Science Concepts And Tools Handbook

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Nature of Science

Scientific Processes & Practices

A scientist is a person who studies many different things about the world and universe. Scientist conduct research in the laboratory and out in the field.

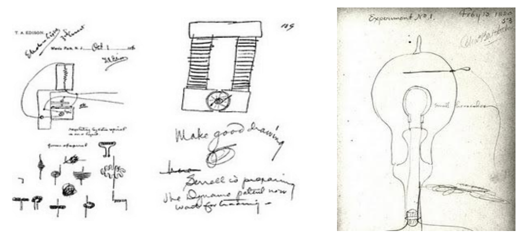
Scientists ask questions, formulate a hypothesis based on what they already know, and choose the right equipment and technology for their investigation.

Scientists collect information through detailed observations and accurate measuring.

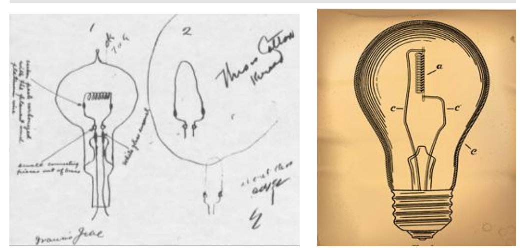
They analyze and interpret the information to form reasonable explanations from direct (observable) and indirect (inferred) evidence.

Scientists conduct repeated trials of their investigations to increase the reliability of their results.

Scientists communicate their conclusions in written and verbal form. They use graphs and charts to see relationships and organize data.



Thomas Edison tried out many different DESIGNS before perfecting the light bulb in 1880.



Scientists evaluate and critique scientific explanations using evidence, logic, observational testing, and critical thinking. Do you have the skills it takes to be a great scientist?

Direct evidence is a first-hand observation that proves whether a claim is true or correct.

Indirect evidence is based on available evidence but cannot be observed directly.

Scientific Tools and Instruments

Timing Devices

Clocks are used to measure and display time.

Stop watches are used to measure an exact duration of time.

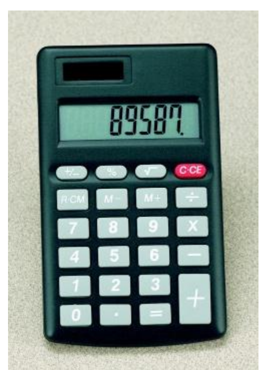
Collecting nets are used to collect samples of animal or plant life.

Hand lenses are used to observe details of materials and observe objects closely.

A **microscope** is used to observe objects too small for the eye to see.

Metric rulers are used to measure the length of items using SI units such as millimeters (mm) or **centimeters (cm).**

Meter sticks are used to measure the length of items using SI units such as millimeters (mm), centimeters (cm), and meters (m).



Calculators are used to do mathematical calculations.

Celsius thermometers are used to measure temperature in degrees Celsius.

A **spring scale** is used to measure weight in metric units such as milligram (mg), gram (g), and kilogram (kg).

A **triple-beam balance** is used to measure the mass of an object.

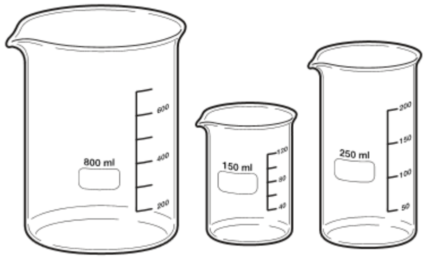
A double **pan balance** is used to compare the mass of an object to a known mass using metric weights.

Magnets are used to test the magnetism of different metals and metallic mixtures.

A **hot plate** is an electric appliance used for heating materials.

A **notebook** is used to record data gathered in a scientific investigation. Notebooks often include pictures, diagrams or technical drawings, and research notes.

A **graduated cylinder** is used to measure liquids in metric units such as milliliters (mL) and liters (L).



Beakers are used to measure and mix liquids.

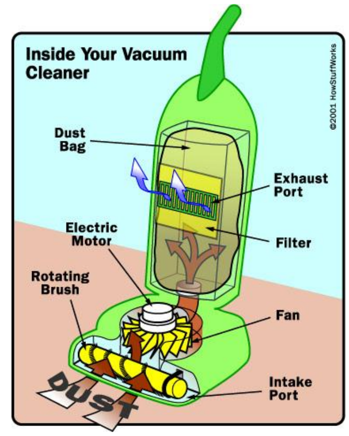
A **wind sock** is used to show the direction and speed of wind.

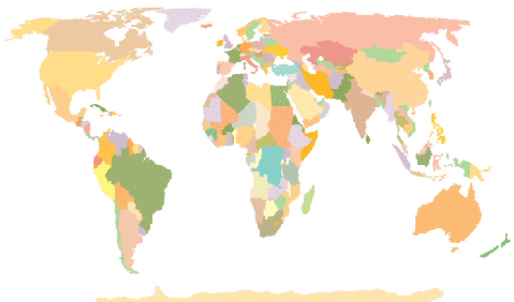
A **wind vane** is used to show what direction wind is coming from.

Safety goggles are used to protect your eyes when working with potentially harmful substances.

A **compass** is used to find the direction in relation to the North Pole. Since Earth acts like a giant magnet with two poles, the needle in the compass always points towards the north.

A **model** is a picture, idea, or object that represents an object or process. Scientists use models to show how something works or what something looks like. An example of a model is the diagram of the vacuum cleaner showing how it works. Models have limitations because they are not the "real thing." For example, in a model of a home electrical system you might be using a 9 volt battery to represent the 110 volts of electricity that flow through your house.





A *map* is a model of all or part of Earth's surface.

A *globe* is a 3D model of Earth, and often includes natural and man-made boundaries and physical features such as mountain ranges.

Diagrams or *technical drawings* are graphic models of data collected by scientists. Labeling parts of a diagram helps to make the information clear. Some examples of this include the picture of the flower and the universe below.

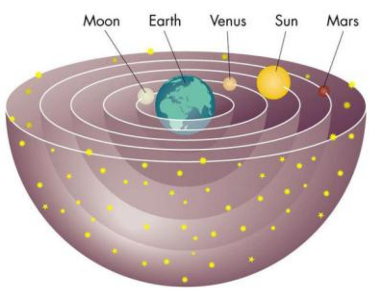


Diagram of the universe

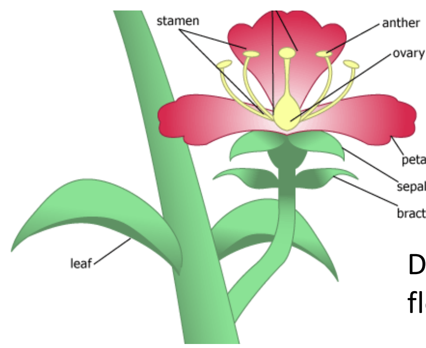


Diagram of a flower

Aquariums and *terrariums* are models that allow us to observe the habitats of organisms.

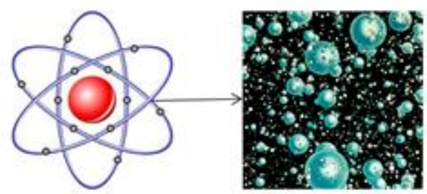
Aquarium

Terrarium

Matter and Energy

Physical Properties

boiling point	insulate	pan balance
Celsius scale	liquid	relative density
density	mass	solid
dissolve	matter	solubility
freezing/melting point	mixture	solution
gas	physical property	triple-beam balance
graduated cylinder	magnetism	



Everything around you – a desk, a chair, rain, your body, the air – is made of matter. **Matter** is anything made up of atoms and molecules which has mass and takes up space.

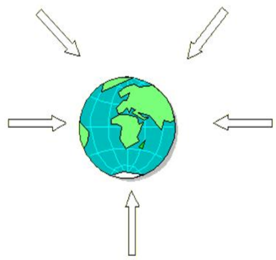
Matter is described by its physical properties. A **physical property** is something that can be observed, measured, or changed without changing the substance itself.

Mass

Mass is the amount of matter contained in an object. A real car has much more mass than a model car because it is made out of more matter. In science, mass is measured in grams or kilograms.

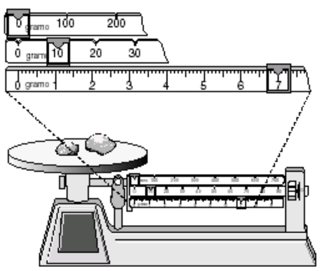
FACTOID:

One gram is equal to the amount of matter in one cubic centimeter of water.



Weight is the amount of force on an object due to gravity. Mass and gravity are often confused with each other. A human might have a mass of 68 kilograms on Earth but will have a weight of 11.3 kilograms on the Moon. On Earth, weight is directly proportional to mass so the human will weigh 68 kilograms. Because mass and weight are similar on Earth, a variety of tools can be used to measure it.

You can measure the mass or weight of something using different types of tools.



A **triple beam balance** is used to find the mass of an object.

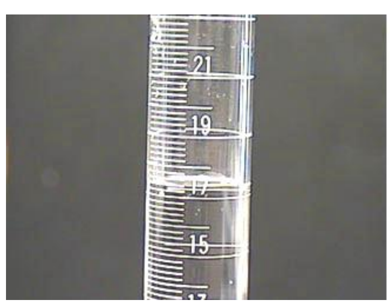
A double **pan balance** compares mass to a known

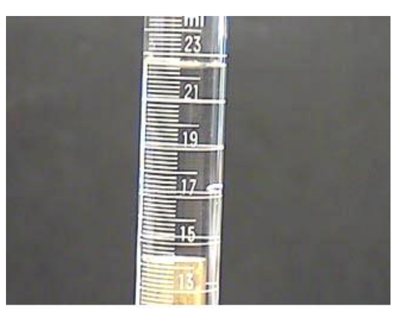
A **spring scale** measures the force of gravity on an object to find its weight.

Volume

Graduated cylinder

Volume is the amount of space that a substance occupies or takes up. The volume of a liquid can be measured using a **graduated cylinder**. Graduated cylinders can also be used to measure the volume of a solid, such as a wood block or a coin, through a technique called water displacement.





Measuring the Volume of a Solid

First, record the amount of the liquid in a graduated cylinder. In this example, the cylinder contains 17 mL of water.

Second, place the object in the water, and record the new volume.

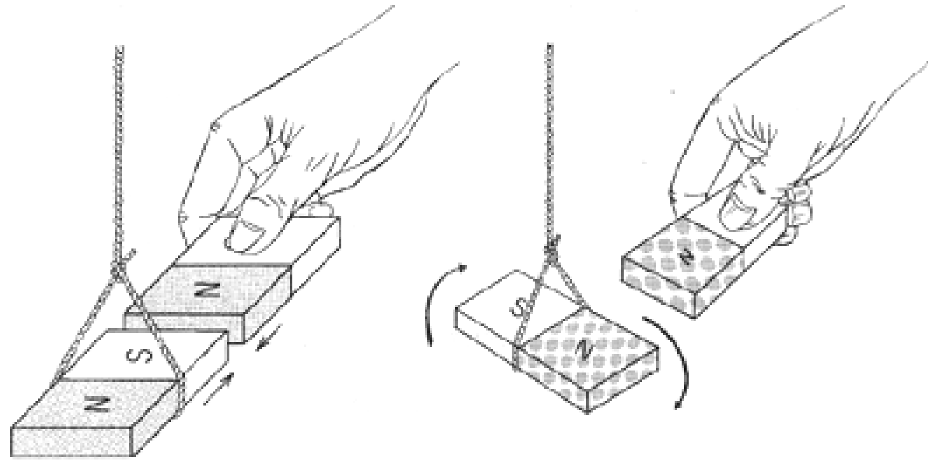
Third, subtract the original measure of water from the new measure to find the difference.

In this example, the water level rose to 23 mL, so the wood block has a volume of 6 mL.

Magnetism

Magnetism is a property that identifies if a materials responds or does not respond to a magnetic field.

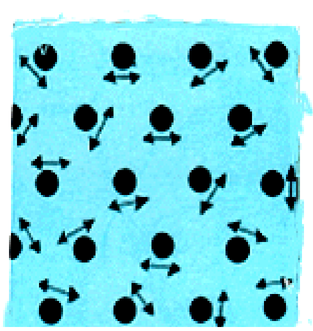
A magnet is composed of metals or metallic substances such as iron that attracts or repels other magnets. Non-magnetic substances such as paper, wood, and plastic do not attract or repel magnets.



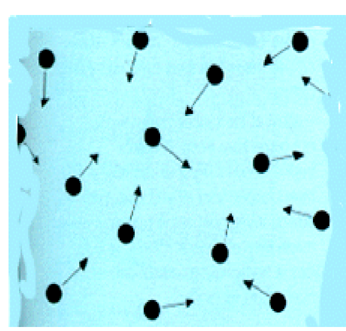
Magnets have two poles, one north and one south. Opposite sides attract each other and make the magnets stick together. Poles that are the same repel and push each other away.

Physical State

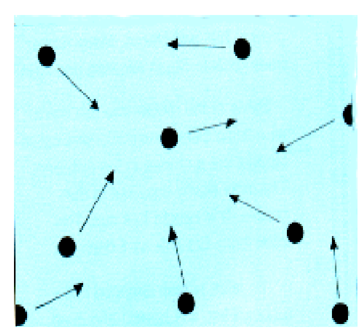
Matter can exist in different forms, or states. The three main states of matter are solids, liquids, and gases. Matter can change states when it absorbs or loses energy. For example, an ice cube left out in the Sun absorbs the Sun's energy and changes from a solid to a liquid. If more energy is added to the water, it will change states again and become water vapor, a gas. If energy is removed by reducing the temperature below freezing, water in a liquid state will turn into ice.



Particles in a solid



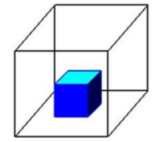
Particles in a liquid

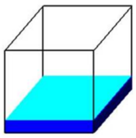


Particles in a gas

During each of these three states, the particles in a substance have different relationships to each other.

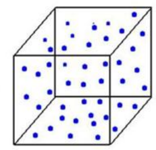
A **solid** is a substance with a definite shape and volume. The particles are tightly bound together which is why solids do not change their shape or volume when placed in another container.





A **liquid** is a substance that has a definite volume but takes the shape of its container. A liquid has a defined volume but not a defined shape. If you pour water into a glass, it will take the shape of the glass. If you pour water into a bucket, it will take the shape of the bucket.

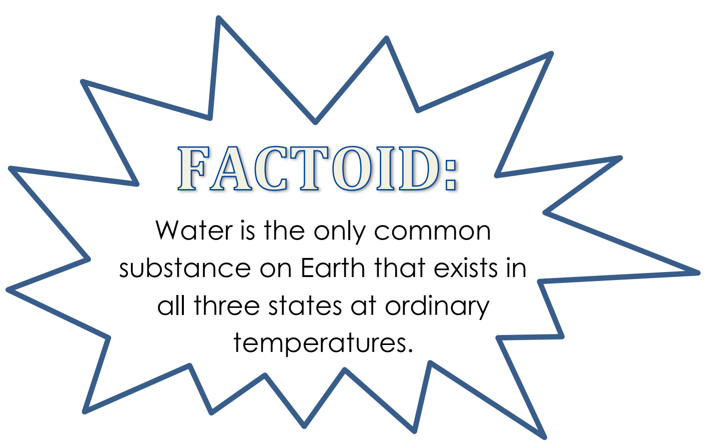
A **gas** is a substance that takes the shape and volume of its container. Gases spread out to completely fill a space.



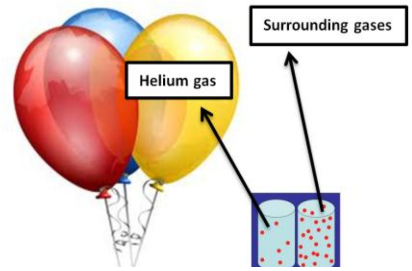
In summary:

State	Description
Solid	Has a definite shape and a definite volume
Liquid	Has a definite volume but takes the shape of its container
Gas	Takes the shape and volume of its container

These changes of state can be observed in the *water cycle*. When water evaporates from bodies of water (lakes, rivers, oceans), it changes from a liquid to gas. As water particles rise into the atmosphere they lose energy and goes through condensation, changing back to liquid and falling to the ground as precipitation (rain, snow, hail). If the temperature is below freezing, it can fall to Earth in the form of sleet or snow.



Relative Density



The helium gas inside this balloon is less dense than the gasses in the atmosphere, so it floats upward. A balloon filled with regular air has the same density as the surrounding air and does not float.

Density is a property of matter. Density is the amount of mass in a known volume of an object or substance. It's the concentration of matter. A shoebox filled with sand would be denser, or more concentrated, than a shoebox filled with ping pong balls.

Relative density is a comparison between the densities of two substances. A liquid that is less dense will float in a more dense liquid. For example, water is more dense than oil, and sinks to the bottom of a container, while the oil will float on top of the water.

Mixtures, Solutions, & Solubility

This snack mix is a mixture. Substances can be easily separated.

A **mixture** is a combination of two or more pure substances. Mixtures can be easily separated by physical means using density, magnetism, size, or other properties.

- A mixture of iron particles in sand can be quickly separated using a magnet to attract the iron particles away from the sand.
- A colander or filter can separate solid particles (like sand) from liquid particles (like water) in a sand and water mixture.
- Density can be used to separate an oil and water mixture by allowing the mixture to settle and pouring off the oil from the water.
- A saltwater mixture can be separated into salt and water by heating water to speed up evaporation, leaving the salt behind.

In all of these examples the separate ingredients keep their same physical characteristics they had in the mixture.

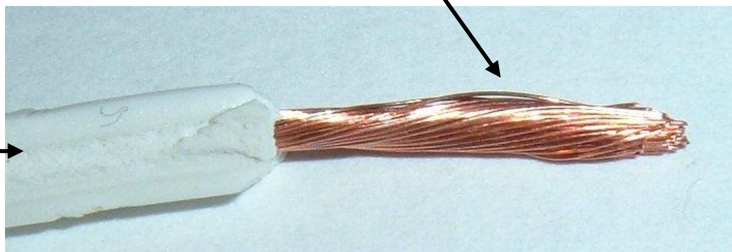
A **solution** is a mixture of two or more substances, combined together so that the individual substances cannot be easily identified. A solution can be a solid, liquid or gas. An example of a solution is mixing sugar and water together. The result is a clear, sweet liquid.
The measure of how much of one substance will dissolve in another substance is **solubility**. If you poured similar amounts of salt and sugar into two different glasses of water, more of the sugar would dissolve into the water than salt. Thus sugar is more soluble than salt in water.

Conductors & Insulators

Matter is made up of particles that are always moving. Conductivity is a property of matter that measures how well energy flows through a substance. A **conductor** is a material that allows energy, such as heat, electricity, or sound, to pass through it easily. Some substances can conduct or carry electricity better than others.

A metal wire is a good conductor of electricity, but the plastic that covers it is not. Electrical cords and wires are covered by a plastic material to protect you from being shocked.

electricity **conductor** – Strands of copper wire easily transmit electricity



electricity **insulator** – Plastic or rubber jacket coating the wire prevents electron flow

An **insulator** is a material that does not let energy pass through it easily. Plastic, rubber, and glass are commonly used as insulators.

Oven mitt

Some materials are used to conduct (transfer or move energy) or **insulate** (prevent energy from traveling) **heat** energy. Many cooking pots are made of metals like copper or aluminum that move the heat quickly from the stove to whatever you are cooking. Oven mitts are made of thick bundles of cloth or silicone, which insulate your hand from being burned.

Some materials are used to conduct or insulate **sound** energy. Sound travels in waves through gases, liquids, and even solids. Sound waves move very fast in hard, solid materials because the particles are so closely connected. Sound travels the slowest in gases like the air. Thick layers of low-density material like rubber foam are often used in studios to insulate microphones from picking up unwanted sounds.

Melting Point, Freezing Point, and Boiling Point of Water

Water's freezing point is the same as its melting point.

The **melting point** of water is the temperature at which water changes from a solid (ice) to a liquid.
This change happens at 0° Celsius.

The **freezing point** of water is the temperature at which water changes from a liquid to a solid (ice).
This change also happens at 0° Celsius.

Ice melts at 0° Celsius and water freezes at 0° Celsius.

The **boiling point** of water is the temperature at which water changes from a liquid to a gas.
Water has a boiling point of 100° Celsius.

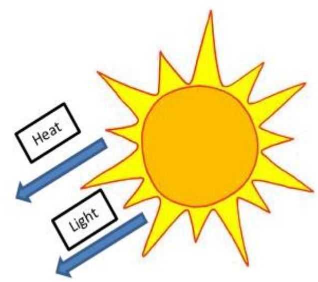
Water boils at 100° Celsius.

Forms of Energy

circuit	heat	refraction
current	light	sound
electricity	mechanical energy	thermal energy
energy	reflection	

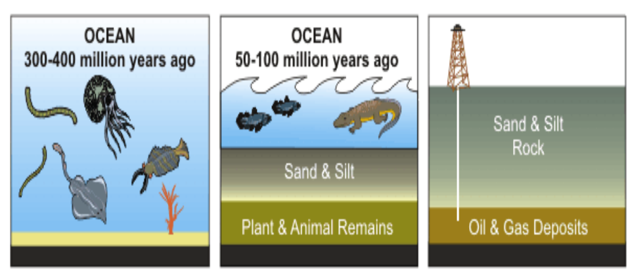
Energy is all around us in many forms and can be used or saved. We need energy to move and/or change matter. To scientists, **energy** is the ability to do work.

Every living thing needs energy to live. We have life on Earth because of the Sun's light and heat energy. Without the Sun we would not have plants or animals. The Sun gives organisms the energy to live, directly or indirectly, and is the source of almost all our energy resources.

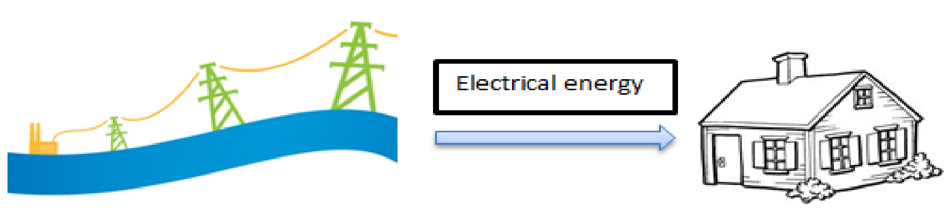


When you watch television, you are indirectly using solar energy. It happens like this:

- Millions of years ago, plants used light energy from the Sun to make food and grow. Animals ate these plants and other animals.
- Dead plant and animal material were buried by layers of sediment. Over millions of years of heat and pressure, their remains turned into fossil fuels. Energy from the plants and animals was stored in fossil fuels.

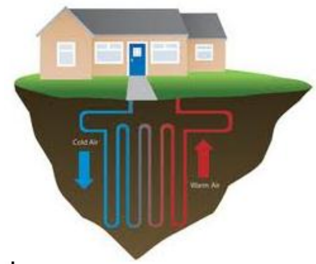


- When fossil fuels are burned today, they release stored energy as heat. Power plants use the heat energy to generate electrical energy.
- Electrical energy moves from power plants to our homes. When someone turns on a television, electrical energy is changed into light and sound energy.



Thermal (Heat) Energy

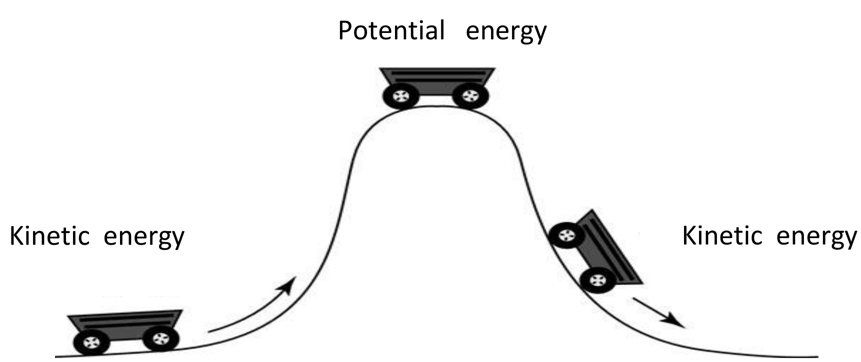
Thermal energy, also called **heat energy,** is the amount of energy in moving particles of matter. Heat from inside the Earth can be trapped and used to create other sources of energy. Since there is steam and hot water deep underground, wells can be drilled to bring them to the surface to run electricity generators. The steam goes directly into a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine.



The pressure of the hot steam coming out of the ground (above, left) can be used to turn the turbines and generators (above, right) and produce electricity without contaminating the air. The movement of the turbine uses mechanical energy to create electrical energy.

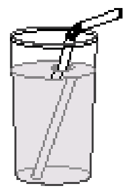
Mechanical Energy

Anything that is moving has energy. Energy is the ability to do work. Energy can be stored to use later. For example, when you stretch a spring, you give it energy that it stores as potential energy. When you let go of the spring, the energy is converted to kinetic energy, the energy of motion. When you compress a spring, the energy is stored. When the spring is released, the energy is in motion. This form of energy is called **mechanical energy**.



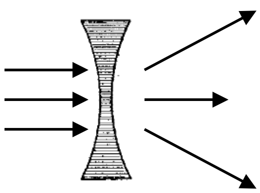
Light Energy

Light is a form of energy that travels in waves. Light waves travel in straight lines, faster than anything in the universe. Light can travel through space, whereas sound cannot. The waves can travel through certain types of matter, such as air, glass, and water.

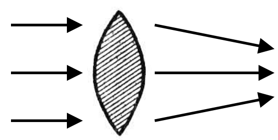


Refraction occurs when light passes from one type of matter to another type at an angle and the light bends. We can see because our eyes can refract (bend) light with the curved lens in the front of our eyes. You can observe refraction when you place a straw in water. The straw appears to magically bend.

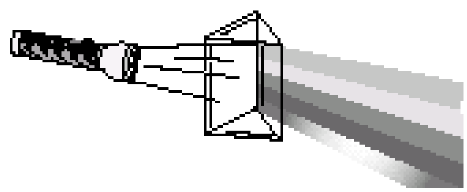
Lenses are used to refract light in different ways for different purposes, such as magnifying or focusing.



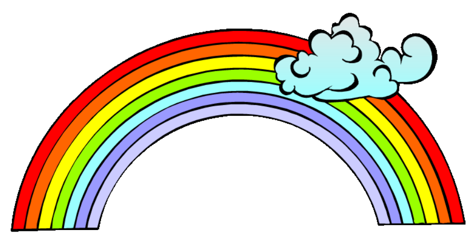
A *concave* lens curves inward; the outer edges are thicker than the inner lens. The light bends out towards the thicker part of the lens.

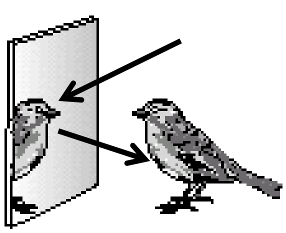


A *convex* lens curves outward; the outer edges are thinner than the inner lens. The light bends in towards the thicker part of the lens.



Other examples of refraction include a rainbow and a prism. As light travels through a prism, the different wavelengths of light separate into all the colors of the visible spectrum.

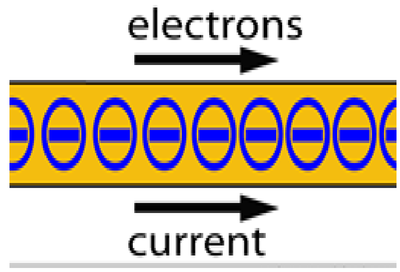


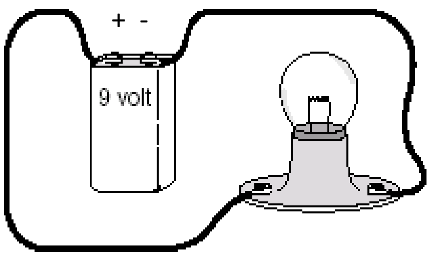


Reflection occurs when light bounces back from a surface. The rays of light bounce off the surface at an angle. If the surface is a highly reflective metal, such as polished silver, then the object reflected can be seen very clearly. Mirrors are made by covering the back of a sheet of glass with reflective metal.

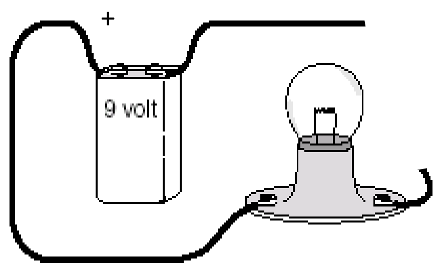
Electrical Energy

Electricity is a form of energy that is produced when electrons move from one place to another. Electricity moves through materials that are conductors, or materials that allow electricity to pass through them easily. **Current** is a constant flow of electrons through a conductor, similar to a flow of water through a pipe. A current moves through wires only when wires are part of a circuit. A **circuit** is a complete path of conductors that an electric current can flow through.





In this *closed circuit*, electricity goes from the positive to the negative battery terminal, turning on the light bulb.



In this *open circuit*, the light will not go on because the flow of electricity is not going through the whole electrical circuit.

When you plug a television into an outlet, you make a closed circuit. The wall outlet is the source of electricity for this circuit.   Electric current travels from the outlet, through the wires in the television's cord to the television, and back again, making a complete path. Unplugging the device breaks the path, making an open circuit.

An **electromagnetic field** is a combining of an electric field and a magnetic field. In the picture below, the closed circuit is the electric field. When a nail is added to the closed circuit, the nail becomes magnetized and acts like a weak magnet. The magnetized nail is called an electromagnet.

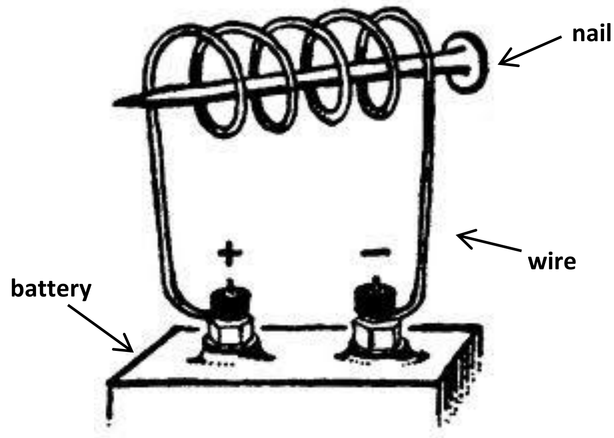


Diagram of an Electromagnet

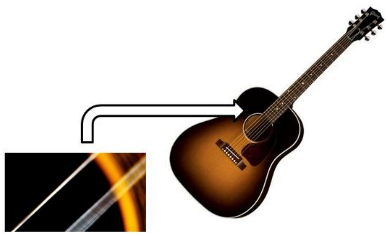
Electromagnetics convert mechanical energy into electrical energy. When driving around in a car, electromagnets are charging the car's battery. Electromagnets are also used in power plants to convert the moving of turbines by wind or water into electricity which we use in our homes.

FACTOID

Electrical energy can be converted into other forms of energy such as light, heat, sound, and even mechanical energy!

Sound Energy

Sound is a wave produced by vibrating objects that can travel through solids, liquids, and gases. Sound energy is the form of energy that comes from vibrations. Every sound comes from a vibrating object. When you talk, your vocal cords vibrate from the air moving out of your lungs, producing sound.



Guitar strings

Sound begins with motion. When you play a guitar, the strings move.

When you hit a drum, the drumhead moves up and down. This is a back and forth movement called *vibration*.

Speed of Sound

Material	Speed (m/s)
Air	340
Water	1,500
Wood	4,200
Iron	5,100

Look at the table above. What do you think a material's density has to do with the speed at which sound travels through it?

FACTOID:

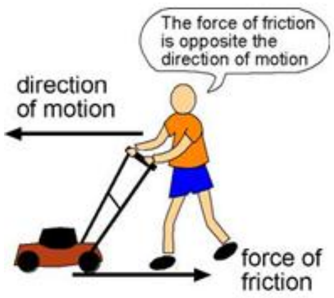
Sound waves cannot travel where matter does not exist.

Force, Motion, and Energy

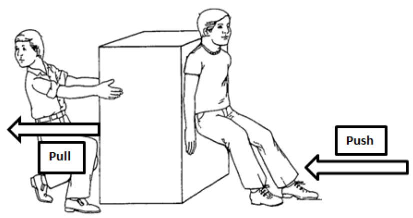
Force and Motion

force friction	gravity magnetism	motion work

Any object that is moving will keep moving until a force slows or stops it. Usually, that force is **friction**. Any object that is not moving will stay still until a force sets it in motion.

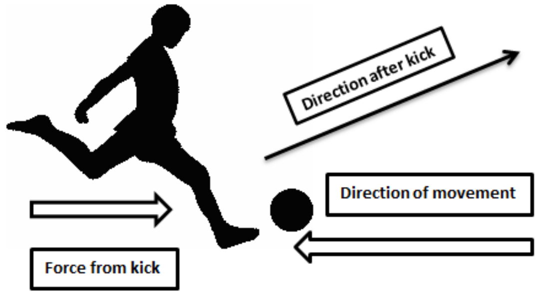


Use the Force



Force is a push or a pull on an object. It takes a force to move something made of matter. Some examples of how forces can cause motion are pulling or pushing a cart, kicking a soccer ball, or sliding a book across a desk.

A force can also stop something in motion. It can change the direction of a moving object. For example, when you catch a baseball, you are using force to stop the ball's motion. When you kick a ball with your foot, you are using force to change the ball's direction.



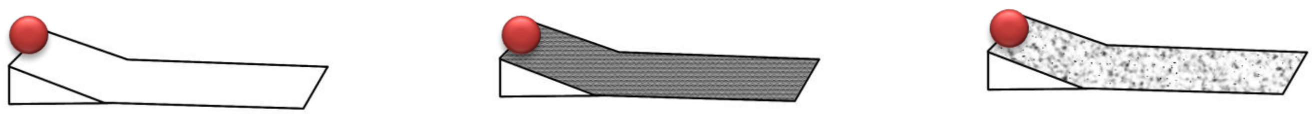
Some forces you might be familiar with are magnetism, friction, and gravity. **Magnetism** is the force of pushing or pulling between poles of magnets. Even Earth can be considered a magnet, which is why a compass needle lines up with Earth's magnetic poles. **Friction** occurs when opposite forces act against each other, such as rubber tires on a concrete surface. **Gravity** is the force that pulls all objects in the universe toward each other.

Experiemental Design

You can design an investigation to test how different or unbalanced forces change the speed or direction of an object in motion or at rest.

You might wonder or question how the force of friction from different surfaces such as carpet, sandpaper, or metal affects the movement of a rolling ball. Drawing on prior knowledge, you form an educated guess about the outcome of the experiment, called a hypothesis. You might hypothesize, based on what you know about friction, that the ball would roll with the least resistance down metal, then carpet, and finally sandpaper.

Next you might design the experiment, being careful to test, or change, only one manipulated variable. In this experiment, a ball will be rolled down a ramp and the total length of the roll will be recorded. The one thing changed for the repeated trials is the ramp surface. In this case, the manipulated variable will be the three surfaces with different amounts of friction – metal, carpet, and sandpaper.



metal ramp **carpet ramp** **sandpaper ramp**

All elements of this experiment are the same, except for one variable being tested: the surface of the ramp.

Every other part of the experiment should stay the same. The controlled variables are things that might change the outcome, or responding variable. The responding variable measured in this experiment would be the total distance the ball rolls. In order to isolate or test only the manipulated variable, we must make sure each controlled variable is the same for each trial. In this experiment, the controls include the kind of ball, the ramp height and length, and the ball release position.

During the experiment, each roll is tried several times and measured in the same way. Using an average of repeated trials helps rule out accidental variables and helps increase the reliability of the results. After the trials, the data is collected, analysed, and shared.

Wordology

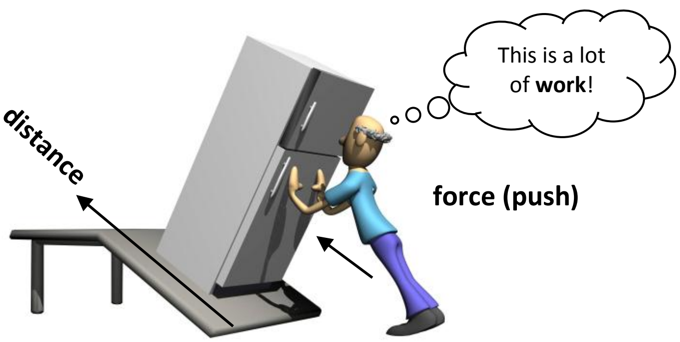
manipulate	to handle or control
variable	something that changes

Work

An object that is sitting still will stay that way until a force, such as gravity or friction, makes it change. **Work** is when a force is used to move an object. Movement, or **motion**, is a change in an object's position. Work is calculated by how much force it takes to move an object a certain distance.

What other forces are affecting this scene?

Do these forces make the work easier or harder?



A **force** acting on an object can have an observable effect – objects that are pushed or pulled may change their position, they may speed up or slow down, or they may change direction.

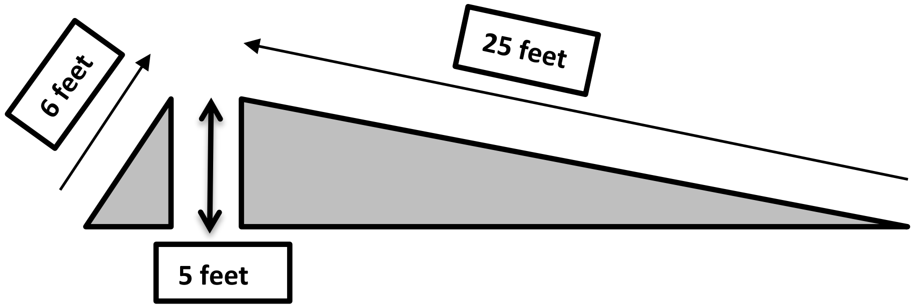
This wagon will not change its position until a force makes it change. Someone might push or pull the wagon, using force to change its position.

The wagon is at rest. The forces acting on it are *balanced*, so it does not move.

Pushing the wagon creates *unbalanced* forces, so the wagon moves in the direction of the largest force.

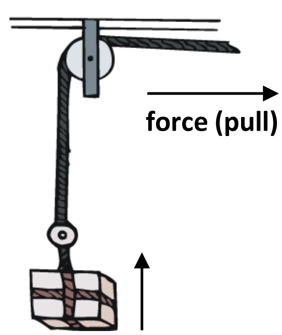
Pulling the wagon creates *unbalanced* forces, so the wagon moves.

The amount of force needed to do work goes down as the distance the force is used increases. It is easier (requires less work) to move an object up a longer ramp than a shorter ramp. The longer ramp requires less force to push a box up to the same height as the shorter ramp.



A ramp is an example of a simple machine. Another example of a simple machine is a pulley. A pulley is a wheel with a rope wrapped around it which is used to lift heavy objects. Because using a pulley requires less force than lifting an object directly, it makes work easier.

Example of a pulley



Earth's Changing Surface

canyon decomposition delta deposition earthquake	erosion eruption fossil fuel landslide sand dune	sedimentary rock soil weathering wind

The surface of Earth is always changing. Earth's natural cycles and processes, like the movement of wind, water, and ice, or the force of gravity, earthquakes, and volcanoes, can cause these changes. Some of the changes happen quickly, and some of them happen very slowly. Wind and rain might wear down a mountain, carry the rocks and soil away in a river, and drop the material in a new location over many thousands or millions of years. A volcanic eruption can form new land or islands within a few hours or days.

How has the flow of water changed these rocks over time?

Weathering, Erosion, and Deposition

Weathering changes landforms by wearing them down and breaking them into smaller pieces. What caused weathering of these rocks? When the pieces broke off, where did they go?

Landforms are made up of smaller pieces, just like living things. The force and movement of wind, water, or ice can wear down large rocks into smaller, smoother landforms. The process of wearing down or breaking rock into soil, sand, and other tiny pieces is called **weathering**.

These small pieces of rock, soil, or sand can then be moved to a new location. Using water, wind, ice, or gravity, **erosion** carries weathered materials away from a place. **Deposition** is the process of depositing the weathered material in a new location.

Changes Create Landforms

Think about a river flowing through a deep and narrow valley, or **canyon**. Over time, the flowing water weathers the sides of the rock as the force of water breaks off tiny particles. Erosion happens as the river picks up the pieces and carries them downstream. Finally the particles of rock and sand are deposited into a **delta**, a large flat area of land at the mouth of a river, where the water flows into the ocean. The sediment that spreads out to build the delta landform was worn away from the canyon.

A canyon has steep, rocky walls. What did it probably look like millions of years ago?

Sand dunes occur in dry, arid deserts or near coastal areas. Which side of this dune do you think faces the wind?

Wind and water may break down mountains, canyons, hills, and rock formations, but they can also build new landforms. **Sand dunes** are large deposits of sand or gravel that were built by the flow of wind or water.

Sand dunes usually have a long, inclined side facing the direction of the wind, and a short, steep side that drops into the lee, or the side protected from the wind.

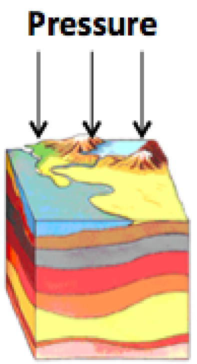
Rapid Changes

In addition to building up or breaking down new landforms over a long period of time, some natural events cause rapid changes to Earth's surface. During a volcanic **eruption**, melted rock from under Earth's crust, called *magma,* is suddenly released to the surface. The hot, liquid-like rock (called *lava* on the surface) builds up new layers of rock as it pours out, then cools and hardens in the air or water.

Earthquakes are caused by the shaking from rock slabs moving against each other deep below Earth's crust. An earthquake can trigger a **landslide**, the sudden downhill movement of a huge mass of rock, soil, and mud.

Ocean islands are still being formed today by active volcanoes. Where on a world map would we expect to find these growing islands?

The Formation of Sedimentary Rock

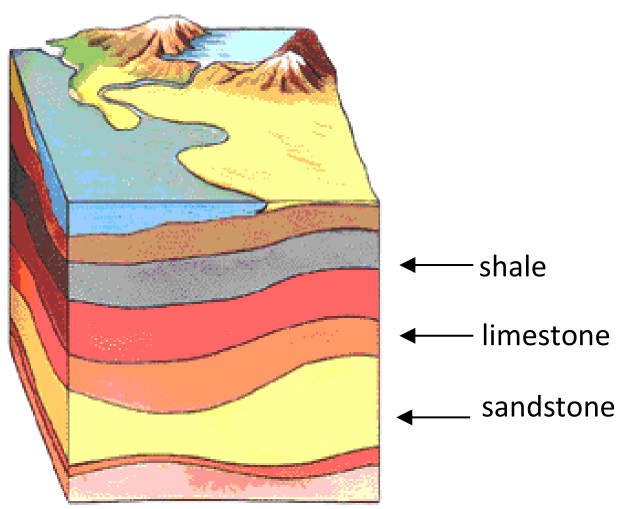


Sediment, or small bits of rock and soil, even shells, bones, and plants, can become new kinds of rock. **Sedimentary rock** is formed when sediments are pressed and cemented together. Compaction takes place when the pressure of newer layers presses together the layers below. Then, sediments are connected during cementation, when minerals in the rocks and water form new crystals that join sediments.

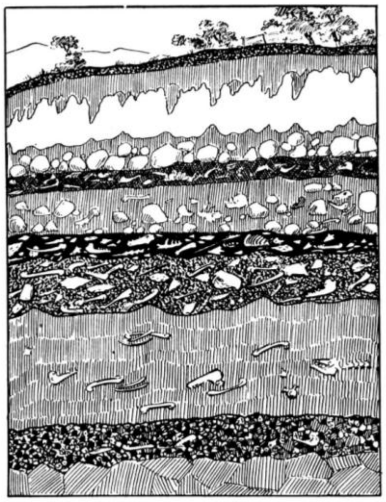
The Earth's surface is made of many layers. The newer layers are deposited on top of older layers. Scientists can determine what happened on Earth by studying different rock layers. When viewing an undisturbed rock bed, the oldest layer is on the bottom, and the newest layer is on the top.

In this figure, the oldest rock layer is made of sandstone, followed by limestone (where fossils are often found), then the newest layer made of shale.

Most fossils found in the limestone layer are similar to the animals that live in the ocean today. This shows that a shallow sea probably covered the area where they were found millions of years ago. Scientists can use fossils to match rock layers from different areas and to understand past changes in climate.



Fossil Fuels



The heat and pressure from upper layers may cause a chemical change in plant and animal remains after millions of years.

The remains of plants and animals are also deposited in layers at the bottom of swamps, lakes, and oceans. The dead plants and animals go through **decomposition**, the decay of organisms into simpler forms of matter. As new layers are built on top of the remains, great heat and pressure change the leftover carbon and hydrogen from dead organisms into **fossil fuels**. Coal, oil (petroleum), and natural gas are fossil fuels that are burned as a source of heat and energy.

Coal

Natural gas

Oil

Soil

Soil, loose material made of rock, minerals, and organic matter, covers almost all of the Earth's land. Even though it is a renewable resource, some soils take about 1,000 years to make one inch of soil.

Properties of Soil

Soil is made up of four different materials:

- *weathered rock* that contains minerals
- *humus*, the decayed or rotting parts of once-living things
- *air*
- *water*

Examining the color is one way to identify and classify types of soil. Soils that are rich in organic material, such as humus, will look darker and blacker than soils that are mostly made of rock and minerals. Soils that are red may have formed from iron-rich sediments.

The top, very dark layer of soil is humus. It is made of the decomposed organic matter, and is very rich in nutrients such as carbon. Why would these materials be found close to the top layer of soil instead of at the bottom?

Another property of soil is texture, the way the soil feels. Soil texture depends on the size and types of particles in the soil. There are three main types of particles in soil – sand, silt, and clay.

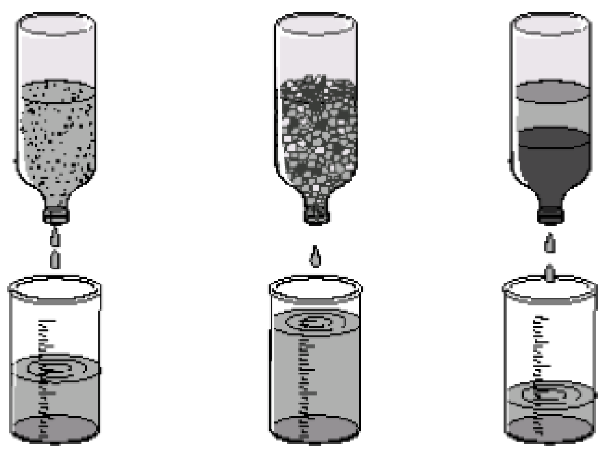
- *Sand crystals* are the largest particles and feel very gritty. Soil with a lot of sand is usually light in color and does not stick well when wet. Sand is usually dry and does not have many nutrients.

- *Silt* is composed of medium-sized particles that feel soft, silky, or like flour.

- *Clay* particles are the smallest in size and feel sticky and hard to squeeze. Different minerals give clay various colors. Dry clays are very hard, and wet clays are soggy.

Capacity to Retain Water

The capacity, or ability, to retain water depends on the size of the spaces between the grains in the soil. Potting soil or loam keeps in more water than sandy soil because it contains humus. Clay soil absorbs more water than sandy soil but the water is hard for plants to use. The experiment below shows how you can measure the retention of water using different materials that might be added to garden soil.



sand gravel clay

The *controlled variable* in this investigation is the amount of water poured into the top bottle.

The *manipulated (independent) variable* is the different type of material in each top bottle.

What is the *responding (dependent) variable* in this experiment?

Ability to Support Life

Soil that is good for growing plants is called topsoil. It is the top layer and contains the most humus with minerals needed for plant growth. Healthy soil depends on renewal through the water, nitrogen, and carbon cycles.

Animals, plants, and humans depend on soil. Overusing soil, which takes out minerals faster than decaying organic matter can replace them, or polluting it with certain chemicals can make it less fertile. Soil can be made fertile, or able to support plant life, by adding products like fertilizers that contain organic matter or elements such as nitrogen which help support life.

Fertilizers contain minerals such as nitrogen, phosphorus, potassium, calcium, and iron. Why would people need to put these substances back into the soil?

Earth's Natural Resources

alternative energy biofuel conservation fossil	fossil fuel geothermal hydroelectric model	natural resource nonrenewable resource renewable resource

Natural resources are materials and energy sources found above, on, and below the Earth's surface. Minerals, water, fossil fuels, and food sources are some of the resources in nature that are used by humans.

Renewable and Nonrenewable Resources

Some of these resources can be replaced more quickly than they are used, such as plants, animals, and clean air and water. These are **renewable resources**, which nature produces again and again.

What resource do these Texas windmills use to turn and generate electricity?

Lumber

Animals, plants, and freshwater are examples of renewable resources.

- Animals can give birth to new animals.
- New plants and trees can grow from seeds. That is why lumber is considered a renewable resource.
- Rain brings freshwater to lakes and rivers.

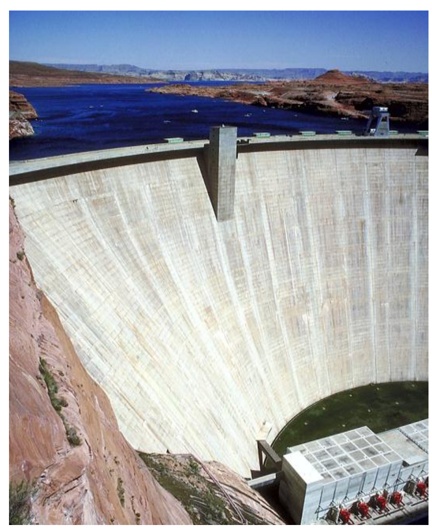
Other resources cannot be replaced quickly enough to meet the needs of people. These natural resources are **nonrenewable resources**. Oil, natural gas, and coal are examples of nonrenewable resources called fossil fuels. It took millions of years for fossil fuels to form. Remember that **fossil fuels** were once living things that were changed to fuels because of pressure and temperature changes. Minerals, such as aluminum, copper, and quartz, are also nonrenewable resources.

Alternative Energy

Many of the energy sources people use every day are made from fossil fuels. Because these energy sources are nonrenewable, there is a limited supply stored in the Earth. In addition, burning the fossil fuels for energy can release pollutants that harm the environment. These issues make it important to use **alternative energy** sources to replace fossil fuels. Alternative energy sources are renewable or inexhaustible resources that cannot be used up and cause less damage to the environment. Some examples of alternative energy sources include:

- **Hydroelectric energy** is produced using the energy of water moving through a dam. Holding back large volumes of water in a dam causes water pressure that flows through the dam to build up and turn turbines to generate electricity.
- **Geothermal energy** is produced from the heat of melted rock deep below Earth's surface. Geothermal energy is used to heat buildings, water, and produce electricity.
- **Biofuels** are made from plants and animals, rather than fossil fuels. Also called biomass, these natural materials from living or dead organisms include wood chips, plants oils, and leftover food or waste products.
- **Solar energy** from the Sun can be collected with *solar panels*. Solar panels convert the energy into useable electrical energy in a very efficient manner. This energy can then be used to power school zone lights or even provide electricity for your home.

House with solar energy panels



When a dam for hydroelectric power is built on a river, a lake is created. Does the water flow towards the lake or away from the lake?

Conservation is the smart use and protection of natural resources. Making efforts to reduce, reuse, and recycle our natural resources helps make the most efficient use of these limited materials. The use of alternative energies will help reduce our use of resources that may one day not exist or be very expensive to find and produce.

Wordology

conserve	*to save*
-ation	*an action or process*

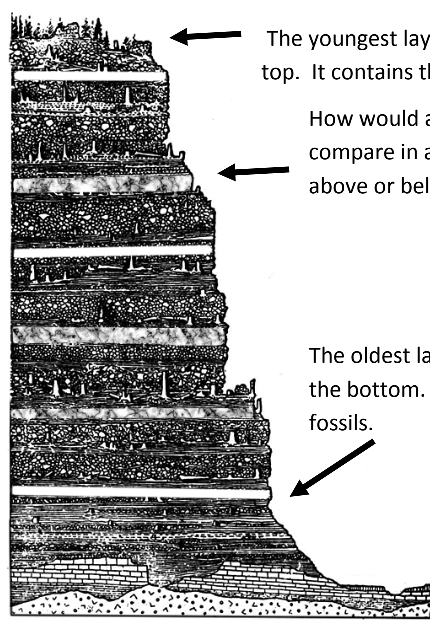
FACTOID:

People in the United States throw away about 229 million tons of garbage each year. That's an average of 4.5 pounds of garbage per person per day!

Fossils Are Evidence of the Past

Earth's rock layers hold evidence of what life was like millions of years ago when the layers were formed.
The properties of the rocks and the things found in the layers help people make a model of the Earth's past.

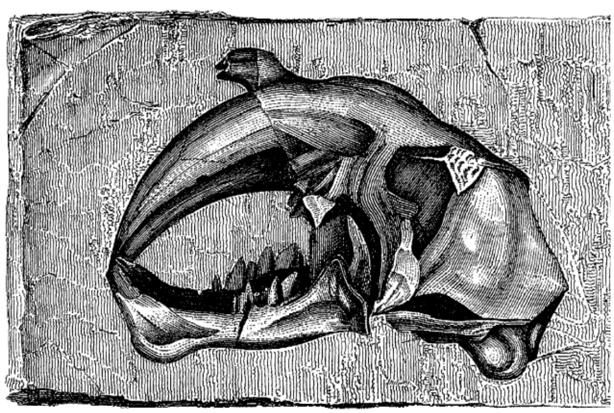
Earth's changing surface gives us clues about what landforms and living organisms were like long ago. The formation of new rock layers from the deposition of sediment and the remains of plants and animals create resources such as fossil fuels. They also leave evidence of what the bodies of living organisms looked like when the layers were formed.



This model helps us reconstruct what kind of plant and animal life existed in the distant past. The oldest layers are deposited on the bottom, as newer layers are built on top. Refer to pp 25-26 to learn how sedimentary rocks are formed.

Fossils are the remains or traces of an organism that lived long ago.

The shells of these ancient ocean animals were preserved in a layer of mud and sediment that turned into rock. What would it tell us about the past if these fossils were discovered in an area that is now a desert?



Above is the fossilized skull of an animal that lived millions of years ago preserved in sedimentary rock. If you found this fossil, what adaptations would you infer this animal used to survive? What kind of food did it probably eat?

Earth and Space

Earth's Weather and Climate

climate weather	weather map weather symbol	wind

Patterns are predictable changes we observe in the world. Sometimes these changes happen over and over again, in cycles. Earth's atmosphere goes through changes in both predictable and unpredictable ways. Some of these patterns and cycles happen over a short period of time, and some occur over a long period of time. Precipitation, humidity, temperature, and air pressure all play a role in the patterns that we see in the atmosphere.

Wordology

air pressure	*the weight of air pressing on everything around it*
humidity	*water vapor in the air*
precipitation	*water or ice that falls to earth*
temperature	*a measure of how hot or cold something is*

Weather

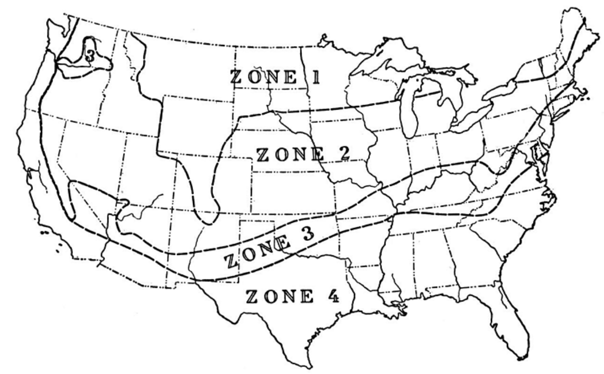
Weather is a description of the outside air in a certain place at a certain time. The air temperature, wind speed and direction, humidity, and precipitation are all used to describe the conditions for the hour, day, or week. The prediction you see on the news or Internet refers to weather. Weather includes measurements of the atmosphere in a certain location for the current time or predictions of what those conditions will be over a short time period.

If you look out the window and see the temperature shown on this thermometer, what prediction would you make about what month or season it is? In making that prediction, are you using your knowledge of weather or climate?

Climate

Climate is the general weather of an area over a long period of time. Instead of describing the conditions of the air at one moment in time, climate describes the average of all the weather conditions through all seasons during a long period of time.

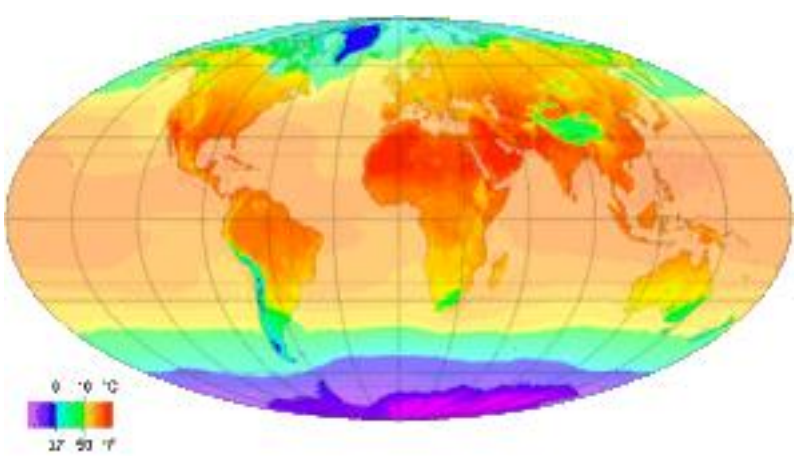
When you study different regions on Earth and find information on temperature and precipitation patterns, you are learning about climate. For example, you may know that most desert regions have a dry and hot climate, while rainforests have a hot and wet climate.



One day in your town might be sunny and warm. Another day, during another season, might be cool and rainy. The conditions of one day describe the weather.

The average weather conditions together, for the entire year, describe climate.

Would the climate of a state in the southern United States be different than a state in the very northern United States? What factors would affect the climate of those areas?

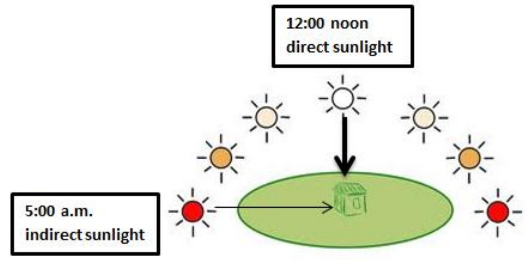


The map above shows the average temperatures, or typical climate, for the month of July in different parts of the world. How might this map look different in the month of January?

Measuring and Recording the Weather

Temperature is measured with a thermometer. The more heat energy in the air, the higher temperature the thermometer will show. The Sun heats the air. Warm air expands and rises while cold air condenses and sinks, creating a flow of air called **wind**.

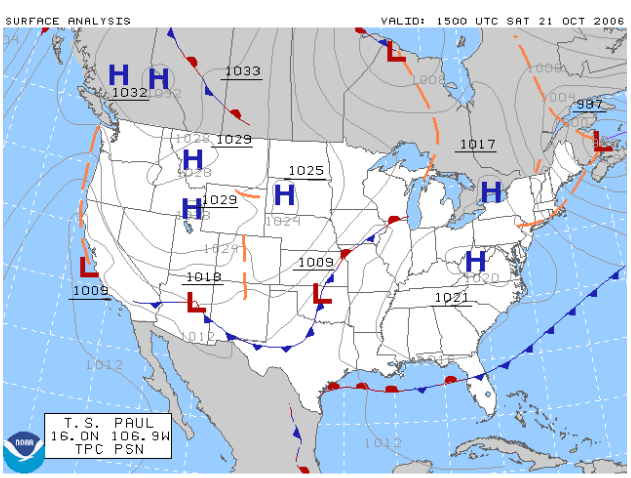
Air pressure is a measure of the weight of the atmosphere over an area. The particles of gas in our atmosphere move and change density as temperature, elevation, and weather conditions change. *Low pressure* is when an area has less dense air above it, while *high pressure* is when an area experiences more dense air. Air pressure is measured with an instrument called a *barometer*.



The direct heat of the Sun causes the temperature to rise during the day. At night, when Earth rotates away from the direct rays of the Sun, the temperature drops.

Cold air masses are more dense than warm air masses, so cold air pressure is greater (higher) than warm air. This difference in pressure causes cold air to sink, and warm air to rise. A **cold front** happens when cold air moves close to a warm air mass. A **warm front** is when a warm air mass moves towards a cold air mass.

When air pressure gets lower, or less dense, there is a greater chance of wind and precipitation. Low air pressure can predict a chance of precipitation such as falling droplets of water, or rain.



common weather symbols

Weather maps use blue lines dotted with triangles to represent the edge and direction of cold fronts, and red lines dotted with half circles to show the edge and direction of warm fronts. The large "H" and "L" are **weather symbols** that represent areas of high or low air pressure.

Weather Events

Scientists observe and record changes in weather in order to make predictions about future conditions. In addition to air temperature, there are many weather events that we observe and study:

- A *thunderstorm* is weather characterized by strong wind, rain, and the presence of lighting, an electric discharge that sends out a shock wave of air we hear as thunder.
- A *hurricane* is a very large rotating storm over the ocean with heavy rain and strong winds from 60 to over 200 miles per hour. Hurricanes may last for many days.
- A *tornado* is a rotating cone of air connected to the ground with wind speeds from 60 to over 200 miles per hour. Tornadoes only last for a few minutes or hours.
- *Haze* is the accumulation of dust, smoke, and other particles in the air that make it hard to see.
- *Fog* is the accumulation of water droplets in the air that make it hard to see.

How might the early morning fog affect drivers who must travel across this bridge?

Earth's Patterns and Cycles

water cycle evaporation	condensation	precipitation

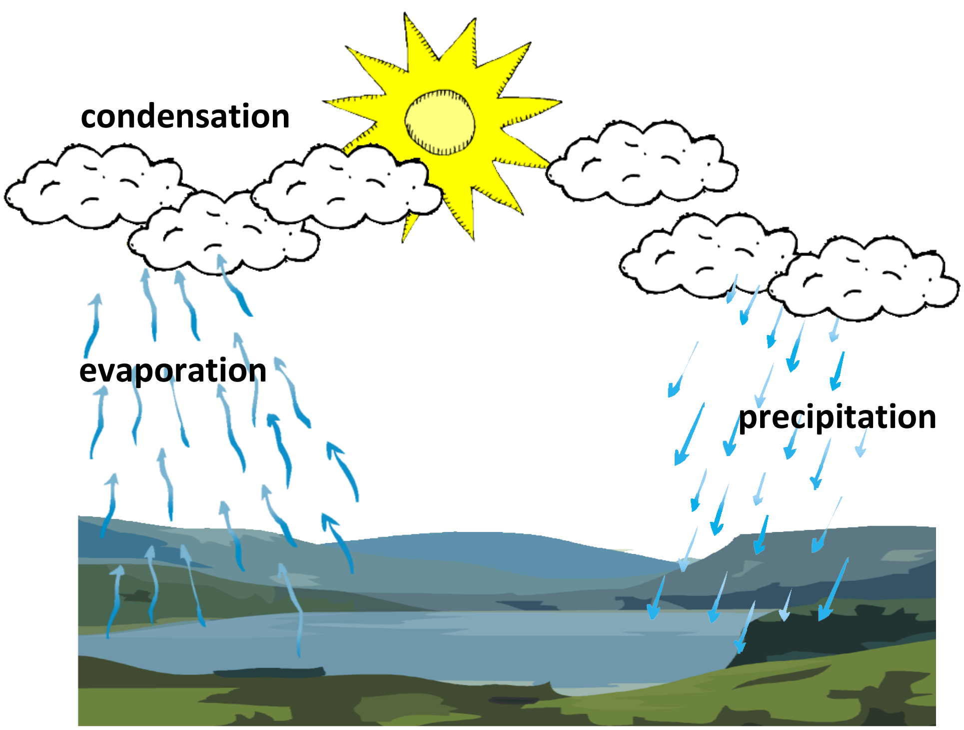
Energy from the Sun interacts with Earth's oceans and other bodies of water to change the physical state of water. As water moves from the Earth's surface to the top level of the atmosphere, water will change back and forth from liquid to water vapor (gas) in a nonstop pattern.

Remember:

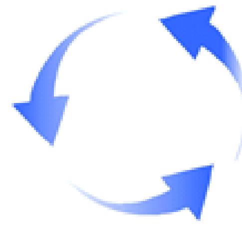
Physical states include **solids**, **liquids,** and **gases**.

The Water Cycle

Water is a renewable resource. It is continually replaced in a process known as the water cycle. The **water cycle** is the movement of water between the air and the Earth. Water changes from one state to another as it travels between the Earth's surface and atmosphere.



Heat energy from the Sun causes **evaporation**, the change from a liquid to a gas. Liquid water from lakes, oceans, and living organisms is heated and becomes water vapor. As water vapor rises into the atmosphere, water goes through **condensation**, the change from a gas to a liquid. Cooler temperatures in the atmosphere condense the water vapor into clouds. Clouds are made of tiny water droplets, just like the ones that form on a glass of ice water. Depending on weather conditions and altitude, water then returns as precipitation.



Precipitation is water that falls to Earth's surface as rain, snow, sleet (frozen rain), or hail (pieces of ice). Back on Earth's surface, water is collected as gravity causes water to pool together in large bodies such as lakes, rivers, or oceans. The Sun heats the liquid water and the process begins again.

FACTOID:

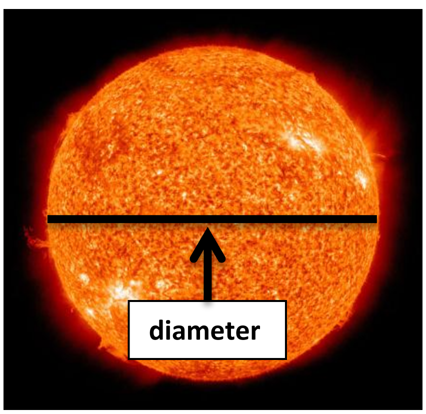
Though over 70% of Earth is covered in water, only 3% of this water is considered freshwater—water found in lakes, rivers, and streams.

The Solar System

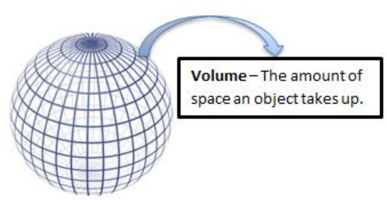
axis	orbit	soil
Earth	physical property	solar system
gravity	plain	star
moon	rock	Sun
mountain	season	tide

The two largest, most easily observable objects in Earth's sky are the Sun and Moon. The Earth, Sun, and Moon have different properties that characterize the roles they fill in our solar system. A property that can be observed, measured, or changed without changing the substance itself is a **physical property**. We can observe the physical properties of matter in our solar system using our eyes or tools that help us see things that are very far away or even invisible to our eyes.

The Sun



The **Sun** is a star, an object in space that produces its own heat and light. This ball of super-hot matter measures more than 800,000 miles in diameter. The volume of the Sun is more than one million times the volume of Earth. It is the largest object in our solar system. The massive gravity of the Sun keeps the planets in our solar system in orbit around it.



The Sun is made up of many elements, mostly hydrogen and helium gasses. The center of the Sun is so hot and has so much pressure that hydrogen atoms crash into each other to produce helium. This process produces energy in the form of light and heat. The Sun sends out massive amounts of energy in all directions. Energy from the Sun fuels many patterns and processes on Earth, such as photosynthesis and the water cycle. Without the Sun, there would be no life on Earth.

Earth

Our planet Earth is about 241 million kilometers (150 million miles) from the Sun. It has one moon, and it takes 24 hours to complete a rotation on its axis and 365 days to complete one revolution around the Sun.

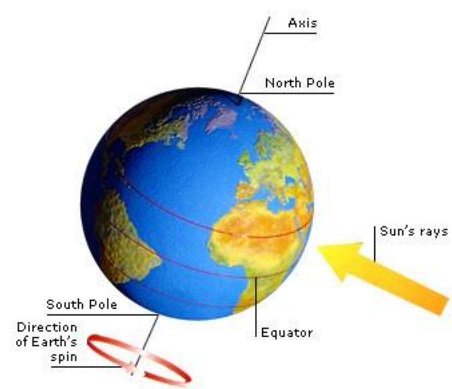
The Earth is titled on its **axis**, the imaginary line that passes from the North to South Pole through the Earth's core. This causes the Earth's hemispheres to have different temperatures and seasons. A **season** is one of the four natural divisions of the year marked by particular weather patterns and daylight hours, resulting from the Earth's changing position in relation to the Sun.

Wordology

revolve	*orbit, circle*
rotate	*spin, turn*

As the Earth revolves around the Sun, the hemisphere tilted most directly toward the Sun experiences the warmer average temperatures of summer. The opposite hemisphere, tilted most directly away from the Sun, receives less direct heat and goes through the cooler temperatures of winter. The warming season after winter is spring, and the cooling season after summer is fall.

Earth's atmosphere, the layer of gases that surround Earth, absorbs and reflects solar energy. The atmosphere is made of different layers with different temperatures and air pressure.

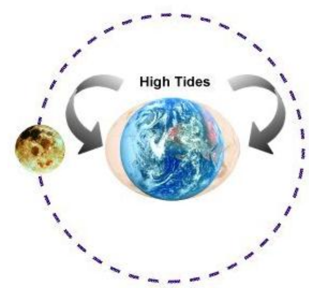


Earth is the only planet in our solar system that has liquid water and the only planet that we know of that supports life. Around 70 percent of the Earth's surface is covered by water. The rocky surface of Earth contains a very diverse mix of landforms. Earth's landforms are mostly made of **rock**, a solid mixture of minerals that was formed in the Earth's crust, and **soil**, a loose mixture of rock, mineral particles, and organic matter that covers Earth's surface.

The Moon

The Moon is a natural satellite that orbits the Earth, due to gravity, in the same way the Earth revolves around the Sun. The diameter of the Moon is only about one-fourth the size of Earth's. A moon is a round body of matter captured by the **gravity** of a planet.

Because of its smaller mass, gravity on the Moon is less than on Earth—only one-sixth as strong. Still, the Moon's gravity affects the oceans on Earth. The Moon's gravity, combined with the Sun's gravity and rotation of the Earth causes the ocean **tides**, when the water falls lower (ebb) or rises higher (flow), twice a day.



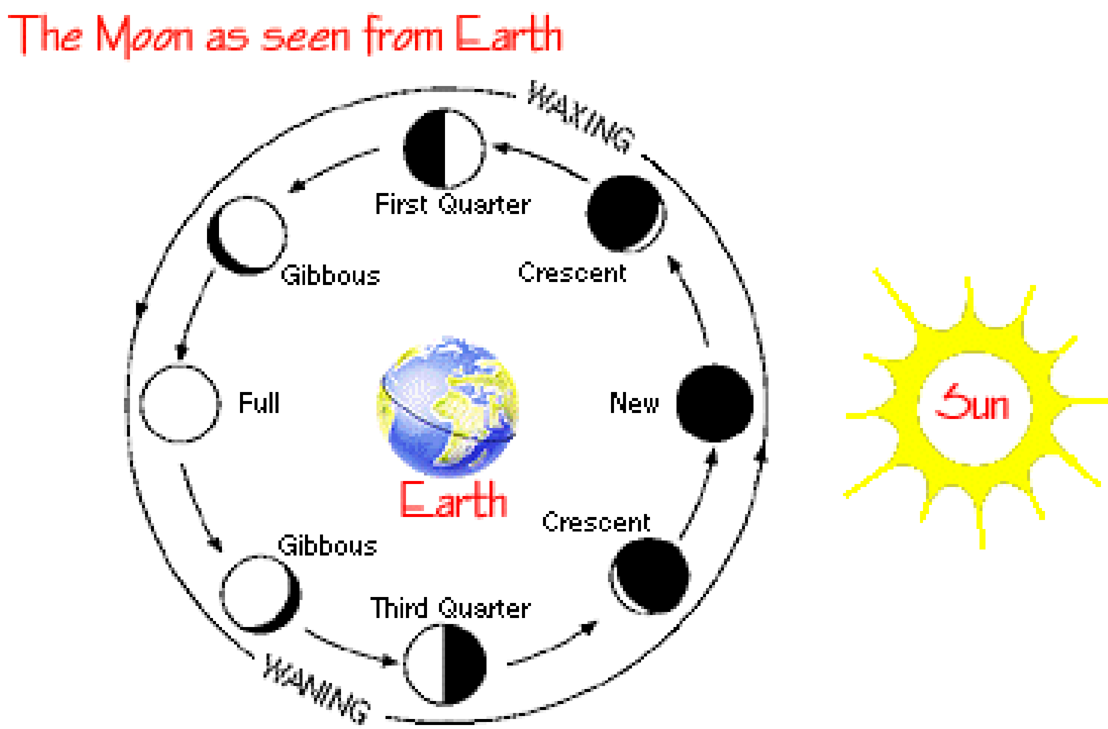
Even though the Moon is the brightest object in our sky at night, it does not produce its own light like the Sun. The light comes from sunlight that reflects off its surface and reaches Earth. Earth's shadow falls on the Moon as it orbits, causing phases that occur in a cycle every 29.5 days.

The Moon has almost no atmosphere to block the Sun's heat during the day or keep heat in at night. The side of the Moon facing the Sun reaches temperatures of over 93 degrees Celsius (200°Fahrenheit), while the opposite dark side's average temperature is -173 degrees Celsius (about -280° Fahrenheit—that's almost 300 degrees below zero!).

The Moon is made of rock and has mountains and plains like Earth. The surface of the Moon is covered in craters, large bowl-shaped pits caused by impact with falling matter. The Moon does not have water or support life.

Moon Phases

When we observe the Moon from Earth's surface, it does not always seem to have the same size or shape. This is because of its position with relation to the Earth and the Sun. Each different position is called a phase.



The Moon moves around the Earth in a movement called revolution, or orbit. It takes about 29.5 days to observe a full Moon cycle. Because of this, we usually only have a full moon once a month. During this time it goes through the phases shown in the diagram above.

New moon: The Moon is in its orbit exactly between the Sun and the Earth so that the side closest to the Earth appears dark. The side that faces the Sun is lit up. In this phase we cannot see the Moon in the night sky.

First-quarter moon: As the Moon continues to revolve around the Earth, the Moon's surface becomes visible as a thin crescent. Each night more of the Moon's surface is visible to a person on Earth. An increasing Moon is said to be waxing. After the Moon moves a quarter of its orbit around Earth (about seven days), we see half of the lighted part of the Moon, or about one quarter of the Moon's surface. A first-quarter Moon looks like the right half of a circle.

Full moon: After the first-quarter phase, the surface of the Moon that can be seen from Earth continues to increase in size. When the Moon reaches the opposite side of Earth from the Sun (about 14 days) the entire side of the Moon facing Earth reflects sunlight back to the Earth. The full Moon appears as a complete circle. When there are two full Moons in a month, the second full Moon is called a blue moon. "Once in a blue Moon" is a saying that means something that doesn't happen very often.

Third-quarter moon: After a full moon, less and less of the Moon's surface is visible each night. A receding moon is said to be waning. A third-quarter moon looks like the left half of a circle. After the third quarter phase, the surface of the Moon that can be seen from Earth continues to decrease in size until the next new moon.

Planets of the Solar System

A planet is a large object that **orbits**, or moves around, a star. All the planets and other objects that orbit the Sun are called our **solar system**. The planets in our solar system are held in orbit around the Sun because of the Sun's massive gravity. Each planet follows an invisible round path as it revolves around the Sun.

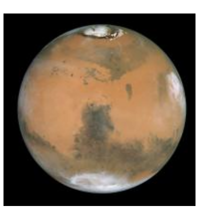
The four planets closest to the Sun are called the inner planets.
The inner planets are made of rock, and are much smaller than the outer planets.

Mercury is the closest planet to the Sun. Mercury is about 58 million kilometers (36 million miles) from the Sun. It's about the size of our Moon. It has no moons of its own and takes about 59 Earth days to complete a rotation, or turn on its own axis. Its revolution around the Sun takes about 88 Earth days. It has craters and some gases, and does not have an atmosphere.

Venus is almost the same size as the Earth, but it is dry and hot. Its atmosphere, which is almost entirely carbon dioxide gas, is much more dense than Earth's. Venus has no satellites and it takes about 225 days to orbit the Sun. The surface of Venus has many volcanoes and plains formed from volcanic eruptions.

Earth is about 150 million kilometers (93 million miles) from the Sun. It has one moon, and it takes almost 24 hours to complete a rotation on its axis. A complete revolution around the Sun takes about 365 days. The Earth is titled on its axis, which causes the Earth to have different temperatures and different seasons. Each season depends on Earth's location in relation to the Sun.

Earth is the only planet that has liquid water and the only one that we know of with living things, because Earth's atmosphere absorbs and keeps in the right amount of solar energy to support life.



Mars is called the "Red Planet" because its surface is covered with reddish, iron-rich soil. It has two moons and the biggest volcano in the solar system. There is no life on Mars, even though some believe that there was liquid water a long time ago on that planet. Scientists have discovered valleys and sedimentary rocks that formed from sediment deposits that were carried by water currents. Mars takes about 24.5 hours to complete a rotation and about 687 Earth days to complete a revolution.

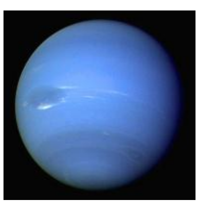
The four planets furthest from the Sun are called the outer planets.

The outer planets are mostly made of gas, and are much larger than the inner planets. This is how the outer planets earned the nickname, Gas Giants.

Jupiter is the largest planet in our solar system. It has one ring and has at least 63 moons. The energy in Jupiter's atmosphere causes a circular storm called the "Great Red Spot." This storm, which looks like a hurricane, has lasted more than 300 years. It takes about 10 hours to complete one rotation and almost 12 Earth years to complete its orbit around the Sun.

Saturn is easily recognized because of its large rings. Its rings, made of individual rocks circling the planet in orbit, are so bright and wide that they can be seen from Earth with a telescope. It has at least 62 moons. It takes about 10 hours to complete a rotation and more than 29 Earth years to complete a revolution.

Uranus can be seen without a telescope. It is a blue and green ball of gas and liquid. Uranus has at least 27 moons and some rings in its orbit. It completes its rotation in about 17 hours and a revolution in about 84 Earth years. Uranus' axis is tilted sideways, unlike any other planet.



Neptune is the planet farthest from the Sun. It has 13 moons and one ring. Scientists observed a very large circular storm on Neptune called the "Great Dark Spot", similar to Jupiter's Great Red Spot. It completes a rotation in about 16 hours and a revolution in about 165 Earth years.

Organisms and Environments

Systems and Cycles

carbon dioxide	energy flow	nonliving
community	environment	oxygen
complete metamorphosis	food chain	overpopulation
consumer	food web	producer
cycle	fruit	population
decomposer	hibernation	seed
decomposition	incomplete	seedling
diversity	interaction	species
dormancy	metamorphosis	system
ecosystem	life cycle	
energy	living	

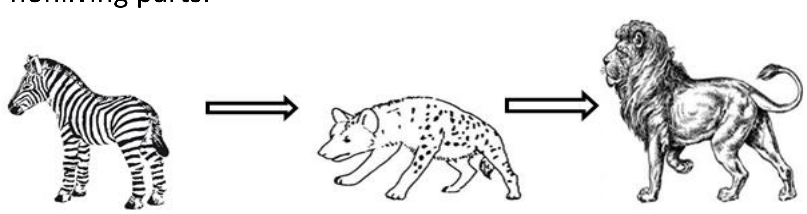
Living things are made of smaller parts – each part has a job in supporting the whole. Even those parts are made of smaller pieces, such as cells. Nonliving things are also made of smaller parts.

Houses, streets, and people all keep a city "alive" and working. A set of connected things working together as parts of a whole is a **system**. Sometimes these things work in predictable, repeating ways called **cycles**. Systems and cycles are everywhere in our world.

How does this stereo system interact as a system?

Ecosystems

An **ecosystem** includes all **living** and **nonliving** things that **interact** with each other in an **environment**. Every living **organism** lives in an ecosystem and has a role, or *niche*, it fulfills. Some **species**, organisms of the same kind that can produce offspring like themselves, might be predators in one ecosystem. The same species might be the prey in a different ecosystem. Plants interact with their environment by providing food, resources, or shelter to other living things. An ecosystem is full of relationships between living and nonliving parts.

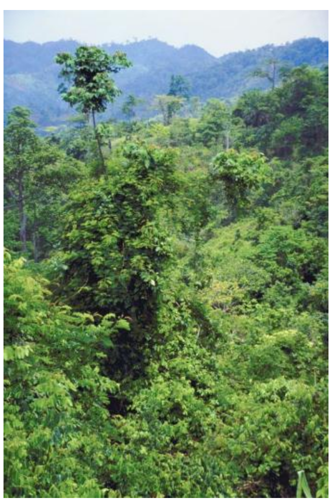


The hyena (predator) feeds on the zebra (prey) for energy, while the lion (predator) feeds on the hyena (prey).

A *desert* is an ecosystem with very little precipitation to support plant growth. Deserts may have very hot or very cold climates. Animals and plants that live in the desert have adaptations that allow them to live in a very dry place with extreme temperatures. The animals of the desert get most of their water eating plants that have adaptations to store water.

A *prairie*, or grassland, ecosystem has a great variety of life. There are tall grasses, short grasses and shrubs. Animals in the prairie compete for food during droughts, or periods with no rain. The majority of the animals in the prairies are mammals, birds, insects, and reptiles. The plentiful grasses and shrubs in a prairie support a diverse range of consumers.

A forest is an area densely covered in trees and other vegetation. There are several types of *forest* ecosystems, including tropical rainforests and deciduous forests.



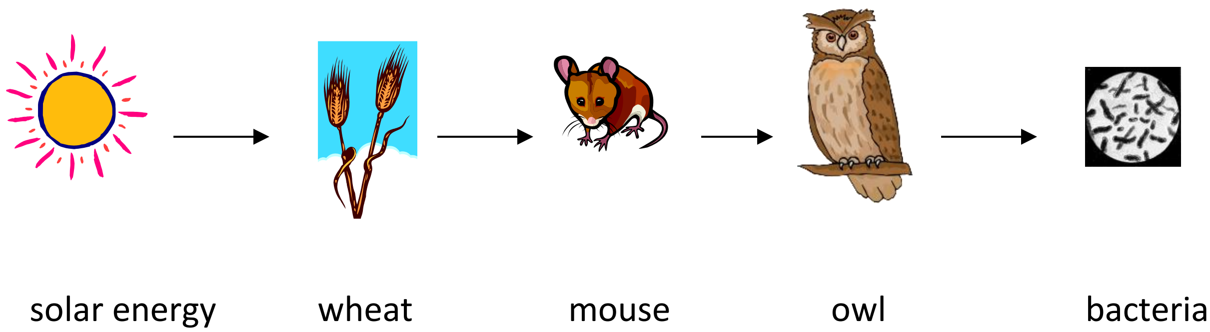
A *tropical rainforest* is a forest with large amounts of rainfall, thick vegetation in many layers that compete for sunlight, and a great diversity of life. *Diversity* is the degree of variation of organisms within an ecosystem.

Because rainforests are mostly found in tropical climates near the Equator, the plants and animals that live there have adapted to the hot and humid climate. For instance, because they live in trees, monkeys have long tails to help them balance as they locate food and avoid predators. Parrots have long, strong beaks that break seeds and tear fruits they take from trees.

In *deciduous forests*, found in climates where most trees lose their leaves in the fall, plants and animals must adapt to the changes in the weather. These forests are found in areas that have warm summers and cold winters. Many of the animals in this type of forest store food for the cold season, or they hibernate (enter a state of dormancy), much like deciduous trees.

The Flow of Energy

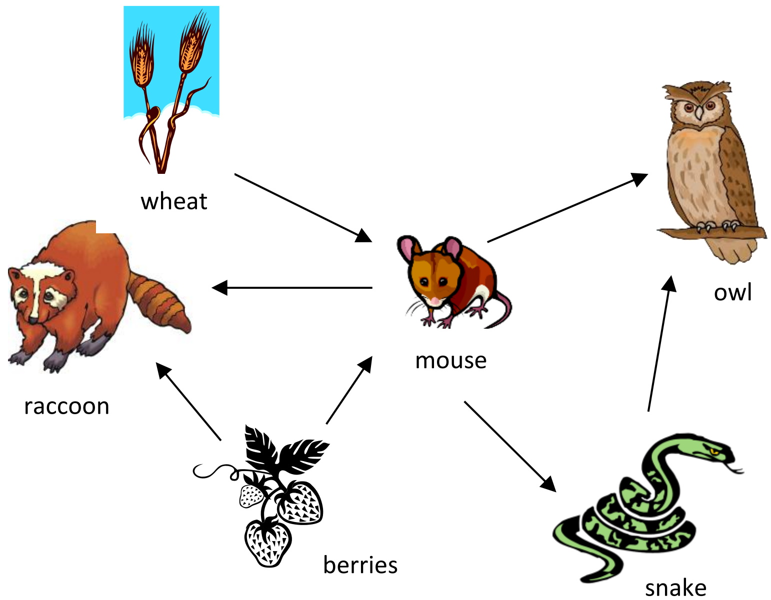
A **food chain** is a model that shows the path of food energy from one organism to another in an ecosystem. The beginning source of this **energy**, something that living things use to live, grow, and move, is the Sun. The arrows below indicate the energy flow, or direction in which the energy moves through a prairie ecosystem.



In this model, the food chain starts with the energy from the Sun. Energy is then passed on to the wheat. This **producer**, or organism that makes its own food, uses energy to make its own food through photosynthesis. After plants use the Sun's energy, **consumers**, or organisms that get energy by eating other organisms, complete the food chain. The mouse, a consumer, eats the wheat to obtain the energy it needs. The owl, a consumer and a predator, eats the mouse as its prey to satisfy its need for energy.

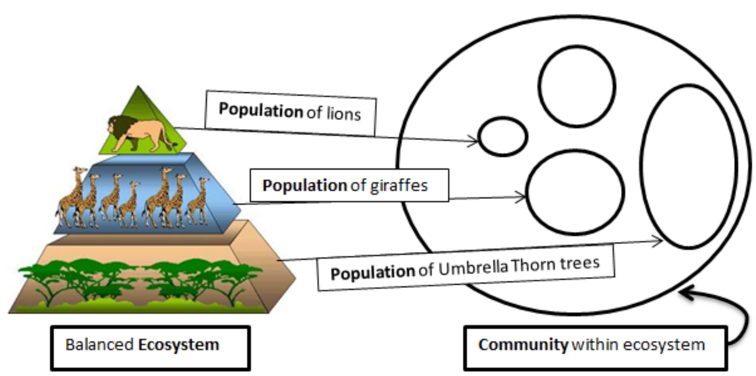
Once the owl in this food chain dies, a **decomposer**, or organism that gets it energy by feeding on dead materials and wastes, will break down its body and return nutrients like carbon and nitrogen to the soil in a cycle that supports the growth of new plants. Bacteria and various kinds of fungus, such as mushrooms, are important decomposers in Earth's ecosystems.

Every ecosystem has many food chains that form complex relationships between energy sources. A **food web** contains all the food chains with different pathways for the flow of food energy in an ecosystem. Within the food web are many producers, consumers, and decomposers. The consumers include **predators** – animals which hunt and eat other animals, and **prey** – animals that are hunted and eaten by other animals. These organisms all **compete** for the limited food resources in an ecosystem.



In an ecosystem, populations of different kinds of organisms live in the same place at the same time. If there were a change in one of these populations, the whole **community** could be affected. In the example above, if the **population**, of mice decreased in number, the amount of strawberries and wheat could increase, since fewer mice are consuming them. This creates an imbalance in the ecosystem.

When a predator is removed from a food web, the number of prey may increase. **Overpopulation** occurs when a population's numbers exceed the habitat's ability to sustain it. If a disturbance, such as human hunters, pollution, or new construction, causes the snakes and owls to be removed from this ecosystem, the mice population might expand very rapidly. The wheat supply in the ecosystem that fed a certain number of mice would be greatly reduced, as the overpopulated mice use up resources more quickly than they can be replenished. Many of the mice would then die out, until more wheat could grow to sustain the new population size.

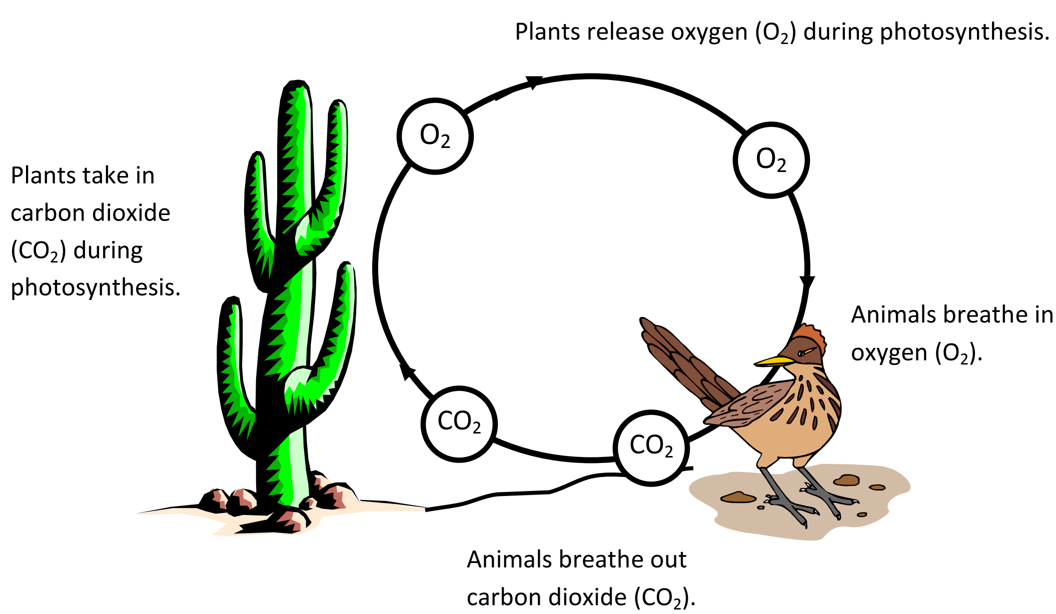


Carbon Dioxide-Oxygen Cycle

Earth's atmosphere, which is the air we breathe, is made up mainly of two types of gasses—nitrogen (78%) and oxygen (20%)—as well as small amounts of other gases such as carbon dioxide. **Oxygen** and **carbon dioxide** gasses in the air are constantly recycled back and forth between plants and animals. Animals use oxygen to make energy from food, and breathe out carbon dioxide as waste. Plants take in carbon dioxide and use it to make food during *photosynthesis*. During that process, plants release oxygen back into the air. In this cycle both gases are moved from the atmosphere, into living things, and back again. Plants and animals depend on each other to renew the supply of air they each need for survival.

The **carbon dioxide-oxygen cycle** is the movement of carbon dioxide and oxygen between organisms and the air.

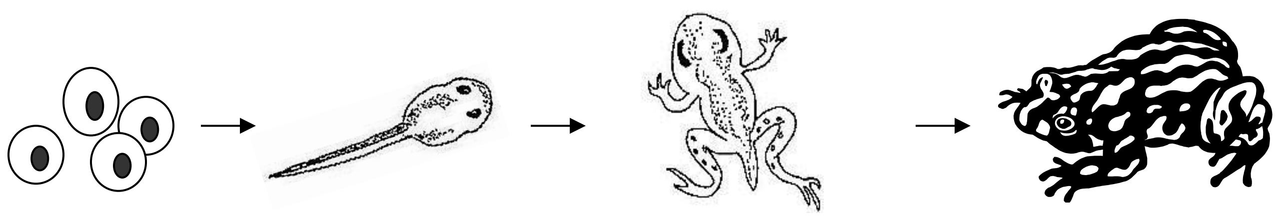
Model of the carbon dioxide-oxygen cycle



Life Cycles

Living things go through changes as they are born, live, reproduce, and die. A **life cycle** includes the stages of growth and development an organism goes through in its lifetime.

Amphibians change when they go from living in water to living on land. The life cycle of frogs is an example of a transformation called **metamorphosis**. During its metamorphosis, frogs go through big changes like going from breathing with gills to breathing with lungs. They go from living in water to living on land. The diagram below shows the changes frogs go through within their life cycle.



egg

The mother lays eggs containing the frog *embryos* in the water.

tadpole

A tadpole lives in the water and breathes with its gills.

froglet

In this stage, the frog develops legs and begins to leave the water. Froglets have short tails.

adult

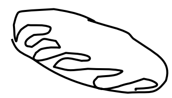
The adult frog breathes with its lungs and lives on land.

Some insects go through a **complete metamorphosis**. During this process, the organism's form changes at each stage of its life cycle. The young larval form is very different from the way it will look as an adult. The life cycle of a butterfly is shown below.

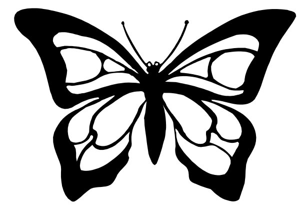
Complete Metamorphosis of a Butterfly

Egg – An **embryo** develops inside the egg after being laid by an adult butterfly.

Larva – the larva hatches from the egg, the caterpillar form of the insect before it transforms.



Pupa – The larva wraps itself in a chrysalis where it will change into an adult form.

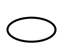


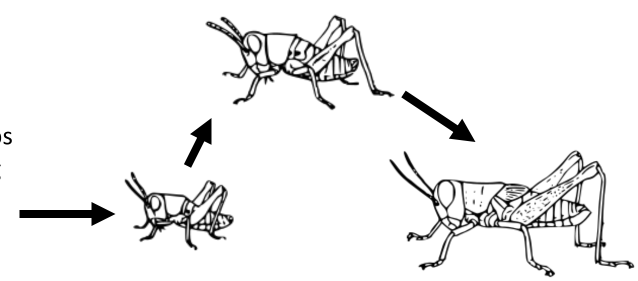
Adult – A butterfly emerges as the final stage, when it is ready to reproduce and begin the cycle again.

Other insects go through **incomplete metamorphosis**. During this process, the organism goes through a slow change. The young insect, called a *nymph*, resembles the adult form, but may be smaller or missing adult structures such as wings. Instead of forming a chrysalis, insects that go through incomplete metamorphosis may molt, or shed their outer layer, as they grow.

Incomplete Metamorphosis of a Grasshopper

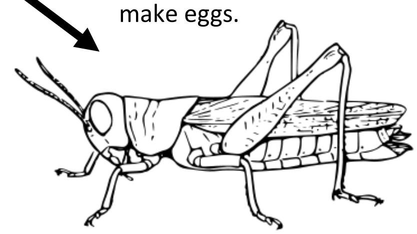
Egg – An embryo develops inside the egg after being laid by an adult grasshopper.





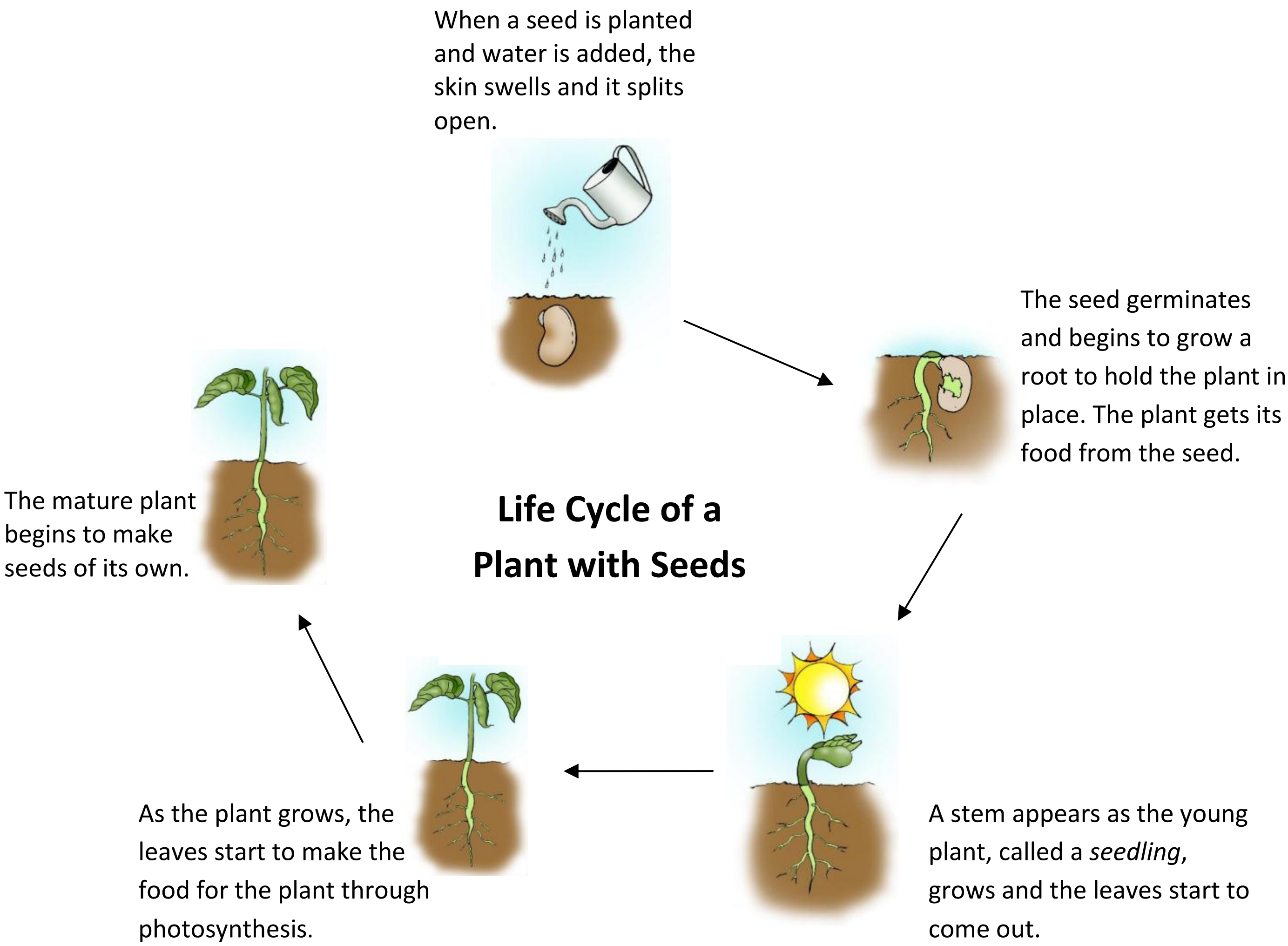
Nymph – The nymph hatches from the egg and resembles the adult, but it is smaller and is missing wings. The young grasshopper will molt, or shed its outer exoskeleton, 5 or 6 times before becoming an adult.

Adult – After a final molt, the adult grasshopper has wings and reproductive organs ready to make eggs.



Plants also follow a series of orderly changes as they go through their life cycle. Like animals, each kind of plant has its own adaptations for reproduction. The process of reproduction lets organisms pass on traits to their offspring, and ensures the species continues to live and survive.

Plants may reproduce in a variety of ways, such as spores, bulbs, runners, or cuttings. Many plants reproduce by producing **seeds**, a plant part that contains a tiny plant and stored food. Many plants store their seeds in parts called **fruit**. The fruit of many plants has adapted to become sweet and edible, which helps spread out the seeds after they are eaten by animals.



Organisms and Environments

Adaptations and Survival

adaptation	inherited trait	structure
behavior	offspring	survival
function	learned behavior	thrive
generation	organism	

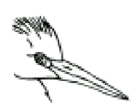
A living thing is called an **organism**. All organisms have basic needs. They need water and other nutrients. Most organisms needs oxygen and sunlight, too. Organisms also need space and shelter. Living things have physical characteristics that help them survive. These characteristics help organisms get food, reproduce, and avoid harm. Over time, the best traits for survival continue to be passed from parent to **offspring**. Some animals also learn behaviors as they grow that help them survive. They weren't born knowing these actions, but observed or were taught how to react in certain situations.

Adaptations

Animals and plants have adaptations for survival that are often inherited from their parents. An **adaptation** is a structure or behavior that helps an organism survive and **thrive** in its surroundings. A **structure** is a body part that does a certain job for an organism. For example, a polar bear has thick fur to help it survive in a cold environment. A **function** is the job that a body part does in an organism. Each adaptation has a purpose.

structure: short beak
function: to break open seeds

structure: strong, curved beak
function: to tear meat

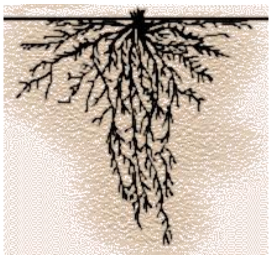


structure: long pointy beak
function: to capture fish

Birds have different kinds of beaks which allow them to compete for resources.

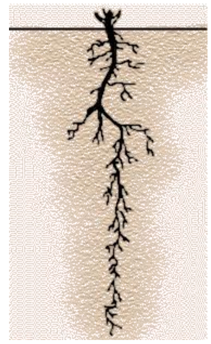
Plants need water, light, soil or nutrients, and air to grow.

Roots help anchor the plant so it stays in one place and helps absorb water and nutrients that help with growth and food production.



Fibrous root

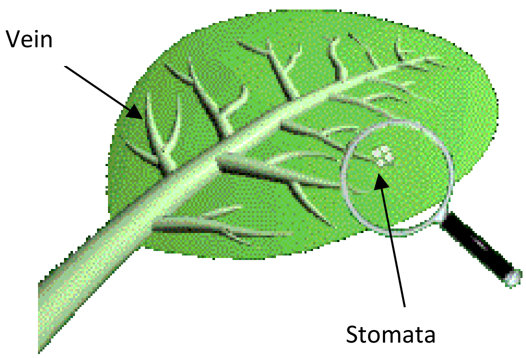
The fibrous root extends in various directions and grows close to the earth's surface. The individual roots are short.



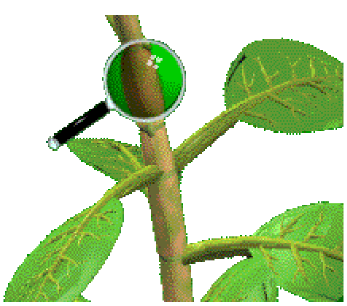
Tap root

The main root is long and grows deep. The dandelion has a taproot. Carrots are another example.

Leaves absorb light energy to make food from carbon dioxide and water through the process of *photosynthesis*. *Veins* carry substances in and out of the leaf. Gases enter and leave the leaf through tiny holes called *stomata*. Plants give off water through the leaf through the process of *transpiration*.



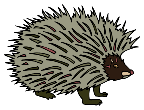
Stems support the leaves and flowers of plants. Substances move up and down the plant through the stem. Oxygen enters through small holes in the stem.



The reproduction of plants take place in structures called *flowers*. A flower's color and/or smell can attract insects to help with pollination.

There are adaptations in animal species for many purposes, such as:

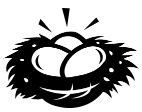
- ***For protection:***



Porcupines have sharp quills to defend themselves against predators trying to attack them.

Skunks can spray their enemies with a stinky liquid.

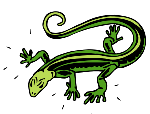
- ***To reproduce:***



Eggshells protect chicks until they are born.

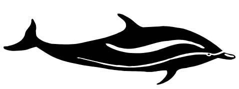
A mother kangaroo puts her newborn joeys in her pouch where she feeds and keeps them safe.

- ***To conserve water***:



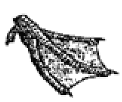
An iguana has thick and scaly skin so the water in its body doesn't evaporate.

- ***To get oxygen:***



Dolphins come up to the water's surface to breathe through a blow hole they have on the top of their heads.

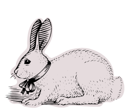
- ***To move:***



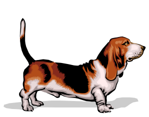
Ducks have membranes between their toes so they can swim quickly.

The hummingbird has wings that move so quickly that it can stay still in one place to get the nectar out of flowers.

- ***To cool off when they are hot:***



Rabbits eliminate the heat in their bodies through their long ears.



Dogs have to pant or breathe rapidly to cool off.

There are also adaptations in plant species for purposes including:

- ***To conserve water:***

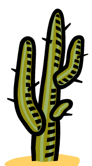
A cactus has thorns instead of leaves to avoid the excessive evaporation of water. Additionally, some cacti have a thick waxy covering. Some cacti can expand like a sponge to save any water they obtain.

The leaf of a pine tree has a narrow and pointy shape. It doesn't allow a lot of water to be lost this way. Its shape also allows the tree to get rid of excess snow during big snowfalls so that it won't break with the weight of the snow.

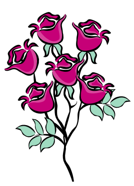
- ***For stability:***

Sometimes the trees in rainforests have roots that grow on the side to give them support because they get so much water they are not stable.

- ***For defense:***



Cacti have a covering made of a thick material called cellulose that is hard for animals to digest. They also have thorns to keep animals away.

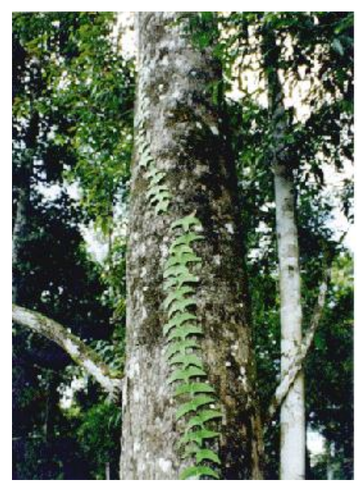


Roses also have thorns to prevent getting eaten by animals.

- ***To reproduce:***

Some plants only live for one year or one season. These plants are called annuals. They concentrate their energy on creating a great number of seeds to ensure their reproduction. Many crops like corn and wheat are annual plants.

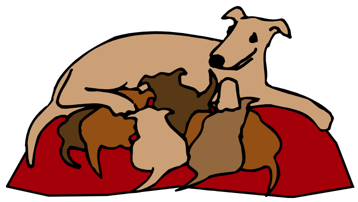
Other plants that live more than one year or season are called perennials, and don't produce as many seeds. Perennials can be bushes, trees, and some herbs.



Trees in a rainforest compete for sunlight. Since the top, or canopy, of the rainforest is dense, trees try to grow higher than the other trees around them.

Inherited Traits

Plants and animals have **inherited traits**, characteristics that are passed from parents to their offspring, from one **generation** to the next. Puppies will share the physical body traits of their parents passed on to them. The size, shape, and color of a leaf would be an inherited trait of a plant.
You inherited some physical traits similar to your parents in the same way, such as hair or eye color.



Behaviors

Plants and animals also have behaviors that can be observed. Some plant and animal behaviors are inherited, which is sometimes called instinct.

Inherited behaviors or instincts are those behaviors that animals and plants inherited. For example, spiders are born knowing how to spin webs, lizards know they must lie in the sun to warm up since they are cold-blooded animals, and plant stems grow up and roots grow down. Many behaviors are adaptations that help plants and animals survive.

A **learned behavior** is a behavior an animal develops by observing other animals or being taught. Learned behaviors are what animals learn with experience. For example, an animal can learn not to eat certain food because it makes the animal sick. It might eat it once but won't do it again. Another learned behavior is a police dog being trained to sit or bark when it smells an illegal drug.

Sometimes a behavior can be both inherited and learned by an animal. For example, lions are born with an instinct to hunt for food, but they learn how to hunt effectively by observing and following the model of their mothers.