium can move, capture and digest food, eliminate solid and liquid wastes, protect itself against enemies and reproduce. The paramecium has many specialized parts that perform these different activities.



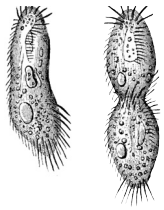
All around the paramecium are ***cilia*** that can move. These tiny hair-like filaments wave back and forth to propel the paramecium. They also can sweep food particles into the *gullet*. The gullet is lined with more cilia to push the food into a food *vacuole* to be digested. Digested food is absorbed directly into the protoplasm. Solid wastes are collected and ejected through a small opening, the cell ***anus***. Because it lives in water, the paramecium must constantly collect and

rid itself of excess moisture. The liquid water is collected in *contractile vacuoles* that periodically contract to squirt the waste water out of the paramecium.

Small structures called ***trichocysts*** are located just inside the cell wall of the paramecium. These bristles are thrust out like poison darts when some other living thing comes too close.

The paramecium has two *nuclei*. The larger one (macro nucleus) controls most of the cell's activity. The smaller one (micro nucleus) controls the cell's reproduction. Most protozoa reproduce asexually by ***binary fission***. A fully-grown organism divides into two daughter cells. The changes that take place are designed to ensure that each daughter cell has a complete set of the genetic instructions for growth and reproduction.

binary fission of paramecium



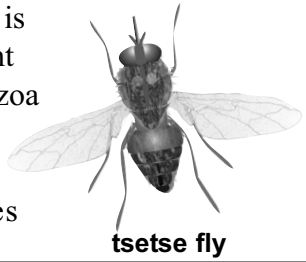
Some protozoa, such as the one that causes giardiasis, live as *parasites*. They gain nutrition from their hosts without providing any benefit in return.

Parasitic protozoa cause ***sleeping sickness*** in humans. Once a person is infected, the protozoa that cause sleeping sickness attack the nervous system. A victim of the disease becomes easily tired, sleeps long hours, loses his or her appetite and falls into a coma. Sleeping sickness is carried from one person to another by tsetse flies, which are about the size and shape of bees.



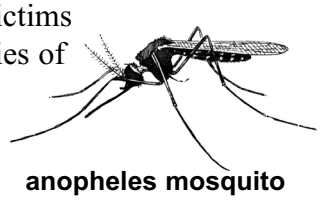
protozoa that causes sleeping sickness

Sleeping sickness is extremely difficult to fight because of the way protozoa shed their outer coats. The human body's immune system releases chemicals, called antibodies, designed to slip through the outer membrane of the protozoan. When antibodies gain entry, they kill the cell. However, the sleeping sickness parasite can change its cell surface. It avoids identification by hiding behind a different chemical coat. The antibodies do not recognize it as an enemy and are not equipped to pass through its new coat. The sleeping sickness parasite can keep on changing until the host dies or doctors use some other method to treat the illness.



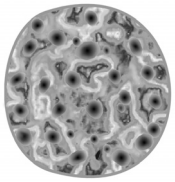
tsetse fly

Malaria is another disease common in the tropics. Protozoa carried by the anopheles mosquito cause malaria. Once inside humans, the parasite infects the liver and red blood cells. Victims of malaria suffer a series of chills and fevers. During the fevers, they are drenched in sweat. Sometimes a person will recover, only to be struck down weeks or months later.



anopheles mosquito

Despite more than four hundred years of study, there is no vaccine to prevent malaria and no cure for it once a person gets the disease. However, treating the patient with quinine can reduce the symptoms. American missionaries, soldiers and engineers who serve in tropical climates are often victims of malaria. The famous American missionary, Adoniram Judson, suffered repeated attacks of malaria. United States soldiers to Cuba, Panama, and Philippine Islands had to guard against malaria.



malaria

Some protozoa can be beneficial to humans. They have an important role in keeping soil fertile. A single gram of soil

may contain 10,000 protozoa. Protozoa excrete nitrogen and phosphorus, two elements that are essential nutrients for plant growth. Bacteria decompose dead organic matter. As they age, bacteria become less efficient in renewing the soil. Protozoa feed on the older bacteria and make room for the young and vigorous ones.

For most of history, scientists divided the living world into the two categories of plants and animals. The plant kingdom contains multicellular life forms that contain chlorophyll. Plants can make food from non-living minerals by photosynthesis. Plants have well-developed organs for reproduction. They stay rooted in one spot and cannot move on their own power.

The animal kingdom contains multicellular life forms that have nervous systems, well-developed organs for reproduction, and can move about. For a time, protozoa were classified in the animal kingdom. However, protozoa live as single-celled organisms, and true animals have many cells. Biologists decided to create a new kingdom for protozoa and called it the *protista kingdom*.

The microscope revealed tiny microorganisms such as diatoms and other kinds of algae. Although algae have chlorophyll, they have no stems, roots or leaves. They do not have vascular systems of special vessels that circulate fluids such as sap. In addition, some algae such as the euglena can move independently. They have characteristics that make them different from true plants and animals. Scientists placed algae with protozoa in the protista kingdom.

Some forms of life did not fit well into any of the three kingdoms. Remember, that because fungi contain no chlorophyll, biologists decided to establish a separate category called the *fungi kingdom*. Scientists also made the ***monera kingdom*** for bacteria. In all, biologists classified all living things into one of five kingdoms or categories of life: plant, animal, fungi, protista and monera.

Some of the photographs that Jory Barnett had left with the museum director were black and white. The photographs appeared to have been taken in and around the mill on Danger Island. Bryan could not imagine how they could be important in solving the mystery of what Mr. Murphy found on the island.

Tom asked suddenly, "Why was Jory Barnett dressed in white?"

The museum director said, "He's an orderly at a mental hospital. He's the guy who puts disruptive patients in straitjackets."

Bryan thanked the director for his information. As the boys stepped back into the hall, they were interrupted by a cry of outrage from Del. "Why didn't you come by and get me? I had to convince mother to bring me here! What did you learn about the box of photographs and Jory Barnett?"

Bryan said, "He's a 'red herring!'"

Tom looked at his friend and asked, "What are you talking about?"

Life Principle



"Parasitic relationships drain a person of resources and contribute nothing but waste products."

—Anonymous

Lesson 5
Biology

Chapter 4

Pioneers in Discovery of Bacteria; Monera Kingdom: Good and Bad Bacteria, Viruses

Section 1

Lessons 1-5

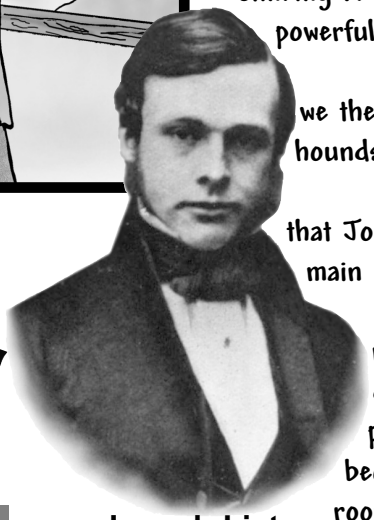
BACTERIA



Bryan explained what he meant by calling Jory Barnett a "red herring". He said, "Writers of mystery stories plant false clues. A *red herring* is a clue that turns out not to have anything to do with the main mystery. A red herring draws attention away from the central issue. I think the name dates back to the time when bloodhounds tracked fugitives. By pulling a stinking red herring fish across the path, the powerful odor confused the blood hounds."

Tom said, "I'm the one confused. Are we the fugitive, the red herring or the blood hounds?"

Bryan continued, "I am convinced that Jory Barnett has nothing to do with the main mystery. We can ignore him."



Joseph Lister

The director had laid out the museum in an interesting format. He devoted each room to a particular period in the area's history. The boys began working their way through the rooms. The French Room had artifacts from the 1600s when the French fur traders passed through the area. One of the displays was a map two feet by five feet that was prominently displayed on the far wall.

Bryan examined the map carefully then exclaimed, "This is the original of the map with the French writing on it that James Olsen left in Tom's backpack!"

Del quipped, "You made a copy for me so I could translate some of the words. I still have it." She had the copy, folded many times, in her school backpack that doubled as her purse. Del unfolded the map and held it below the one in the frame.

Bryan said, "Now we can see what our copy is missing!"

VOCABULARY

Food poisoning: a disorder caused by eating food contaminated with bacteria; usual symptoms include vomiting and diarrhea

Botulism: a type of food poisoning caused by eating food that contains a rod-shaped type of bacteria that releases toxins; in severe cases can cause death

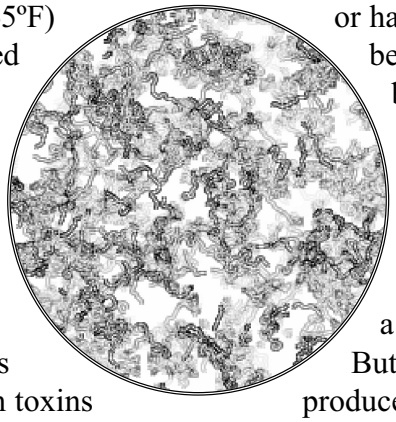
Nitrogen-fixing-bacteria: bacteria that restore nitrogen compounds to the soil

Bacteria cause the putrid odor in any decaying substance, such as a red herring fish that has been left unrefrigerated too long. Bacteria use practically any organic material for food, grow and divide quickly.

Milk products are excellent foods for bacterial growth, enabling them to grow and reproduce in large numbers. They cause milk to spoil and give rancid butter its disagreeable odor. To kill the bacteria and thereby prevent milk from spoiling, Louis Pasteur proposed that the milk be heated. Pasteurized milk is heated to about 63ºC (145ºF) for thirty minutes and then heated to 71ºC for a few seconds. The bacteria that cause milk to spoil cannot survive at a temperature hotter than 60ºC.

The single best way to prevent food poisoning is cook food thoroughly and serve it promptly. Cooking not only kills bacteria, but it also breaks down toxins that may have been released in the food.

bacteria



VOCABULARY

Symbiosis: a relationship between two or more different organisms that live together, usually to the benefit of all members
Anaerobic: without oxygen
Germ Theory of Disease: the theory that some (but not all) diseases are caused by microorganisms such as bacteria
Antiseptics: keep things free from contamination by bacteria; *anti* means "against"; *septic* means "disease-producing microorganisms"
Pathogen: any disease-producing agent, especially a virus or bacterium
Pili: hair-like structures on a bacterium that aid it in clinging to objects and detecting friends and foes; singular is *pilus*

Many foods eaten by humans contain bacteria. If foods, such as meats (that are meant to be cooked), are not cooked, then bacteria can grow. They release chemical toxins that are harmful to humans. People who eat food containing certain toxins may suffer from ***food poisoning***. Sometimes toxins result only in an upset stomach. However, some bacteria produce deadly results. ***Botulism*** is the most deadly form of food poisoning. Bacteria that grow in food that has not been completely cooked or has been improperly sealed after being cooked can produce botulism. Foods meant to be eaten raw, such as certain fruits and vegetables, should be washed to remove contaminants before eating.

Sometimes bacteria serve a useful purpose in food. Buttermilk, cheese and yogurt are produced by the action of various types of bacteria. ***Nitrogen-fixing-bacteria*** are important factors needed for healthy plant growth. Although the atmosphere is more than three-fourths nitrogen gas, plants cannot use that nitrogen directly. Instead, they must get the nitrogen from compounds in the soil.

As most plants grow, they remove nitrogen from the soil. The same crops grown on the soil year after year deplete the soil of nitrogen compounds. One solution is for farmers to spread nitrogen-rich compounds on the soil. Another solution is to grow plants that restore the nitrogen. Some plants have nitrogen-fixing bacteria around their roots. As they grow, the bacteria convert nitrogen from the air into nitrogen compounds that the soil and future crops can use.

Plants with the nitrogen-fixing bacteria include clover, peanuts and peas. Bacteria that live on the roots of such plants are not

considered parasites. Instead, when two organisms survive by helping one another, the relationship is called ***symbiosis***. The term is from a Greek word meaning *living together*. Another example of symbiosis are lichens, which contain algae and fungi living together.

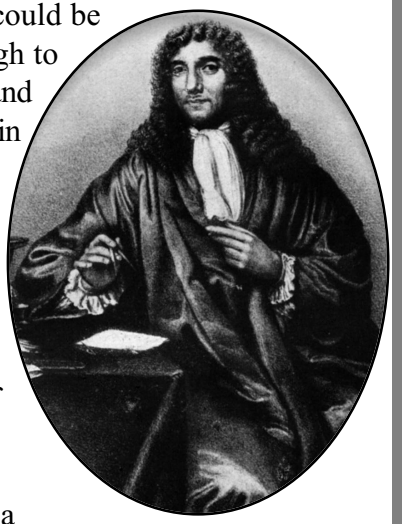
The action of bacteria feeding on dead plant and animal matter hastens decay. In a world without bacteria, dead trees, leaves and animals would not decay. They would only wear away by the physical action of weathering. Bacteria return the nutrients to the soil for the next generation of plants and animals.

Bacteria flourish in large numbers in almost any type of environment. Some thrive in hot springs in temperatures as hot as 60ºC (140ºF). Others exist in water as cold as 6ºC (43ºF). About half of all bacteria thrive in environments without oxygen. They are described as ***anaerobic***. The bacteria in a septic system that breaks down waste products are of the anaerobic type. Botulism is also anaerobic. *Aerobic* organisms thrive in the presence of oxygen.

Bacteria are the smallest living things. An average bacteria is about two thousandth of a millimeter (0.002 mm, or 0.00008 inch) in length. About 12,500 bacteria laid end to end equal one inch. They can barely be glimpsed through a microscope at 200 power. Bacteria must be magnified 1,000 times in order to be studied. Through a microscope at that power, bacteria appear no larger than a small ant appears to the unaided human eye.

The first person to detect bacteria was Anton Leeuwenhoek, an amateur scientist who lived in Holland. He made his own microscopes. Anton constructed each microscope with a single, extremely tiny lens that had to be held nearly touching his eye. Effective use required remarkable skill. At the very limit of his microscope, Anton saw tiny moving things that were later identified as bacteria. He noticed that bacteria came in three shapes: round as a ball, a long rod shape and a spiral or corkscrew.

Leeuwenhoek lived in the late 1600s. Although he described bacteria in his letters to the Royal Society of London, other scientists did not have microscopes powerful enough to reveal bacteria. Two hundred years passed before bacteria could be magnified enough to be seen clearly, and before their role in disease was realized. Because bacteria were so small, scientists at that time believed bacteria were of no particular importance to humans. Bacteria were dismissed without a thorough study.



Anton Leeuwenhoek

In the late 1700s, a British country doctor named Edward Jenner developed the first serum and vaccination procedure for the deadly disease, smallpox. In later years, Jenner's discovery of vaccination against disease was considered one of the most important medical discoveries of all time. However, at the time, Jenner was ridiculed and rejected by the British medical community, even after successfully vaccinating 12,000 people in London within 18 months.

Elsewhere in the world, Jenner and his vaccinations were gratefully accepted and honored. At one point, chiefs of five Indian Nations in Canada wrote to Jenner, "We shall not fail to teach our children to speak the name of Jenner; and to thank the Great Spirit for bestowing upon him so much wisdom and so much love. We beseech the Great Spirit to

take care of you in this world and in the land of the Spirits." In all of these things, neither Jenner nor anyone else had knowledge of bacteria or why the vaccinations worked.

In France, Louis Pasteur was the first scientist to point out the importance of bacteria. He was a chemist without a medical degree. The silk industry was an important part of the French economy. In 1865, French silk growers asked Pasteur to investigate the cause of a disease that was killing silkworms.

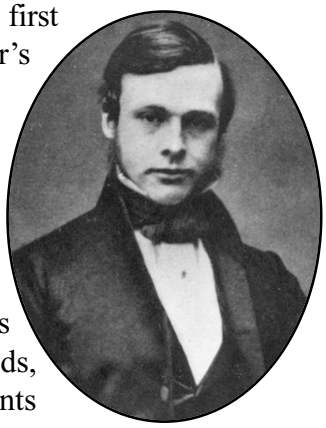


Louis Pasteur

Pasteur studied diseased silkworms with a microscope and concluded that the deadly disease was caused by microorganisms. Louis Pasteur showed that bacteria could cause harmful diseases in animals and humans. Pasteur stated his discovery as the ***Germ Theory of Disease***, the single most important medical discovery of all time, making Pasteur the single most important figure in the history of medicine.

In Scotland, Joseph Lister tried to prevent infection in humans following surgery. Joseph Lister was a medical doctor and a surgeon. Often, patients would survive difficult surgeries only to die later because of infection. Joseph Lister was a kind-hearted person who cared about his patients. He saw his work as a surgeon as an expression of his faith. He once wrote, "I am a believer in the fundamental doctrines of Christianity." Like Pasteur and scores of other scientists who claimed the Christian faith, Lister was a humble, gracious man.

Joseph Lister became convinced that microorganisms such as bacteria caused infection. Lister, the first doctor to put Pasteur's germ theory into practice, developed antiseptic methods to exclude bacteria and other small life from the operating room. When doctors used Lister's methods, the number of patients who survived surgery increased.



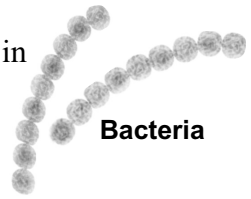
Joseph Lister

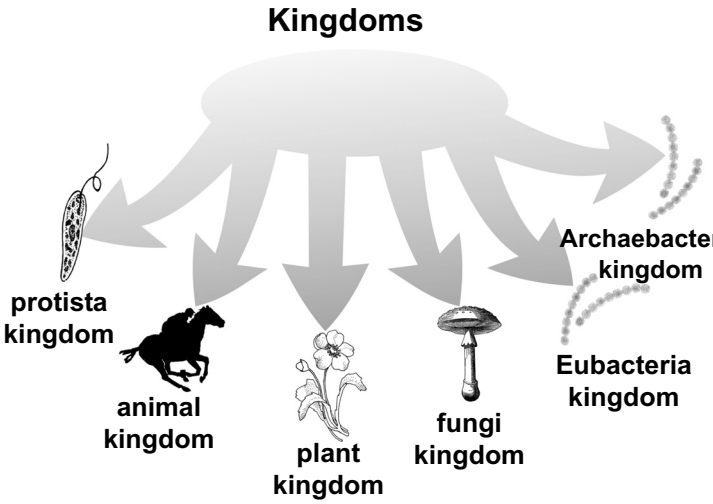
By the mid 1870s, Pasteur and Lister, against stiff opposition from close-minded scientific peers, had convinced a reluctant scientific world that bacteria could cause disease. Finally, scientists who had ridiculed or ignored the Germ Theory of Disease decided they wanted to know more about bacteria. Today, Joseph Lister is considered one of the greatest physicians of all time due to his pioneering of ***antiseptics*** and disinfectants during surgeries. The antiseptic mouthwash known as *Listerine* is named after him.

Biologists learned that bacteria caused Black Death (plague), cholera, tuberculosis, pneumonia, strep throat and many other diseases. ***Pathogen*** is the name given to bacteria that cause disease. In the 1300s, outbreaks of the Black Death killed as many as one person in three in Europe. In the 1940s, antibiotics such as penicillin and streptomycin produced by certain molds showed promise of eliminating many diseases. However, over the past fifty years, some bacteria have become resistant to antibiotics. Ancient diseases once thought under control are again posing a threat to humanity.

Unlike other organisms, biologists noticed that bacteria have no nuclei. Cells of

animals, plants, fungi and protista (protozoa and algae) each have a separate nucleus enclosed in a membrane. DNA with genetic information is stored and copied in the nucleus. Bacteria do have DNA, but it is not separate from the rest of the cell. The cytoplasm and genetic material are mixed together. Because of their lack of separate nuclei, bacteria were, in times past, classified in a kingdom of their own—the *Monera Kingdom*. (The word *monera* comes from *mono* meaning "single" or "one.")





However, in view of more recent discoveries, the *Monera Kingdom* was divided into two new kingdoms—*Archaebacteria*, meaning "ancient" and *Eubacteria*, meaning "true bacteria". Viruses are traditionally classified with bacteria, although viruses are non-living destructive particles.

The cytoplasm is surrounded with a cell membrane. Some bacteria are enclosed in a thick wall similar to the cell wall of plants. Although small, bacteria have a method to move about. They are propelled by one or more hair-like flagella. Bacteria can advance toward food and retreat from areas that cause discomfort, such as too intense of a light or toxic chemicals.

Around the surface of the bacteria are ***pili***, small hair-like features similar to cilia, that serve a variety of purposes. Pili help the bacteria attach firmly to surfaces. Tooth decay is caused by bacteria that attach themselves to teeth by pili. In addition, pili give bacteria a sense of touch. Bacteria of the same type that bump against one another are not treated as enemies. If the pili strike a dangerous or harmful microorganism, the bacterium moves away.

Bryan and Tom finished their comparisons of the two maps. Although Del's version had been copied a couple of times, it matched the original in every way.

Bryan said, "I had hoped the original would have more detail. But I can't find a single feature on the original that isn't on the copy." Tom agreed that he could not see anything new.

Suddenly, Walt Harrington, the museum director, stepped into the room. He demanded, "What is the meaning of this? Didn't you learn what you needed to know the first time you tampered with my map!"

Life Principle



"The hardest thing to open is a closed mind."

—Anonymous

Lesson 6
Biology

Chapter 4

Contrasts and Comparisons of Basic Plant Kingdom Phyla; Diffusion and Osmosis

Section 2

Lessons 6-10

VASCULAR AND NONVASCULAR PLANTS



Bryan explained, "We have not touched the original map! We are merely comparing it with our copy. When we recovered Tom's back pack that had been stolen, a copy of this map was inside one of the pockets."

The museum director now seemed more puzzled than angry. He asked, "Who stole your backpack?"

Bryan said, "The ferry captain identified him as James Olsen. Do you know him?"

Mr. Harrington nodded. "James Olsen was a handy man at the museum until a few weeks ago. One day I noticed the map was crooked inside the frame. He blamed a couple of kids that he claimed to have seen in the room. He quit that very day. I realize now James Olsen must have taken the map out of the frame and made a copy."

The museum director suddenly stopped talking as if struck by an idea. "Before he worked at the museum, James Olsen worked at a home for aged residents, in which Ed Barnett worked. Olsen supplied Ed Barnett with wild herbs. Ed made an herbal tea that was supposed to cure almost every ailment. I imagine that while helping Mr. Barnett, James questioned the old guy closely about events on the island. Maybe that is how Olson learned about the map."

Bryan asked, "How did the museum get the map?"

The director explained, "When Ed Barnett moved away from the island, he gave some boxes to the museum. Most of the items in the boxes came from Barnett's time on the island. The map, however, dated from the 1600s. I often wondered how he came to be in possession of it. Maybe Mr. Murphy gave it to him."

VOCABULARY

Herbs: flowering plants prized for their medicinal properties, flavor or scent
Nonvascular: plants such as liverwort and true mosses that do not have special tissues for the transport of water and nutrients
Peat moss: a nonvascular moss from which peat may form; used to enrich soil
Phyla: in biological classification, the primary division of a kingdom; in plants, the two phyla are vascular and nonvascular, singular form is *phylum*

Using herbs as natural remedies to cure diseases and medical ailments has a long history. People who studied the Bible noticed verses like, "***Herbs*** are for the service of man," and "The fruit of the tree shall be for your food and the leaves for the healing of nations." Until the birth of modern medicine, people were knowledgeable about which ways plants could be used to treat ailments. Herbs such as parsley, ginger and garlic were used as spices as well as for healing. Seasoning food with herbs added healthy variety to meals. People used leaves and juice from crushed plants to treat wounds. Some plants were dried and steeped in water as a tea to treat internal ailments. Many herbs have proven effective in combating illnesses. Garlic is known to aid circulation, as is cayenne pepper, making them helpful in preventing heart disease.

Herbs



garlic



cayenne pepper



mandrake



liverwort

Many books about the healing properties of plants were printed. Some of the cures worked very well. Some information had little medicinal value. Ancient "healers" identified plants by the organs of the body, which were supposed to be healed. Many people claimed that mandrake and ginseng plants had healing powers because their roots resembled the shape of the human body.

The liverwort is an example of a plant that was used for its supposed medical benefit. Liverworts have lobes that are shaped like the liver. Therefore, people thought the leaves helped cure liver conditions.

Liverworts are ***nonvascular*** plants. They do not have structures to transport water. Mosses are another example of nonvascular plants. Because they cannot transport water, mosses and liverworts must live in water or in shady areas where water is nearby. Forest floors are carpeted by mosses. They also grow on rocks, on the bark of trees, in swamps and streams. Spanish moss, lichens, and algae are sometimes incorrectly called moss. An example of a true moss is ***peat moss***. Peat moss is dense and absorbs water readily. Plants are often shipped with their roots wrapped in wet peat moss.

VOCABULARY

Vascular tissue: tissue in vascular plants that conduct water and nutrients, the xylem and phloem; composes a plant's circulation system
Xylem: the water-conducting tissue of vascular plants; xylem is also a supportive tissue
Heartwood: older and harder nonliving central wood of trees that gives them support (the living part of the plant is sapwood)
Diffusion: the mixing of molecules of two or more substances because of the random motion of their molecules; diffusion of a substance is always in the direction away from the greater concentration and toward the lesser concentration
Concentration: the amount of substance in a given volume
Sucrose: a type of sugar ($C_{12}H_{22}O_{11}$) found in many plants, photosynthesis forms the simple sugar glucose ($C_6H_{12}O_6$) that is then modified to give sucrose or fructose ($C_6H_{12}O_6$) (same formula as glucose, but the arrangement of atoms is different)
Osmosis: diffusion of fluid through a semipermeable membrane until the concentration is equal on both sides of the membrane; in plants osmosis continues because plant cells continuously remove minerals
Humidity: moisture (water) content of the air
Phloem: the food conducting tissue of vascular plants
Sieve plates: openings in the end of a phloem for the passage of food

In biological classification, a kingdom is divided into ***phyla***. The plant kingdom is divided into two phyla. (The singular of phyla is *phylum*.) One phylum is for nonvascular plants. The phylum of nonvascular plants includes mosses and liverworts.

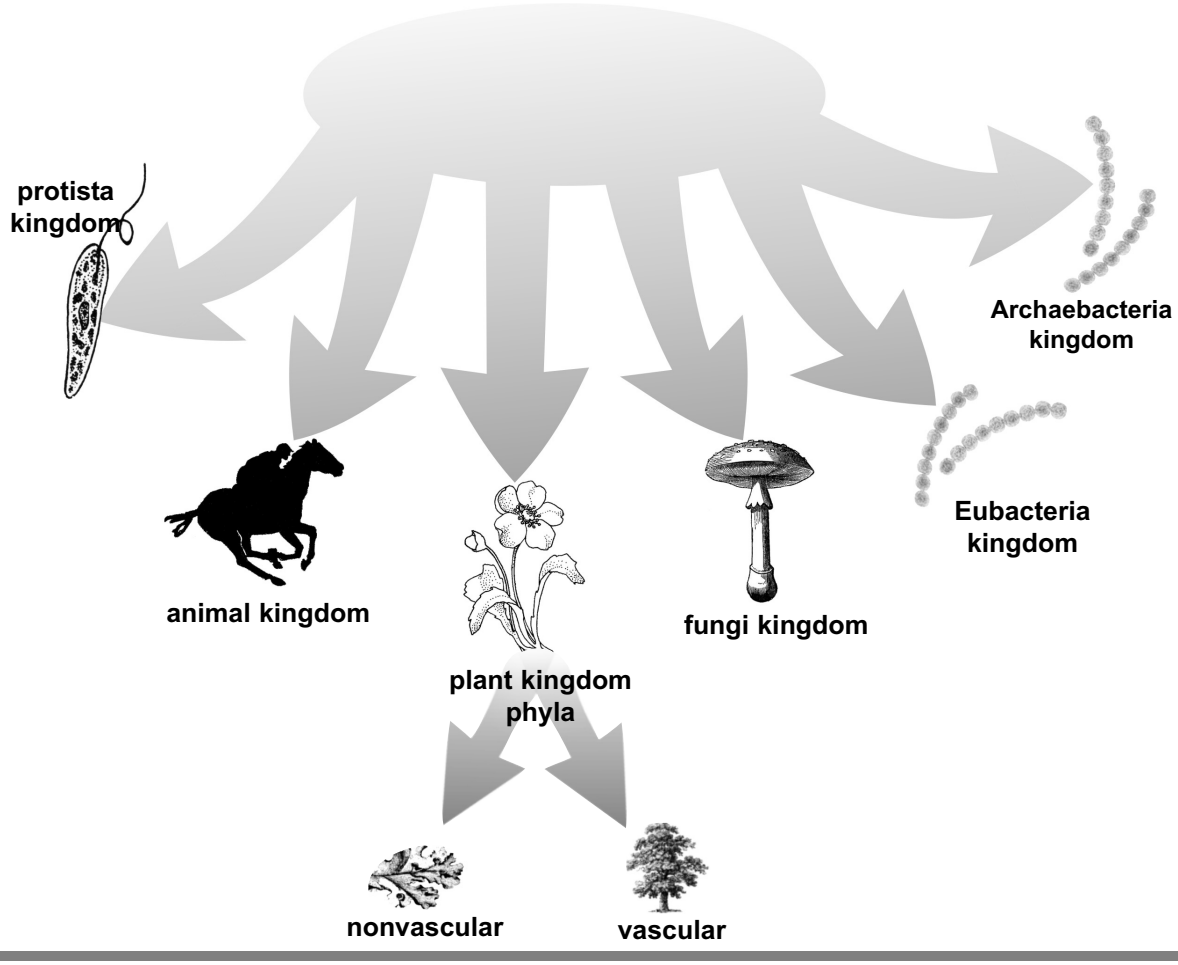
The other phylum is for vascular plants. Most large plants are vascular. Their tissues transport water, minerals and food. In plants, specialized cells include those in roots, stems, leaves, flowers and ***vascular tissue***. Vascular tissue transports water, nutrients and food between roots and leaves.

In vascular plants, the ***xylem*** tissue carries water and minerals from the roots to the rest of the plant. The xylem is made of specialized cells. An individual cell is too small to make a tube for the passage of water with its dissolved minerals. Cells in the xylem grow end to end and then change form. The walls of the cells thicken, and the ends of the cells dissolve. The cells also change on the inside. The cytoplasm and nucleus dissolve. Instead of a long line of individual cells, the ends of the xylem cells disappear to give a continuous tube. What began as a stack of individual cells changes to become a long vessel for carrying water.

As a tree grows, new xylem cells are added and old ones die. The outer wood of the trunk and older branches of a large tree have active xylem. The inner part, called ***heartwood***, is dead. However, it still serves a purpose because it is structurally strong and helps support the tree. The living part of a tree is the *sapwood*.

Plants have no hearts or other pumps to make water move. The big redwoods of California, also known as Giant Sequoias, are the largest living things on earth. They are

Kingdoms



even larger than whales. They can top out at a height above 300 feet. The leaves at the top of the tree need water and other nutrients. The roots at the bottom of the tree need the food that is produced in the leaves by photosynthesis. Water is transported up to the leaves and food produced in the leaves is transported down to the roots.

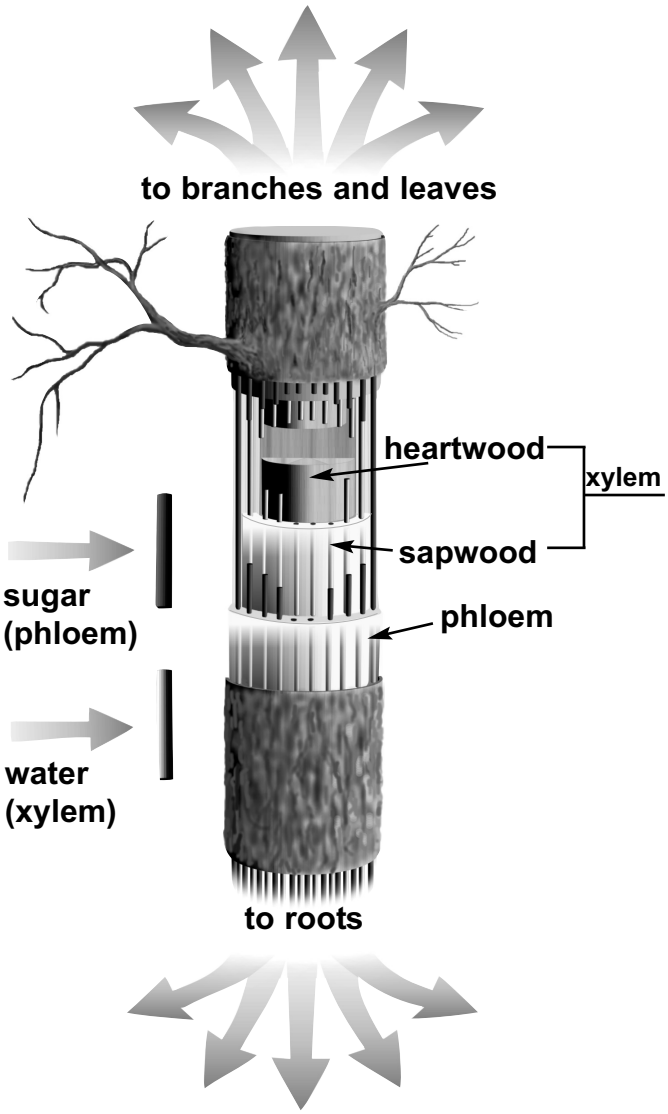
Diffusion is the movement of molecules from a region of higher ***concentration*** to a region of lower concentration. For instance, when a person drops a cube of sugar (concentrated item) into a cup of liquid (less concentrated), he expects the sugar molecules to dissolve and mix with the beverage. This is an example of diffusion.

Diffusion is always toward the region of reduced concentration. You would not expect sugar in a cup of liquid to come back together and form a solid cube of concentrated sugar. Instead, you expect it to move outward and mix with the water molecules in the beverage.

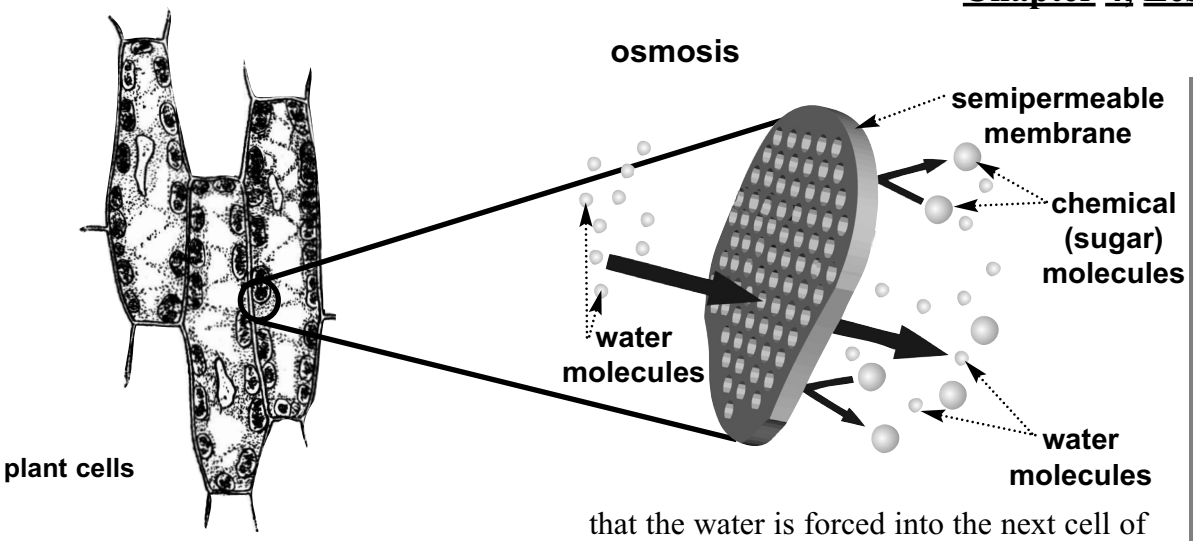
Each of the body's 100 million cells has a semipermeable membrane that does not give equal passage to all molecules. The cell membrane is designed to control diffusion so only certain chemicals pass, but others do not pass.

Membranes treat chemicals differently because molecules are not alike. Molecules differ in size and shape. They do not contain the same elements. The way atoms share electrons varies from one molecule to another. Water is a small molecule made of only three atoms: one oxygen atom and two hydrogen atoms (H_2O). Although the atoms share electrons, the charge is not evenly distributed. The oxygen atom has a slight negative charge and the two hydrogen atoms each have a slight positive charge. Compare the water molecule with the ***sucrose*** (sugar) molecule ($C_{12}H_{22}O_{11}$) found in many plants. A sucrose molecule is larger than a water molecule, and the electrical charges of sucrose are more evenly shared among its atoms.

Plants also have cells with semipermeable membranes. Water can go through the membrane, but a chemical such as sugar is trapped inside. This process of molecules passing through a semipermeable membrane is ***osmosis***.



Both diffusion and osmosis are physical actions that can also take place in the non-living world. However, in physical systems in which living organisms are not present, the action stops. A stage is reached where the concentration on each side of the membrane becomes equal. Once the water on both sides of the membrane has equal concentration, osmosis stops. However, plant cells in leaves actively absorb the minerals they need and eliminate the molecules they do not need. In this way, the transport of minerals from the roots to stems, trunks, branches and leaves continues.



When the ***humidity*** is high, water may drip from the tips of leaves even when there has been no rain. Water and nutrients are transmitted from the roots by osmosis. Cells use the nutrients but have an excess of water, which they eliminate from the tips of the leaves. Droplets of water fall to the ground. Plants in rain forests are often wet and drippy. The leaves create a rain shower, although no rain is falling from the sky. The ***phloem*** of a plant conducts sugary solution produced in the leaves to the rest of the plant. Instead of becoming hollow tubes like xylem cells, phloem cells change so that they can transfer the material from one cell to the next. The sections of the cell walls in contact with cells above and below it develop a series of pores. These pores are called ***sieve plates***. A sieve is a device with a mesh of fine openings that allows objects of a certain size to pass through.

Imagine a cell in a leaf that contains sugar. The sugar is dissolved in water. The cell expends some of the energy of the sugar to move the sugar solution through a sieve pore and into a phloem cell.

Once the sugar is inside the phloem, osmosis and diffusion help transport the sugar solution. The concentration of water inside the phloem is less than the concentration of water outside the phloem. The semipermeable membrane of the phloem cell allows water to pass inside but prevents the sugar from escaping. The cell can hold only so much water. The cell becomes so full that the water is forced into the next cell of the phloem through the sieve plates. As the water travels, it carries the dissolved sugar it contains to the next cell.

The phloem acts like a long soda straw to transport the sugar solution to other parts of the plant. The plant has to expend only enough energy to get the sugar into the phloem and to extract it at the other end. Within the phloem, movement of food through the tube is by osmosis.

The museum director said, "Ed Barnett and Mr. Murphy were friends. They both lived on the island and knew each other well. Ed Barnett was a closed-mouth sort of person. He seldom spoke of Mr. Murphy or what mystery his friend pursued. I wonder if he got more talkative in his old age."

Del had grown bored. She asked, "Are you guys ready to go?"

"I guess so," Tom replied.

"No!" countered Bryan. "I want to see the Viking Room."

Life Principle

"Men of character are always men of principle."

—Ronald E. Johnson, Ph. D.

Lesson 7
Biology

Chapter 4

Structure and Function of Ferns, Gymnosperms and Angiosperms

Section 2

Lessons 6-10

SEED AND NON-SEED





VOCABULARY

Seeds: plant embryos containing a small undeveloped plant and a store of food
Ferns: vascular plants without seeds that have roots, stems and fronds and reproduce by spores
Extinct: no longer living
Fronds: fern leaves
Rhizomes: underground stems of plants that produce new roots and stems
Vegetative reproduction: asexual reproduction in which a new plant emerges from a stem or other part of a plant
Clones: organisms that grow from cells with the same genetic material as the parent

As Bryan, Tom and Mr. Harrington walked down the hall, Bryan asked the director, "Do you have any idea what Mr. Murphy might have discovered on the island?" 1

Mr. Harrington shook his head. "No, although I have often thought about it. Other people speculated that it was a lost gold mine or buried treasure. I thought it could as easily have been something of historical importance. If Ed Barnett knew, the secret died with him. He was just short of 101 years old." 2

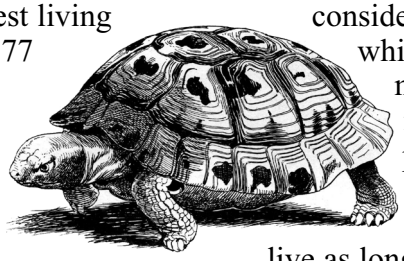
The Viking Room turned out to be a disappointment. The little museum had not a single authentic item of Viking origin. 3

Walt apologized, "Although there are a lot of stories about the Vikings, finding physical evidence of their presence in North America is difficult. What you see here are replicas and drawings of what it must have been like. I do have an interesting video showing how we think they buried a fallen leader." The director pushed the play button. 4

The scene had been shot at night and illuminated by flickering torches. Actors dressed as Vikings slowly pulled a Viking ship from a river into a hand-dug canal. In a series of quick scenes, the video showed how they put the ship in a pit dug for it. Then, they packed the ship in thick clay. After burying the captain with his ship, they filled in the canal. Finally, the vikings restored the site to look as if nothing unusual had been there. 5

As the short video finished, the camera showed a stone with writing on it. Tom whispered urgently to Bryan, "Those markings look like the ones we saw on the rock wall in the ravine on Danger Island! " 6

7 Today, we are not surprised to hear of a person living to be 100 years old. Although greater ages have been reported for people, the maximum confirmed age is 113 years. Human beings live longer than other animals, except turtles. A box turtle is believed to live up to an age of 123. The oldest living animal is a giant tortoise at 177 years.



8 Plants, however, often live for centuries. Bristlecone pines that grow in California and Nevada are ancient. Their age, as determined by counting the growth rings, shows that some are more than 5,000 years old. Despite the great age, many are less than ten feet tall. The trees grow slowly in harsh climates.

9 The average life of trees can vary considerably. Some only survive 50 years while others live around 300 years or more. Trees like the giant redwoods in California and the bristlecone pines can live for several thousand years. Shrubs also survive for several years. Some desert shrubs live as long as trees. The creosote bush in the desert Southwest may be one of the the oldest living species on Earth. No currently living species extends back beyond about 2400-3500 B.C.. Ancient manuscripts, histories of many cultures plus fossil and geologic records point to a great flood that destroyed the then known world along with its plant forms. Fossilized plants and trees appear to be much different than plant life after that time. Plants die and become extinct because of changing climatic conditions, overuse, disease, forest fires or human activities.

10 Within the phylum of vascular plants are two divisions—those that produce ***seeds*** and those that do not. Non-seed plants are primarily ***ferns***, although a few other types of non-seed plants do exist in the tropics. Some types of non-seed plants are ***extinct***. They no longer exist anywhere on Earth. The leaves of ferns are called ***fronds***. Fern fronds have a feathery appearance. Fossil leaf impressions of extinct ferns are found in layers of rock and coal.

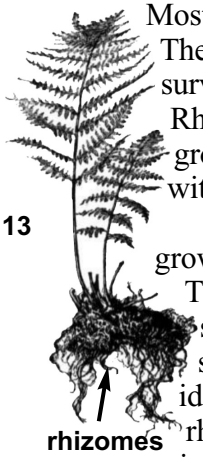
11 Ferns grow best in warm, damp, shady places such as tropical rain forests. Ferns do not grow as well in dry, cold climates. Ferns can range in size from a few inches to those that tower 60 feet high. Some ferns do not grow from the ground but instead grow on other plants. Ferns depend on other plants for support but do not take any nutrients or interfere with life processes of the host plant. Ferns are not considered parasites. New types of ferns are still being found in South America. Ferns can grow in remote areas and

VOCABULARY

Embryo: an undeveloped or immature form of life; seeds contain plant embryos
Gymnosperms: plants that do not have seeds enclosed in protective tissues; plants that do not produce flowers or fruit
Conifers: gymnosperms that produce seeds in cones; examples include pine, spruce and fir trees
Evergreens: trees whose leaves stay green year around; conifers are evergreens
Angiosperm: a plant that encloses its seeds in a protective tissue (fruit); a flowering plant
Cotyledon (kot-il-ē′ don)***:*** a leaf of a plant embryo; also known as seed leaf
Dicotyledon: a seed with two cotyledons; also known as dicot
Dicot: shortened form of *dicotyledon*
Monocotyledon: a seed with one cotyledon; also known as monocot
Monocot: shortened form of *monocotyledon*
Annual: a plant that goes through its entire life cycle from sprouting seed to flowering plant in one growing season
Biennial: a plant that requires two years to go through its entire life cycle from sprouting seed to flowering plant
Perennials: plants that live three or more years without replanting seeds

in the tops of trees where they are difficult to find and study.

12 Rather than possessing true roots, ferns have horizontal stems called ***rhizomes***. Most of the stem grows underground. The underground rhizome can survive unfavorable conditions. Rhizomes ensure the plant can grow back after fires or seasons with too little rain.



13 One way new ferns grow is by ***vegetative reproduction***. The rhizome runs under the surface and then sends up a new shoot. A whole colony of identical ferns grows from the rhizome. Vegetative reproduction is a type of asexual reproduction. The plants are ***clones***. Each one carries the same genetic information as the other.

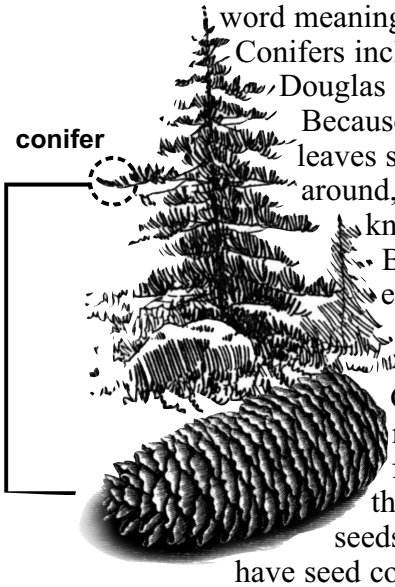
14 Ferns also reproduce by spores. The underside of the frond appears to have small reddish or brown spots. These spots are the spore cases. They dry out, pop open and release spores.

15 A *spore* is a single living cell protected by a thick cell wall. Spores are light enough to be carried by air currents to other locations. Only a small percentage of the spores land in favorable conditions for growing. However, a spore is capable of surviving for several years. Modern biologists have taken samples of spores collected more than a hundred years ago and have successfully grown ferns from the ancient spores.



16 The other division of vascular plants produces seeds. A seed contains a plant ***embryo*** that results from sexual reproduction. Plants with seeds are divided into two groups depending on how the seeds are protected. Some plants are designed to protect the seed inside a larger growth. Fruit trees are of this type. The seeds are in the protective tissue of the fruit.

17 Some seed plants are not designed to wrap the seeds in protective tissue. The plants with unprotected seeds are called ***gymnosperms***. The word means "naked seed." Most gymnosperms are ***conifers***, a word meaning "cone bearing." Conifers include pine, spruce, Douglas fir and cedar trees. Because their needle-like leaves stay green year around, conifers are also known as ***evergreens***. Bristlecone pines are examples of evergreens.



18 Gymnosperms do not produce flowers, although they do produce seeds. Most evergreens have seed cones. The cone may take two or three years to develop. In some evergreens, the cone opens and the seeds fall to the ground. In other evergreens, the cones fall to the ground and remain closed for several years. The seeds are not released until the cone rots away or until the cone is torn apart by an animal searching for food. However, cones may open because of the heat of a forest fire. This amazing process can release thousands of seeds to replace trees killed by the fire.

19 Conifers are important building materials. Most of the commercial lumber in North America comes from conifers such as pine, Douglas fir and spruce trees. The grain of the wood in conifer trunks is straight. The wood is light but strong for its weight and easily shaped. Most poles used for electric lines are made of conifers, as are railroad ties. Cedar is noted for its pleasing aroma. Chests are made of cedar for the storage of wool clothing. Not only does the cedar chest have a pleasing aroma, but also the vapors repel wool-eating moths.

20 ***Angiosperms*** are plants designed to cover their seeds with protective tissue. The protective tissue is called "fruit." An apple is an example of an angiosperm. Its seeds are in the middle of the apple. (Cut an apple in half

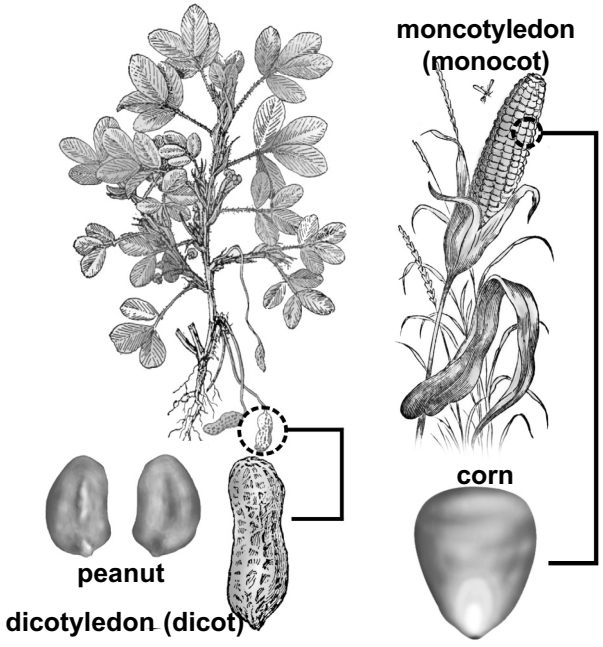


angiosperm (apple)

crosswise and observe the beautiful star design.) A flower blossoms and becomes fruit. For that reason, all angiosperms produce flowers and are also known as flowering plants, such as roses. The fruits of roses are called "rose hips."

21 After a seed is planted and begins growing, it sprouts from the soil. Some types of plants emerge as a sprout with a single leaf. Other types of plants emerge as a sprout with two leaves. Angiosperms are put into two categories depending upon the type of the seed leaves. A ***cotyledon*** is a seed leaf. A plant that sprouts with two leaves is a ***dicotyledon***, commonly called a ***dicot***. The prefix *di* means "two." A plant that sprouts with one leaf is a ***monocotyledon***, commonly called a ***monocot***. The prefix *mono* means "one."

22 From the seed alone, you can identify the plant as a monocot or dicot. If the seed is split into two parts, then it is a dicot. A peanut is a dicot. If the seed is in one part, then it is a monocot. Corn is a monocot.



23 Another way to categorize plants is by their growing seasons. An ***annual*** plant lives its entire life in one growing season. Corn and wheat are annuals. They grow from seeds, mature, then produce flowers and seeds in one season. Sunflowers, peas and beans are also annuals. They must grow from seeds each year.

24 A ***biennial*** plant is designed to have a two-year life cycle. The plant grows during the first season and produces roots, stems and leaves. At the end of the first year, most of the leaves and stem die away, but the root continues to live. During the second season, the stems and leaves re-grow and the plant blooms and produces seeds. Cabbage, carrots, onions, radishes and lettuce are examples of biennials. However, they are usually harvested for food at the end of the first season, so people seldom see them in the flowering or seed stage.

25 ***Perennials*** are plants that live from year to year. Underground roots and stems enable these plants to live from three to hundreds of years. Trees and shrubs are the best known examples of perennials.

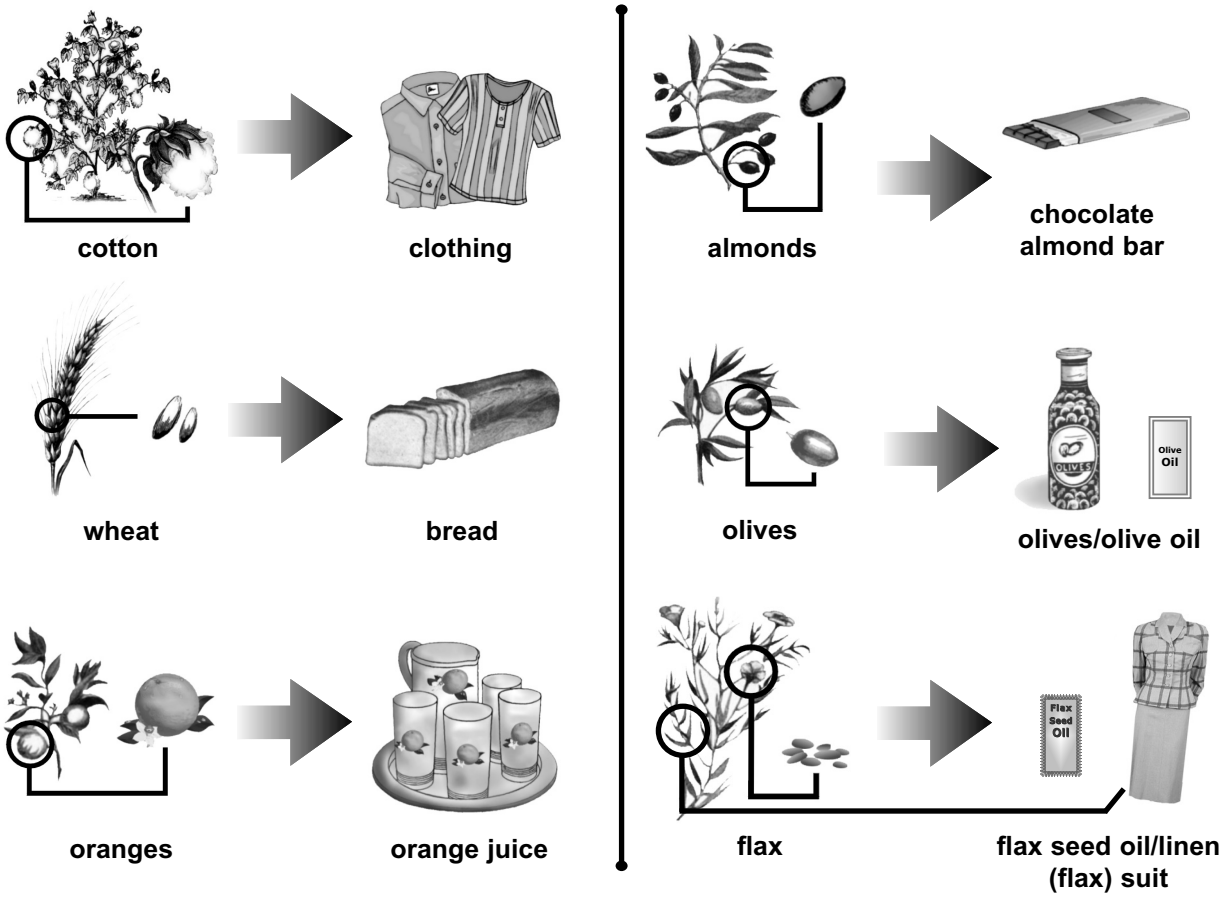
26 The role of plants in human affairs cannot be overstated. Benefits of plants include controlling erosion, providing shade, restoring oxygen to the air and providing food for animals. For humans, direct benefits include herbal medicines (camphor, quinine and castor oil), perfumes and flavoring (licorice, jasmine, lilac), spices (mustard, pepper, nutmeg), building materials (lumber), fabric (cotton and flax/linen) and oils (flax, olive, peanut, coconut). Of course, the single most important use is as food. Plants directly used by humans for food include nuts, grains (rice, wheat), fruits, vegetables and legumes (peas, beans, peanuts, and soybeans).

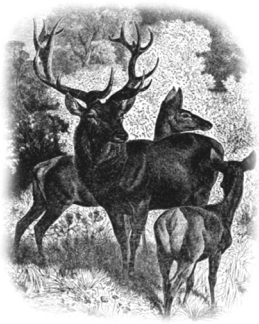
27 The museum director said, "This short scene is part of a longer video that is not yet finished. The filmmaker is doing a documentary about the Vikings in North America. The end of the movie shows how a Viking leader would have been buried should he have died during an expedition."

28 Bryan whispered to Tom, "They're not the same letters, but they are of the same style. If this video is accurate, then those rock letters we found could have been made by the Vikings!"

29 Suddenly, the museum director realized what Bryan and Tom were talking about. He became very agitated. He asked, "Have you seen letters like those? Where did you see them?"

Some Beneficial Plants





Life Principle

"The workings of nature are for our instruction."

—Middle Eastern Proverb

Lesson 8
Biology

Chapter 4

Examples and Functions of Edible and Non-edible Roots, Stems and Leaves

Section 2

Lessons 6-10

ROOTS, STEMS AND LEAVES

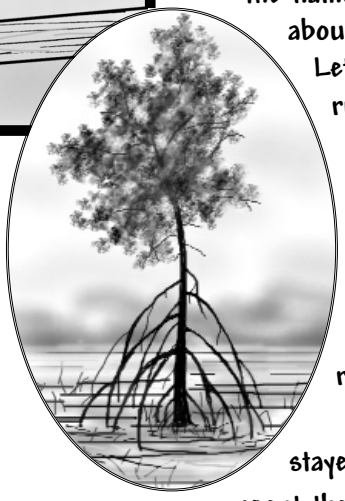


Tom explained about the writing on the rock that he found. He said, "I climbed down into a deep ravine on Danger Island. I found a row of carvings on a large, flat stone. They looked something like dancing men. I made a drawing of the figures."

The director became very insistent, "I must see the drawing! They may be runes."

Tom asked, "Ruins?"

"Not ruins," fumed the director, "but *runes*—the names of letters in ancient writings from about the 300s to 1200s in Europe. Letters in the Viking alphabet are called runes."



The boys did not have the sheet with them showing the line of characters. The director made them promise to bring it to the museum before they caught the ferry the next morning. "If you bring a copy, I will research the meaning."

While on the mainland, Del had stayed with her mother. Bryan and Tom spent the night in a dormitory for seasonal workers and ate their evening meal at the dormitory cafeteria. Most of the vegetables were freshly grown in the area—carrots, lettuce, radishes and spinach. The boys had the choice of regular baked potatoes or baked sweet potatoes with brown sugar. The drink was a "wild" refreshment that tasted like root beer—a tea made from sassafras.

Later that evening in their dormitory room, Tom unfolded the sheet of paper with his drawing of the writing from the rock. "Do you think these are letters or pictures?"

VOCABULARY

Root: the part of a plant that is usually underground; has no leaves or buds; and serves to support the plant and draw water and minerals from the soil; in some plants the roots store food

Dormant: resting; plants and seeds become dormant by shutting down all but the most essential life processes

Water table: the depth at which the ground becomes saturated with water

Taproot: the main root of a plant that grows vertically downward and sends out secondary roots

Bryan said, "I have visited some western sites where similar markings were made by ancient Native Americans. They used pictures. I remember one petroglyph that looked like a crying face. Another showed a man with a big head and skinny arms. Other images were of birds, lizards and animals. You could never mistake those animal pictures for letters of an alphabet!"

"What we saw on the island looks more like letters," concluded Bryan.

At the evening meal, each food the boys ate came from a specific part of a plant. Radishes, beets, turnips and sweet potatoes are roots of plants.

Most of the ***root*** of a plant is underground. The root anchors and supports a plant, draws water and minerals from the soil, and sometimes it grows large to store food. The shape and location of the roots depend on how the plant absorbs moisture.

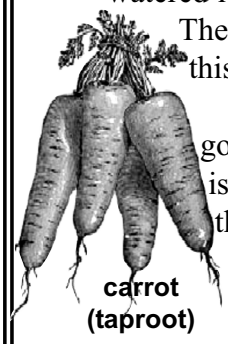
VOCABULARY

Prop roots: above ground roots that extend out to provide support to a plant
Knee roots: tree roots in swamps, such as cypress "knees" that extend above ground level; the knee root absorbs oxygen from the air
Stem: the main stalk or trunk of a plant; the stem connects the leaves and roots and transports water and nutrients between them
Tuber: an underground stem that is used for food storage; tubers have places where buds can grow into new plants; a potato is a tuber
Runners: underground stems that put out new plants at intervals along its length; also called rhizomes
Stomata: pores or openings in leaves for the passage of gases
Guard cells: cells on either side of a stomata that control its opening and closing

Some plants grow by taking in rainwater that soaks into the soil. Corn has roots that run near the surface of the ground but spread out in all directions. The wide-spreading roots do not go deep into the ground but instead remain near the surface. They absorb water that falls as rain.

For some desert plants, the growing season is measured in weeks rather than months. The desert primrose is an annual. It has but one growing season to produce seeds. Seeds of the desert primrose are ***dormant*** until the first rains of spring. Seeds then sprout, put out tiny roots that spread quickly to catch the small amount of desert rain. The primrose quickly grows flowers on a short stem and then produces seeds. All of this is done in the space of a few weeks. Such short-lived plants do not have time to grow deep roots that reach down to a ***water table***. Perhaps the most dramatic example of plant dormancy is the resurrection plant, a small, fern-like plant. It grows green in the desert areas, then turns brown and "dies" for lack of water and rolls around like a miniature tumbleweed. When watered it "resurrects" and lives again. The life, "death" and resurrection of this plant goes on indefinitely.


desert primrose


carrot (taproot)

A single main root that goes into the ground to reach water is a ***taproot***. A carrot is a taproot that has grown larger for food storage.

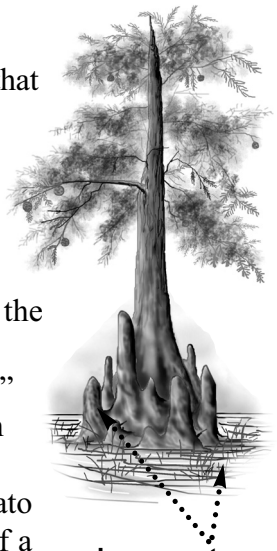
Tall trees such as oaks, redwoods and pines are perennials. They live several years and grow deep roots that reach far down into the earth to take-up water that is deep in the soil. Each

tree has a single, large, main taproot. Spreading out from it are increasingly smaller roots until they become as fine as hairs. The many small hair-like roots increase the surface area of branches and limbs. In general, the roots of a tree are as extensive underground as the limbs and branches are above ground.

In addition to collecting water and minerals, roots give support to a plant and hold it upright. The mangrove is a plant that grows in thickets along salt marshes by the ocean. Mangroves are designed with ***prop roots*** that spread out at an angle and hold up the trees up in the waterlogged soil. Corn is a tall plant with prop roots that keep the stalk from being knocked over by wind.

Some trees that grow in the swamp have ***knee roots*** that project above ground level. Knee roots have openings to admit air that passes to the roots beneath the water-soaked soil. Bald cypress trees in the southern United States grow in swamps or at the edges of streams that flood. Cypress "knees" are often used as lawn and garden decor.

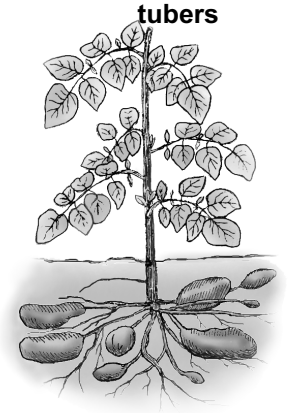
cypress tree



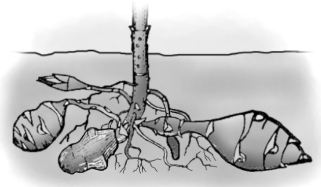
knee roots

The sweet potato grows from the root of a plant, but the white potato grows from the underground ***stem*** of a plant. Buds and leaves grow only from stems. Underground stems have buds and markings where leaves once grew. Like the root, a stem can be a source of food. A stem that stores food is a ***tuber***. The white potato and Jerusalem artichoke are examples of tubers. Jerusalem artichokes are tubers of a certain type of sunflower.

tubers



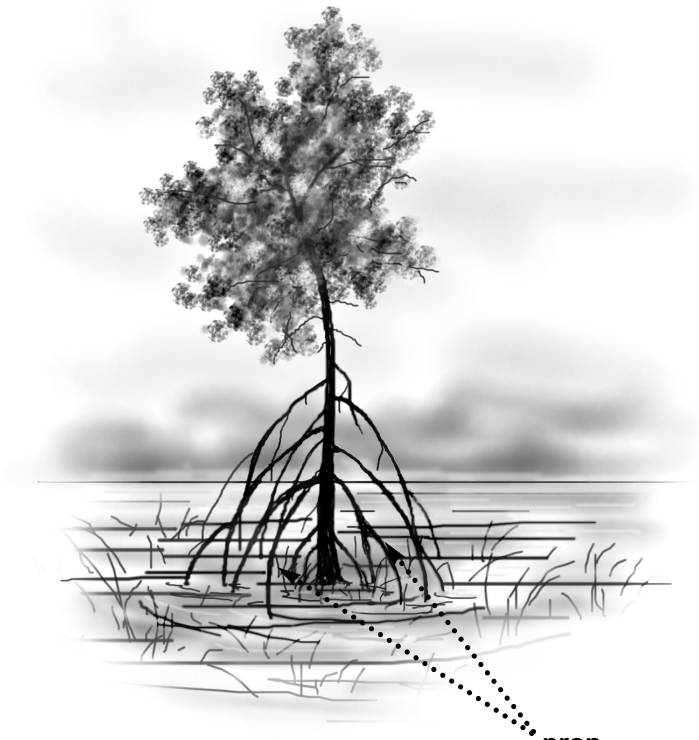
potato plant



Jerusalem artichoke

The above-ground part of a stem also stores food. The bulbs of onions are stems with leaves attached. Other examples include asparagus, celery and sugar cane. Sugar cane is the primary source of the world's supply of sugar, although sugar is also processed from

mangrove tree

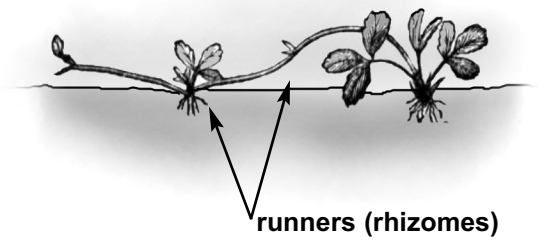


sugar beets and to a lesser degree from the sap of sugar maple trees.

For desert plants, stems act as water tanks. Cacti have stems with suckers, folds and grooves. These features enable the plants to swell up and store water during rainy seasons, in order to survive long, dry spells.

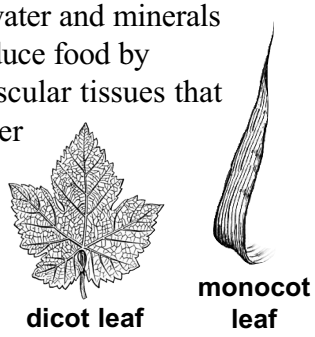
Although stems can store food and water, the chief function is to support leaves and to transport nutrients, like a miniature freeway system. *Xylem* tissues in the stems carry water and minerals up from the roots to the leaves, while *phloem* tissues transport food manufactured by the leaves down to the rest of the plant.

Some plants reproduce by stems. The plant sends out stems that grow horizontally just under the ground. These stems are called rhizomes or ***runners***. They grow roots from their lower sides and send up shoots at the same point. The strawberry plant is noted for its runners that give rise to new plants. If a rhizome is dug up and cut away from the plant, it can be replanted to grow new plants. The plant is produced by asexual vegetative reproduction.



Leaves are the food factories of the plant. Leaves receive water and minerals from the roots and produce food by photosynthesis. The vascular tissues that transport food and water are seen in leaves as veins.

Leaves vary considerably in their sizes, shapes and arrangements on stems. Biologists tend to use leaves to identify plants. For instance, whether a plant is a monocot or dicot is revealed by the way that veins grow in leaves. The veins in monocot leaves run parallel to one another along the length of the leaf. In dicot leaves, the veins form a network and branch out from a central vein.



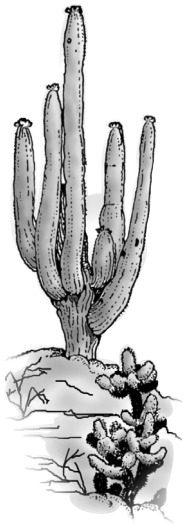
Most leaves have distinctive shapes. For instance, the sassafras tree grows leaves that are of three shapes. One leaf is a single lobe that looks like a mitten with a single thumb, the second looks like a mitten with a thumb on either side and the third is a single lobe without a thumb. Usually, all three types are found on the same stem. Sassafras has a distinctive aroma, and it was once used as a flavoring in root beer. Sassafras is still used to make sassafras tea, although too much of it can cause diarrhea.



Leaves are food factories that accept water from the roots and carbon dioxide from the air. The products of photosynthesis are sugar, with which to feed the plant, and oxygen gas as a waste product. Water and sugar are carried by the vascular tissue. Leaves have openings to accept carbon dioxide from the air and to release waste oxygen gas. These microscopic openings are usually located on the underside of the leaf and are called ***stomata***. Plants take in carbon dioxide and expel oxygen. Man, as well as

animals, takes in oxygen and expels carbon dioxide. Each life form appears to be designed to help the other maintain life.

On either side of the stomata are two sausage-shaped ***guard cells***. When the guard cells become full of moisture, they swell and open the pores. This allows air to enter and excess water and waste gases to escape. Land regions with little moisture produce limp guard cells. They collapse and the stomata closes, thus preventing the escape of moisture.



The opening and closing of the stomata is perfectly suited to the climate in which a plant lives. Plants that live in hot and dry climates are designed to prevent water loss and have only a few stomata. Most cacti are designed to reduce water loss by not having leaves at all. Instead, chlorophyll is found in the stem of the cactus, and the stem carries out photosynthesis.

Humans eat the roots, stems and leaves of many different plants. Examples of leaves that end up on the dinner plate include lettuce, cabbage and spinach.

As Tom examined his sketch of the markings, he could see what Bryan meant. Instead of a man standing upright and holding something in his hand, the symbol could have been a crude "K". Tom ran his fingers along the drawings. He saw an "X", an upside down "Y", two triangles touching one another and other figures that could be part of an ancient language.

Tom asked, "Do you think we should give the museum director a copy of this? Can we trust him?"

Life Principle

"Unless the root cause of a problem is destroyed, it will come back to confront you."



—Anonymous

Lesson 9
Biology

Chapter 4

How Nature Inspired Velcro;
Botanist John Ray

Section 2

Lessons 6-10

TREASURES OF BIOLOGY



Bryan was still thinking about Tom's question the next morning. Bryan put on his shoes and pressed down the Velcro security straps. He wore the comfortable shoes when he did not have to do hard walking. He was surprised by the secure way Velcro held shoes in place.

Although Tom was not certain the boys should share their discovery with the museum director, Bryan said, "I think we can trust him. I think he is exactly as he appears to be. He's a person dedicated to preserving the history of this region. We should enlist his help."

The next morning, they had to hurry to the museum before the ferry left. Walt Harrington, the museum director, anxiously waited for them. He grabbed Tom's paper with the drawings and exclaimed, "These are definitely Viking runes!"

Tom asked, "What does the message say?"

"I have no idea at all," the museum director admitted. "It could be a person's name, the date, or a property marker. It could say something like, 'this valley belongs to Eric,' or 'keep out!' I'll send this to an expert. When he figures out what it states, I'll let you know."

Bryan urged, "Please do so as soon as possible! James Olsen is still on the island. I would not like for him to make the discovery first."

The museum director agreed. "For twenty years, James Olsen bragged about the day that he would make his fortune. He must have heard rumors about the possible treasure on Danger Island. He apparently saw this as his last chance to strike it big."

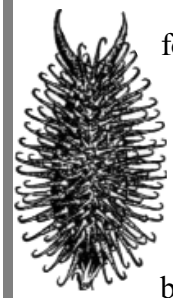
At the ferry landing, Del had some interesting news. "We're going back to the island this morning on a special tourist excursion. The ferry will take us between Danger Island and Shell Island. From ocean level, we'll have a good view of the bluff with the twisted tree."

VOCABULARY

Velcro: brand name for hook and loop fasteners modeled after the burrs of the burdock plant
Convictions: strong beliefs for which one would give up worldly goods and even life itself
Botany: scientific study of plants
Zoology: scientific study of animals
Royal Society of London: a society of important scientists who meet to share scientific discoveries
Ideologies: the types of thinking that motivate people to act in certain ways; opposing ideologies often results in arguments, debates, intolerance and persecution of those with opposing viewpoints and can lead to war.

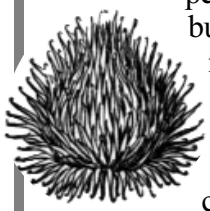
Velcro is in common use worldwide, from straps that hold on sandals to patches on the Space Shuttle to keep objects from floating about. Velcro can be pulled apart and closed again thousands of times. It can be manufactured to hold so lightly that a small child can undo his or her coat. It can also be strong enough to hold metal parts together on aircraft.

cocklebur



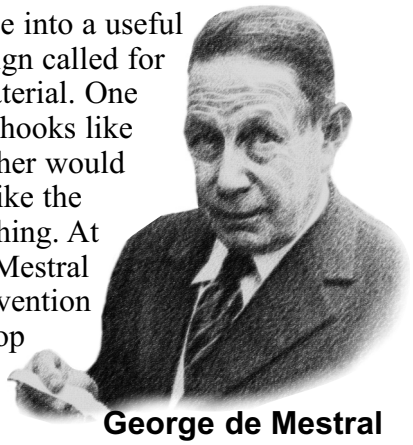
Velcro is a discovery that came directly from a useful design found in nature. In the United States, the cocklebur has seeds in a burr that attaches itself to animal fur or human clothing. In Europe, the burdock is another plant that manages to spread its seeds by clinging to fur or clothing. The burrs are a bother because they cling so well. Removing them from clothing is a chore. For years people picked off the offending burrs and tossed them aside as a nuisance.

burdock

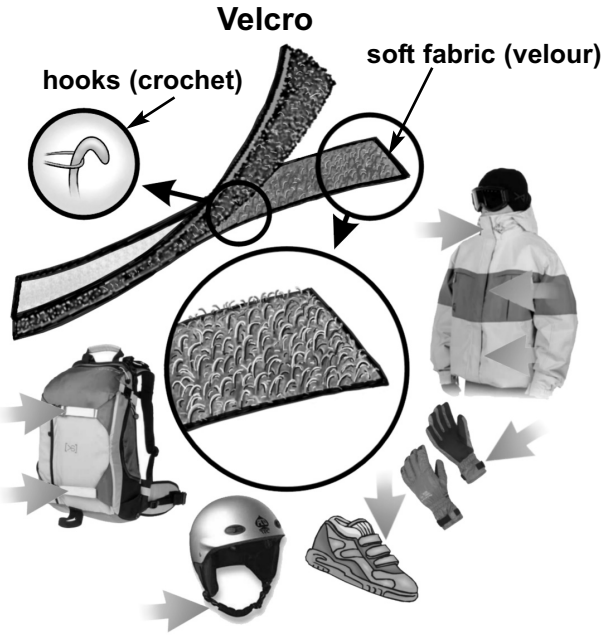


In 1948, George de Mestral and his dog took a hike in the Alps. They returned home covered with burrs. The dog waited patiently for George de Mestral to pick out the burrs. As he worked, George wondered what caused the burrs to hold so strongly. He studied a burr under a magnifying glass. He quickly saw that the burr had spines that curved around to form hooks at the end. The hooks stuck in the loops of fabric.

As he experimented with the burr, he realized he could convert the common nuisance into a useful product. His design called for two pieces of material. One would have stiff hooks like the burrs. The other would have soft loops like the fabric of his clothing. At first, George de Mestral thought of his invention as a hook and loop fastener. Later, when he was granted a patent, he came up with a trademark name. He put together *velour* (a soft fabric) with *crochet* (French for "hook") to produce *Velcro*.



George de Mestral



Thousands of people have picked cockleburs from clothing. A person with curiosity, willingness to think, and persistence turned a chance observation into a useful product.

One of the first accurate observers of plants and animals was Englishman John Ray. He was born in 1627. As a boy, he proved to have a sharp mind with a strong interest in science. He learned about plants from his mother who made herbal remedies for sick neighbors.

John won a scholarship to Cambridge, one of England's great universities. After graduation, university officials asked John to stay on as a lecturer. Cambridge was a pleasant place. The college provided Ray with an apartment and students to cook and deliver meals. The college gave Ray a plot of land near the main gate for planting a garden. During the 16th and 17th centuries, clergymen, professors and teachers usually planted vegetable gardens.

In addition to his scientific duties, John Ray became a clergyman in the Church of England. He often presented the daily devotion during chapel services at Cambridge.

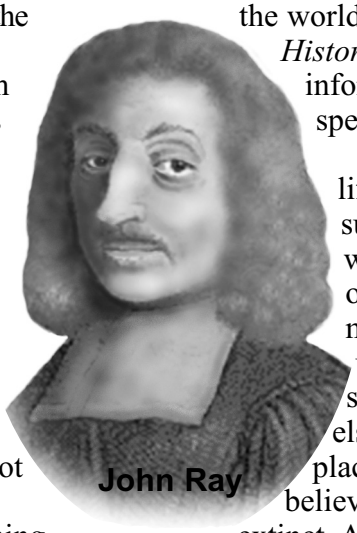
The study of plants and animals became John Ray's passion. On long summer days, he explored the countryside around Cambridge. His garden became a living museum of interesting plant specimens.

The number of plants became so great Ray could not easily comprehend all he learned about them. Ray rejected the idea of picking a single trait and using it as the basis of classification. Instead, he studied the whole plant. Ray pioneered a natural system of classification that reflected the Biblical order of plants and animals according to the concept of creation.

He noticed that some plants produced flowers. Others did not. Flowering plants were one division. Some flowering plants had single seed (monocot) leaves. Others had double or split seed (dicot) leaves. This separated the flowering division into two distinct classes.

His thoughts on classification were interrupted by political turmoil at Cambridge. The new king, Charles II, insisted that all college professors sign a document that renounced the religious ideas of Oliver Cromwell, the previous ruler of England.

"Sign or be dismissed from your post at Cambridge!" officials told John Ray, who did not take lightly his religious ***convictions***. He refused to sign. Therefore, in 1662, he was dismissed from his post and lost his home and salary. He could not use the college library. He also lost his garden containing 700 plants that he had cultivated for 10 years on school property. He was saddened, but not discouraged.


John Ray

Without the duties of teaching, Ray had time to see more of nature. He told his friends, "I shall make an effort to extend my plant studies to include all of England." He had time but no money. A former student suggested that John Ray lead a tour of England. The student and a friend would go with John Ray and pay all of his expenses.

Exploring England at that time was not as simple as one might suppose. No maps had been made showing the trails and roads in the country. Although heroic navigators had sailed across the ocean to the New World, most would have quickly become lost in the bewildering back roads of England. John Ray was the first person to explore England, Scotland and Wales thoroughly, for the purpose of studying plants and animals.

In 1667, he published *Catalogue of British Plants*. Often, professors tried to prove how smart they were by making books difficult to understand. Not John Ray. He wrote to reveal nature and show the sense of wonder in creation. His book was noted for its accurate descriptions of plants.

Ray urged people to send corrections and samples of plants that had not been described. He said, "The bounds of science are not fixed. The treasurers of nature are inexhaustible."

By 1685, a persistent infection in his legs restricted Ray from long travels. He wrote other books based on his own studies and specimens that friends sent from all over the world. His most important work, *History of Plants,* contained detailed information on 18,600 different plant species.

Friends sent fossils of plant life for John Ray to study. Ray supported the idea that fossils were the remains of once living organisms. John Ray lived when much of the Earth remained unexplored. He suggested that strange animal forms might live elsewhere on Earth in hidden places. At that time scientists believed that no species had become extinct. As friends continued to provide samples of unusual fossils, John Ray was one of the first to suggest that species could die out—become extinct.

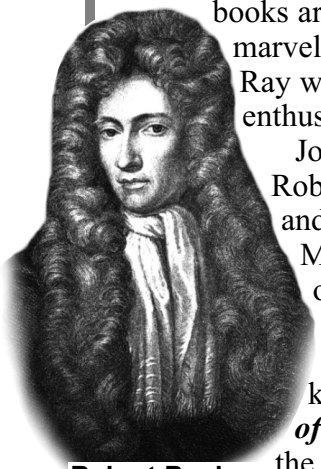
In 1691, John Ray wrote a book titled *The Wisdom of God Manifested in the Works of the Creation*. The main idea of the book was that living things were so complex and so marvelously designed that they had been created by a supremely intelligent being.

Unfortunately, the book was not published for many years because Ray's religious writings were banned. At that time, only priests were permitted to give out religious information. Printers faced heavy fines if they printed Ray's religious books. This intolerant policy changed after William and Mary became joint rulers of England in 1689. For the first time in 30 years, John Ray found a printer who was willing to publish religious books. By 1705, Ray had written 22 books about nature and religious subjects.


plant fossil

As John Ray realized his life was ending, he made financial arrangements for his family and gave his nature collections to a student. Ray sent money to Cambridge to buy books for the library—the same library that had been closed to him for 30 years.

In his day, John Ray was considered to be the greatest expert in the field of ***botany*** and ***zoology.*** Today, John Ray is called one of the founders of modern botany and the "Father of English Natural History." John Ray said, "I predict that our descendants will reach such heights in the sciences that our noblest discoveries will seem slight, obvious and almost worthless." Of course, his work has proven to be far from worthless. Ray's books are still read today. Scientists marvel at the precision with which Ray wrote and his evident enthusiasm for each subject.


Robert Boyle

John Ray, together with Robert Boyle, a fellow believer and scientist (the "Father of Modern Chemistry"), and others co-founded an organization in the middle 1600s that came to be known as the ***Royal Society of London.*** The ***ideologies*** of the times in which one lives affects every aspect of life, including science. For example, most of the "Founding Fathers" of modern science maintained a firm belief in the authority of the Bible pertaining to science (and other aspects of life). Many scientific discoveries such as the water cycle, ocean currents, the earth being spherical and numerous other concepts were motivated by passages of scripture studied by the founders of the various branches of science. Today, however, some segments of the scientific community hold views contrary to those of science's Founding Fathers—proclaiming, for example, that evolution is accepted by reputable scientists throughout the world. In truth, hundreds of reputable scientists worldwide, past and present, have disputed the claims of evolution based on scientific evidence.

When the boys first arrived on Danger Island, Bryan and Tom learned that Mr. Murphy had left a strange present for his daughter, Del's mother. The gift was a broken souvenir plate with a map of the island painted on it. The cracks in the plate seemed to diverge from a point on the north end of the island where the twisted tree grew.

Bryan and Tom were convinced that the tree had something to do with the enduring mystery of Danger Island. Bryan exclaimed, "Maybe we will see something from the ocean-level angle that will clear up the mystery! Right now I am more interested in seeing Shell Island up close!"

Del asked, "Why? What is your interest in Shell Island?"

Bryan looked at Tom. "What do you think? Should we tell her?"

Life Principle



"People who make decisions based on truth and moral principles are trustworthy."

—Ronald Johnson

Lesson 10
Biology

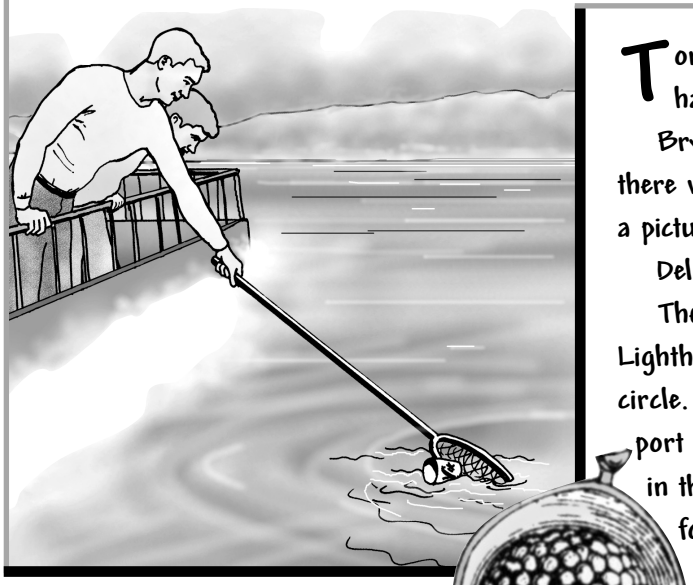
Chapter 4

Germination, Pollination and Dispersion Methods of Various Seeds

Section 2

Lessons 6-10

FLOWERS, FRUITS AND SEEDS



Tom shrugged. He said, "Go ahead, but she had better not laugh!"

Bryan said, "When we first viewed Shell Island, there was a village on it. Later, we came back to take a picture of the village,but it had entirely vanished!"

Del searched his face and saw that he was serious.

The excursion ferry passed Schooner Shoal Lighthouse. The captain steered the ferry in a circle. He told his passengers, "Look below on the port side for the dark outline of a ship that sunk in these waters. This area has become a graveyard for ships from as far back as the 1600s."

Tom said, "I wonder if Mr. Murphy's secret is a treasure from a sunken ship. The crew could have taken it ashore and stashed it in a cave or buried it."

Bryan said, "I think the mystery has something to do with the Vikings—Look! We are coming up on Shell Island!" He got out his binoculars. Bryan had a good view of the cleared place where the boys had seen the village. Bryan examined the area carefully with his binoculars.

"What do you see?" Tom asked.

Bryan said, "The ground looks trampled. I can see some wooden poles extending a few inches above the surface. Some small objects are on the ground. They look very white on the green meadow."

Tom said, "Probably dandelions or some other flowers."

The white head of a dandelion is filled with seeds. The wind is one of the agents used to ***disperse*** or spread seeds. The fruit of the maple tree has the shape of helicopter wings. When the seeds become mature, they fall from the tree and whirl in

VOCABULARY

Disperse: to scatter; wind, water, animals, insects and a variety of other methods by which plant seeds are scattered

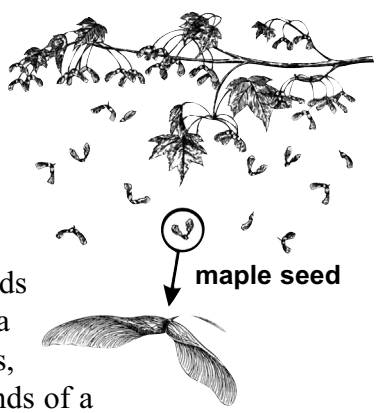
Germinate: to sprout or begin to grow

Species: a basic category of living organisms that can interbreed

Traits: features of a plant or animal that can be inherited

Stamen: the part of a flower that produces the pollen; the stamen usually consists of an *anther* that bears the pollen at the end of a stalk called the *filament*

the wind, which can carry the seeds hundreds of feet from the parent tree. Probably the dandelion holds the record for wind dispersal. Light winds can carry the seeds a distance of six miles, while the strong winds of a storm can carry seeds much farther. The milkweed is another plant that produces wind-borne seeds.





VOCABULARY

Pistil: the part of a flower that produces the unfertilized embryo; the pistil usually consists of *stigma* where the pollen is deposited, *style* (passageway from stigma to ovary) and *ovary* that contain the ovules (unfertilized seed embryos)

Pollen: fine, powder-like material produced by the anthers of seed plants; pollen grains contain half of the total genetic material required to make a seed embryo

Ovary: the embryo-bearing part of a seed plant; the ovary ripens into fruit and surrounds a fertilized seed embryo

Pollination: transfer of pollen from the stamen to the pistil of a flower

Self-pollination: pollination that takes place in a flower before it opens; also refers to fertilization between flowers on the same plant

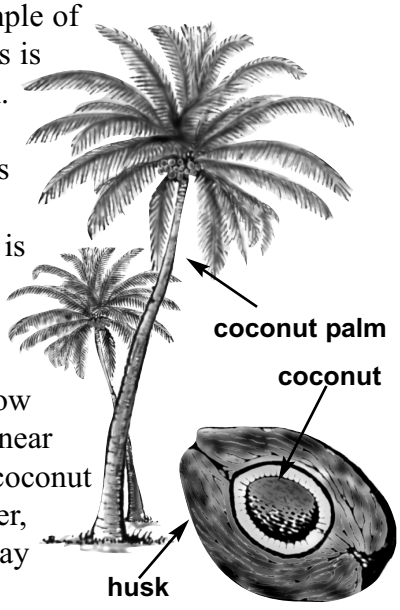
Cross-pollination: pollination that takes place between two flowers of the same species, each on a different plant

Poppies produce flowers on the top of tall stalks. When the wind blows, the flowers rock back and forth. Seeds are shaken out of the flower by the back and forth motion caused by winds.

The tumbleweed is designed to disperse its seeds in an unusual way. The plant grows as a round bush. When it matures and produces seeds, the plant dries up and becomes very lightweight. The stem snaps off and the tumbleweed tumbles along the ground in the slightest breeze. The tumbleweed bounces across the uneven landscape. With each tumble and bounce some seeds shake loose and fall to the ground.

Cottonwood trees bear seeds with soft plumes. The plumes catch the wind which carries the seeds. When stands of cottonwood trees release their seeds at the same time, the air is filled with cottony seeds like a snowstorm in the summer. Cottonwood seeds are so light they can settle on the surface of a flowing stream without sinking. The water carries seeds even farther than could the wind alone.

Water is the main method of dispersal for many plants that live along waterways such as lakes, rivers, ponds, oceans or in swamps. The mangrove, for instance, bears a seed that will float in water. Probably the best known example of water-borne seeds is the coconut palm. The coconut that is sold in stores is not the complete seed. The coconut is enclosed in a fibrous outer husk that floats. Coconut trees grow along shorelines near oceans. When a coconut falls into the water, ocean currents may

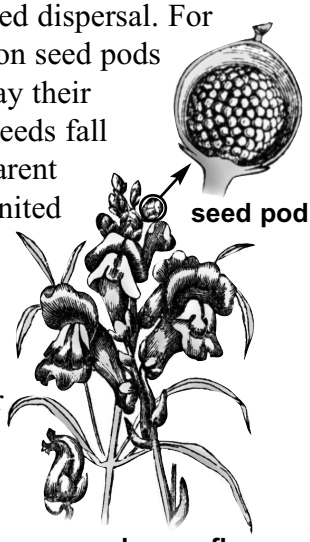


carry the seed thousands of miles from the original site. The seed may wash ashore on a sandy beach where growing conditions are unfavorable. However, the outer husk soaks up rainwater and helps the coconut begin growing. The milky-looking water inside the coconut also provides fresh water full of nutrients to get the seedling established.

Some seeds have hooks or burrs that latch onto animal fur or human clothing. The burdock in Europe and the cocklebur in the United States have seeds covered by hooks that embed in fur. The animal carries the seeds as he forages for food. Eventually, the seed falls off or is brushed off.

Animals consume edible fruits with seeds inside. Birds eat the soft part of berries, but seeds stick to the birds' beaks. Later, birds clean their beaks and knock the seeds free. Some seeds have tough coatings that resist digestive processes, so the seeds pass through the animal as undigested material. Either way, the seeds spread and grow.

Some plants have no need for wind, water or animals for seed dispersal. For example, dry snapdragon seed pods snap open and hurl away their seeds. Sometimes the seeds fall several feet from the parent plant. In the western United States, the dwarf mistletoe can shoot its seeds about 50 feet. Impatiens (touch-me-not flowers) are another example of plants that eject their seeds.



snapdragon flower

A seed that has come to its resting place, may begin growing right away. A seed that begins growing is said to ***germinate***. Some seeds, however, do not grow until germination conditions are just right. For instance, some desert plants appear to be purposely designed to produce seeds with specific "intelligent" chemicals that actually prevent germination until climate conditions are right. A soaking rain washes out the chemicals. In this way, certain seeds remain dormant until a rainstorm provides sufficient water for the plant to grow.

Because of prevailing winds or the migration of birds, plant seeds can fall far from their original locations. Most flowering plants are designed to be pollinated by a particular insect or other animal. In some cases, wide dispersal of seeds can be a problem, too. The insect the plant requires for cross-pollination may not live in the new area in which the seed has come to rest. The seed germinates and grows into a mature plant; but without the right insect for cross-pollination, the plant produces no offspring.

Angiosperms are flowering plants. In addition to roots, stems, leaves and vascular systems, angiosperms also include structures that produce seeds enclosed in fruit. Seeds are packaged in many different ways. Those that grow in pods include peas, beans and peanuts. Hard shells protect various kinds of nuts such as walnuts, hickory nuts and hazelnuts. Some seeds are in or on berries such as the blueberry and strawberry. Wheat and rice are examples of "tassel-top" seeds that are grains. Cherries, plums and apricots have stony seeds inside the fruit. Citrus fruits such as limes, lemons, oranges and grapefruit are noted for juicy pulp that surrounds the seeds.


angiosperms

Flowers of plants are found in as many varieties

as the seeds they produce. They differ in color, size and how the parts of the flower are arranged. Some flowers are produced as individual large blossoms such as magnolias. Others are very tiny but are produced in a cluster of flowers such as the lilac. Some flowers grow together to produce a single cluster of fruit. The strawberry, mulberry and pineapple are actually multiple fruits that grow together as one.


strawberries


mulberries

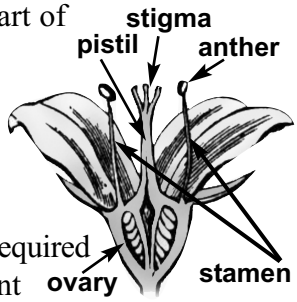

pineapple

Regardless of the type of seed produced, the essential function of the flower is to produce seeds to ensure reproduction of the next generation. If, for some reason, most seeds of a certain plant were destroyed before they could germinate, the remaining plants would be called *rare*. They would be listed as endangered and protected ***species***. If all plants of that species died, they would be called *extinct*.

Reproduction combines ***traits*** from the male and female parts of plants to produce offspring. Each feature of a plant is a trait. For instance, in his study of the inheritance of traits in pea plants, Gregor Mendel selected particular traits that were easy to observe. Some pea plants were tall and others were short. Some had smooth seed pods and others had wrinkled pods. Each plant had many traits that could be passed on to the next generation.

In reproduction, some traits may come from one plant and some traits come from another plant. The offspring will not necessarily be an exact copy of either one of the parents. Within certain limits, the traits of the offspring will be different from the parents. Usually, the slight changes make no difference in how well the plant survives. Therefore, should the environment change, at least some of the next generation should be able to survive. The offspring may be able to withstand wet weather better, survive a drought longer, or be more aggressive in growing among competition from other plants.

Although a flower has many parts, the most important parts are the ***stamen*** and ***pistil***. The stamen, the male part of the flower, produces ***pollen*** which is contained in the *anther*. A single pollen grain contains one half of the genetic material that is required to make a complete plant embryo. The pistil is the female part of the flower. The top part of the pistil that receives the pollen is the *stigma*. At the base of the pistil is the ***ovary*** that contains egg cells.



Pollination occurs when ripe pollen is released from the male part of a plant (stamen) and transferred to the stigma of the female (pistil) part of a plant. If the pollen grains are transferred to the same flower or another flower on the same plant, the result is ***self-pollination***. If it goes to another plant, then it is ***cross-pollination***. Cross-pollination is carried out by wind or by birds or insects that go from one flower to another. Once the genetic material in the pollen reaches the ovary, each egg cell (ovum) is fertilized and becomes an embryo (seed). The ovary enlarges to protect the embryo. The ripened ovary with the seed is the *fruit*.


cross-pollination

In summary, all natural fruits contain seeds. Fruit (plant ovaries) may be fleshy or juicy (apples, peaches, citrus fruit, melons),

dry (nuts) or compound/clustered (pineapple, certain berries). Many foods people think of as vegetables are actually fruits, due to their seed content, such as tomatoes, squash, cucumbers and avocados.

The seed itself contains a store of food, the seed leaf (cotyledon) or two leaves (dicotyledon) and the plant embryo. The mature fruit surrounding the seed serves two purposes. One is to protect the seed. The other is to release or disperse the seeds.

bean seed



"No," Bryan suddenly exclaimed, "The white objects in the meadow on Shell Island are Styrofoam cups!"

Del said, "Look, there's one right by the ferry! It has writing on it. Quick — grab the net and we can scoop it up!"

The ferry came to a stop while the Captain talked to the passengers about the twisted tree. Tom ran for a circular net on a long pole. He put it into the water and brought the white cup onto the deck. The cup had a design on the side. It showed a Viking ship with shields along the side and long oars extending on either side. The writing in English read, "Viking Quest."

Perplexed, Tom held the cup and wondered aloud, "What does that mean?"

Life Principle

"Bloom where you are planted."

—Anonymous



Lesson 11
Biology

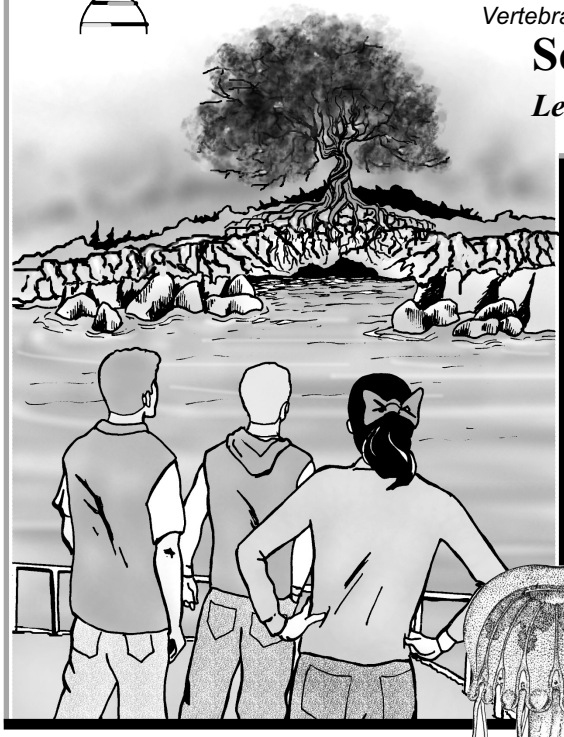
Chapter 4

Animal Kingdom Divisions: Vertebrates and Invertebrates

Section 3

Lessons 11-15

PHYLA AND SPONGES

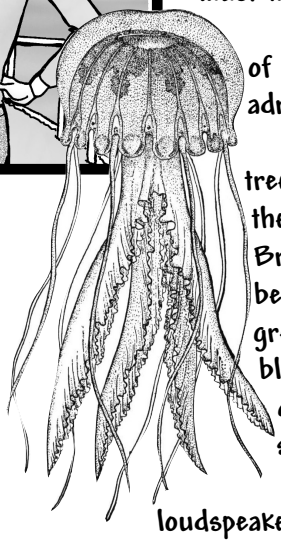


Bryan had no idea of the source of the cups with the written words "Viking Quest" or how they had been dropped on Shell Island. Shaking his head in bewilderment, Bryan walked to the other side of the ferry. It gave a better view of the bluff and the twisted tree.

As the ferry cut through the choppy waters, Bryan said, "I can't imagine James Olsen crossing over to Danger Island in his little open boat. That must have been quite a ride!"

Tom agreed, "He may be a poor excuse of a man in every other way, but you have to admire his determination."

Bryan marveled again that the hardy tree on the bluff had been able to grow out of the face of the rock. Much to his surprise, Bryan saw that the area under the bluff had been hollowed out by the action of waves. A great U-shaped opening extended below the bluff. Waves crashed against the shallow cavern and produced a hollow, thumping sound.



The ferry captain spoke over the loudspeaker, "Although this undercut of the cliff is large, many islands have far more extensive cave systems. When a sinkhole connects to a natural channel, an interesting effect is often heard. The sound of waves crashing against the bluff is led to the surface through the vertical passageway. It echoes and reechoes to produce a "thunder hole."

The captain continued, "The first explorers reported a thunder hole near the twisted tree. However, the passageway must have collapsed or been sealed in some way, because it has not been heard in recent years."

Bryan said, "Thunder hole? I remember seeing or hearing that phrase somewhere. Where could I have encountered that?"

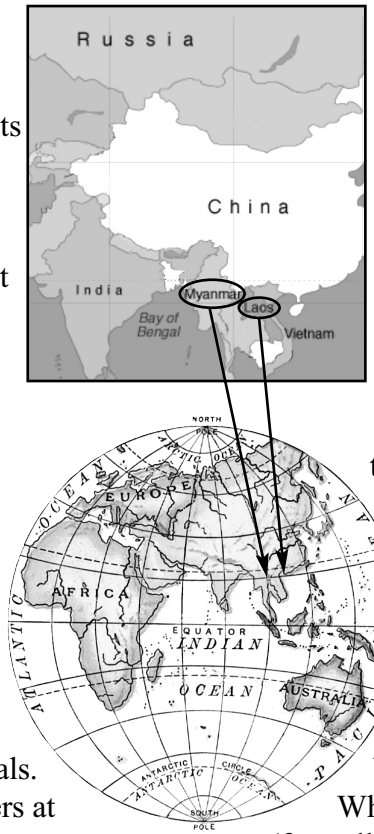
VOCABULARY

Carcasses: the dead bodies of animals; may have been slaughtered for food with inside waste parts removed

Biology: the scientific study of living things

Arbitrary: choices made by individual judgement and not fixed by law or inherent nature; much of biological classification is based on agreements worked out among knowledgeable biologists

Like Bryan, biologists marvel that the earth is so full of life. Living things, both plants and animals, are able to grow and even thrive in the harshest conditions and most unlikely places. So far, biologists have identified about 260,000 plant species. The animal kingdom is far more extensive. Zoologists have identified about two million (2,000,000) animal species. A *species* is a basic category of living things.



Biologists suspect many animal species have not been identified in remote areas of the Earth and in the sea. For instance, in 1999 two new large animal species were discovered. Robert Timmins, a biologist who worked for the Wildlife Conservation Society, discovered one of the new animals. The organization has headquarters at the Bronx Zoo in New York City.

Late in 1999, Robert Timmins was far from his home base. He was walking through an open-air food market in Ban Lak, Laos, a country in Southeast Asia. Timmins noticed some rabbit ***carcasses*** for sale. The rabbits had short ears, dark brown stripes on their faces and backs, and red fur on their rumps. The markings were unlike any Timmins had seen. The rabbits belonged to an entirely new species, never before reported. They lived in the rugged Annamite Mountains of Laos and Vietnam. Other species may still be hidden in mountain regions that have not been explored thoroughly.

Most modern scientists thought all large mammal species had been classified. The largest previously unrecorded mammal, found in the 1900s, was a deer located in a nature preserve in China. However, in 1997, Alan Rabinowitz found a new deer species. He, too, worked for the Wildlife Conservation Society. While exploring northern Myanmar (formally Burma), Rabinowitz saw local hunters carrying a small deer which had been killed. It weighed only about 25 pounds and would stand about 20 inches at the shoulder. It is known as the leaf deer.

These and many other discoveries, of new species or specimens once thought to be extinct, cause some biologists to think the total number of animal species may be as high as five million. If that is true, fewer than half of all animal species have been discovered and studied.

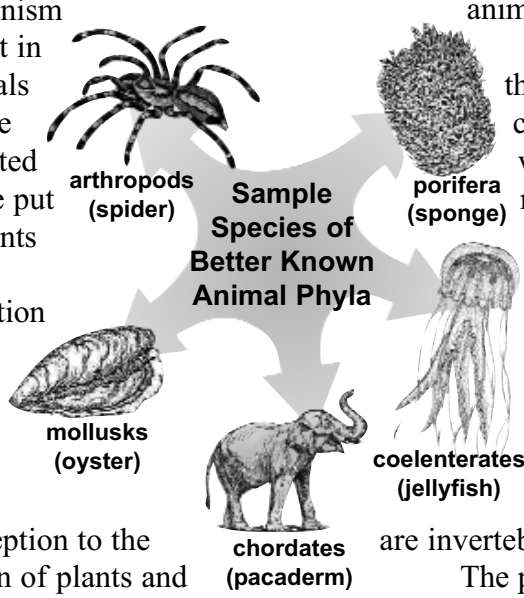
Biology is the study of living things. *Bio* is a Greek word meaning "life," while *logy* means "a field of study." The vast number of plants and animals is too great for a single person to understand. Therefore, biologists specialize in a particular field. Biologists who study plants are called *botanists*. The words *botanist* and *botany* are from a Greek word meaning "plants."

VOCABULARY

Fertile: capable of reproducing
Phylum: a division of plant or animal life below that of kingdom, *phylum* is singular, *phyla* is plural
Porifera: the phylum of sponges
Vertebrates: animals with backbones; fish, amphibians, reptiles, birds, mammals
Invertebrates: animals without backbones
Regenerate: to re-grow lost or damaged tissue
Limestone: a white, crystalline rock made of calcium, carbon and oxygen; calcium carbonate ($CaCO_3$)

Scientists who study animals are called *zoologists*. The words *zoologist* and *zoology* are from the Greek word *zoo,* meaning *living being*. If you have visited a zoo and walked around reading names of the animals, you can understand some of the problems zoologists face. The number of animals is vast. One way zoologists make their study easier is by classification of living things by similarities.

Biological classification is considered an ***arbitrary*** system. No single feature of a plant or animal declares its name classification. Biologists identify plants and animals based on research and opinion. Until about fifty years ago, zoologists insisted that the single-celled organism *euglena* should be put in the kingdom of animals because it could move about. Botanists insisted the euglena should be put in the kingdom of plants because it contained chlorophyll. The solution was to change the classification system and put euglena with algae and protozoa in the protista kingdom.



The only exception to the arbitrary classification of plants and animals is the smallest category known as *species*. Of all the categories, the species is the easiest to define. Members of the same species are designed to mate with each other and produce ***fertile*** offspring. However, members of different species cannot mate and produce fertile offspring. Corn and peas can grow in the field with one another. Each one is a different species. The pollen from corn may fall onto pea plants. However, the two different species cannot produce a plant that is a combination of peas and corn.

The largest division in the biological system is called a *kingdom*. The next division is called ***phylum***. (The plural form of the word is *phyla*.) The plant kingdom is divided into two phyla. One phylum contains plants with vascular systems for moving water and nutrients. The other phylum contains plants without vascular systems.

The animal kingdom is currently divided into 33 phyla. Not all of the phyla are well known or contain many species. Examples of the better known animal phyla include ***porifera*** (sponges), coelenterates (jellyfish, hydra, coral and sea anemones), mollusks (clams, oysters and snails), arthropods (insects, spiders, lobsters, crabs and shrimps), and chordates (primarily animals with backbones).

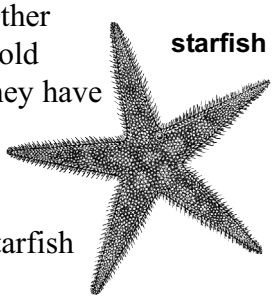
Another way to separate the animal kingdom into categories is to distinguish whether each animal does or does not have a backbone. ***Vertebrates*** are animals with backbones. The other division is ***invertebrates***. The prefix "in" means *not*. Invertebrates are animals without backbones. Animals such as fish, amphibians, reptiles, birds and mammals are vertebrates. All other animals are invertebrates.

The porifera phylum contains sponges. The name "porifera*"* comes from a Latin word meaning *pores* or *passageways*. Most sponges grow in the salt water of oceans and seas. These sea animals attach themselves to hard or rocky surfaces and do not move about. That is why some people mistakenly think sponges are types of sea plants.

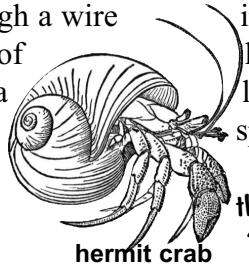
Sponges feed by straining out food as water circulates through the sponges' pores. Cells lining the pores are designed with flagella that put the water in motion. Sponges make a meal of algae, protozoa and food particles. Some sponges have the ability to close off the exit and suck in

water to build up pressure. Then they expel the water like a squirt gun. This sends away from the sponges' neighborhood the water that no longer contains food.

Sponges thrive throughout the world. They are abundant in warm and shallow seas such as the Mediterranean and Caribbean. Certain species are found in the deepest parts of the Pacific Ocean. Other species survive in the cold waters of the Arctic. They have succeeded against intense competition from other ocean life.


starfish

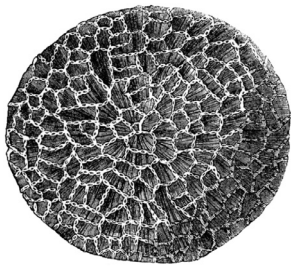
Sponges, like starfish and a number of other creatures, have an interesting ability to ***regenerate*** lost parts. A sponge is designed to grow a replacement piece torn off by other animals or by the action of waves. If the sponge were to be forced through a wire mesh with fine openings, each of the individual cells could start a new sponge. Some scientists prefer to think of sponges as colonies of individual cells rather than a single individual.


hermit crab

Hermit crabs use sponges as camouflage. Hermit crabs live in discarded shells that they squeeze into and carry about for protection. When threatened, the crab either retreats into its shell or grabs a sponge and holds it in front of the shell as a shield. Apparently, sponges have a disagreeable taste, because fish will not eat the sponge to get at the crab.

The cells of a sponge secrete a tough outer coating. In some sponges, especially those that live deep in the sea, the coating is a glass like compound of silicon and oxygen. Others produce a material similar to ***limestone***. The "bath" sponge builds a softer protein covering. After a bath sponge is harvested by a diver, the living material in the sponge dies and is washed out. The flexible covering and not the cells themselves are sold as bath sponges.

Before the invention of plastics and artificial fibers, sponges served a variety of purposes. Because they are porous, sponges soak up liquids. One ancient use of a sponge employed during Roman crucifixions was to fill a sponge with a sour wine and herb mixture, put it on a stick, and offer it to the victim, as in the crucifixion of Jesus Christ. The mixture was supposed to deaden some of the pain of that most painful of all deaths. Sponges were also used as paint brushes and mops. Today, sponges made of synthetic material have nearly replaced the natural ones.


sponge

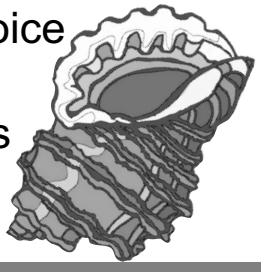
Despite being well known and economically useful, much remains to be learned about sponges. For instance, basic information such as how long they live is not known. Scientists believe that some probably live no more than a year, while the bath sponge may have a life span of twenty years.

Bryan and Tom's interest in both the thunder hole and the Styrofoam cup with "Viking Quest" on it were quickly put aside when the boys came ashore in the rubber dingy at Rocky Port. Ranger Eldridge was waiting for them with camping gear and an unusual electronic device. It appeared to be a combination of a virtual helmet and a binocular. Ranger Eldridge said, "That is a night vision scope; it will allow you to see objects in the dark. I want you to count the species of animals on this island."

Life Principle

"Listen to the voice of nature, for it holds treasures for you."

—Huron Native American proverb



Lesson 12
Biology

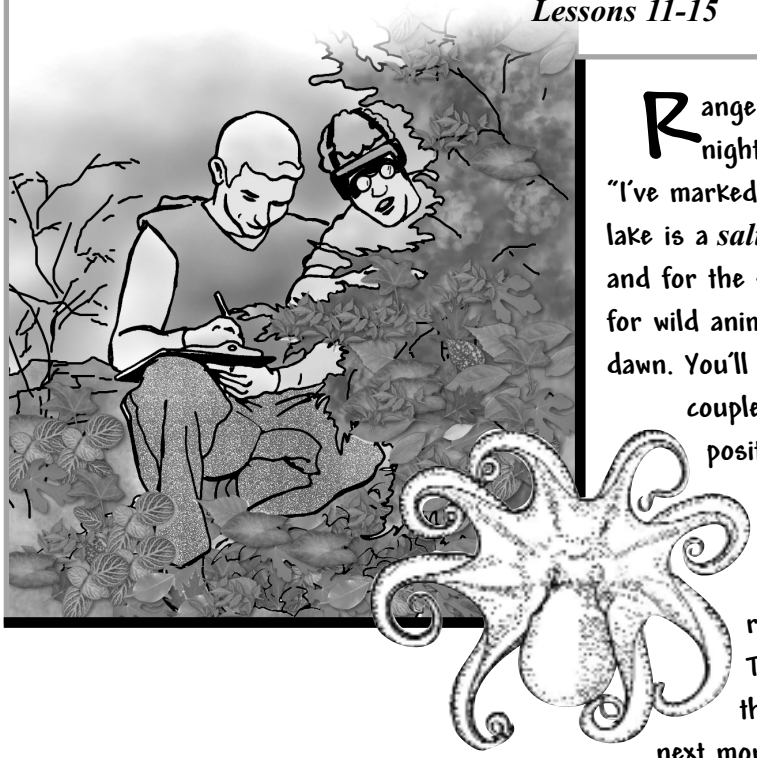
Chapter 4

Types and Descriptions: Bivalves, Univalves, Squids, Octopuses, Centipedes, Millipedes

Section 3

Lessons 11-15

MOLLUSKS AND ARTHROPODS



Ranger Eldridge explained the purpose of the night vision scope, then handed it to Bryan. "I've marked a lake on the map. Next to this small lake is a ***salt lick***. Many animals go there for water and for the salt. You could call it a high traffic area for wild animals. The animals visit the area before dawn. You'll need to camp nearby and wake up a couple hours before sunrise to get into position to count the animals. After daylight you can start the other project of planting trees."

The boys set out that evening to reach the area to make the game count. They camped a few hundred yards from the watering hole and salt lick. Early the next morning the boys positioned themselves in a tight clump of trees on a hill above the lake and salt lick. Bryan put on the night vision scope. Within a few minutes his eyes adjusted to the ghostly, flickering view it offered. "It looks like I'm watching a grainy black and white television picture," he commented quietly.

Bryan began whispering the names of animals that came to the pond. Tom recorded the information on a clipboard equipped with a faint red light. Bryan was astonished at the number and variety of animals, including a herd of 12 deer. During a break in the action, Bryan swept the scope around the area. On the trail that ran along the ridge, Bryan saw a ghostly object lumbering along. Bryan handed the scope to Tom and asked, "What do you see up on the ridge trail?"

A night vision scope not only helps rangers count animals that visit watering holes before sunrise, but it also can

VOCABULARY

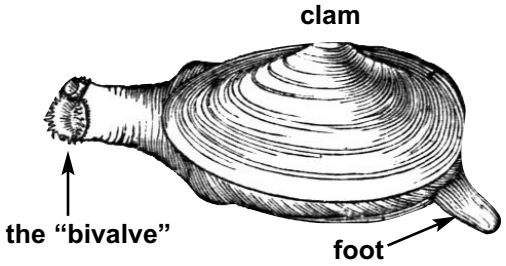
Salt lick: a natural deposit of salt, or a hard block of salt placed in various places for wild or domestic animals
Poaching: taking fish, game or other animal life in an area that has been set off limits to such activity
Mother-of-pearl: the hard, iridescent inner surface of a mollusk shell; used as jewelry; mother of pearl is composed chiefly of calcium carbonate

be used to identify poachers who work at night. People in the United States normally think of ***poaching*** as hunting and killing deer, elk and other large game animals illegally. However, the illegal activity of poaching also applies to fish and other smaller animals. In the Midwest, poachers harvest clams illegally from rivers.

The value of clams is in their shells. Some clams line the inside of the shell with the same smooth substance as in pearl and it hardens into ***mother-of-pearl***. The layer gives the inside of the shell an iridescent shine. Mother-of-pearl appears to shift colors when viewed from different angles. Mother-of-pearl mainly is used to make buttons, beads and other jewelry items. For many years, people made buttons from the shells of clams, bone or leather. Today, most buttons are made of plastic. However, the demand for mother-of-pearl is sufficiently high that mussels (a type of clam) in some streams are protected. Game wardens monitor lakes and streams, and poachers are fined or otherwise prosecuted by law.

Biologists group clams, oysters, snails, squids and octopuses in the ***mollusk*** phylum. The word *mollusk* is from a Latin word meaning "soft." Mollusk bodies are soft and without any segments. However, some mollusks are designed to grow hard shells which protect their soft bodies. The shells of mollusks are made of calcium carbonate, a compound of calcium, carbon and oxygen ($CaCO_3$).

Clams, oysters, scallops and mussels each have a two-part shell that attaches by a hinge made of muscle tissue. Mollusks in this group are called ***bivalves***. The word *bi* means "two" and *valve* in Latin means "door." Clams can move about by opening the shells and extending a single muscular foot. If danger threatens, the clam closes its shell tightly. Clams have strong muscles that can resist all but the most determined attempts to open the shell.



Sometimes a grain of sand or some other irritating particle gets into an oyster shell. The oyster generates a liquid that hardens into a smooth layer around the offending particle. Over time, as many layers are deposited, a round lustrous ***pearl*** is produced. Perfectly formed pearls can be both beautiful and costly. They are made of calcium carbonate, the same substance that makes the shells of the oysters themselves.

VOCABULARY

Mollusk: phylum of invertebrate animals composed of clams, oysters, scallops, snails, slugs, octopuses and squids; mollusks have soft, unsegmented bodies; the largest numbers are found in the sea, some are covered with protective shells; source of food for humans
Bivalves: mollusks having shells made of two hinged parts (such as clams, mussels, oysters)
Pearl: a smooth, lustrous deposit of calcium carbonate secreted by a mollusk to enclose an irritating piece of sand or other foreign matter
Gastropods: mollusks each with a single, muscular foot for locomotion; snails and slugs are gastropods, each having eyes and feelers on a distinct head
Univalves: mollusks having one-piece shells (such as those of snails and their relatives)
Habitat: the area and specific environment in which a particular plant or animal lives; some plants and animals are sensitive to variations in the habitat and cannot grow or reproduce if it changes

Snails and slugs are a type of mollusk known as ***gastropods***. The prefix *gastro* means "belly" and *pod* means "foot." Snails and slugs move about on a single foot that can change shape. The foot moves in a series of waves from the back to front, gliding the foot along. A snail in high gear can reach a speed of about 5 inches per minute. A snail has a distinct head with feelers and eyes on stalks.


snail

Snails each have a shell composed of only one piece; therefore, they are called ***univalves***. Snails that live on land need water. Most are active only at night to avoid the drying effect of the sun. Snails tend to stay in damp areas. During drought, when water is scarce, snails retreat into their shells and remain inactive until touched by rain. Some snails that live in the desert can hibernate for several years between rains.

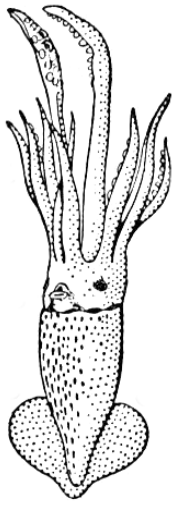
As the mollusks in shells grow, they are designed to produce more material which enables a new and larger chamber to form. Snails need calcium to build their shells. In some parts of the world such as on the sides of volcanoes, calcium is scarce. Snails that do survive there tend to have thin shells because of the deficiency of calcium needed to make thick shells.

Not all mollusks have shells. Slugs are without shells. They have moist, slimy bodies. Wherever they go, they leave a trail of slimy "glue" that is very difficult to wash off. Because slugs cannot retreat into a shell to wait out dry times, they require a ***habitat*** that remains moist. Slugs and snails are ***scavengers***. They feed on algae and dead plant or animal matter.


slugs

The squid and octopus are also mollusks, but without shells. They are protected by thick, tough, rubbery skin. Squids vary in size from four inches to about 80 feet long. The giant squid is thought to be the largest of the invertebrates with the largest eyes in the animal kingdom, measuring up to about 18 inches across. However, until recent years, scientists denied its existence. The largest known squid weigh about one ton (2,000 pounds). Squid are predators and deadly enemies of sperm whales. Squid have 10 arms, two of which are long slender tentacles with rows of suckers for grasping prey. A strong, beak for eating is located in the center of the area where tentacles attach to the torso. The beak of a giant squid is able to cut a steel cable. Squid are the fastest swimmers of the invertebrates. They achieve their speed by squirting water rapidly in one direction in

squid




squid beak

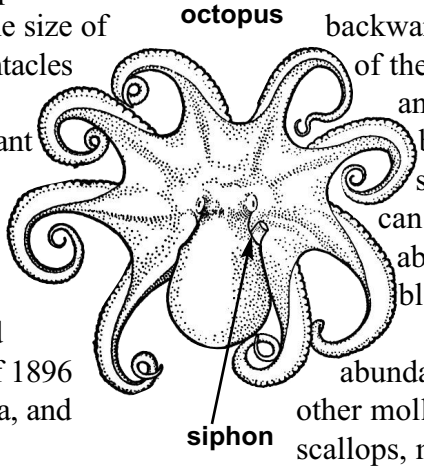
VOCABULARY

Scavengers: animals that feed on dead or decaying plants or animals

Arthropods: compose the phylum of invertebrate animals, each having a hard exoskeleton and segmented body with jointed appendages in pairs (millipedes, centipedes, lobsters, crabs, ticks, spiders, insects); biologists classify different members by number of body segments and number of legs: insects (six legs and three body segments), spiders and ticks (eight legs and two body segments), lobsters and crabs (ten legs — counting two claws — and two body segments)

order to propel themselves in the opposite direction.

The word *octopus* is composed of *oct* meaning "eight" and *pus*, which is another form of the word *pod* meaning "foot." An octopus is an invertebrate with eight arms. Each of the eight arms is a muscular tentacle with two rows of suckers capable of holding prey. At the center of the eight tentacles an octopus has a mouth that is a parrot-like beak for tearing apart food The size of an average octopus with its tentacles outstretched is about a yard across. Like the giant squid, giant octopuses were thought to be figments of human imagination. However, a giant octopus corpse estimated to be 150-200 feet long was reported washed ashore in November of 1896 on St. Augustine Beach, Florida, and photographs were taken.



Octopuses are predators who eat other marine animals. Biologists believe octopuses are the most intelligent of all invertebrates. They use a variety of tricks to entice prey to come near. For instance, an octopus lures a meal close by waving a single tentacle as if it were a worm.

Normally, octopuses move about along the bottom of the sea. An octopus brings in water through a short tube called a *siphon,* and oxygen is removed from the water. When alarmed, the octopus moves swiftly backward by squirting a jet of water out of the siphon. As an added defense, an octopus can release an inky black cloud that provides a screen behind which the octopus can escape. Octopuses also have the ability to change color so they blend in with the sea bottom.

Squid and octopuses are abundant in the sea. They and the other mollusks such as clams, oysters, scallops, mussels and snails are a food resource for humans as well as for whales, seals, fishes and seabirds.

Arthropods are the most numerous and probably show more varied forms than any other group of animals. Insects are examples of arthropods, as are spiders, lobsters, crabs, crayfish, centipedes and millipedes. All arthropods are invertebrates. They are found in the water, on land and in the air. Crayfish live in drainage ditches. Fleas make a home on the family pet. Hordes of flying locusts can devour entire crops. Some arthropods are predators which eat other animals. Some eat only plants. Others filter food particles from water.

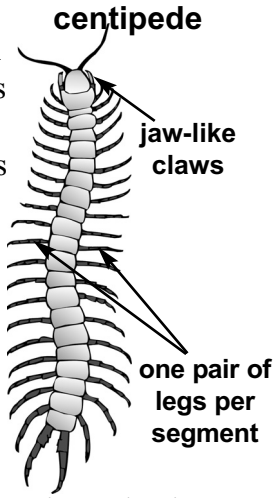
The word *arthropod* is from *arthro* meaning "joint" and *pod* meaning "foot." Arthropod refers to the fact that invertebrate animals in this phylum have jointed legs. Arthropods have hard outer coverings called ***exoskeletons***. Their bodies have distinct segments and their legs grow in pairs and can bend at joints placed along the length of the

VOCABULARY

Exoskeleton: hard outer structures of invertebrate that provide protection and support (such as those of crabs or beetles)
Appendages: arms, tails, legs or fins attached to the bodies of animals and are usually capable of grasping objects or helping the animals move
Millipedes: crawling, cylinder-shaped arthropods with two pairs of legs for each segment; eat plants; bite is harmless to humans
Centipedes: crawling, cylinder-shaped arthropods with one pair of legs for each segment; a centipede has a stinging bite that can be painful to humans
Accomplice: someone who knowingly helps another person in crime or wrong doing

legs. Members of the arthropod phylum can be classified based on the number of body segments and the number of legs, called ***appendages***.

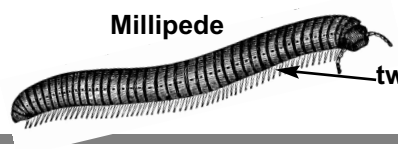
For instance, ***millipedes*** and ***centipedes*** are arthropods. They hold the record for number of body segments. As you know, *centi-* means "100" and *milli-* means "1,000." The word *ped* (as well as *pod*) means "foot." However, in this case the names are misleading. Centipedes do not have 100 legs and millipedes do not have 1,000 legs. The way to tell centipedes from millipedes is not by the number of legs, but the number of legs per each body segment.



Centipedes have one pair of legs per body segment. Their legs as well as their long antenna have many joints, or segments. Centipedes can move swiftly. Each has a pair of jaw-like claws with poison glands near the head. Centipedes are predators that disable their prey with poisonous bites from the claws. The venom is strong enough to kill small insects and cause pain in humans.

Centipedes are nocturnal; they stay hidden during the day and come out to hunt at night. Centipedes are found in dark, damp locations. They are often disturbed when a rock is overturned. Most of the 2,500 varieties of centipedes encountered in this way are about one to four inches long. However, giant centipedes that live in the Southwestern United States and the tropics can be 18 inches long.

The millipede has two pairs of legs for each segment. Millipedes eat plants and are harmless to humans. As millipedes walk, their legs form a wavelike motion down their bodies. They are not very good at running. A millipede's method of defense is to tuck in its head and curl into a tight ball so it is not as vulnerable. Ten thousand species of millipedes exist. Most grow to less than six inches in length; however the giant millipede of the tropics reaches a length of ten inches.



With the scope, Tom looked where Bryan indicated and said, "Whatever it is is nearly hidden by the trees. "It is big! Could it be a bear?"

Bryan took back the scope and watched the ghostly figure a moment longer. Suddenly, the blurry image separated into two figures walking upright. Bryan said, "It is not a bear! It is two men walking! Why are they out this early?"

As soon as dawn appeared, the two boys walked up to the trail. They found footprints left by two men. "Uh-oh," Bryan said. "I recognize one of those sets of tracks. They are the tread of James Olsen's shoes!"

Tom said, "You know what this means —James Olsen is still on the island and now he is not alone! He has an ***accomplice***!"

Life Principle



"Science still contains unanswered questions and undisclosed errors that have not yet been weeded out."

—John H. Tiner

Lesson 13
Biology

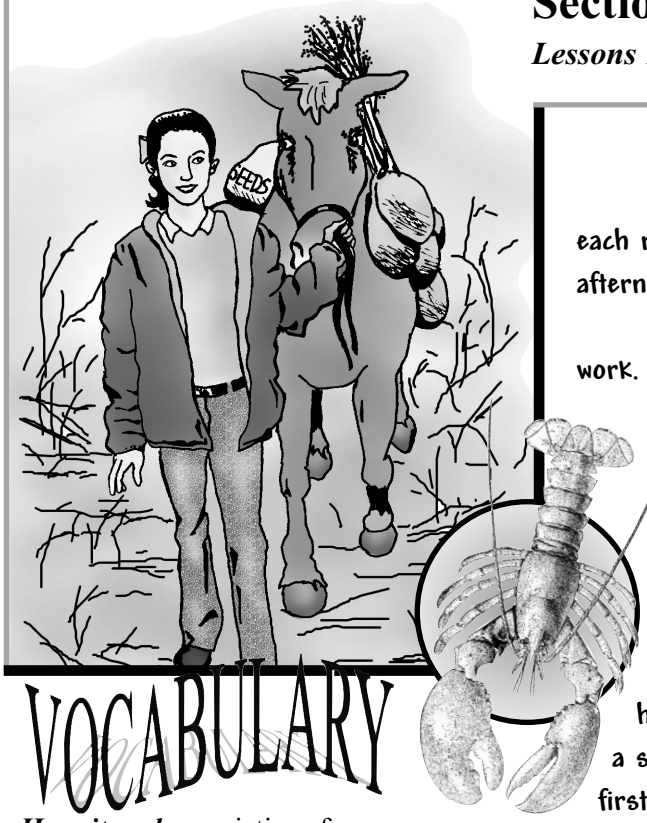
Chapter 4

Types and Descriptions: Shellfish, Barnacles, Scorpions, Mites

Section 3

Lessons 11-15

CRUSTACEANS AND ARACHNIDS



VOCABULARY

Hermit crabs: varieties of crabs that insert their bodies into the empty shells of snails or other mollusks for protection
Crustaceans: members of the arthropod phylum with ten legs (counting two claws) and two body segments; lobsters, crabs, shrimp, barnacles and crayfish are crustaceans
Aquatic: plants or animals that live or grow in water
Gills: the organs of aquatic animals that allow them to breathe oxygen dissolved in water; gills contain membranes that allow gases to be exchanged between the organism and water

True to her word, Del hauled in the seedling trees with her horse, Major. She came early each morning with the load for that day. Then every afternoon, Del rode in with a picnic lunch.

By Thursday, Tom complained about the work. It was hard enough on flat land, but they planted the trees on the side of a hill near the shoreline. "I think one of my legs is shorter than the other," he groaned. Suddenly he jumped back because of a sudden movement he saw out of the corner of his eye.

"What is it?" Bryan asked.

Tom laughed and picked up the object that had startled him. "It's just a little hermit crab in a shell," he said as he set down the creature. At first, all he saw was the large claw used to close off the opening to its borrowed home, an empty snail shell. In a few minutes, the tiny crab came fully out of it's shell. The crab first extended its antennae, then claws and two pairs of walking legs and scurried away.

On Friday afternoon, Del had some exciting news. She reported, "I received a message from Walter Harrington at the museum. His expert confirmed that the markings you discovered are runes, dating from around 1000 A.D., and were almost certainly written by Vikings! The museum director says that the writing contains too few letters to make much of a message, however. The expert thinks they may mark an entrance to something. The letters spell a word that means 'portal', like a doorway or gateway."

Tom said, "That's not much help!"

Del said, "Tomorrow, Saturday, I've arranged for us to go to Kitchener Island. It's one of a small group of islands to the north."

Tom asked, "Why should we go there?"

Del promised, "Wait and see. You won't be disappointed!"

VOCABULARY

Soft-shelled crabs: crabs that have molted (shed their outgrown shells) and not yet regrown their exoskeletons

Seafood: usually means shellfish such as lobsters, crabs, shrimps, crayfish, oysters

Hepatitis A: a liver disease caused by ingesting contaminated food or water; also called *infectious hepatitis*

Arachnids: members of the arthropod phylum with eight legs and a body with two segments; scorpions, mites, ticks and spiders are arachnids

Scorpions: arachnids that live in warm, dry climates; noted for their curving tails with venomous stingers

Mites: tiny arachnids found worldwide both in water and on land; they infest stored food products and live on plants and animals as parasites

Chiggers: mites that are human parasites, noted for their bites that produces extreme itching

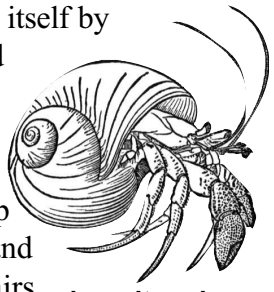
Chitin (kit-in)***:*** the tough, protective material that composes outer skeletons of arthropods; similar to the material of fingernails in humans; composed of glucose (sugar) combined with protein (a compound of hydrogen, oxygen, carbon and nitrogen)

Range: the geographic region in which a plant or animal normally grows or lives

Molting: a process of shedding the outer body layer for growth; when arthropods molt, they lose their protective exoskeletons and have reduced defenses against predators until new exoskeletons harden in place

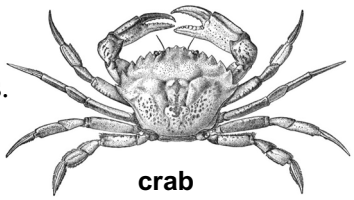
Camouflage: protective coloration that makes animals appear to be part of the natural environment

Hermit crabs like the one Tom saw make their homes in the empty shells of snails, or other mollusks. The abdomen of a hermit crab does not have a hard covering; therefore the hermit crab protects itself by backing into a shell and carrying it around as a portable home. The hermit crab uses its back pair of legs to grip the inside of the shell and walks with the other pairs of legs. When frightened, the crab pulls into the borrowed shell and extends the largest claw across the shell opening. As the crab grows, it periodically leaves its host shell and moves into a larger one.



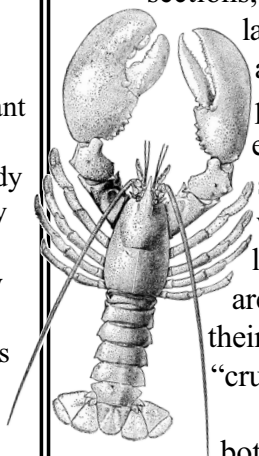
hermit crab

Most hermit crabs stay around a sandy beach near shore. However, some hermit crabs venture a mile or more from the sea. Sometimes hikers on mountain trails come across crabs. If the mountain is steep, the crabs roll and tumble down the trail, tucked safely inside their shells. Usually, hermit crabs return to the water to reproduce. Some hermit crabs are kept as pets.



crab

Crabs, lobsters, shrimps, crayfish and barnacles are arthropods that have two body sections, four pairs of legs and a pair of large claws. On the head are two antennae that act as feelers to provide a sense of touch. Crab eyes are located on movable stalks. A crab's body is protected with an *exoskeleton*. Crabs, lobsters, shrimps and crayfish are called ***crustaceans*** because of their hard shells, *Crustacean* means "crust."



lobster

Lobsters live mainly on the bottom of the sea. They are

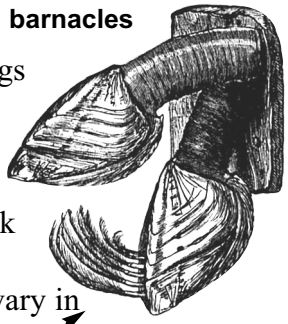
aquatic animals because they have ***gills*** and spend their lives in water. Lobsters are caught in traps baited with fish. The average lobster weighs from one to five pounds. A few lobsters that live in deeper water may weigh as much as 40 pounds. Lobsters and crabs are as plentiful in the sea as insects are on land. For that reason, crustaceans are vast sources of food.

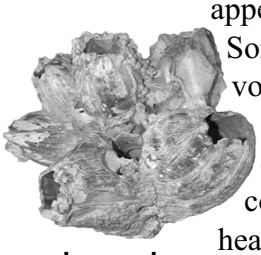
Crabs are not dependent on the ocean as much as are lobsters. Like the hermit crab, many species of crabs venture upon the beach. Crabs can move very fast and have a curious way of running sideways. They have another peculiar habit which is exhibited when several crabs are placed in a tub or bucket. As the crabs mill about, trying to get out, they pile up on top of each other against the side of the container. Then, just as it seems one will be able to escape, the others pull him back down into the jouncing mass to repeat the process. Like lobsters, crabs must molt to produce a new exoskeleton. ***Soft-shelled crabs*** are those that have not yet regrown hard exoskeletons.

Crayfish are also known as "crawdads." Like lobsters, crayfish tails are designed with flippers for locomotion. Rather than moving forward, crayfish flip their tails to pull themselves backward very rapidly. Lobsters, crabs, shrimps and crayfish are popular ***seafood***. The meat is rich in protein and low in fat. However, crustaceans have been termed the "garbage collectors of the deep" because they absorb mercury and toxins easily from polluted waters. Contaminated crustaceans can be poisonous and even deadly if eaten. ***Hepatitis A*** disease is also an ongoing risk to seafood consumers. Because of the expense of trapping them, lobsters, crabs and crayfish are more expensive than other sources of food.

crayfish

Although, they have thick shell coverings and may look like mollusks, barnacles are actually crustaceans. Barnacles, however, look nothing like other crustaceans. Barnacles vary in appearance.

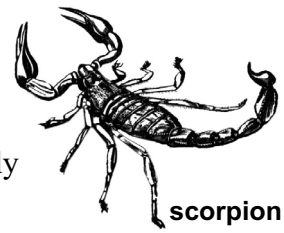



barnacles

Some look like miniature stone volcanoes, others appear to be stone versions of prickly pear cacti. All barnacles live in colonies, standing on their heads and eating with feathery legs that collect plankton from the surrounding sea water. Barnacles build on nearly any solid surface that gets covered by water, including ships' hulls. Unlike other crustaceans, barnacles are not used for food.

Arachnids are another large division of the arthropods. An arachnid has four pairs of segmented legs and a body that is divided into two segments. One segment is the abdomen. The other is the head and chest that are together without a division. Most arachnids live on the land. The word *arachnid* comes from a Greek word meaning "spider," although the division also includes ticks, mites and scorpions. Some spiders, (black widow, brown recluse) are poisonous and can be deadly.

Scorpions live mostly in warm, dry regions such as the deserts of the southwestern United States. A scorpion has an exoskeleton and powerful claws for grasping prey. A jointed tail curls over the top of the scorpion. The tail has a pair of poisonous glands that can deliver a disabling sting. The scorpion's poison attacks the nervous system of the prey. Scorpions normally hunt at night. They are


scorpion

carnivorous and eat insects, spiders, and other scorpions, as well as small snakes and lizards.

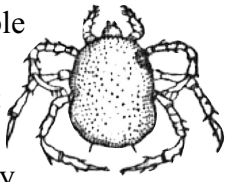
Scorpions usually hunt by sitting motionless and waiting for prey to come near. They detect vibrations and turn to ambush the victim. Once a victim comes within range, the scorpion pounces on the target, holding it by means of the scorpion's front pinchers, and inflicts a deadly sting. Scorpions, spiders and the other arachnids do not have jaws with which to chew their food. Instead, arachnids inject digestive fluids into their prey, then suck the liquefied remains from the exoskeletons of the victims. The indigestible husks of the victims are discarded.

The sting is also used for defense when the scorpion feels threatened. The species of scorpions that live in the United States have painful stings. Small children and adults who are sensitive to the venom can be killed by a sting, depending on its location. Even if it does not prove fatal, the sting is certainly painful. People who live in areas where scorpions are common remember to shake out shoes and clothing before dressing. When exploring or working outside, you should never put your hands into or beneath objects where you cannot see insects.



Mites are arachnids similar to scorpions, but much smaller. Various species inhabit every part of the world both on land and in water. They cause damage to plants, grains, and animals.

Some mites live on the flesh of animals, including humans. Those that live on animals and humans deposit eggs in soil. After the eggs hatch, the mites climb grass or leaves from where they can fall on hosts. They attach themselves to any human who brushes against the grass or leaves. Mites are so small they are barely visible to the unaided eye. Tightly woven clothing will keep out ticks but not mites. They can wiggle through clothing. They attach themselves to the skin and inject digestive juices in the flesh. The chemical dissolves human tissue and causes severe itching. In the southern United States, the mites are known as ***chiggers*** (red bugs). A person who has experienced an attack of chiggers can attest to the very unpleasant itching they cause. Chiggers are most prevalent during dry summer months. A mixture of sulphur and cornstarch or talcum powder dusted on feet, ankles or lower legs will deter chiggers.



mite/chigger

A member of the arthropod phylum has an exoskeleton, a body of two or more segments, and legs that grow in pairs. The arthropod phylum contains a large and diverse group of animals. Biologists subdivide the phylum based on the number of body segments and the number of legs. Lobsters, crabs, shrimps, crayfish and barnacles each have ten legs (counting two claws) and two body segments. Spiders and ticks each have eight legs and two body segments. Insects have six legs and three body segments. All have exoskeletons.

The word *exoskeleton* is made from *exo* meaning "outside," and *skeleton* a Greek word meaning "dried-up." The exoskeletons of lobsters and crabs are made of ***chitin***. Chitin is a strong, firm compound similar to the material that makes fingernails in humans. Chitin is made of chemical elements that can be found in most places, so unlike the snails that use calcium for their shells, arthropods have a greater ***range***.

The exoskeleton is a covering that protects the animal and gives it support.

Although rigid, the exoskeleton has joints that allow lobsters, crabs and other arthropods freedom to move. Arthropods such as insects are designed with small holes in the exoskeletons to allow intake of oxygen. In addition to providing protection and support, the exoskeleton prevents land based arthropods from drying out. Without the exoskeleton, arthropods would have to stay in damp climates. With the exoskeleton, insects live every place on Earth wherever land life is found.

One problem with an exoskeleton is that it cannot grow with the animal. As the organism grows, it must shed its exoskeleton and produce a new one. This process is called ***molting***. During a molt, lobsters are defenseless until they restore the protective shell. Land-based arthropods such as insects molt, too. They face danger from predators and from extreme changes in weather. Most find a hiding place with constant temperature and moisture until the new covering forms.

The outer layer of the animal's skin cells is designed to produce the exoskeleton. The chemicals needed for the shell come from the surrounding environment, therefore arthropods often have the same color as their environment. The color of the exoskeletons acts as ***camouflage***. It gives the animal a protective coloration that matches the surroundings.

The next morning, a man with a boat met the boys and Del at Rocky Port. Del said, "Martin Alonso runs a water taxi service. He is delivering some cargo to Kitchener Island, and he agreed to take us with him!"

Martin grinned and said,"No charge, provided you help me unload the cargo!"

Bryan and Tom readily agreed, although they were still puzzled by why Del wanted to go to that particular island. Martin's craft, the Sequoia II, was an ancient but well maintained cabin cruiser of wood construction. The interior paneling appeared to be of mahogany. The craft was powered by a powerful-sounding diesel engine.

"Why are we going to Kitchener Island?" Tom asked, "What is there?"

As Martin powered up the cabin cruiser and they sped away, Del announced, "I've solved the mystery of the missing village!"

Life Principle



"True friends encourage our best efforts, but wrong companions pull us down." —Anonymous

Lesson 14
Biology

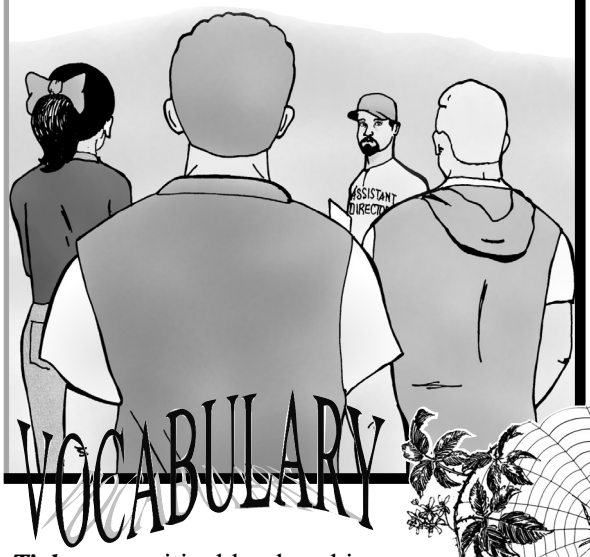
Chapter 4

Tick Characteristics and Diseases; Spider Types and Characteristics

Section 3

Lessons 11-15

TICKS AND SPIDERS



VOCABULARY

Tick: a parasitic, blood sucking arachnid, having four pairs of clawed legs; ticks transmit the bacteria that cause Lyme disease and Rocky Mountain spotted fever

Butyric acid: an acid that occurs in animal fat, especially butter; one of the causes of body odor

Lyme disease: a disease transmitted by deer ticks to humans; the victim experiences flu-like symptoms at first; disease can progress to a point that affects the nervous system and causes joints to ache; if left untreated, the victim may be unable to walk and suffer damage to the heart

Nearly an hour passed before Martin slowed the engine and threaded the cruiser toward the center of three islands. As the boat circled around to a point of land, a small town came into view. Tom could not believe his eyes. He yelled, "No way! Look! It's the village we saw on Shell Island!"

Although Tom was right, Bryan saw that something was very wrong with the buildings. From the angle he viewed them, some of the buildings were made of a single wall. The people looked out of place, too. Some wore medieval costumes. Others were dressed in blue jeans and casual clothes. People scurried around, then suddenly a voice boomed out. "Everybody, stop moving!" The voice commanded, "Quiet on the set! Action!"

"It's a movie set!" Bryan exclaimed.

Del quickly boasted, "I figured it out! *Viking Quest* is the name of a movie being filmed. The director did not want his set to be overrun with curious onlookers, so he has kept it quiet. Because of some mix-up, they built the set on Shell Island. When the director learned about the unexploded shells, he ordered the set taken down and rebuilt here."

After the boys helped Martin unload his cargo, he said, "We can stay awhile and watch them film the movie." "All right!" the boys chorused. "Then, let's walk over to the set," said Martin.

They walked up the hill and met a man carrying a clipboard. He wore a tee shirt with the title "assistant director". "You're late," he barked, "All extras should have reported hours ago!"

When the boys first came to Danger Island, they helped Ranger Eldridge with a moose that had an infection caused by a ***tick*** infestation. For animals such as moose, deer and elk, ticks can be a real danger because ticks discharge a toxin that numbs the nervous system causing host animals to be unaware of the tick. The animal does not feel the bite. On some animals, ticks become so numerous that the toxin from their many bites can cause paralysis or death. The sores serve as an entry point for bacterial infections. Ticks are killed by heat from brush fires. Tick infestations are more likely in wilderness areas where underbrush fires are forbidden.



Ticks are bloodsucking, parasitic arachnids that live on reptiles, birds, mammals and humans. Ticks are found wherever warm-blooded hosts live. Ticks begin their lives in woods, tall grass and shrubs where they wait on the underside of leaves for a passing host.

One way ticks detect a host is by sensing the vibration caused by approaching steps. Another way is by body odor. Ticks can also detect ***butyric acid***. This chemical gives spoiled butter its rancid smell. Living things produce butyric acid. which causes the body odor that ticks detect. Once a host comes nearby, ticks jump aboard.

For example, when a dog comes near a leaf supporting a tick, the tick will sense the animal and jump from the leaf onto the dog. The tick crawls to a protected spot on the dog and bites into the flesh and begins drawing blood. When the female has gotten her fill, she drops from the dog, finds a place for her eggs, lays them and dies. The eggs hatch and the cycle starts again.



The deer tick also bites humans. Usually the bite of a deer tick causes no pain and it does not itch. Although the bite itself is not a threat, the danger is the bacteria transmitted from one host to another. People are unaware they have been infected with bacteria that cause disease.

Lyme disease is caused by bacteria transmitted to people by infected deer ticks. Lyme disease is often difficult to ***diagnose***. A circular skin rash develops days after the bite. The person may experience symptoms such as headaches, loss of appetite and aching muscles. All of these are symptoms of the flu. Because victims may not remember the tick bite, patients and doctors often fail to recognize Lyme disease. Meanwhile, the disease can progress to a dangerous stage. Months after the bite, victims experience pain in their joints similar to arthritis. As time



VOCABULARY

Diagnose: to identify a disease by the symptoms reported by the victim
Rocky Mountain spotted fever: an infectious disease caused by a microorganism transmitted to humans by ticks; the victim suffers headache and a high fever, muscle ache, and red skin rash; Rocky Mountain Spotted fever is found throughout North America
Spiders: arachnids each with eight legs, two body segments, and two poisonous fangs; spiders can produce a silk for webs to trap food and line their nests
Orb weaver: a type of spider that makes a regular, spiral-shaped web
Spinneret: the organ on the abdomen of a spider that secretes the silk threads for making webs, for lining burrows or for making draglines and parachutes
Filaments: continuous fine strands of thread, fiber or wire; spiders produce filaments of silk
Tarantula: a large, hairy spider with a fierce appearance; produces a bite that is not seriously harmful to humans

goes by, the nervous system is damaged and a person may be unable to walk. Diagnosis and treatment should start as soon as the symptoms begin to appear.

The disease was first recognized in Lyme, Connecticut in 1975. Today in the United States, Lyme disease is the most common disease carried to humans by ticks. Strangely, numerous cases having no history of tick encounters have contracted the disease, causing some researchers to evaluate other origins of the disease.

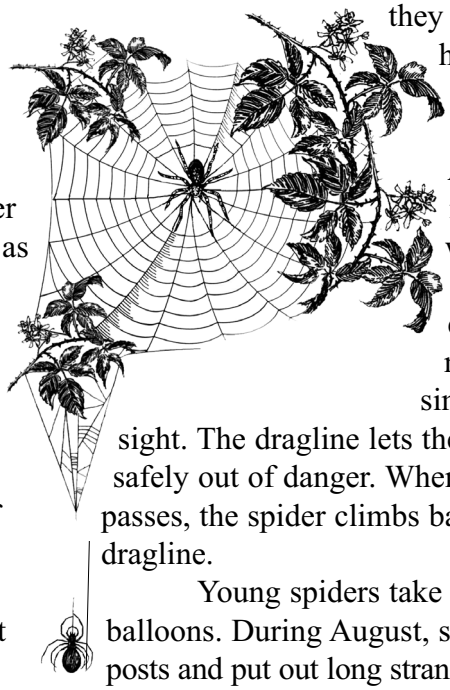
Until the discovery of Lyme disease, the most prevalent tick-borne disease was believed to be ***Rocky Mountain spotted fever***. It was first recognized more than a hundred years ago. It is an infection of a bacteria carried by the wood tick. Despite the name, "Rocky Mountain" spotted fever has been found in all of the states as well as foreign countries.

Like scorpions and ticks, ***spiders*** are arachnids. The name *arachnid* has an interesting history. According to a Greek myth, a peasant girl named Arachne became the best weaver of cloth in the world. The Greek gods became jealous of Arachne's skill. As punishment, she was turned into a spider to weave forever.

Spiders are noted for the webs that they build to catch food. ***Orb weaver*** spiders make webs that are very regular in shape, like spirals around the spokes of a wheel. The webs are woven in open areas between tree branches or flower stems. The orb web is made of threads of dry silk that go out from the center of the web. Sticky silk connects to the spokes in a spiral. The spider can spin a complete web in about one hour.

Most orb weaver spiders attach a signal cord to the center of the web. Then they hide out of sight on a nearby limb. The spider feels the strands of the signal cord with its feet. The spider can tell the difference between the wind-blown leaf and an insect caught in the sticky, coiling threads of the web. As the insect struggles to free itself, the strands of the web shake. The spider feels the vibrations with its legs, then dashes out and stings the insect. The spider either eats the victim, or wraps it in silk to save for a later meal. Like other arachnids, spiders eat only liquid food by piercing the victim's body and sucking out the body juices.

Spiders use their web material for other activities, too. Many spiders spin a single strand of silk wherever they go. The thread helps the spider find its way back to the home site. Also, the dragline is a way to escape when danger threatens. If an enemy comes near, the spider simply drops out of sight. The dragline lets the spider hang safely out of danger. When the danger passes, the spider climbs back up the dragline.

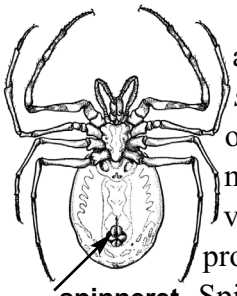


Young spiders take to the air on web balloons. During August, spiders climb tall posts and put out long strands of silk. Updrafts of air catch the lightweight strands. The spider holds onto the end and is carried aloft. Spiders sometimes rise a half mile into the sky and are carried hundreds of miles from their original locations. The spiders cannot control where they go. Sailors more than two hundred miles from land have seen ballooning spiders floating through the air.

When over land, the balloon strands catch on tree limbs, highline wires and automobile radio antennas. Sometimes in the autumn, spider webs become so thick they cause the air to have a shimmering appearance.

Not all spiders spin regular orb webs. Tiny "house" spiders manufacture loosely woven, shapeless jumbles of threads. When a house is not dusted for awhile, the cobwebs give the house an abandoned look. Black widow spiders spin an unorganized pattern of very tough strands that funnel into a dark corner or crevice in which the widow waits to strike her victims.

A trap door spider burrows into the ground, then lines the tunnel with a liquid, nonsticky body material that hardens to a smooth web surface similar to paper. The spider makes a door of the same material to block the entrance of its nest and fastens a silken hinge to one side. When it senses the vibration of an insect above ground, the spider quickly opens the trap door and grabs the insect as it passes by the door.



A spider manufactures and secretes its web from a ***spinneret*** on the underside of the abdomen. The web material is called *silk*, and is very similar to the silk produced by a silkworm. Spider web ***filaments*** are long protein molecules that are designed not to dissolve in water. In the human body, the material that causes a cut to stop bleeding contains the same protein.

Spider silk is much tougher and finer than silk made by silkworms. The silk from certain spiders is very strong. It is actually stronger than a steel wire of the same size. Scientists found that the dragline was especially strong and very fine. Instrument makers have used dragline thread as cross hairs in the eyepieces of scientific instruments.

Spiders, unlike the other arachnids, are beneficial to human beings by feeding on flies and other insect pests. Only a few spiders are harmful to humans. They include the tarantula, black widow and brown recluse.



The ***tarantula*** is a large, hairy spider. It is usually portrayed as a villain in movies. It looks fierce. Because it is so large, it photographs well. The bite is painful, like that of a bee sting but not poisonous. Very little evidence exists about its bite causing lasting harm to humans. Bites from black widows and brown recluse spiders, however, can lead to paralysis or death.

Martin, the captain of the Sequoia II cabin cruiser, told the assistant director, "They're with me."

The man waved his clipboard as he spoke to the boys, "We need more people for this scene. How would like to be in a movie?" He stretched out the word so it sounded like "moo-o-o-vie."

"Sure," Bryan and Tom agreed.

"What about me?" Del asked.

The assistant director wrote a note and gave it to Bryan. He pointed to a big tent and said, "Go to the wardrobe tent. You boys will need warrior outfits. The girl can dress as a peasant. She will be herding some ducks when the real action begins."

Life Principle

"The best way to stop big troubles is to begin stopping the little troubles."



—Anonymous

Lesson 15
Biology

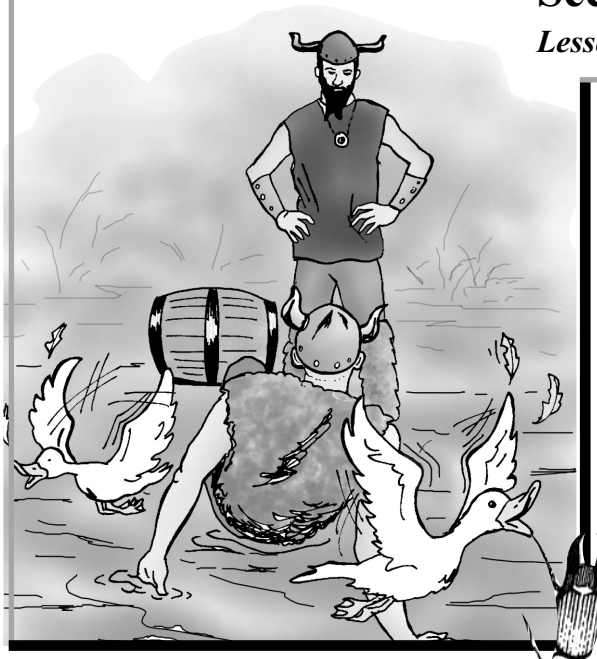
Chapter 4

Poisonous Spiders; Structure of Spiders vs. Insects; Insect Metamorphosis; Social Insects

Section 3

Lessons 11-15

SPIDERS AND INSECTS



The woman at the wardrobe tent said, "Shake out everything carefully. These costumes were stored in a warehouse in Georgia. Yesterday, we found a brown recluse spider in a pair of boots."

Del and the boys got into their costumes. When they reported to the set, the director told Tom, "You're going to be on the losing side of the discussion in the council house. You are to come through the door backwards, trip over the barrel and land in the mud. Your friend, Bryan, comes out and brushes his hands as if disposing of you. All right, let's try it. Bring on the ducks."

As instructed, Tom backed out through the door, crashed into the barrel and landed on his back in the street. Bryan stepped out, looking heroic, as if he had sent Tom crashing through the door. Del herded the ducks by so that they scattered in every direction when Tom came flying through the door.

The director said, "Tom, let's have you flip around so you land on your face in the mud."

After a half dozen tries, the director yelled, "This next one will be a take! Action!" Tom did the scene again. "Great," shouted the director, "That was perfect! End of rehearsal!"

At noon, Del and the boys were invited to eat with the cast and crew. The food was served on Styrofoam plates with cups carrying the name "Viking Quest". Bryan found himself beside a man who had been ignored all morning by the director and everyone else. Bryan asked, "Who are you?"

"I'm the writer," the man moaned. "The director has changed every scene! I spent months researching for the script to get it right. My research shows that one of the first Viking landings was somewhere in this area. Although five ships set out on that voyage, only four came back."

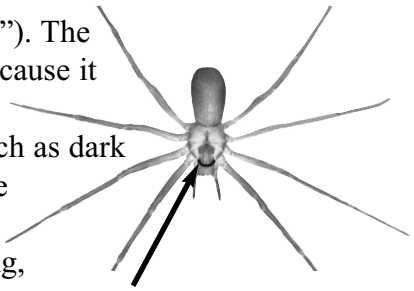
Bryan asked, "What happened to the fifth ship?"

VOCABULARY

Brown recluse: a small, two-tone brown spider with a tendency to stay hidden from view; the bite of the brown recluse can cause a substantial sore that heals only slowly and can lead to death

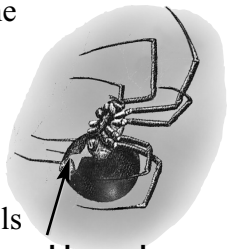
Black widow: a spider named after the fact that the female often attacks and eats the male after mating; the female black widow spider has a toxic bite; she has a glossy, black body with a red hourglass mark on the underside of the abdomen

The ***brown recluse*** spider lives in the central and southern United States. The spider is not large. With legs outspread, the largest ones are only about one inch across. A brown recluse does not have the fierce appearance of a tarantula. As its name indicates, the recluse is light brown in color. The spider's distinguishing mark is a darker, violin-shaped design on the upper back (thus earning it the nickname: "fiddleback"). The recluse is so named because it prefers dark areas away from activity, such as dark closets, wood piles, the backs of desk drawers or in little-used bedding, clothing or shoes.



The venom of the brown recluse has a delayed reaction. The venom attacks the walls of blood vessels around the bite and kills the tissue. A sore develops that grows larger and larger. It can become several inches in diameter. The wound may take months to heal. Sometimes it is fatal.

The ***black widow*** is another spider that is poisonous to humans. It has a smooth and shiny, jet-black body with a reddish hourglass-shaped mark on the underside of the abdomen. The female produces a venomous bite that can harm humans. She can grow to about one and a half inches long. The venom attacks the victim's nervous system, causing pain and swelling. The victim feels nauseous and has trouble breathing. Although the venom affects children more than it affects adults, most victims recover without any prolonged complications. The spider normally lives in out-of-the-way places and bites as a way of defense.



Spiders are not ***insects***, although both spiders and insects are arthropods. All spiders have eight legs. All adult insects have six legs. Spiders have no antennae. Insects have antennae. Their eyes differ, too. Insects have compound eyes. An insect eye is made of several lenses and light receptors that work

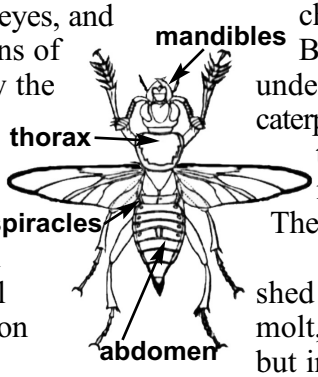
VOCABULARY

Insects: invertebrates of the arthropod phylum; adult insects have six legs, three body segments and usually two pairs of wings
Thorax: middle segment of an insect between head and abdomen to which wings and legs are attached
Mandibles: insect jaws that are designed for holding and biting food
Proboscis: the tube-like mouth parts of some insects such as flies, mosquitoes or "kissing bugs;" extended for piercing or sucking
Spiracles: openings in the exoskeleton on the abdomen of an insect; spiracles are breathing tubes
Larva: one of the stages in the life cycle of an insect; a larva hatches from an egg and usually has a physical appearance that is far different from the adult insect; many are wingless and worm-like; plural of larva is *larvae*
Metamorphosis: the change in form of an insect or other animal; the change of a caterpillar to a butterfly is an example of metamorphosis
Nymph: a larval form of an insect that has an appearance similar to the adult but usually without wings and incapable of reproduction
Pupa: the non-feeding stage of an insect in which the larva undergoes metamorphosis to change into an adult
Chrysalis (kris-al-is)***:*** the case or cocoon that contains the pupa; a protected stage of development
Entomology: the scientific study of insects
Social insects: insects that live in organized groups with individuals that have specialized functions; social insects include ants, termites and bees
Caste: rigid system of social distinctions and work divisions

together to form the complete image. The compound eye looks like a single structure with a honeycomb pattern. A spider has several eyes made of single lenses. The eyes of a spider are not together but are instead arranged in a pattern on the spider's head.

All spiders have two body segments, a head-thorax combination and an abdomen but adult insects have three body segments. The number of body segments is a good guide to whether an arthropod is an insect. Only adult insects have three body segments.

The three divisions of an adult insect's body are the head, ***thorax***, and abdomen. The head has antennae, compound eyes, and mouth. The antennae are organs of touch. The mouth reveals how the insect gets its food. Grasshoppers have mouths designed to eat grass. Beetles have sharp jaws, or ***mandibles***, that can catch and devour insects and other small invertebrates. Mosquitoes live on the blood of animals sucked through a long tube that pierces below the animal's skin. Butterflies have delicate ***proboscis*** tubes for sucking the nectar of flowers.



The thorax, or chest, of an adult insect serves as the attachment for wings and three pairs of legs. Insect leg and wing muscles are attached to the hard plates of the exoskeleton. Wings are made of the same material as the exoskeleton but are much thinner and crossed with veins.

The abdomen, the third part of the insect, has openings in the exoskeleton for breathing. The openings are called ***spiracles***. In female insects, the abdomen contains an egg-laying organ. The organ may also be capable of delivering a sting. The spider wasp uses its stinger to subdue spiders used for food. The wasp carries or pulls the stunned spider to a nest and deposits an egg on the living but paralyzed spider. After the egg hatches, the ***larva*** of the wasp dine on the spider's body.

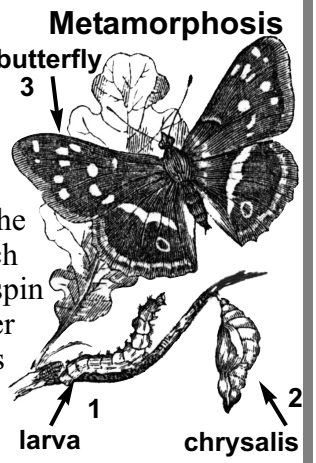


Some insects deposit eggs inside the stems of plants. The egg-laying organ is capable of cutting a slit or drilling into the plant.

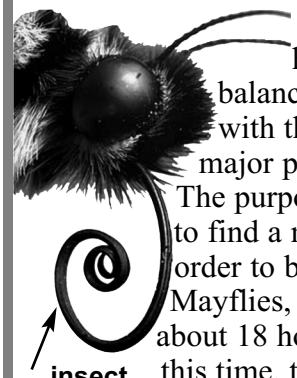
Insects go through a ***metamorphosis***, a distinct stage of development. In the case of some insects, the transformation is not particularly dramatic. For instance, a grasshopper egg hatches into a ***nymph*** that looks like an adult grasshopper. However, a nymph is wingless and cannot reproduce. As it grows and sheds the exoskeleton, the nymph emerges with wings. At the last stage, the nymph becomes an adult and can reproduce.

A butterfly has a more noticeable change during its metamorphosis. Butterflies begin as eggs laid on the underside of leaves. The eggs hatch into caterpillars, the larva stage. The larvae have tube-like bodies. The larvae of many insects are efficient eating machines. They can cause serious damage to crops.

As the larva becomes larger, it must shed its outer covering. It *molts*. At the last molt, the butterfly caterpillar does not emerge but instead becomes a ***pupa***. The pupa weaves a hard-shelled cocoon, or ***chrysalis,*** around itself. The chrysalis is a case that is designed to protect the pupa. Some insects such as the silkworm moth spin a silken chrysalis. Other insects have a chrysalis that is more like paper. The pupa appears to be resting, but enormous changes in its form are taking place. It is like a rebirth. Former characteristics are gone and all operations are new. After the last metamorphosis, an adult butterfly emerges from the chrysalis. The new creature has folded wings that soon spread to dry. In an hour or so, the wings are wrinkle-free and the butterfly is ready to fly, no longer earth bound. Its mouth no longer has biting parts. Instead, it is equipped with a coiled tube called a *proboscis* tube for sucking



nectar from flowers. Butterflies are changed in form (physically) and in behavior (socially). They associate with other butterflies, not larvae.


insect proboscis

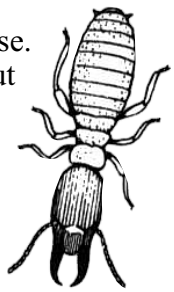
In nature, everything has a purpose and is balanced. (When man tampers with the balance of nature, major problems usually result.) The purpose of an adult insect is to find a mate and reproduce in order to become food for birds. Mayflies, for instance, live only about 18 hours as adults. During this time, they go without food until eaten by migrating birds or until death. Insects with short adult life spans have various ways to announce their presence to prospective mates. Fireflies use flashing lights on their abdomens.

Entomology is the study of insects. Insects include bees, ants, wasps, termites, grasshoppers, locusts, crickets, mosquitoes, beetles, butterflies, moths, flies and many others. Insects are the most numerous of the invertebrates. They are found in every type of habitat and climate throughout the world. They outnumber all other animals combined. About a million insects live on a single acre of land. Scientists have estimated that the total mass of all living insects is greater than the total mass of any other animal life.

Some insects are beneficial to humans while others are pests. In general, animals that are either a threat or a benefit to humans are the ones that are studied in detail. Bees, ants, locusts, termites and other insects such as mosquitoes and silkworms are well studied because they have such a direct impact on humans. Insects that do not have an impact on people usually are not as well studied, and much information still remains to be learned about them. The total number of insect species may be in the millions, although only about eight hundred thousand (800,000) have been studied in enough detail to be given names.

Locusts are well studied because they can destroy crops. Locusts are a type of grasshopper. They fly fast, eat a lot and are almost impossible to stop. In the Middle East (Egypt, Turkey, Iran, Arabia and other countries in that area), swarming locusts cause great damage to crops. Weather forecasts in farming communities in those countries give the latest information about swarms of locusts that are on the move. One of the major plagues recorded in the Bible refers to locusts which destroyed all edible vegetation in the Egyptian Nile River area.

Termites feed on cellulose, the organic material of plant cell walls. As animals, termites cannot digest cellulose; however, they carry certain bacteria in their stomachs that partially break down the cellulose. Termites do not like sunlight, but they do like humid air. They build homes in the ground or in wood that is sealed to trap moisture. Termites build tunnels to food sources. Because wood is mostly cellulose, termites can destroy the supports and flooring of homes that are made of wood. However, cedar and redwood are not susceptible to termite damage.


termite

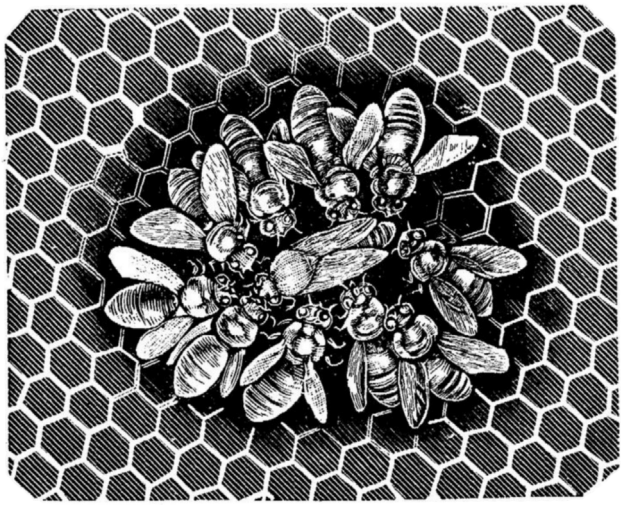
Termites are ***social insects***. They live in organized groups or colonies in a three-level ***caste*** system: royalty, soldiers and workers. Termites have a division of labor in which the adults have different physical characteristics, depending on their duties within the society. Some termites, for instance, digest food and then pass it on to other termites that do not have digestive bacteria in their stomachs. Termite workers dig tunnels and carry in food; and soldier termites protect against invaders such as ants. Nurses take care of eggs and larvae. Only the king and queen are designated for reproduction at the rate of 30 to 80 thousand eggs a day for decades. Other social insects include bees and ants.

Ants have always been a model of hard work and perseverance in the face of adversity. They find a way to get the job done. A Middle Eastern proverb states, “Go

to the ant, you sluggard (lazy person); consider her ways, and be wise." Ant colonies operate on a caste system: queens which lay all the eggs, males which contribute sperm to the queen (and die shortly thereafter), and workers (including soldiers). Ants are fearless. They tackle jobs that seem beyond their abilities, like moving objects many times their own size, and work until the task is completed.

Animals, including ants, cannot think as do humans. Instead, their behavior is programmed. For example, ants collect and store food for the winter in harsh climates when a daily supply might not be available. Ants also communicate well with each other. Ants and other social creatures work together for the good of the colony. Humans can learn many lessons by studying creatures of nature.

Honey bees are another hardworking class of social insects. When people rush about to complete a task, they are observed to



be as "busy as bees." A beehive is an intensely organized place with three castes, or social levels of bees. One large queen rules the hive while laying more than twice her own weight in eggs each day. The large drones (males) provide air conditioning by whirring their wings rapidly at the entrance to the hive. The worker bees (females) are the smallest occupants of the colony and do most of the work. They maintain police patrols and sanitation squads in addition to flying many miles per day to gather nectar from flowers to make honey. Bees perform a little dance to communicate to fellow workers the direction and distance of the latest nectar finds. A honeybee lives about four to six weeks, flies hundreds of miles and gathers enough nectar to produce only ½ teaspoon of honey! Bees model responsibility, hard work and dedication to purpose.

The scriptwriter said, "I think the captain of the ship died. If he died at sea, the crew probably set the ship afire and burned it. If the captain died after the ship anchored near land, another possibility is likely. The crew would have placed the captain's body and all of his possessions on the ship; then, the crew would have dug a pit. The ship and captain would have been packed in clay and buried in the pit. Did you know that clay is a good preservative of wood?"

Bryan, Tom and Del were listening intently.

"It's a fact," the writer continued, "If that ship were buried in clay on land, then it should be perfectly preserved. Imagine, a Viking ship exactly as it was built when it sailed from Scandinavia!"

Life Principle



"Human 'worms' can become 'butterflies' as their lives are redirected toward loftier goals."

—N. S. Johnson