5th grade SCIENCE

Credits

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Utah Science Core Curriculum Alignment

Standard 1

Objective 1 : Describe that matter is neither created nor destroyed even though it may undergo change.

a. Compare the total weight of an object to the weight of its individual parts after being disassembled.
b. Compare the weight of a specified quantity of matter before and after it undergoes melting or freezing.
c. Investigate the results of the combined weights of a liquid and a solid after the solid has been dissolved and then recovered from the liquid (e.g., salt dissolved in water then water evaporated).
d. Investigate chemical reactions in which the total weight of the materials before and after reaction is the same (e.g., cream and vinegar before and after mixing, borax and glue mixed to make a new substance).

Objective 2: Evaluate evidence that indicates a physical change has occurred.

a. Identify the physical properties of matter (e.g., hard, soft, solid, liquid, gas).
b. Compare changes in substances that indicate a physical change has occurred.
c. Describe the appearance of a substance before and after a physical change.

Objective 3: Investigate evidence for changes in matter that occur during a chemical reaction.

a. Identify observable evidence of a chemical reaction (e.g., color change, heat or light given off, heat absorbed, gas given off).
b. Explain why the measured weight of a remaining product is less than its reactants when a gas is produced.
c. Cite examples of chemical reactions in daily life.
d. Compare a physical change to a chemical change.
e. Hypothesize how changing one of the

materials in a chemical reaction will change the results.

Standard 2

Objective 1: Describe how weathering and erosion change Earth's surface.

a. Identify the objects, processes, or forces that weather and erode Earth's surface (e.g., ice, plants, animals, abrasion, gravity, water, wind).
b. Describe how geological features (e.g., valleys, canyons, buttes, arches) are changed through erosion (e.g., waves, wind, glaciers, gravity, running water).
c. Explain the relationship between time and specific geological changes.

Objective 2: Explain how volcanoes, earthquakes, and uplift affect Earth's surface.

a. Identify specific geological features created by volcanoes, earthquakes, and uplift.
b. Give examples of different landforms that are formed by volcanoes, earthquakes, and uplift (e.g., mountains, valleys, new lakes, canyons).
c. Describe how volcanoes, earthquakes, and uplift change landforms.
d. Cite examples of how technology is used to predict volcanoes and earthquakes.

Objective 3: Relate the building up and breaking down of Earth's surface over time to the various physical land features.

a. Explain how layers of exposed rock, such as those observed in the Grand Canyon, are the result of natural processes acting over long periods of time.
b. Describe the role of deposition in the processes that change Earth's surface.
c. Use a time line to identify the sequence and time required for building and breaking down of geologic features on Earth.
d. Describe and justify how the surface of Earth would appear if there were no mountain uplift, weathering, or erosion.

Standard 3

Objective 1: Investigate and compare the behavior of magnetism using magnets.

a. Compare various types of magnets (e.g., permanent, temporary, and natural magnets) and their abilities to push or

pull iron objects they are not touching.
b. Investigate how magnets will both attract and repel other magnets.
c. Compare permanent magnets and electromagnets.
d. Research and report the use of magnets that is supported by sound scientific principles.

Objective 2: Describe how the magnetic field of Earth and a magnet are similar.

a. Compare the magnetic fields of various types of magnets (e.g., bar magnet, disk magnet, horseshoe magnet).
b. Compare Earth's magnetic field to the magnetic field of a magnet.
c. Construct a compass and explain how it works.
d. Investigate the effects of magnets on the needle of a compass and compare this to the effects of Earth's magnetic field on the needle of a compass (e.g., magnets effect the needle only at close distances, Earth's magnetic field affects the needle at great distances, magnets close to a compass overrides the Earth's effect on the needle).

Standard 4

Objective 1: Describe the behavior of static electricity as observed in nature and everyday occurrences.

a. List several occurrences of static electricity that happen in everyday life.
b. Describe the relationship between static electricity and lightning.
c. Describe the behavior of objects charged with static electricity in attracting or repelling without touching.
d. Compare the amount of static charge produced by rubbing various materials together (e.g., rubbing fur on a glass rod produces a greater charge then rubbing the fur with a metal rod, the static charge produced when a balloon is rubbed on hair is greater than when a plastic bag is rubbed on hair).
e. Investigate how various materials react differently to statically charged objects.

Objective 2: Analyze the behavior of current electricity.

a. Draw and label the components of a complete electrical circuit that includes switches and loads (e.g., light bulb, bell, speaker, motor).

b. Predict the effect of changing one or more of the components (e.g., battery, load, wires) in an electric circuit.
c. Generalize the properties of materials that carry the flow of electricity using data by testing different materials.
d. Investigate materials that prevent the flow of electricity.
e. Make a working model of a complete circuit using a power source, switch, bell or light, and a conductor for a pathway.

Standard 5

Objective 1: Using supporting evidence, show that traits are transferred from a parent organism to its offspring.

a. Make a chart and collect data identifying various traits among a given population (e.g., the hand span of students in the classroom, the color and texture of different apples, the number of petals of a given flower).
b. Identify similar physical traits of a parent organism and its offspring (e.g., trees and saplings, leopards and cubs, chickens and chicks).
c. Compare various examples of offspring that do not initially resemble the parent organism but mature to become similar to the parent organism (e.g., mealworms and darkling beetles, tadpoles and frogs, seedlings and vegetables, caterpillars and butterflies).
d. Contrast inherited traits with traits and behaviors that are not inherited but may be learned or induced by environmental factors (e.g., cat purring to cat meowing to be let out of the house; the round shape of a willow is inherited, while leaning away from the prevailing wind is induced).
e. Investigate variations and similarities in plants grown from seeds of a parent plant (e.g., how seeds from the same plant species can produce different colored flowers or identical flowers).

Objective 2: Describe how some characteristics could give a species a survival advantage in a particular environment.

a. Compare the traits of similar species for physical abilities, instinctual behaviors, and specialized body structures that increase the survival of one species in a specific environment over another species (e.g., difference between the feet of snowshoe hare and cottontail rabbit, differences in leaves of plants growing at different altitudes, differences between the feathers of an owl and a hummingbird, differences in parental behavior among various fish).
b. Identify that some environments give one species a survival advantage over another (e.g., warm water favors

fish such as carp, cold water favors fish such as trout, environments that burn regularly favor grasses, environments that do not often burn favor trees).

c. Describe how a particular physical attribute may provide an advantage for survival in one environment but not in another (e.g., heavy fur in arctic climates keep animals warm whereas in hot desert climates it would cause overheating; flippers on such animals as sea lions and seals provide excellent swimming structures in the water but become clumsy and awkward on land; cacti retain the right amount of water in arid regions but would develop root rot in a more temperate region; fish gills have the ability to absorb oxygen in water but not on land).

d. Research a specific plant or animal and report how specific physical attributes provide an advantage for survival in a specific environment.

Why Science?

Many students view science as learning vocabulary terms, labeling pictures, and memorizing facts. Science includes much more than that! Have you ever wondered or asked yourself questions about the world around you? This is science. Science works best when driven by your own curiosity and innovation. In order for you to experience science in its fullest sense you must take it beyond the classroom and into your everyday experience. In order to be meaningful certain guidelines can help us. Science is not limited to **matter**, **changes in the earth's surface, or electricity,** but there are **cross-cutting concepts** threaded throughout all scientific disciplines. These include:

- Patterns; such as heredity.
- Cause and effect: Mechanism and explanation; such as chemical reactions.
- Scale, proportion, and quantity; such as mass in matter.
- Systems and system models; such as circuits.
- Energy and matter: Flows, cycles, and conservation; such as electricity.
- Structure and function; such as landforms.
- Stability and change; such as earth's surface.

When studying any specific scientific discipline, keep these cross-cutting concepts in mind to gain a better understanding of the world and the nature of science. Scientists and engineers utilize skills and practices in these concepts daily. When you ask questions about the natural world, use scientific practices to generate better conclusions, explanations and inferences. These include:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

While these practices and cross-cutting concepts are crucial to your overall success in science, to be most meaningful they need context. This is where the study of disciplinary core ideas has the most impact. If you study **magnetism** or any other science discipline without scientific practices, you limit yourself to fact memorization and never discover how these concepts relate to your world. Studying individual scientific concepts is the method for understanding cross-cutting concepts and acquiring scientific skills. By studying individual disciplines within the context of scientific practices and concepts, they will be more meaningful and have a greater impact.

For example, when examining how volcanoes and earthquakes affect earth's changing surfaces, scientists from varying disciplines work collaboratively to determine how these changes will impact people's lives. What might have happened if scientists had not studied Mount St. Helens prior to its eruption in 1980? How has studying earthquakes improved construction in places such as Utah or Southern California? How will technology continue to help scientists and engineers predict and improve the impact of earth's changing surface on our lives? When scientists and the community come together problems such as these can be resolved.

Chapter 1

Matter

Standard I Objective 1:
5th Grade
Text Structure: Description

What is everything around us made of? Does it always exist? How do you know?

Imagine that you are an astronaut, off to explore Mars. You start your journey strapped into the acceleration couch of the space shuttle. Suddenly, the engines ignite and you are pressed into the couch as you are flying through space. You have begun your long journey through the solar system. Hopefully, you didn't forget anything, because it is a long way to the grocery store. The substances you have with you must be enough to get you to your destination.

Matter is defined as anything that has mass and volume. **Matter** is all the "stuff" that makes up the universe. Everything you can see and touch is made of matter, including you! The only things that aren't matter are forms of energy, such as light and sound. Mass and volume measure different aspects of matter.

You can define matter as something that has mass and volume. Matter can exist as a solid, liquid, or gas. So, the air in the space ship is matter, the water you must bring along to drink is matter, and the steel used to make the ship itself is matter. Matter can neither be created nor destroyed, even though it can undergo changes. Examples of matter are books, shoes, all kinds of food, water, and air. When describing or identifying matter, we might describe the shape, size, or state of the matter, e.g. solid, liquid or gas. What are some other terms or ways we can describe matter?

Mass is a measure of the amount of matter in a substance or an object. To measure **mass**, you would use a balance. In the lab, mass may be measured with a triple beam balance or an electronic balance, but the old-fashioned balance pictured below may give you a better idea of what mass is. If both sides of this balance were at the same level, it would mean that the fruit in the left pan has the same mass as the iron object in the right pan. In that case, the fruit would have a mass of 1 kg, the same as the iron. As you can see, the fruit is at a higher level than the iron. This means that the fruit has less mass than the iron, that is, the fruit's mass is less than 1 kg.

Q: If the fruit were at a lower level than the iron object, what would be the mass of the fruit?
A: The mass of the fruit would be greater than 1 kg.

Mass is commonly confused with **weight** –the measure of the force of gravity on an object. The two are closely related, but they measure different things. Whereas mass measures the amount of matter in an object, **weight** measures the force of gravity acting on an object.

What are solids, liquids and gases?

All solids, liquids, and gases in the universe are matter. Matter takes up space and has mass, this means we can weigh matter. When we use one kind of matter to make something such as a wooden or plastic chair we say the material used was wood or plastic.

Materials are all around us. Some materials are solids, some are liquids, and some are gases. A material will always be one of these three things. But what exactly are solids, liquids, and gases? Let's investigate the properties of solids, liquids, and gases!

When is a material a solid?

A chair is made of solid material.

http://www.flickr.com/photos/epsos/6018530849/

The word **"property"** has different meanings. We say this house is the property of Mr. Jones (he is the owner of the house). When we use the word **"property"** in science we look at what makes that kind of matter special; how it behaves differently from other kinds of matter. For example, when you shift a chair to another place, it will still have the same shape. This is because the chair is **solid**- matter that keeps its shape. So we can say that all **solids** keep their shape. We say that keeping its shape is a property of a solid. Let's look at some of the properties of solids.

Exploring the properties of solids

MATERIALS (What you will need):

- acetone
- cloth
- paper
- a table or chair
- a variety of containers
- pen or any solids around you

INSTRUCTIONS (What you have to do):

Work in pairs.

1. Use the questions below to investigate each solid.
    - Does it feel hard or soft?
    - Does it make a sound when you knock on it?
    - Does it break easily? Can it break?
    - Can you put your finger through it?
    - Is your hand dry or wet after handling the object?
    - Does it change its shape when you put it in something else?
    - How would you describe the shape? Can its shape be changes, or does it remain the same? Explain.

2. Use the table below to fill in some of your answers about each of the objects.

3. There are some empty rows at the bottom for you to fill in any other solid objects that you might have investigated.

Object	Your observations
Stone	
Cloth	
Paper	
A table or chair	

QUESTIONS:
Which properties were the same (common) for all the solids you investigated?

List some other solid objects in your classroom. Give at least 4 examples.

What is a liquid?

There are **liquids,** matter that keeps its volume but not its shape, all around you and you use them in your everyday lives. Some examples of **liquids** are water, paraffin, baby oil, fruit juice, gas for a car, and drinks. What are the common properties of liquids? When scientists want to know more about something, they ask questions, and try to answer the questions by doing experiments.

Exploring the properties of liquids

MATERIALS (What you will need):

- water
- paraffin
- baby oil
- fruit juice
- rubbing alcohol
- 5 small pieces of cloth
- 5 containers for each of the 5 liquids
- 5 other clean and empty containers, such as a glass, cool drink bottle or tin
- 5 saucers

INSTRUCTIONS (What you have to do):

1. Work in groups. Each group MUST test a different liquid.
2. Select someone in your group to collect a liquid in a container from the teacher. Each group must also collect another empty container and a saucer from your teacher.
3. Answer these questions while you are studying your liquid. Write your answers in the table that follows. DO NOT TASTE THE LIQUID!
    - How does it smell?
    - Can you put your finger through it?
    - Is your hand dry or wet after feeling the liquid?
    - Can you soak the liquid up with a cloth?
4. Put a small amount of the liquid in the saucer and leave it for a while in a warm place.
    - Was it easy to pour the liquid from one container to another?
    - Can the liquid flow or spread out on a saucer?
    - How will you describe the shape of the liquid? Is it fixed, or does it take the shape of the container?
    - Did the amount of the different liquids remain the same after leaving them in a warm place?

5. WASH YOUR HANDS AFTER HANDLING THE LIQUID.

Observation	Answer
What did your liquid smell like?	
Was your hand dry or wet after touching the liquid?	
Did the shape of the liquid change when you poured it into another container?	
What do you think happened to the liquid when you left it in a warm place?	

QUESTIONS:
Write down the safety rules for this investigation. Why must these safety rules be followed?

Write down those properties that were the same (common) for all the liquids investigated.

After doing this activity where we investigated the properties of liquids, we can say that a liquid: a) can flow, b) it has no fixed shape, and c) it takes the shape of the container that it is in.

This is different than a solid. Remember a solid has a fixed shape and you cannot pour a solid!

What is a gas?

Gas –matter that does takes the volume and shape of a container- is all around us. It is the air we breathe, the steam coming off of a boiling pot, and smoke off of a fire. Oxygen is a gas that is necessary for us to live. Trees use carbon dioxide. Gasses are necessary for many living things to survive.

Video on gases http://goo.gl/rgte96
Look at the following pictures of where a gas is being used.

A patient in hospital has an oxygen mask on. The oxygen gas is given to her in a tube attached to the mask.
http://www.flickr.com/photos/donhomer/4037179901/

These balloons are filled with helium gas. You cannot see the gas, but it is there as the balloons are blown up and floating.
http://www.flickr.com/photos/92833011@N00/1160780781/

A scuba diver has an oxygen tank on his back to breathe under water.
http://www.flickr.com/photos/87241965@N00/371591593/

Think like a scientist

1. What is everything around us made of? Does it always exist? How do you know?
2. Compare and contrast mass and weight.
3. How are solids, liquids and gasses the same and different?
4. What properties do all solids have? Liquids? Gasses?

Science Language

liquid – matter that has a definite volume but takes the shape of its container
gas – matter that takes the shape and volume of its container
mass - the amount of matter that makes up an object
matter - physical substance that takes up space and has mass
solid – matter with a definite shape and volume
substance – a specific kind of matter with similar characteristics
weight - the measure of the force of gravity on matter

Online Activities to Try

- Explore properties of common materials on this site. **http://tinyurl.com/UT5th4-1b**
- "Zoom in on Matter" and discover the structure of matter. http://tinyurl.com/UT5th41-c

Standard I Objective 2
5th Grade
Text Structure: Description

Is it possible to change something and have it still be made of the same "stuff" it was made of before? Is it possible to have the same material be a solid, liquid or gas?

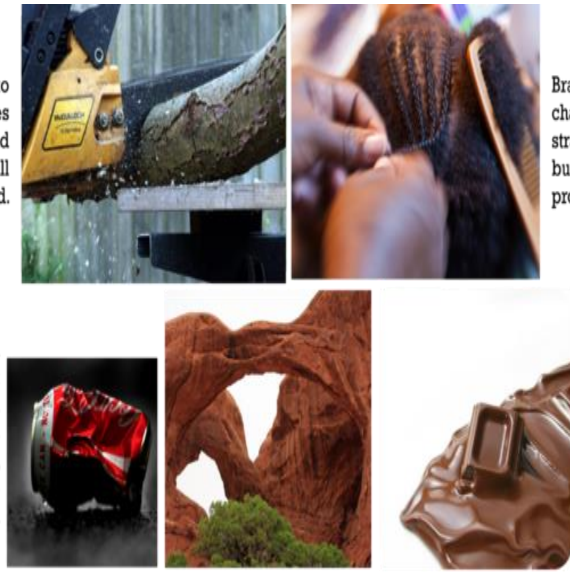
You hit a baseball out of the park and head for first base. You're excited. The score is tied, and now your team has a chance of getting a winning home run. Then, you hear a crash. Oh no! The baseball hit a window in a neighboring house. The glass has a big hole in it, surrounded by a web of cracks (see Figure below). The glass has changed. It's been broken into jagged pieces. But the glass is still glass. Breaking the window is an example of a physical change in matter.

When glass breaks, its physical properties change. Instead of one solid sheet of glass, it now has many pieces.

Physical Changes in Matter

A **physical change** in matter is a change in which the one or more of matter's physical state. Glass breaking is just one example of a **physical change**. Some other examples are shown in the figures and video below. In each example, matter may look different after the change occurs, but it's still the same substance with the same chemical properties. For example, smaller pieces of wood have the ability to burn just as larger logs do.

Video: http://goo.gl/LXqeSO



Cutting a log into smaller pieces changes its size and shape, but it's still wood.

Braiding hair changes how the strands are arranged but not their other properties.

Crushing a metal can changes its shape. But the crushed can is still made of metal and has the same properties, such as the ability to conduct heat.

Crisp squares of chocolate melt into a shapeless puddle in the heat. The puddle tastes yummy because it's still chocolate.

Wind-blown sand has worn away this rock to create an arch, but the rock's composition has not changed. The bits of rock worn away by the wind still contain the same minerals as they did when they were part of the large rock.

As an ice cube melts, its shape changes as it acquires the ability to flow. However, its composition does not change. Melting is an example of a physical change. A physical change is a change to a sample of matter in which some properties of the material change, but the identity of the matter does not. Physical changes can further be classified as reversible or irreversible. The melted ice cube may be refrozen, so melting is a reversible physical change. Physical changes that involve a change of state are all reversible. Other changes of state include vaporization (liquid to gas), freezing (liquid to solid), and condensation (gas to liquid). **Dissolving -** combining matter with a liquid into a solution- is also a reversible physical change. When salt is **dissolved** into water, the salt is said to be in a solution. The salt may be regained by evaporating off the water, leaving the salt behind.

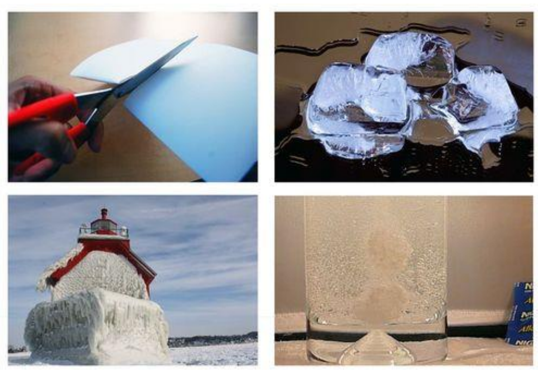
Arches are formed by wind, but also by moving water. The minerals in the water may react with the sediments to cause a chemical change. In each of these changes, only the physical properties of matter change. The chemical properties remain the same.

Because the type of matter remains the same with physical changes, the changes are often easy to undo. For example, braided hair can be unbraided again. Melted chocolate can be put in a fridge to re-harden. Dissolving salt in water is also a physical change. How do you think you could undo it?

These stunning rock arches in Utah were carved by wind-blown sand. Repeated scouring by the sand wore away the rock, bit by tiny bit, like sandpaper on wood. The bits of rock worn away by the sand still contain the same minerals as they did when they were part of the large rock. They have not changed chemically in any way. Only the size and shape of the rock have changed, from a single large rock to millions of tiny bits of rock. Changes in size and shape are physical changes in matter.

You can learn more about physical changes and why they occur by watching the video at this URL:
http://goo.gl/owp66s

Q: In the Figure below, what physical changes are occurring?



A: The paper is being cut into smaller pieces, which is changing its size and shape. The ice cubes are turning into a puddle of liquid water because they are melting. This is a change in the state of matter. The tablet is disappearing in the glass of water because it is dissolving into particles that are too small to see. The lighthouse is becoming coated with ice as ocean spray freezes on its surface. This is another change of state.

Reversing Physical Changes

When matter undergoes physical change, it doesn't become a different substance. Therefore, physical changes are often easy to reverse. For example, when liquid water freezes to form ice, it can be changed back to liquid water by heating and melting the ice.

Q: Salt dissolving – being combined with water in a solution- is a physical change. How could this change be reversed?

A: The dissolved salt water could be boiled until the water evaporates, leaving behind the salt. Water vapor from the boiling water could be captured and cooled. The water vapor would condense and change back to liquid water.

How does a car go from new and shiny to old and beaten up?

Want to buy a car – cheap? Notice there is no specification such as "in good condition" or "needs a little work." The car above is pretty beat up. The body is damaged, the windows are broken, and the interior is probably torn up. But this is still a car. It has all the components of a car, even though you would not want to buy it in the present condition. But change that condition and you have a (possibly) useable car.

Melting ice in the Beaufort Sea.

Not all physical changes can be reversed. When a piece of wood is ground into sawdust, the change is irreversible since the sawdust cannot be changed into the same piece of wood that it was before. Cutting the grass or pulverizing a rock would be other irreversible physical changes. Firewood also represents an irreversible physical change since the pieces cannot be put back together to form the tree. Even though these physical changes cannot be reversed, they are still physical changes because the matter hasn’t changed into something new. There hasn’t been a change in the chemical makeup of the matter.

Change of state

Remember that we spoke about the states of matter? These were solids liquids and gases. A substance can change from one state to another. For example, a solid can change into a liquid; water can be a liquid in your glass or turn into ice in the freezer. Ice is a solid. But what makes these substances change from one state to another?

What causes a change of state?

- Melting
- Freezing
- Boiling (vapor)
- Condensation
- Sublimation
- Deposition

We know that matter can be in the solid, liquid or gas state. Let's use water as an example. If you place tap water into an ice tray and put this in the freezer, what will happen to the water? If you now take ice cubes and place them in the sun, what happens to the ice cubes?

The difference between a freezer and the sun outside is that one is hot and the other is cold. If we place the water in a place that is cold enough, it freezes. If we place the ice cubes in a hot place, they melt.
This is because the state of matter can be changed from one to another by adding or removing heat.

Let's read a story to try understand this a bit more.

The Story of Steven

Steven is a boy in first grade at a primary school in a small village, which gets very hot in summer. He loves to play soccer. After school he often goes over to soccer field to play a game with his friends. They really like having Steven play with them. Even though he is a few years younger, he is very talented and also fun and caring. Steven especially likes Joe and they play well together as a team.

One day after school, Steven thought he would do something nice for his friends, and surprise them with popsicles after they were finished playing. Steven bought 5 ice popsicles, one for himself and one for each of the other kids. He put the popsicles in a bowl and placed some ice blocks around them to keep them cool. Steven then ran off to join the others playing soccer.

After the game, Steven ran back to the bowl to get the popsicles. But he got such a shock when he got there. They were all gone! He was so upset and started to cry. The other kids saw that Steven was upset and ran over to see what was wrong.

"Hey Steven, what's wrong? Did you hurt yourself while playing?" Joe asked.

"No, I didn't. I bought some popsicles for all of you as a surprise and when I came back to get them, they were all gone! I think someone stole and ate them and just left the sticks! Look!" Steven cried out.

"Oh no, don't cry Steven! It's not your fault, and no one stole them or ate them either," Zach said while patting Steven on the back.

"Yes, Steven, actually we learned in class today about what happened to your popsicles," said Sophie, "and I can explain it to you too. Do you see that your bowl is actually not empty? There is a liquid in it. And it also has a red color, which was the color of your popsicles."

"Yes, I see that," answered Steven, "but then how did that happen?"

Tom then answered, "Your popsicles melted from the heat in the air around us. Even if the sun was not so hot, they would have melted! For something to stay frozen it needs to be at a very cold temperature, like in a freezer."

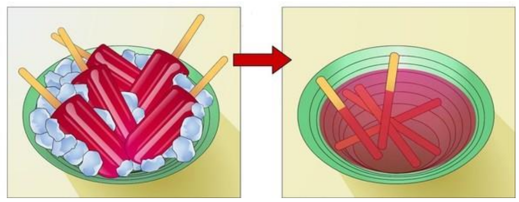
"Yes, melting is when heat causes the solid popsicles to change into a liquid," Sophie replied, "So no one stole the popsicles, they just melted."

"Oh ok, I see," said Steven, "I must be really silly not to know that!"

"No, not at all Steven! We only learned about it today in class!" laughed Zach.

"I know what we should do!" shouted Joe, "Let's go to the store now. I have some extra change and we can buy some more frozen popsicles!"

They all really liked this idea, especially Steven, who was now laughing. So off they all went, the kids and Steven, and bought some more popsicles and sat under the tree to eat them.



Now that we have read about Steven and his experience of changes of state, let's do some practical demonstrations in class to learn more.

Heating and cooling to cause a change of state

MATERIALS (What you will need)

- kettle
- liquid water
- glass or mirror
- gloves or towel

INSTRUCTIONS (What you have to do)

1. This activity could be quite dangerous as you might burn yourself with the hot water, so your teacher is going to demonstrate it for you.
2. Boil the water in the kettle.
3. Put a glass or mirror 30 cm above the boiling kettle (you need to wear gloves made of thick material or use a towel to avoid burning your skin)
4. Your teacher will then let you come up to see what is taking place. Make sure you have a look at the mirror.

QUESTIONS:
What was the change of state when the water boiled and became steam?

Evaporation takes place when heat is added to the liquid. It means the water changes from the liquid to the gas state.

We hang wet clothes out to dry in the sun. They dry as the water evaporates.

The steam that comes out of the kettle is extremely hot and you cannot see it. The steam quickly cools and forms tiny droplets in the air. These tiny droplets are visible and form the “cloud” that you see. When these tiny droplets hit the mirror they cool more and form the bigger droplets, which you see forming on the mirror. We say the steam condensed to form water. The change of state from the gas state to the liquid state is called condensation, which takes place when heat is removed.

When you leave a glass filled with cold water on the table, small droplets form on the outside. This is because there is water vapor in the air which cools down when it is near the cold glass. The water vapor in the air around the glass condenses as it changes from a gas to a liquid and forms the tiny droplets you can see.

We now know that substances react to temperature changes around them. But where do we use what we learned in everyday life? Let us look at how milk reacts to low temperature.

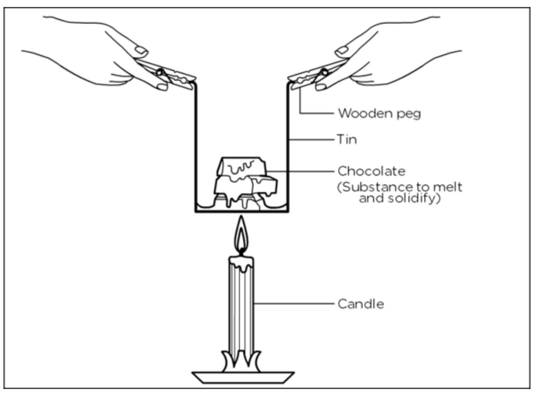
Water droplets on the outside of a cold glass.

Melting and solidifying substances
MATERIALS (What each group will need)

- butter, fat or margarine
- chocolate or wax
- ice blocks or ice cream
- 3 containers which will not melt (they can be empty tins)
- 6 wooden pegs
- a candle
- matches

INSTRUCTIONS (What you have to do in your group)

1. In your groups, plan how you are going to melt and solidify the substances.
2. Look at the diagram below. Which shows how you can do this?
3. Be careful not to burn yourself when working with the candle! In your group, discuss the safety rules that you are going to apply.
4. Test each different substance that you have by placing it in the tin and holding it over the candle.
5. Then remove the tin from the candle and leave it on the side to cool.
6. Observe what happens to each substance and write down your observations in the table opposite.



OBSERVATIONS:

Substance	Observation before heating	What happened after heating	What happened after cooling
Butter/margarine			
Chocolate/wax			
Ice blocks/ice cream			

QUESTIONS:
What happened when the solids were heated by the candle?

What happened to the substances when they cooled down again?

Did the ice cream solidify again or did it remain a liquid?

The science of chocolate.
http://goo.gl/2JAAlX

Chocolate melting on a hot surface.

http://www.flickr.com/photos/jaynelloyd/6782664355/

We have seen that solids that have melted can be solidified again. So the process can be reversed or turned around again by adding or removing heat.
Let's revisit what we have learned from the story of Steven and the activities. We have learned some new big words which may be quite confusing!

Here is a summary of the different state changes:

Change of state	Heating or cooling?	We call the process
Solid to a liquid	Heating	Melting
Liquid to a gas	Heating	Evaporating
Gas to a liquid	Cooling	Condensing
Liquid to a solid	Cooling	Freezing or solidifying

Solids, liquids and gases

- How are the 3 states of matter different from each other?
- How can we draw pictures of the 3 different states of matter, that show how the particles in the matter behave?
- When matter changes from one state to another, do the particles themselves change, or only their behavior?
- What is needed to make matter change from one state to another and back again?

Arrangement of particles

- state (of matter)
- particle
- vacuum

Particles of Matter (video) http://goo.gl/FPSLLb

We have learned that matter can exist in 3 different states: solids, liquids and gases. All the materials around us are in one or more of these three states. For example, you have all three states in your body! There is bone in your skeleton. There is water in your blood. There is air in your lungs. We have also learned that each of the states (solids, liquids and gases) has unique properties:

- Solids keep their shape.
- Liquids flow and take the shape of their container. They fill up a container from the bottom up to a certain level. They take up a fixed amount of space in the container.
- Gases also flow and take the shape of their container. They always fill up the whole space of the container and will escape if the container is open.

We know when we have a solid or a liquid. It is easy to see a solid or a liquid. We cannot normally see gases. We can still check that gases are present by seeing their effects.

Why do solids keep their shape but liquids and gases flow? Why does a liquid stay inside an open container (unless it is poured out), but a gas escapes?

We have to look deep inside each state for the answers to these questions. We will have to use our imaginations like never before!

Did you know that all matter is actually made up of very small particles? These particles are called atoms and molecules, and we will learn more about them much later. For now, we are going to use the term *particle* to describe the smallest 'building blocks' that matter is made of.

The particles that matter is made of are very, very small. Much, much smaller than a tiny grain of sand. Much, much smaller even than a speck of dust! Do you have any idea how small that is?

Mmm, that is quite hard to imagine. I am not so sure.

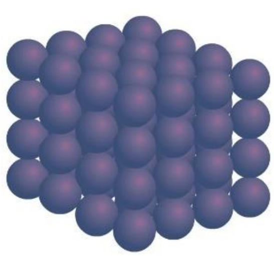
It is hard to imagine, isn't it? Most people find it very hard to think about, so do not worry, we will go through it slowly.

The particles in a solid

The particles that matter is made of are much too small to see with the naked eye. They are even too small to see with a strong microscope. So how do we know they exist? Scientists, with special microscopes and other special scientific instruments, have collected evidence that they exist. It is now a well-known and accepted fact that all matter is made up of particles.

Let's imagine that we can shrink ourselves down to the size of such a 'matter particle'. What would we see if we could look around inside a solid? We would see the particles in the solid are packed tightly together. This explains why solids cannot be squeezed into a smaller shape - solids cannot be compressed.

We would also see that the particles in the solid have fixed positions; they cannot move from their positions. This explains why solids keep their shape.



The particles in a solid.

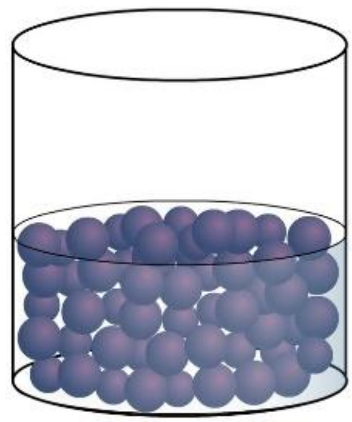
The particles in a liquid

Even when it looks like the water inside a glass is still, the water particles are constantly moving!

If we could shrink ourselves down to the size of a 'matter particle', and we could look around inside a liquid, what would we see?

We would see that the particles in the liquid are also very close together. Like solids, liquids cannot be compressed either.

Unlike solids, the particles in a liquid do not have fixed positions. They are always moving around. This explains why liquids flow, to take the shape of their container.



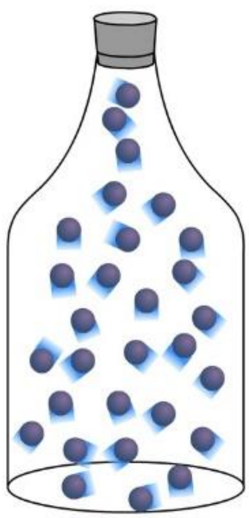
The particles in a liquid.

The particles in a gas.

Acting out the states of matter (video) http://goo.gl/7VmWRm
If we could shrink ourselves down to the size of a 'matter particle,' and we could look around inside a gas, what would we see?

We would see that the particles in the gas are far apart. The spaces between the particles are huge compared to the size of the particles themselves. These spaces are empty! We call this a vacuum. This explains why gases can be compressed - they can be squeezed into a smaller shape by pushing them closer together. We can make the spaces between them smaller.

The particles of a gas are always moving freely. If they are in a closed container, they will spread out to fill the whole container. If they are in an open container, they will not stay inside for long. They will flow out of the container, and disperse (disperse means to spread out over an area or space.)



The particles in a gas

Pretending to be particles!

In this activity we are going to pretend to be particles! We are going to behave in the same way that particles do in the 3 different states of matter.

Your teacher will divide the class into groups and then we will go through the different states pretending to be the particles!

INSTRUCTIONS:

Solid:

Since you are the particles in a solid, you should sit or stand as closely as possible to (touching) each other, in neat rows, and move your body, but without moving your feet.
If we wanted to move these particles from their fixed positions, what should we give them?

If we wanted these particles to move into fixed positions again and not move around, what must we take away from them?

Liquid:

1. Now let's pretend to be the particles in a liquid. Stay in the same group.
2. Since you are the particles in liquid, you should now move around but stay in contact with each other all the time.
3. If we wanted to move these particles further away from each other, what should we give them?
4. If we wanted these particles to move into fixed positions and not move around, what must we take away from them?

Gas:

1. Now let's pretend to be the particles in a gas. Stay in the same group.
2. Since you are the particles in gas, you should now move around and be as far from each other as possible.
3. If you should come into contact, you must move away from each other immediately.
4. If we wanted these particles to move more slowly and come closer to each other, what should we take away from them?
5. If we wanted these particles to move into fixed positions and not move around, what must we take away from them?

How do we decide whether a material is a solid, a liquid or a gas? The next activity will help us answer that question. We are going to think about some everyday materials. We will use our skills of observation to decide whether they are liquids, solids or gases.

Solids, liquids and gas particles (video) http://goo.gl/gQ51id

Once we have decided whether a material is a solid, a liquid or a gas, we can make some predictions about the behavior of the particles in each material. For this we will need our imagination, as particles are much too small to see with the naked eye.

A fun game on solids, liquids and gases. http://goo.gl/aDEltpA
Song on solids, liquids and gases. http://goo.gl/GwgXJ3

Think like a scientist

1. Is it possible to change something and have it still be made of the same "stuff" it was made of before? What do you call this change? Is it possible to have the same material as a solid, liquid and gas? How do you know?
2. How can water be a solid, liquid and gas?
3. What does it mean when we say that matter is changing state? How do you know when an object has changed state?
4. What causes changes in states?

Science Language

physical change - a change in matter's physical state

dissolve – matter combined into a solution with a liquid

Online Activities to Try

- In this virtual lab, explore chemical changes that are reversible and irreversible. http://tinyurl.com/UT5th4-2a

- Sort common items into solids, liquids, and gasses on this site: **http://tinyurl.com/UT5th4-2b**

Standard I Objective 3
5th Grade
Text Structure: Compare and Contrast

Why does wood turn to ash? Why is there less ash than wood?

Communities often use fireworks to celebrate important occasions. Fireworks certainly create awesome sights and sounds! Do you know what causes the brilliant lights and loud booms of a fireworks display? The answer is chemical changes.

What Is a Chemical Change?
A chemical change occurs whenever matter changes into an entirely different substance with different chemical properties. A chemical change is also called a chemical reaction. Many complex chemical changes occur to produce the explosions of fireworks. An example of a simpler chemical change is the burning of methane. Methane is the main component of natural gas, which is burned in many home furnaces. During burning, methane combines with oxygen in the air to produce entirely different chemical substances, including the gases carbon dioxide and water vapor.

Chemical Changes in Matter
Did you ever make a "volcano," like the one in figure below, using baking soda and vinegar? What happens when the two substances combine? They produce an eruption of foamy bubbles. This happens because of a chemical change. A chemical change occurs when matter changes chemically into an entirely different substance with different chemical

properties. When vinegar and baking soda combine, they form carbon dioxide, a gas that causes the bubbles. It’s the same gas that gives soft drinks their fizz.

This girl is pouring vinegar on baking soda. This causes a bubbling "volcano."

Not all chemical changes are as dramatic as this "volcano." Some are slower and less obvious. Figure below and the video below show other examples of chemical changes.

http://goo.gl/OnGjCo

These chemical changes all result in the formation of new substances with different chemical properties. Do you think any of these changes could be undone?

Identifying Chemical Changes
Most chemical changes are not as dramatic as exploding fireworks, so how can you tell whether a chemical change has occurred? There are usually clues. You just need to know what to look for. A chemical change has probably occurred if bubbles are released, there is an unexpected change of color, or an odor is produced. Other clues include the release of **heat** – energy being given off or absorbed-, light, or loud sounds. Examples of chemical changes that produce these clues are shown in the figure below.

Q: In addition to iron rusting, what is another example of matter changing color? Do you think this color change is a sign that a new chemical substance has been produced?

A: Another example of matter changing color is a penny changing from reddish brown to greenish brown as it becomes tarnished. The color change indicates that a new chemical substance has been produced. Copper on the surface of the penny has combined with oxygen in the air to produce a different substance called copper oxide.

Q: Besides food spoiling, what is another change that produces an odor? Is this a chemical change?

A: When wood burns, it produces a smoky odor. Burning is a chemical change.

Q: Which signs of chemical change do fireworks produce?

A: Fireworks produce heat, light, and loud sounds. These are all signs of chemical change.

Can Chemical Changes Be Reversed?

Because chemical changes produce new substances, they often cannot be undone. For example, you can't change ashes from burning logs back into wood. Some chemical changes can be reversed, but only by other chemical changes. For example, to undo tarnish on copper pennies, you can place them in vinegar. The acid in the vinegar combines with the copper oxide of the tarnish. This changes the copper oxide back to copper and oxygen, making the pennies reddish brown again. You can try this at home to see how well it works.

Signs of Chemical Change

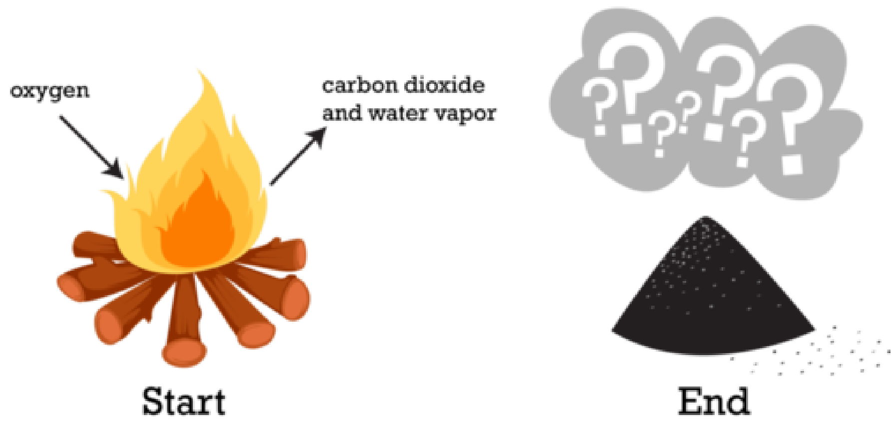
How can you tell whether a chemical change has occurred? Often, there are clues. Several are demonstrated in figures above and in the video below.
http://goo.gl/ujJPVe

To decide whether a chemical change has occurred, look for these signs:

- Gas bubbles are released. (Example: Baking soda and vinegar mix and produce bubbles.)
- There is an unexpected color change. (Example: Leaves turn from green to other colors.)
- An odor is produced. (Example: Logs burn and smell smoky.)
- A solid comes out of a solution. (Example: Eggs cook and a white solid comes out of the clear liquid part of the egg.)

Conservation of Mass

If you build a campfire, like the one in Figure below, you start with a large stack of sticks and logs. As the fire burns, the stack slowly shrinks. By the end of the evening, all that's left is a small pile of ashes. What happened to the matter that you started with? Was it destroyed by the flames? It may seem that way, but in fact, the same amount of matter still exists. The wood changed not only to ashes but also to carbon dioxide, water vapor, and other gases. The gases floated off into the air, leaving behind just the ashes.



Burning is a chemical process. Is mass destroyed when wood burns? Assume you had measured the mass of the wood before you burned it. Assume you had also trapped the gases released by the burning wood and measured their mass and the mass of the ashes. What would you find? The ashes and gases combined have the same mass as the wood you started with.

This example illustrates the law of conservation of mass. The law states that matter cannot be created or destroyed. Even when matter goes through physical or chemical changes, the total mass of matter always remains the same. (In the chapter Nuclear Chemistry, you will learn about nuclear reactions, in which mass is converted into energy. But other than that, the law of conservation of mass holds.) For a fun challenge, try to apply the law of conservation of mass to a scene from a Harry Potter film at this link: http://goo.gl/tvNEI4

Lesson Summary

- Physical changes are changes in the physical form of matter but not in the makeup of matter. An example of a physical change is glass breaking.
- Chemical changes are changes in the makeup and chemical properties of matter. An example of a chemical change is wood burning.
- Matter cannot be created or destroyed even when it changes. This is the law of conservation of mass.
- A chemical change occurs whenever matter changes into an entirely different substance with different chemical properties. Burning is an example of a chemical change.
- Signs of chemical change include the release of bubbles, a change of color, production of an odor, release of heat and light, and production of loud sounds.
- Because chemical changes result in different substances, they often cannot be undone. Some chemical changes can be reversed, but only by other chemical changes.

Think like a scientist

Recall

1. What is a physical change in matter?
2. What happens during a chemical change in matter?
3. State the law of conservation of mass.

Apply Concepts

4. When a plant grows, its mass increases over time. Does this mean that new matter is created? Why or why not?
5. Butter melts when you heat it in a pan on the stove. Is this a chemical change or a physical change? How can you tell?

Think Critically

6. Compare and contrast physical and chemical changes in matter. Give an example of each type of change.

Some physical changes in matter are changes of state.

7. What are the states of matter?
8. What might cause matter to change state?
9. Why does wood turn to ash? Why is there less ash than wood?
10. What happens in any chemical change?
11. List three signs that a chemical change has occurred.

12. Give an example of a chemical change. Explain why you think it is a chemical change.
13. Compare and contrast chemical changes and physical changes.

Science Language

chemical change - one or more substances are changed to form a new substance

heat - energy being given off or absorbed

product - something that is made, for example, a new substance from a chemical change

reactants - substances mixed together in a chemical reaction

Resources

See Activity from Sci-Ber Text, "Changes in Matter - It's the Law.
http://goo.gl/MMSBEq

Online Activities to Try

- ****Discover chemical and physical changes to the copper in the Statue of Liberty over time on this site. http://tinyurl.com/UT5th4-3a**
- **Discover what happens to everyday items when heated or frozen.
  http://tinyurl.com/UT5th4-3b

Earth's surface

chapter 2

Standard II, Objective 1
Grade 5
Cause and Effect

Do the mountains outside look the same as they did 100, 1000, or even 1,000,000 years ago?

Do you like to be absolutely certain about things? One thing you can be certain of is that the Earth's surface is constantly changing. Take a look outside. Every landform you see at one time used to be something else. A mountainside may have been at the bottom of an inland sea. A canyon may have formed from a plateau. A stream may have changed its course. The sand between your toes may have come from rock, carried from the top of a mountain by a glacier and dumped in a riverbed. Some changes happen quickly, while other changes take thousands of years. Whether the changes happen in an instant or over eons of time, you can count on the fact that Earth's surface is constantly changing.

Weathering–the breaking down of earth's materials into smaller pieces–is a process that takes a very long time. **Weathering** breaks large boulders into rocks, rocks into pebbles, and pebbles into soil or sand. These pieces are called sediments. Sediments are different sizes of rock particles. Boulders are sediments; so is gravel. Silt and clay are smaller sediments. The small rock you pick up on the playground may once have been part of a large boulder on the mountain you see in the distance. No one can watch for millions of years as mountains are built or watch as those same mountains gradually are worn away. But you can see the evidence that a change has occurred.

Powerful forces of weathering include wind, water, temperature, chemical changes, and living organisms. You may call these the "Agents of Weathering."

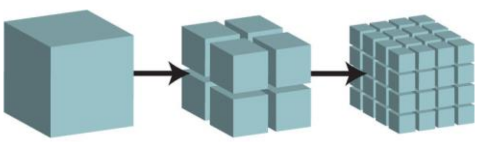
- Agent Temperature: Water seeps into small cracks in rock. When the temperature falls below freezing, water expands as it becomes ice. Freezing and thawing make the cracks bigger until some of the rock breaks away.
- Agent Living Organisms: The roots of plants can grow in cracks. As the roots grow larger, they split the rocks.

- Agent Water: Water can break rock into very small pieces. Rocks carried down a swiftly moving river are weathered as they bump against each other.
- Agent Wind: Particles carried by wind smooth and polish rocks.
- Agent Chemical Change: Weathering may also cause the minerals at the Earth's surface to change form. The new minerals that form are stable at the Earth's surface.

Animations of different types of weathering processes can be found here:
http://www.geography.ndo.co.uk/animationsweathering.htm#
http://goo.gl/Ow4B1Z.

There are two types of weathering: Mechanical (Physical) and Chemical.

Mechanical Weathering-- (also called physical weathering) breaks rock into smaller pieces. Rocks changes physically without changing composition. Smaller pieces have the same minerals in the same proportions as the original rock. Here are some forms of **mechanical weathering**:



As rock breaks into smaller pieces, overall surface area increases.

Ice Wedging: main form of mechanical weathering in any climate that regularly cycles above and below the freezing point

- Breaks apart large amounts of rock
- Common in Earth's polar regions and mid-latitudes, and at higher elevations

- **Abrasion:** one rock bumps against another rock; smoothens sharp or jagged rocks
  - Caused by gravity as a rock tumbles down a mountainside or cliff
  - Caused by moving water as particles in the water collide and bump against one another
  - Caused by strong winds carrying pieces of sand which can sandblast surfaces

    - Caused by ice in glaciers, which carries many bits and pieces of rock. Rocks embedded at the bottom of the glacier scrape against the rocks below.

  Organisms: plant and animals can cause mechanical weathering
    - For example, plant roots gradually grow larger, wedging open the crack
    - For example, burrowing animals can break apart rock as they dig for food or make living spaces for themselves
- **Humans:** digging or blasting into rock to build homes, roads, subways; quarrying stone.

Chemical weathering and mechanical weathering are different. Minerals in the rock change their chemical makeup. They become a different type of mineral or even a different type of rock. Chemical weathering is the result of chemical reactions that change the rock.

Most minerals form deep within Earth's crust. At these depths, temperatures and pressures are much higher than at the surface. Minerals that were stable deeper in the crust are not stable under surface conditions. That’s why chemical weathering happens. Minerals that formed at higher temperature and pressure change into minerals that are stable at the surface.

Agents of Chemical Weathering

There are many agents of chemical weathering. Remember that water was a main agent of mechanical weathering? Well, water is also an agent of chemical weathering. That makes it a double agent! Carbon dioxide and oxygen are also agents of chemical weathering. As rock is broken down by these agents, new chemical compounds are formed. Examples of chemical weathering include rusting and acid breakdown. You may know that several years ago we replaced the copper surface on the dome of the Utah State Capitol. When it was first replaced, it was a beautiful copper color. Now it is green! Why? The copper color changed through chemical weathering.

Water

Water is an amazing molecule. It has a very simple chemical formula, H_2O. It is made of just two hydrogen atoms bonded to one oxygen atom. Water is remarkable in terms of all the things it can do. Lots of things, like salt and sugar, dissolve easily in water. Some types of rock can even completely dissolve in water (Figure below)! Other minerals change by adding water into their structure. Hydrolysis is the name of the chemical reaction between a compound and water.

Weathered rock in Walnut Canyon near Flagstaff, Arizona.

Carbon Dioxide

Carbon dioxide (CO_2) combines with water as raindrops fall through the air. This makes a weak acid, called carbonic acid. This happens so often that carbonic acid is a common, weak acid found in nature. This acid works to dissolve rock. It eats away at sculptures and monuments. While this is normal, more acids are made when we add pollutants to the air. Any time we burn any fossil fuel, it adds nitrous oxide to the air. When we burn coal, rich in sulfur, it adds sulfur dioxide to the air. As nitrous oxide and sulfur dioxide react with water, they form nitric acid and sulfuric acid. These are the two main components of acid rain. Acid rain accelerates chemical weathering.

Oxygen

Oxygen strongly reacts with elements at the earth’s surface. This process is called oxidation. You are probably most familiar with the rust that forms when iron reacts with oxygen. Many minerals are rich in iron. Red rocks are full of iron oxides (Figure below). As iron changes into iron oxide, the iron oxides can also make red color in soils.

Plants and Animals

Plants and animals also cause chemical weathering. As plant roots take in nutrients, they remove elements from the minerals. This causes a chemical change in the rock.

Mechanical Weathering and Chemical Weathering
Mechanical weathering increases the rate of chemical weathering. As rock breaks into smaller pieces, the surface area of the pieces increases. With more surfaces exposed, there are more places for chemical weathering to occur (Figure below). Let's say you wanted to make some hot chocolate on a cold day. It would be hard to get a big chunk of chocolate to dissolve in your milk or hot water. Maybe you could make hot chocolate from some smaller pieces like chocolate chips, but it is much easier to add a powder to your milk. This is because the smaller the pieces are, the more surface area they have. Smaller pieces dissolve more easily.

Erosion–the movement of earth materials from one place to another–also contributes to our changing landscape. **Glaciers**–large, slow-moving masses of snow, ice, rock and dirt–are common causes of erosion. Water and wind are other erosional forces that change Earth's landscape over time.

Water is the most powerful erosional force on earth today. Rain carries soil away as it washes over the land, leaving behind gullies, valleys, and canyons. The paths of some rivers have changed as water erodes the banks. Rivers and streams have formed many natural wonders including arches–curved rock formations, formed by a combination of erosional forces. Ice, rain, and wind continue to weather the arches found in Utah's Arches National Park. Someday, erosion will cause the arch to collapse, but until that time, we can enjoy their spectacular beauty.

This is Delicate Arch at Arches National Park

Running water from streams and rivers can also form a **butte**– an isolated hill with steep, even sides, and a flat top. Hard rock on the top of the butte protects the softer rock below from erosion. Mesas are much larger landforms similar to buttes that form in the same way.

This is a butte from the San Marcos Shale near Price.

Water erosion from rivers and streams can cut through layers of rock to form deep canyons, as in Canyonlands National Park and the Grand Canyon.

Wind erosion moves soil in the air from place to place on Earth's surface. This is especially true in arid climates like

Utah's climate. When there is soil in the air, gravity pulls the soil out of the air and deposits it somewhere else. When the wind blows away smaller, finer particles, this leaves behind a desert "pavement" with rocky, pebbled surfaces. Particles moved by the wind hit other landforms, too, weathering their surfaces by abrasion

Glaciers–slow-moving, large masses of snow, ice, rocks and dirt--form in cold regions of the Earth where snowfall does not melt. The weight of the snow builds up over time and is compacted by its own weight. After thousands of years, it turns to ice and becomes very heavy. Gravity can pull the **glacier** down a mountain very slowly. As it inches along, the glacier erodes the surface beneath it. Valleys form as the boulders and rock carried in the ice scrape the rock beneath the glacier. Glaciers also polish and scratch the land beneath them as they travel across its surface. You can see these features when glaciers melt and you walk across smooth rock surfaces in the bottom of canyons. Evidence of glaciers in

Utah are U-shaped canyons in the Wasatch Mountains.

Rivers may also form canyons with steep walls, but those canyons have a V-shape, like the lower section of Big Cottonwood Canyon on the east side of the Salt Lake Valley.

This glacier is modifying the landscape it's flowing through. Glaciers erode and deposit landforms that tell us stories about Earth's history. They show the direction a glacier flowed and how far it advanced. They create fantastic and unique features in mountain areas. What evidence of past glaciers do you see in the valleys near you?

A **horn**, like the one pictured above is a sharp peak that is left behind when glaciers erode all sides of a mountain.

Gravity causes erosion because of weathering. Weathered material falls from a cliff because there is nothing to hold it in place. Rocks falling to the base of a cliff create a slope. Landslides occur when falling rocks hit other rocks causing them to fall. When there is high precipitation, mud will form and contribute to the cause of the landslide.

Multiple landslides created the mass weathering seen on this cliff. Humans also cause erosion when they disturb the natural landscape in agricultural and urban areas.

Agricultural Erosion

- Agriculture is the largest contributor to soil pollutions caused by humans.
- Farming removes native plants, and plowing land loosens up nutrient-rich dirt that could be blown away.
- Animals grazing on farmland can expose dirt and pull up plants.

As a result of agriculture and animal grazing, erosion can slow or halt future plant growth.

Urban Factors

- Construction and urban development greatly reduce the amount of water and rainfall that enters the ground, which results in erosion nearby.
- Even activities like mountain biking and hiking can lead to erosion, since these activities disturb the landscape in ways that can hinder plant growth.

5th Grade Standard II Objective 2
Text Structure: Cause and Effect

What causes volcanoes and earthquakes to occur?

Volcanoes

Volcanoes–openings in the Earth's crust that allow hot, melted rock, ash, and gases to erupt outward-- change the Earth's surface very dramatically in a short period of time. More than half of Earth's surface is made up of volcanic rock. **Volcanoes** themselves are evidence that we live on an active, changing planet. Do you know how a volcano forms? Most form along cracks in the earth's crust and reach far below the surface where temperatures are hot enough to melt rock. You'd likely want to watch a volcanic eruption from a great distance, since many are violent, spewing out huge quantities of lava, gas, rocks, and ash. Other eruptions pour out rivers of lava but cause little damage. The difference is in the quantity of dissolved gasses in the lava. Volcanoes can erupt underwater, forming huge ranges of volcanic mountains on the ocean floor.

Volcanic Stages

- **Active** volcanoes are currently erupting, or showing signs of eruption soon.
- **Dormant** volcanoes have no current activity, but have erupted recently.
- **Extinct** volcanoes have had no activity for a long time, and will probably not erupt again.

The Different Types of Volcanoes

Composite Volcanoes	Shield Volcanoes	Cinder Cone Volcanoes
Often very steep	Large, not steep	Small, cone-shaped, steep
		
Explosive eruptions	Non-explosive eruption, lava is fluid and spreads further, creates a less steep structure	Usually erupts strongly once, shoots rocks called pumice up in the air

This is Cedar Hill, a shield volcano near the Great Salt Lake.

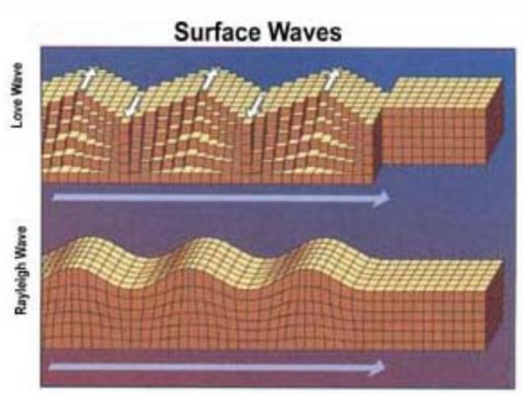
This is a cinder cone in Snow Canyon State Park near St. George.

Volcanoes are useful because they can enrich soil. The ash from volcanoes is rich in minerals, especially nitrogen; this makes land fertile and is good for farming. However, volcanic eruptions can injure people and damage property. Scientists who study volcanoes try to predict when they will erupt. They use gas detectors, tilt meters, and seismographs to measure the movement of Earth. If unusual gasses are present or Earth is shaking, volcanic eruptions may follow.

Earthquakes

Earthquakes–energy waves passing through Earth caused by a sudden shift of Earth's crust along faults--a crack in Earth's crust that allows the crust to slip. Earthquakes are sudden changes that alter Earth's landscape dramatically. The faults are factures resulting from movement along Earth's tectonic plate boundaries.

You know you are in an earthquake if the ground starts to shake. Tremendous forces under Earth's surface build up pressure, which is released in waves along a fault. Imagine you are bending a Popsicle stick. When the pressure is great enough, the stick snaps in two. The energy released by the snap produces waves that travel through the stick to your hands. The fault, however, doesn't come apart like the stick. Portions of Earth's crust slide past each other, creating waves. Some of the waves are surface waves. Other waves, called body waves, travel through the Earth's interior. In an earthquake, body waves are responsible for the sharp jolts. Surface waves are responsible for the rolling motions that cause most of the damage.



P-waves and S-waves are the two types of body waves.

Love waves and Rayleigh waves are the two types of surface waves.

Earthquakes can create landforms on the Earth's surface. Mountains, like the Wasatch Mountains in northern Utah, form during an earthquake as the valley rocks slide down and the mountain rocks slide up.

Mt. Nebo, the tallest peak in the Wasatch Mountain range.

The fault may slip deep underground and leave no evidence on the surface that an earthquake has occurred. Earthquakes in the ocean may cause a tsunami, a large ocean wave. Scientists use technology to measure and record the strength and locations of earthquakes. They measure earthquakes in various ways, including from 1-10 on the Richter Scale. Any earthquake measuring a 6 or higher is a very significant earthquake. Scientists try to predict when and where earthquakes will occur because earthquakes cause loss of life and property damage every year all over the world.

Uplift—upward movement of Earth's crust--occurs when part of Earth's surface rises above the surrounding land by great forces of heat and pressure deep within the Earth. **Uplift**

formed the Colorado Plateau, creating nearly all the spectacular variety of Canyon County in Southern Utah.

Imagine you are in a raft floating down the Colorado River through the Grand Canyon. One of the first things you will notice are the steep canyon walls on both sides of the river. You may ask, why are the walls so steep? Why do you see different layers of rock exposed?

Millions of years ago, much of the western United States was covered by a shallow sea. The area of the Grand Canyon was once flat, marshy land under the sea. Scientists have determined many seas have come and gone, leaving different layers of rock during various time periods. Some of the layers contain fossils of sea creatures exposed in the walls of the canyon.

Uplift formed a high, flat plateau. As the land rose, water cut a channel down through the plateau, creating a deep canyon. The oldest rocks at the base of the Grand Canyon are about 2 billion years old. Each layer above the base was formed under different conditions. Different types of sedimentary rocks can weather differently. In the photo of the Grand Canyon, you can see some layers create cliffs. The cliffs are formed by hard rocks that do not weather easily. Rock layers that resist weathering and erosion form the top of the canyon and the tops of features. Softer layers form slopes made from rocks that weather more easily. It took thousands of years for erosion to uncover the rocks of the Grand Canyon. In your lifetime you won't notice many changes because the changes happen so slowly. Thousands of years from now, however, the Grand Canyon will look different than it does today.

This photograph shows the different rock layers uncovered by erosion in the Grand Canyon. The Colorado River cuts through the plateau from which the Grand Canyon was formed.

5th Grade Standard II Objective 3
Text Structure: Cause and Effect

How does deposition change the Earth's surface?

Deposition– the dropping of sand or rock carried by wind, water, or ice – reates many interesting landforms such as beaches, sandbars, deltas, and sand dunes. **Deposition** occurs when weathered rocks, soil, and sediments are carried by erosion to a new location and left there. Deposition happens when the forces carrying the sediments–wind, water, or glaciers–are no longer strong enough to move the sediments. Rivers and streams fill with melting snow in the springtime. The water rises and moves quickly down from the mountains into the valleys. When the streams spread out across the land and into other bodies of water, they become less powerful; this is when deposition is likely to happen. Deposits form at bends in a river, as well as in locations where rivers dump water into lakes, seas, and oceans. Rivers like the Colorado River carry enormous loads of sand and soil they pick up from erosional processes. In the spring, the Colorado River looks like chocolate milk from all the sediments it carries.

The word deposition has the same root as the word deposit. Think of it this way: when you earn some money and want to save it for a special purchase, you may deposit it in the bank. The money is still the same, and it is still yours, but you have put it in a different place in order to save it. Deposition works the same way. Wind and water move sediments and deposit them in a new location. As all of these sediments build up, you can easily see the results of de-deposition.

Animations of deposition can be found here:
http://www.kidsgeo.com/geology-for-kids/0079-deposits.php

Waves transport sediments along a coast and create beaches through deposition. Waves have higher energy during winter than in summer, so sand is pushed onto shore in the summer, and pulled offshore during winter. People try to control the processes of erosion and deposition by building:

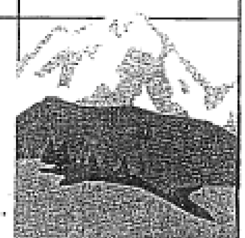
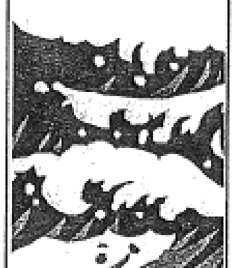
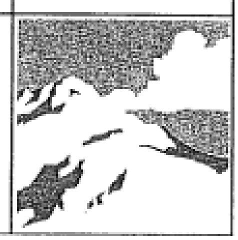
- **Groins:** piles of rocks that run perpendicular to the shore to prevent erosion.
- **Breakwaters:** built in the water parallel to the shore to protect from strong incoming waves
- **Seawalls:** built parallel to the shore on the beach to protect against both erosion and deposition

Groins

Breakwaters

Seawalls

Scientists use a variety of time lines, like the one below, to identify the sequence of events and the time required to build up and break down the geologic feature on Earth. When you look at the timeline below, notice how old the earth is and how remarkable all of the changes to its surface have been. Volcanoes, uplift and earthquakes build up new landforms.

Geologic Era	Time (In Million Years Ago)	Geologic Events	
Cenozoic	0 to 65 MYA	Thick glaciers in much of the world. Rocky Mountains, Alps, Andes, and Himalayas form. Glaciers cover North America.	
Mesozoic	65 MYA to 248 MYA	Widespread volcanic activity Age of the dinosaurs American and Europe/African continents move apart.	
Paleozoic	248 MYA to 544 MYA	Age of Ocean life Appalacchian Mountains begin to form. Warm, shallow seas cover much of North America. Two ancient continents are found near the equator.	
Precambrian	544 MYA to 4,600 MYA	Earth's first ice age occurs. First sedimentary rocks form. Oceans form. Earth forms.	

Weathering and erosion wear those landforms away. Some changes are immediate, like landslides, earthquakes, and volcanoes, but most take thousands of years, like weathering, erosion, and uplift. Without weathering and erosion, the rock you found on the playground would still be on the top of the mountain, a tiny piece of the boulder from which it came. Without volcanoes, uplift and earthquakes, the surface of the Earth would look the same as when it formed, a smooth sphere. You're always going to be right if you say Earth's surface is constantly changing.

We live on an incredible, changing planet. What we observe today in our landscape will be vastly different in 10,000 years. In the future, people will look back and wonder just what the landscape looked like in our day. We won't be there to tell them, but the evidence in rocks, soil, and geologic features will reveal what we see today.

Science Language

- Arch: curved rock formation, formed by a combination of erosional forces
- Butte: an isolated hill with steep, even sides, and a flat top
- Deposition: the dropping of sand or rock carried by wind, water, or ice, which creates the layering of each materials layering of earth materials by wind, water, or glaciers
- Earthquake: energy waves passing through Earth caused by a sudden shift of Earth's crust along faults
- Erode: to wear away
- Erosion: the movement of earth materials from one place to another
- Fault: a crack in Earth's crust that allows the crust to slip
- Geological: relating to the structure of Earth and the changes that have taken place over the years
- Glacier: slow-moving, large mass of snow, ice, rocks and dirt
- Uplift: upward movement of Earth's crust
- Volcano: opening in the Earth's crust that allows hot, melted rock, ash, and gases to erupt outward
- Weathering: the breaking down of earth's materials into smaller pieces

Think like a Scientist

1. What are the geological processes that change Earth's surface over time?
2. Describe how the Grand Canyon was formed.
3. What is the difference between weathering and erosion?
4. What are the Agents of Weathering?
5. How do volcanic eruptions change the landscape?
6. What is deposition?
7. How do seismic waves and faults combine to cause earthquakes?
8. Compare and contrast what the Earth looks like now to what it would look like if there was no mountain uplift, weathering, or erosion.

Additional Resources

http://www.earth.dke-guides.com

Online Activities to Try

- Create new landforms using different agents of weathering on this site. **http://tinyurl.com/UT5th2-1a**
- Watch an animation to observe how plate tectonics contribute to earthquakes **http://tinyurl.com/UT5th2-2a**
- Use this site to build 4 different types of animated volcanoes. **http://tinyurl.com/UT5th2-2b**
- Discover how tsunamis form on this site. **http://tinyurl.com/UT5th2-2c**
- On this site, scroll through a timeline to watch continental drift and the formation of the Grand Canyon. **http://yinyurl.com/UT5th2-2d**

magnetism

chapter 3

Standard III, Objective I
Fifth Grade
Compare and Contrast

What has the ability to push or pull iron objects they are not touching?

Magnets

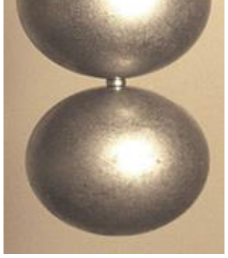
There is an old folk tale about a Greek shepherd named Mangus. The tale tells about a time Mangus climbed a mountain to rescue a lamb, and he found that the iron nails in his sandals stuck to pieces of a particular rock. This type of rock attacks iron and is called loadstone. Loadstone is a natural magnet- a mineral made magnetic by Earth's magnetic field. The magnetic field is the area around a magnet where the magnet has power to attract magnetic material.

In 1269 A.D., a French scientist named Peter Peregrinus of Maricourt wrote a letter that described the properties of lodestones. He discovered that there were two points on opposite sides of the lodestone that he called the North Pole and the South Pole. He found that small bits of iron were attracted - two or more objects drawn together - most strongly at these points. He also found that a small piece of iron shaped like a needle would stand straight up at those two points. When he placed the lodestone in a small wooden bowl floating in a larger container of water, the north pole of the lodestone will turn the dish around until its north pole is pointing north.

He discovered that "the north pole of one lodestone attracts the south pole of another, while the South Pole **attracts** the north." On the other hand, he found that two north poles or two south poles **repelled** - to push objects apart - each other. When he cut lodestones into smaller pieces, he found that each smaller piece had both a north and south pole.

He also found that a piece of iron that touched a lodestone would point north if it was attached to a small piece of wood that was floating in water.

Today, we are able to make objects that have the same properties as lodestones. They are called magnets.



This photo shows three solid steel balls suspended by three small magnets. Its not a trick. The tiny magnets are actually strong enough to hold the very heavy steel balls. That's because the magnets are made with neodymium.

A **permanent magnet** is an object that keeps its magnetism after it has been magnetized. Iron and nickel are the most common elements that magnets are made of. Very strong permanent magnets can be made by combining other elements with iron, like neodymium and boron or aluminum, nickel and cobalt.

Watch this video demonstration of the awesome force of a large neodymium magnet. Warning: Do not try this at home! http://goo.gl/5j54LE

Summary of the Properties of Magnets

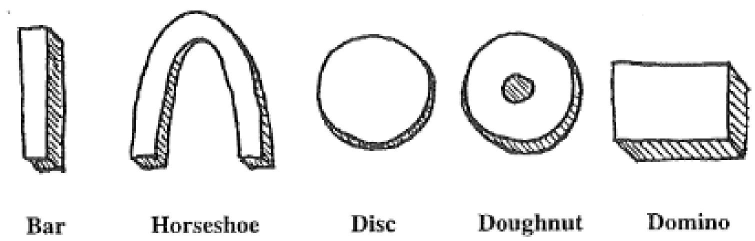
- Magnets attract certain metals like iron, nickel and cobalt.
- Magnets have two poles, called north and south.
- The poles of a magnet are where objects are most strongly attracted.
- Like poles repel each other and unlike poles attract each other.
- If a permanent magnetic is cut in half repeatedly, each piece will still have a north and a south pole.

A Compass

A **compass** – an instrument used to determine geographic direction on Earth – is made from a free swinging magnetized needle that points north and south. A bar magnet with a string tied to the middle will rotate until one end points north and the other end points south. To make a compass, a magnet may be rubbed on a needle to magnetize it. The needle is placed on a thin piece of Styrofoam in a cup of water. The needle will rotate so that one end points north.

Permanent Magnets

Permanent magnets are often named for their shape. Common shapes include: bar, horseshoe, disc, doughnut, and domino magnets. In disk or domino-shaped magnets, the flat surfaces are the poles. A horseshoe magnet is simply a bar magnet that has been bent into a “U” shape. When a magnet is broken or cut, each piece has a north and south magnetic pole. No matter what shape a magnet may be, it has a north

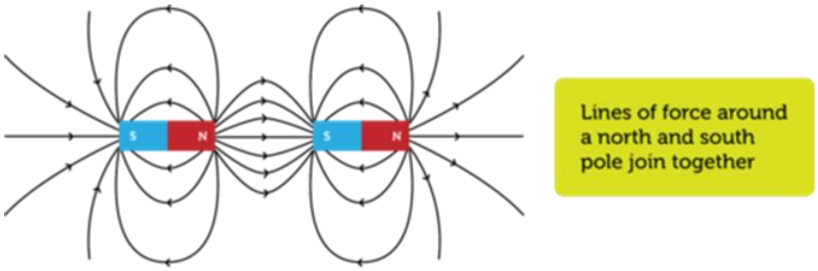


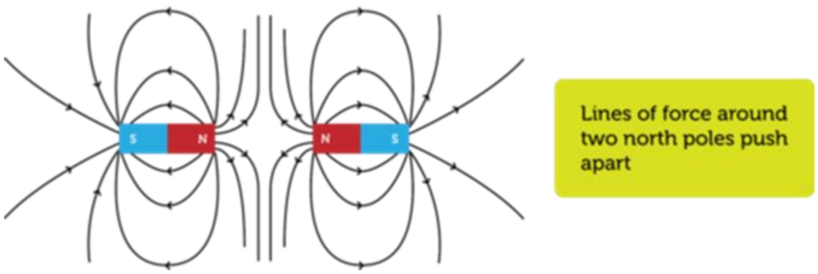
and south pole.

Magnets exert forces on other objects without touching them. There is something in the space around a magnet that cannot be seen. It is called a magnetic field. We think of the magnetic field going out from the north pole of a magnet, arching around and returning to the magnet at its south pole. The direction of the magnetic field at any location near a magnet is the direction in which a compass needle points at that location. A compass can be used to show the direction of the magnetic field at points in space around a magnet.

The picture below shows how the magnetic field of a bar magnet can be traced with the aid of a compass. Iron filings are also used to show the pattern of the magnetic field. If you shake iron filings around a bar magnet, they will line up to the magnetic field.

When two magnets are brought close together, their magnetic fields interact. You can see how they interact in the Figure below. The lines of force of north and south poles attract each other whereas those of two north poles repel each other. The animations at the following URL show how magnetic field lines change as two or more magnets move in relation to each other. http://goo.gl/31ArIN





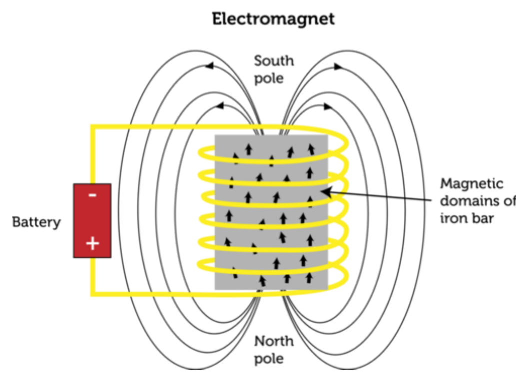
You can make a **temporary magnet** – a magnet that does not keep its magnetism - from a steel nail by taking a magnet and rubbing the nail in the same direction several times. Now the nail will pick up pins or staples or other small items made of iron. If it doesn't you may need to rub the needle more. If you want to demagnetize these types of magnets, you can hit them or heat them.

Another example of a temporary magnet is an **electromagnet** – a magnet that can be turned on or off and is made by sending electricity through metal. An electromagnet uses electricity to produce a magnetic force.

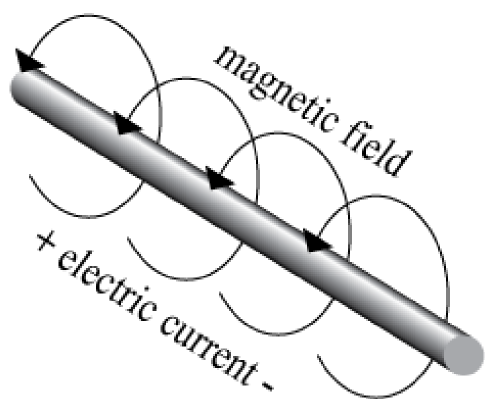
In 1820, Hans Christian Orsted discovered that an electric current in a wire was able to deflect a compass needle. This means that an electric current can create a magnetic field. It was later found that materials like iron can make the magnetic field from an electric current much stronger.

This crane is dangling a big round magnet that has picked up metal car parts in a junk yard. The parts practically leap up to the magnet because it's so strong. That's because it's an electromagnet.

An electromagnet is made from a coil of wire wrapped around a bar of iron or other magnetic material. The magnetic field of the coil of wire magnetizes the iron bar by aligning its magnetic domains. You can see this in the Figure to the right. You can learn how to make an electromagnet at this URL: http://goo.gl/uNjr8X



The strength of this temporary magnet depends on the number of loops in the wire and the amount of current in the wire. More loops and more current make stronger magnetic fields. The iron core of this temporary magnet is magnetized only while the electric current is flowing. The magnetic force from a wire coil and iron bar can make an electromagnet very strong.



Besides their strength, another advantage of electromagnets is the ability to control them by controlling the electric current. Turning the current on or off turns the magnet on or off. The amount of current flowing through the coil can also be changed to control the strength of the electromagnet.

Q: Why might it be useful to be able to turn an electromagnet on and off?

A: Look back at the electromagnet hanging from the crane in the opening photo. It is useful to turn on its magnetic field so it can pick up the metal car parts. It is also useful to turn off its magnetic field so it can drop the parts into the train car.

Magnets in today's world

Magnets are used constantly in everyday life. Electric motors use electromagnets that run everything from refrigerators and washing machines to electric trains and robots. Audio and videotape players have electromagnets called heads that record and read the tape. TV picture tubes use an electromagnet to help form the screen images. Magnets are essential in business and industry, and are used in everything from cranes and construction machinery to copy machines and computers. Magnets help produce electric power in generators, and are used in radar systems and navigation. Medical science uses magnets for diagnosing diseases with a technique known as magnetic resonance imaging (MRI). In every aspect of our society we depend on this amazing force called magnetism.

The train in this photo is called a maglev train. The word maglev stands for "magnetic levitation." Magnets push the train upward so it hovers, or levitates, above the track without actually touching it. This eliminates most of the friction acting against the train when it moves. Other magnets pull the train forward along the track. Because of all the magnets, the train can go very fast. It can fly over the tracks at speeds up to 480 kilometers (300 miles) per hour! How do magnets exert such force? In this article, you'll find out. You can also watch a video introduction to magnets at this URL: http://goo.gl/qxyKfu

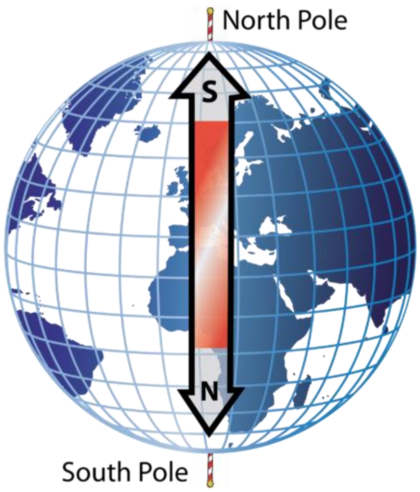
How is a magnet similar to Earth? Earth has a magnetic field like a bar magnet or electromagnet. Scientists hypothesize that Earth's core is made of nickel and iron. Electric currents in the core may be responsible for Earth's magnetic field.

Did you ever see a globe like this one? Magnets in the globe and its stand repel each other, allowing the globe to hover in midair.

Earth's Magnetic Field

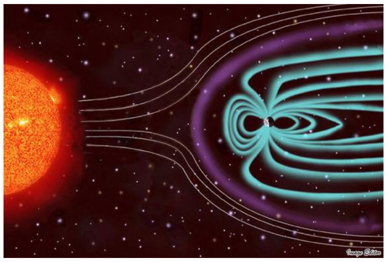
The idea that Earth is like a magnet is not new. It was first proposed in 1600 by a British physician named William Gilbert. He used a spherical magnet to represent Earth. He moved a compass around the spherical magnet and demonstrated that the spherical magnet causes a compass needle to behave the same way that Earth causes a compass needle to behave. This showed that a spherical magnet is a good model for Earth and therefore that Earth is like a magnet.

Q: Can you describe Earth's magnetic poles and magnetic field?



A: Earth has north and south magnetic poles. The magnetic poles are not in the same location as Earth's geographical North and South Pole. Because the north pole of a magnet points north, the magnetic pole near the north geographic pole must be a south magnetic pole! Remember, opposite poles attract. The magnetic pole near the south geographic pole is a north magnetic pole. The location of the magnetic poles changes over time. To find out more about the changing location of the magnetic poles, see: http://goo.gl/uvI9f

Earth's magnetic field in space is called a magnetosphere. You can see it in the Figure below. The magnetosphere protects Earth's organisms from solar radiation.



Like an Umbrella

The sun gives off high speed charged particles called the solar wind. The lines coming from the Sun in the diagram above represent the path of some of these particles. Notice what happens to the solar wind when it reaches the magnetosphere. It is deflected by Earth's magnetic field. If the particles in the solar wind were able to reach Earth's surface, they could harm most living things. The magnetosphere protects Earth's organisms from the solar wind like an umbrella protects you from rain.

You may recognize the eerie green glow in this cold northern sky as the northern lights, or aurora borealis. But do you know what causes the northern lights? Earth's magnetic field is a major factor.

Q: Can we explain the northern lights?

A: Bursts of energetic particles in solar wind collide with Earth's magnetic field which causes charged particle trapped in Earth's magnetic field to move toward Earth's poles. They collide with atoms in the atmosphere over the poles, and energy is released in the form of light. The swirling patterns of light follow lines of magnetic force in the magnetosphere.

Some organisms—including humans with compasses—use Earth's magnetic field for navigation.

One benefit of Earth's magnetic field is its use for navigation. People use compasses to tell direction. Many animals have natural "compasses" that work just as well. For example, the loggerhead turtle in the Figure below senses the direction and strength of Earth's magnetic field and uses it to navigate along migration routes. Many migratory bird species can also sense the magnetic field and use it for navigation. One scientist speculates that they may have structures in their eyes that let them detect Earth's magnetic field. You can learn more at this URL: http://goo.gl/Sb5VRi

Q: In the past, Earth's magnetic poles have switched places and reversed Earth's magnetic field. How might a magnetic reversal affect loggerhead turtle navigation?
A: You can find out at this URL: http://goo.gl/d101eX

Summary

- A magnet is an object that attracts certain materials such as iron. All magnets have north and south magnetic poles. The poles are regions where the magnet is strongest.
- The force that a magnet exerts is called magnetic force. The force is exerted over a distance and includes forces of attraction and repulsion. A magnet can exert force over a distance because the magnet is surrounded by a magnetic field.
- A magnet is an object that attracts certain materials such as iron. All magnets have north and south magnetic poles. The poles are regions where the magnet is strongest.
- The force that a magnet exerts is called magnetic force – the power of a magnet to push or pull other magnetic material. The force is exerted over a distance and includes forces of attraction and repulsion. A magnet can exert force over a distance because the magnet is surrounded by a magnetic field.
- An electromagnet is a coil of wire wrapped around a bar of iron or other ferromagnetic material. The magnetic field of the wire magnetizes the iron bar.
- The combined magnetic force of the magnetized wire coil and iron bar makes an electromagnet very strong.
- Electromagnets can be turned on or off and their strength can be changed by controlling the electric current.

Science Language students Need to Know and Use

attract: to draw objects together

compass: and instrument used to determine geographic direction of Earth

Electromagnet: a magnet that can be turned on or off and is made by sending electricity through metal

Magnetic field: area around a magnet where it exerts magnetic force

Magnetic force: Force of attraction or repulsion exerted by a magnet

Natural Magnet: a mineral made magnetic by Earth's magnetic field

Permanent Magnet: an object that keeps its magnetism after it has been magnetized

Properties: qualities or characteristics
Repel: to push objects apart
Temporary magnet: a magnet that does not keep its magnetism

Think like a Scientist

1. Compare and contrast permanent, temporary, and natural magnets and their abilities to push or pull iron objects they are not touching.

2. In what ways are permanent magnets and electromagnets alike and different?

3. Compare the magnetic fields of various types of magnets.

4. How is a magnet similar to Earth?

5. Explain how a compass works.

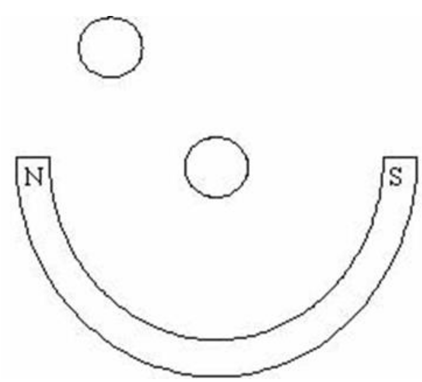
6. What are the uses of magnets?

Practice

Fill in the blanks in the sentences below.

1. Increasing the number of loops in the wire coil ___________ the strength of the magnetic field.

2. Decreasing the current ___________ the strength of the magnetic field.
3. Sketch the magnetic field lines for the horseshoe magnet shown here. Then, show the direction in which the two compasses (shown as circles) should point considering their positions. In other words, draw an arrow in the compass that represents North in relation to the compass magnet.



Online Activities to Try

- Test the strength of different kinds of magnets and review which metals are magnetic on this site. http://tinyurl.com/UT5th4-1d

- Use a crane with an industrial magnet to move items from one part of a junkyard to another. **http://tinyurl.com/UT5th3-1a**

- Use a compass to help you find buried treasure. http://tinyurl.com/UT5th3-2a

- Use a compass to help you find magnetic north on a globe, a map, and in a campground. http://tinyurl.com/UT5th3-2b
- Use a magnetic field simulator on this site to pick up iron fillings and view magnetic field lines. http://tinyurl.com/UT5th3-3a

chapter 4

electricity

Standard IV, Objective I
Fifth Grade
Compare and Contrast

How are lightning and the shock your brother gives you after rubbing his feet on the carpet the same and how are they different?

You're a thoughtful visitor, so you wipe your feet on the welcome mat before you reach out to touch the brass knocker on the door. Ouch! There is suddenly a spark between your hand and the metal, and you feel an electric shock.

Q: Why do you think an electric shock occurs?

A: An electric shock occurs when there is a sudden discharge of static electricity.

What Is Static Electricity?

Static electricity is a buildup of an excess of positive or negative electric charges on objects. This usually happens when negative electrons are transferred from one object to another. The object that gives up electrons becomes positively charged, and the object that accepts the electrons becomes negatively charged. This can happen in several ways.

One way **static electricity** can build up is through contact between materials that differ in their ability to give up or accept electrons. When you wipe your rubber-soled shoes on the wool mat, for example, electrons are transferred from the mat onto your shoes. As a result of this transfer of electrons, positive charges build up on the mat and negative charges build up on the bottom of your shoes.

Once an object becomes electrically charged, it is likely to remain charged until it touches another object or at least comes very close to another object if the air surrounding it is dry. That's because electric charges cannot easily escape into dry air. However, a water molecule in the air can easily accept an electron. So, if the air is humid, an object with excess electrons will have them pulled off into the air by water molecules after a short time.

Q: You're more likely to get a shock in the winter when the air is very dry. Can you explain why?

A: When the air is very dry, electric charges are more likely to build up objects because they cannot escape easily into the dry air. This makes a shock more likely when you touch another object.

Some things will produce a much greater static charge than others. Rabbit fur rubbed on a balloon will have a much greater charge than cotton fabric rubbed on a balloon. A wool sweater pulled over clean, dry hair will transfer more charge than a cotton sweater. Objects with excess electric charge can **attract** – draw together- objects. However, it can also **repel** – push away - objects. For example, when your hair acquires extra electrons, the hairs **repel** each other because they have the same charge. Static electricity can also cause items to **attract**. When we say that a sock sticks to your clothing because of static electricity, we mean the socks and clothing attract each other because they have opposite charges.

Static Discharge

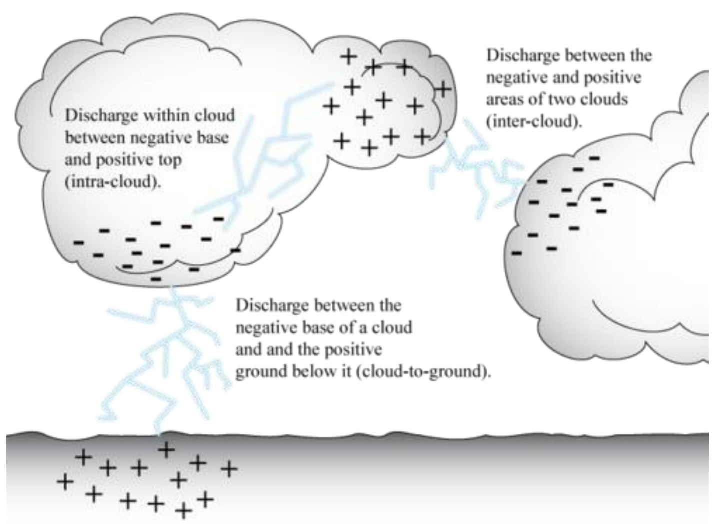
What happens when you have become negatively charged and your hand approaches a metal doorknocker? Your negatively charged hand repels electrons in the metal, so the electrons move to the other side of the knocker. This makes the side of the knocker closest to your hand positively charged. As your negatively charged hand gets very close to the positively charged side of the metal, there are strong electric forces at work in the air between your hand and the knocker. Any free electrons in the air are strongly repelled by the negative charges in your hand and strongly attracted to the positive charges in the metal. As they move quickly towards the metal they collide with molecules in the air, knocking electrons out of those molecules. These new electrons are now attracted to the knocker and they collide with more molecules eventually creating an avalanche of electrons moving quickly toward the metal and a lot of positively charged air molecules moving toward your hand. This process results in a sudden flow of charge between your hand and the knocker. The sudden flow of charge is called a **static discharge**. As electrons recombine with the positively charged air molecules, they give off light, which is the spark you see. Watch the animation “John Travoltage” at the following URL to see an example of static electricity and **static discharge**.

http://goo.gl/5slJoL

How Lightning Occurs

Another example of static discharge, but on a much larger scale, is lightning. An electrical charge builds up in the clouds. When the charge becomes large enough, or the cloud moves closer to the ground, that static electricity is discharged in what we call a lightning bolt. You can see how it occurs in the following diagram and animation as you read about it below.

http://goo.gl/c1B3h6



During a rainstorm, clouds develop regions of positive and negative charge. The negative charges in the form of electrons are usually concentrated at the base of the clouds, and the positive charges are usually concentrated at the top. The negative charges repel electrons on the ground beneath them, so the ground below the clouds becomes positively charged. At first, electrons flowing out of the cloud toward the ground lose their energy in collisions with air molecules so they only travel a short distance. This creates a conducting path so the next group of electrons can follow it and go farther. This process repeats until the conducting path gets close to the ground. When this happens, the static build up is discharged as current electricity that we call lightning.

At the following URL, you can watch an awesome, slow-motion lightning strike: http://goo.gl/HRFvup. You'll be amazed when you realize how much has occurred during that split-second discharge of static electricity.

Summary

- Static electricity is a buildup of an excess of either negative or positive electric charges on an object. It occurs when electrons or molecules that have a positive or negative charge are transferred from one object to another.
- A sudden flow of charged particles between objects is called static discharge.
- Examples of static discharge include lightning and the shock you sometimes feel when you touch another object.

Practice

Watch the video at the following URL: http://goo.gl/ib60UY. Then, answer the discussion questions. Read the background essay if you need help with any of the questions.

Using Static

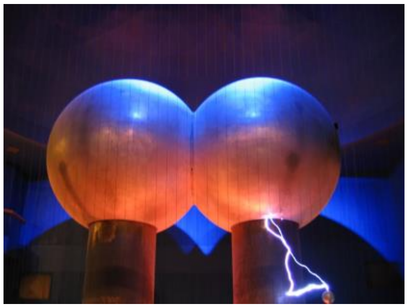


Image Attributions
Credit: Mark Barker; **Source:** http://goo.gl/Lh1Oe0; **License:** CC BY-NC 3.0

This odd-looking machine is called a Van de Graaf generator. It's located in the Boston Museum of Science. Like other Van de Graaf generators, it generates static electricity. When enough static electricity builds up on its surface, it discharges the electricity as an artificial bolt of lightning.

The Back Story

Static electricity can be entertaining. Not only can you use it to generate artificial lightning with a Van de Graaf generator. You can use it to stick a balloon to a wall or to cause your hair to stand on end. Static electricity is also responsible for the shock you may get when you reach out to touch a metal doorknob.

How does a Van de Graaf generator work, and what causes static electricity? Watch this Bill Nye the Science Guy video to find out:
http://goo.gl/GF3GzE

Static Electricity: Snap, Crackle, Jump

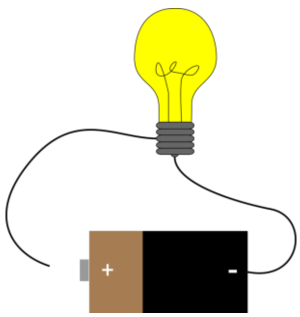
Watch a vinyl record get charged by rubbing it with a wool scarf. The record is then used to demonstrate static electricity in action: breakfast cereal is lifted off the table!
http://goo.gl/YsHfwd

Think like a scientist

1. How are lightning and the shock your brother gives you after rubbing his feet on the carpet the same and how are they different?
2. What is static electricity? Where does this type of electricity get its name?
3. What is static discharge? Where do electrons in static electricity go when the static electricity is discharged?
4. Why do electric charges build up on an object?
5. How are static electricity and static discharge related?
6. If a person touches a Van de Graaf generator, his or her hair stands on end. Explain why.
7. A sudden flow of electrons between oppositely charged objects is called static ___________.
8. Would it be practical to capture, store, and use static electricity to power homes? Why or why not?

What properties do electrical circuits have?

Electric currents - a closed loop through which current can flow -are everywhere. Elevators in skyscrapers, jumbo jets, arcade games, lights, heating, and security . . . none of these work without **electric current**. Clothes washers and dryers, refrigerators, toasters, automobiles, thermostats, computers, televisions, and radios all use electric current.



Jose made this sketch of a **battery** - a device that generates electricity by combining certain chemicals - and a light bulb for science class. If this were a real set up, the light bulb wouldn't work. The problem is the loose wire on the left. It must be connected to the positive terminal of the **battery** in order for the bulb to light up.

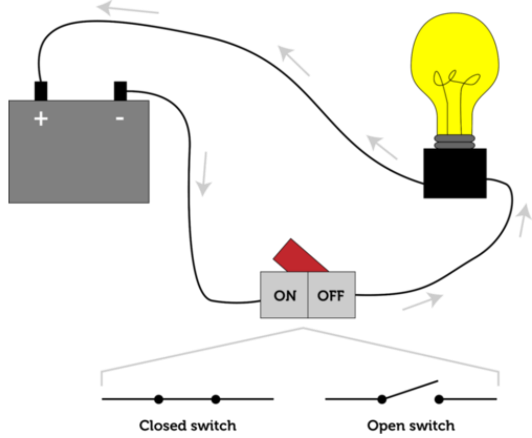
Q: Why does the light bulb need to be connected to both battery terminals?

A: Electric current can flow through a wire only if it forms a closed loop. Charges must have an unbroken path to follow between the positive and negative ends of the battery.

Electric Circuits

A closed loop through which current can flow is called an **electric circuit**.

All **electric circuits** have three parts parts: a source of electric current and a path that contains mobile electric charges. We call the material that makes this path a **conductor** - material that allows electricity to pass through easily. A circuit may have other parts as well, such as light bulbs and **switches** - a device that immediately changes a circuit from complete to incomplete - as in the simple circuit seen in the Figure below.



- The source of electric current in this simple circuit is a battery. In a home circuit, the source of current is an electric power plant, which may supply electric current to many homes and businesses in a community or even to many communities.
- The **conductor** in most circuits consists of one or more wires. The conductor must form a closed loop from the current source and back again. In the circuit above, the wires are connected to both terminals of the battery, so they form a closed loop.
- Most circuits have devices such as light bulbs that convert electrical energy to other forms of energy. In the case of a light bulb, electrical energy is converted to light and thermal energy (heat).
- Many circuits have **switches** to control the flow of current. When the switch is turned on, the circuit is closed and current can flow through it. When the switch is turned off, the circuit is open and current cannot flow through it.

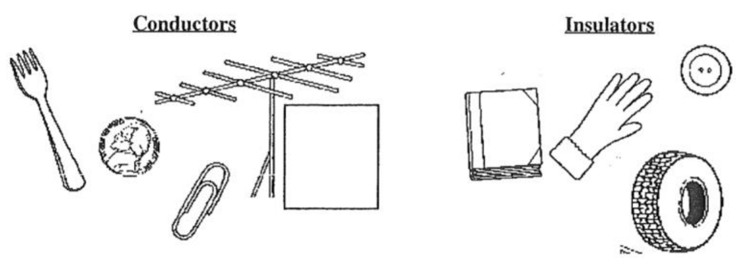
Current electricity is a flow of electric charges. Current electricity requires a continuous **pathway** - a course through which electricity can flow - made of a material that contains mobile electric charges to make a complete circuit. Current electricity cannot flow if there are any gaps in the path (unless the voltage is high enough to create a spark). A battery, bulb, and wire connected together can make a simple complete circuit. If the wires are not connected properly it causes a gap. Electric current cannot flow through the gap so you have an incomplete circuit.

A **power source** is a device that supplies electric current to a circuit. The safest **power source** for you to use in a circuit is a battery. Other power sources could include a generator, a solar panel, or a fuel cell.

A general term for any device that uses electricity is a **load** – an item that uses electricity to do work. A light bulb is one type of **load**. Other examples are fans, motors, computers, TVs, and can openers. How many more can you name?

These three basic parts, power source, **pathway**, and load, can be arranged to do many different things. However, designing a circuit that works as desired requires a lot of planning and a good understanding of electricity. For example, using one battery with two or more light bulbs will result in dimmer lights. Using just one light bulb with two or more batteries will result in a brighter light. To turn a circuit on or off requires a switch. When we turn the lights on in our classroom the circuit is complete. With a flip of the switch the lights are off and the circuit is incomplete.

Current electricity flows more easily through some things than others. A conductor allows electricity to flow through it easily. A conductor contains charges that can move easily. Wires and the metal parts of a light bulb are good conductors. Pennies, keys, and nails make good conductors, but conductors are not always metal. Some conductors are liquids.



Insulators are materials that do not allow electricity to pass through them. The charges inside an insulator cannot easily move. Plastic is an **insulator**. Some wires are coated with plastic to keep the electricity from flowing to an unsafe place.

Do you see the wires and peaks on top of this old house? They are lightning rods, and their purpose is to protect the building in the event of a lightning strike. Each lightning rod is an electrical conductor that goes down the side of the house and into the ground. If lightning strikes the building, it will target the rod and be conducted by the rod the ground. Lightning rods may differ in style, but to work they must be good at conducting electricity.

Electric Current and Matter

In order to travel, electric current needs mobile electric charges. It cannot pass through empty space. However, most types of matter resist the flow of electric current. In a metal wire, flowing electrons collide with metal atoms, which absorb their energy. Some types of matter offer more or less resistance to electric current than others.

Electric Conductors

Materials that allow the flow of electricity are called electric conductors. Many metals—including copper, aluminum, and steel—are good conductors of electricity. The outer electrons of metal atoms are loosely bound and free to move, allowing electric current to flow. Water that has even a small amount of impurities such as salt is an electric conductor as well. That is because salt will dissolve in water, breaking apart into positively charged sodium atoms and negatively charged chlorine atoms. These charged atoms can move in response to electric forces and make an electric current in the water.

Q: What do you think lightning rods are made of?

A: Lightning rods are made of metal, usually copper or aluminum, both of which are excellent conductors of electricity.

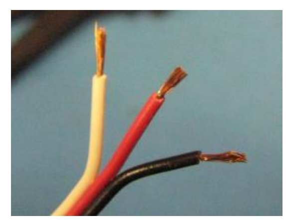
Electric Insulators

Materials that prevent the flow of electricity are called **electric insulators**. Examples include most nonmetallic solids: wood, rubber, and plastic. Their atoms hold onto their electrons tightly, so electric current cannot flow freely through them. Dry air is also an electric insulator. You can learn more about electric insulators, as well as how to test whether a material is an insulator, by doing the activity at this URL:http://goo.gl/e4MyKc

Q: You may have heard that rubber-soled shoes will protect you if you are struck by lightning. Do you think this is true? Why or why not?

A: It isn't true. Rubber is an electric insulator, but a half-inch layer on the bottom of a pair of shoes is insignificant when it comes to lightning. The average lightning bolt has enough energy to force charges to move through most insulators, even the insulators on high-voltage power lines.

Look at the electric wires in the Figure below. They are made of copper and coated with plastic. Copper is very good conductor, and plastic is a very good insulator. So, the current flows through the copper wire and cannot easily flow out of the wire through its plastic coating.



We are using electricity all the time. We need to understand it and how to use it safely and correctly.

Have you ever used a flashlight? What is it used for? How do you get the flashlight to work? Let us try to get the bulb of a flashlight to work. We want to do this without using the flashlight itself.
A simple electric circuit has at least three components:

1. A source of electrical energy, such as a battery.
2. A pathway, such as the electric wires.
3. A device that transforms electrical energy into another useful form, such as the bulb that provides light.

Do you think there is something flowing through the bulb when it lights up? When we connect the bulb so that it lights up there is something flowing through the whole circuit. When it does not light up, we have not made a proper or complete pathway for the current. If the bulb lights up, we say there is an electric current in the circuit. The electric circuit is a system for transferring energy. Think again about the circuits that you have constructed so far.

We already said that a switch is used to turn an electrical device on or off. We can also say that a switch is used to close or open an electrical circuit. When the switch is on, the circuit is closed. An electric current then exists in the circuit. We could also say there is an unbroken electric pathway in the circuit.

When the switch is off the circuit is open. In this case there is no electric current in the circuit. The electric pathway is now broken.

What are Conductors and Insulators?

We can say that a material or object conducts electricity or it does not. But what does this mean? Let's do an investigation to find out. To do this we are going to use a simple circuit. We will insert pieces of different materials into a closed circuit with a light bulb in it. We can easily see if the material is a conductor by observing if the light goes on or stays off.

Good electrical conductors and insulators

A good **electrical conductor** is a material or substance that allows an electric current to pass through it easily. We call the ability to conduct *conductivity*. **Electrical conductors** are usually metal because metals generally have high conductivity. Copper is one of the best electrical conductors and this is why it is the most common material used for electrical wiring. Gold and silver have similar conductivity to copper, but they are very expensive and only used in special situations.

Insulators are non-conducting materials that do not easily allow current to pass through them. This does not mean that current cannot pass through them at all. For example, we generally consider air to be an insulator. However, lightning is an electric current passing through air. Similarly, rubber gloves and shoes will not protect you from lightning. Examples of insulators are plastic, rubber, and wood.

When two conducting materials make contact, electricity can pass through them. Our bodies are also good conductors of electricity. This means electric current can easily flow through you giving you a shock. That is why we cover most conducting wire with insulating materials (like the plastic around extension cords). We want to protect ourselves from being shocked, and prevent the electrical current from passing to other conductors.

The importance of electrical insulators

Think about the wires students may use in class for electricity labs. Why do you think some are covered in plastic? The plastic coating acts as a barrier that prevents you from getting a shock, allowing you to handle the wire when the circuit is on.

Electrical insulators - material that has high resistance to the flow of electric current - are also used in other places. Have you ever looked up at power lines or telephone lines? You will see that the poles that carry the lines are sometimes made of wood. Wood does not conduct electricity so the electric current will not flow from the wires into the pole.

Sometimes you will also see little white or colored caps holding the wires as in the photo below. These caps are made of ceramic, which also does not conduct electricity.

In this photo, the wooden poles and white ceramic caps are electrical insulators.

Key Questions

- What does it mean if something conducts electricity?
- What is the difference between an electrical conductor and insulator?
- Why are insulators important?

Summary

- Electricity must travel through matter. Almost all matter offers some resistance to the flow of electric charges in an electric current. Some materials resist current more or less than others.
- Materials that allow the flow of electric current are called electric conductors. Many metals are good electric conductors.
- Materials that prevent the flow of electric current are called electric insulators. Wood, rubber, and plastic are good electric insulators.
- An electric circuit is a closed loop through which current can flow.
- All electric circuits must have a power source, such as a battery and a pathway, which is usually wire. They may have one or more electric devices as well.
- An electric circuit can be represented by a circuit diagram, which uses standard symbols to represent the parts of the circuit.

Science Language Students Need to Know and Use

- **attract** – to draw together
- **battery** – a device that generates electricity by combining certain chemicals
- **complete circuit** – a connected pathway through which electricity can flow; includes a power source, load, and pathway
- **conductor** – material that allows electricity pass through easily
- **electric conductor**: Material that allows the flow of an electric current
- **electric insulator**: Material that has prevents the flow of an electric current
- **electricity** – flow of energy along a path
- **incomplete circuit** - a circuit with a gap through which electricity cannot flow
- **Insulators** - things that don't allow electricity to pass through them
- **load** – an item that uses electricity to do work
- **pathway** – a course through which electricity can flow

- **power source** is a device that supplies electricity to a circuit; such as a battery, a solar cell, a wall outlet, or a generator
- **repel** – to push apart
- **static discharge** - sudden flow of static electricity from one object to another object
- **static electricity** - an excess of positive or negative charges on an object
- **switch** – a device that immediately changes a circuit from complete to incomplete

Think Like a Scientist

1. What components do electrical circuits have?

2. Draw and label the components of a complete electrical circuit that include switches and loads.

3. Describe the effect of changing one or more of the components (e.g., battery, load, wires) in an electric circuit.

4. Compare and contrast conductors and insulators and give examples of each.

5. Describe how static electricity and current electricity are different.

Online Activities to Try

- **On this site, test your knowledge of static and current electricity by designing three experiments.** http://tinyurl.com/UT5th4-1a
- Investigate positive and negative charges as you use a balloon to generate static electricity. http://tinyurl.com/UT5th4-1g
- Try this interactive simulation with "John Travoltage." http://tinyurl.com/UT5th4-1h
- Experiment with the polarization of an aluminum can using contact with glass and rubber rods. http://tinyurl.com/UT5th4-1i
- Check out the difference between series and parallel circuits on this site. http://tinyurl.com/UT5th4-2c
- Create electrical circuits on this website and light them. http://tinyurl.com/UT5th4-2d
- In this online simulation, place batteries and switches in circuits to light bulbs. http://tinyurl.com/UT5th4-2e
- Build various circuits with different requirements on this website. http://tinyurl.com/UT5th4-2f
- Use magnets and coils to uncover Faraday's Law. http://tinyurl.com/UT5th4-2g
- Determine which objects conduct electricity when inserted in a circuit. http://tinyurl.com/UT5th4-2h
- Examine different ways to create electricity using generators, geothermal energy and solar cells. Build your own wind turbine and take a quiz on this site. http://tinyurl.com/UT5th4-2i

chapter 5

heredity

Standard V, Objective I
Fifth Grade
Cause and Effect

Why doesn't a cow quack and why don't puppies look like kittens? And why do children look like their parents?

Has anyone ever come up to you and told you that you look just like your parents? You probably have some characteristics or traits in common with each of your parents, aunt, uncle, or other relative.

For a long time people understood that traits are passed down through families. The rules of how this worked were unclear, however. The work of Gregor Mendel was crucial in explaining how traits are passed down to each generation.

Mendel's Experiments

What does the word "inherit" mean? You may have inherited something of value from a grandparent or another family member. To **inherit** is to receive something from someone who came before you. You can **inherit** objects, but you can also inherit traits. For example, you can inherit a parent's eye color, hair color, or even the shape of your nose and ears!

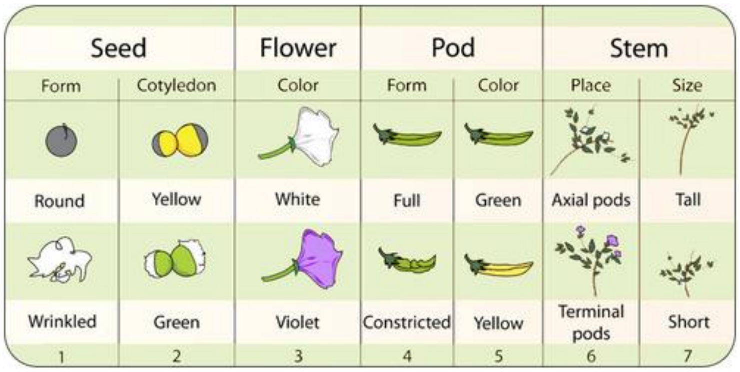
Genetics is the study of inheritance. The field of **genetics** seeks to explain how traits are passed on from one generation to the next.

In the late 1850s, an Austrian monk named Gregor Mendel (left) performed the first genetics experiments.

Gregor Mendel, the "father" of genetics.

To study **genetics**, Mendel chose to work with pea plants because they have easily identifiable traits (Figure below). For example, pea plants are either tall or short, which is an easy trait to observe. Furthermore, pea plants grow quickly, so he could complete many experiments in a short period of time.

He studied the inheritance patterns for many different traits in peas, including round seeds versus wrinkled seeds, white flowers versus purple flowers, and tall plants versus short.

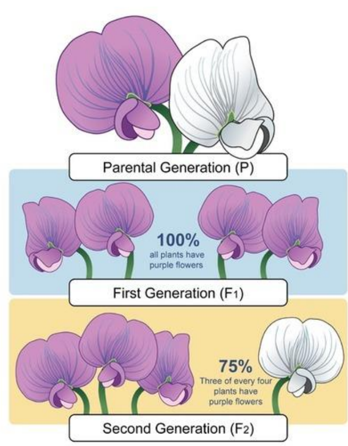


In one of Mendel's early experiments, he crossed a short plant and a tall plant. What do you predict the offspring of these plants were? Medium-sized plants? Most people during Mendel's time would have said medium-sized. But an unexpected result occurred.

Mendel observed that the offspring of this cross were all tall plants!

Next, Mendel let this generation self-pollinate. That means the tall plant offspring were crossed with each other. He found that 75% of their offspring were tall, while 25% were short. Shortness skipped a generation. But why? In all, Mendel studied seven characteristics, with almost 20,000 plants from the 2^{nd} generation. All of his results were similar to the first experiment—about three out of every four plants had one trait, while just one out of every four plants had the other.

For example, he crossed purple flowered-plants and white flowered-plants. Do you think the colors blended? No, they did not. Just like the previous experiment, all offspring in this



cross were one color: purple. In the next generation, 75% of plants had purple flowers and 25% had white flowers. There was no blending of traits in any of Mendel's experiments.

Mendel's work provided the basis to understand the passing of traits from one generation to the next.

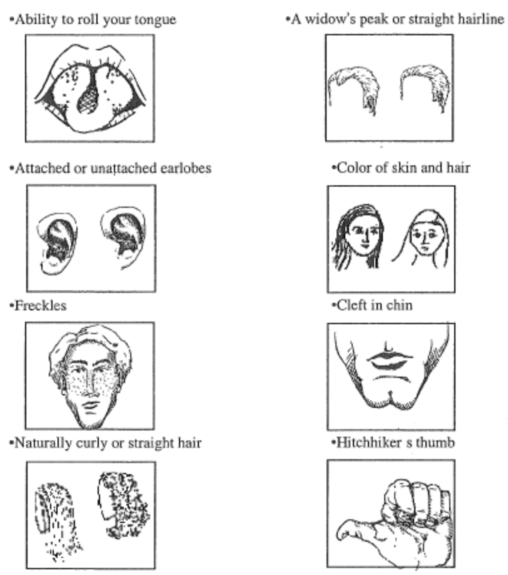
Some trees grow very tall with thick bark while others are very short with thin bark. It all depends on an organism’s **heredity**, the passing of traits from parents to their young. An **organism** is any living thing that can carry out its life activities on its own. Heredity applies to all **organisms** including humans, plants, insects and even bacteria.

In a pond, every frog is unique because of various traits it inherited from its parents. A **trait** is a characteristic that determines how an organism looks, acts or functions. An **inherited trait** is a characteristic passed from parents to their young. Some examples of **inherited traits** are fur color, stripes, or spots. The big cats pictured below show inherited traits. Can you see similarities and differences between the two cats?

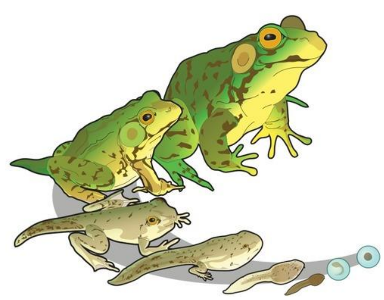
Dogs will always have puppies, just as cats will always have kittens and acorns will always grow into oak trees. That is why people are alike in most ways. We look like people!


All organisms are made up of small building blocks. A person consists of about ten trillion of these building blocks, which come in over 200 varieties. These building blocks give organisms their individual **traits** and vary from organism to organism. These small differences are enough to keep organisms from looking identical. These differences establish our color of hair or eyes, whether we are tall or short, and whether we have freckles or not. Each of us has inherited his/her own mixture of traits. Within each building block are special instructions that tell an organism how it will grow and what traits it will develop.

Parent organisms, producers of offspring, pass these instructions to their **offspring,** the young of an organism. For example, a puppy may inherit dark hair from its mother; a seedling may develop wide, broad leaves from its parent plant; or human beings may inherit a variety of traits. A few of these inherited traits include: ability to roll your tongue, a widow's peak or straight hairline, attached or unattached earlobes, color of skin and hair, freckles, cleft in chin, naturally curly or straight hair, and a hitchhikers thumb.



Sometimes, **offspring** do not look like their **parent organism**. However, as they go through their life cycles they begin to look more like their parents. For example, the legless little tadpole with its large tail looks very



different than it will as a full-grown frog.

Compare puppies in a litter. Even though these puppies may have had the same two parents, there are **variations,** differences in the appearance of an inherited trait among the members of a group or species, in how they look and act. The differences in paw size, tail length, or hair coloring are examples of **variations**. Some variations do not have much of an effect on an organism. For example, the different colors of hair on puppies may have little effect on whether or not each puppy will survive.

However, for some organisms living in the wild, color can make a big difference. For example, a moth with brightly colored orange and yellow wings will not survive very long if its environment is the dark bark of pine trees. The brightly colored moth can be easily seen and eaten by birds. A moth with similar color patterns to its surroundings may survive longer. These variations give a **species**, a certain group of plants or animals that can only reproduce among themselves, a better chance to live or survive.

Learned Behaviors vs. Instincts

Did you ever see a dog sit on command? Have you ever watched a cat trying to catch a mouse? These are just two examples of the many behaviors of animals. Animal behavior includes all the ways that animals interact with each other and the environment. Some animal behaviors are **learned behaviors**,an action that is learned through trial and error or is brought about by the environment. Other behaviors are instinctual, meaning animals are born with them. Examples of common animal behaviors are pictured in the figure below. Herding for the dog is both learned and instinctual, the nursing piglet is an instinctual behavior, and blowing dandelion seeds is a **learned behavior**.

Examples of Animal Behavior. Can you think of other examples of animal behavior besides the three shown here?

Studying Animal Behavior

The branch of biology that studies animal behavior is called ethology. Ethnologists usually study how animals behave in their natural environment, rather than in a lab. They generally try to answer four basic questions about the behaviors they observe:

1. What causes the behavior? What is the stimulus, or trigger, for the behavior? What structures and functions of the animal are involved in the behavior?
2. How does the behavior develop? Is it present early in life? Or does it appear only as the animal matures? Are certain experiences needed for the behavior to develop?
3. Why did the behavior evolve? How does the behavior affect the fitness of the animal performing it? How does it affect the survival of the species?
4. How did the behavior evolve? How does it compare with similar behaviors in related species? In what ancestor did the behavior first appear?

As you read about animal behavior in the rest of this lesson, think about these four questions. Try to answer the questions for different types of animal behavior.

Evolution of Animal Behavior

To the extent that behaviors are controlled by genes, they may evolve through natural selection. If behaviors increase fitness, they are likely to become more common over time. If they decrease fitness, they are likely to become less common.

Nature vs. Nurture

Some behaviors seem to be controlled solely by genes. Others appear to be due to experiences in a given environment. Whether behaviors are controlled mainly by genes or by the environment is often a matter of debate. This is called the nature-nurture debate. Nature refers to the genes an animal inherits. Nurture refers to the environment that the animal experiences. In reality, most animal behaviors are not controlled by nature or nurture. Instead, they are influenced by both nature and nurture. In dogs, for example, the tendency to behave toward other dogs in a certain way is probably controlled by genes. However, the normal behaviors can't develop in an environment that lacks other dogs. A puppy raised in isolation from other dogs may never develop the normal behaviors. It may always fear other dogs or act aggressively toward them.

How Behaviors Evolve

It's easy to see how many common types of behavior evolve. That's because they obviously increase the fitness of the animal performing them. For example, when wolves hunt together in a pack, they are more likely to catch prey. Therefore, hunting with others increases a wolf's fitness. The wolf is more likely to survive and pass its genes to the next generation by behaving this way.

Wolves Hunting Cooperatively. Wolves hunt together in packs. This is adaptive because it increases their chances of killing prey and obtaining food.

Inherited Behavior

How do kittens know how to "hunt"? This kitten was probably adopted and separated from its mother at a young age. It never got a lesson in how to stalk and pounce on prey. So how does this kitten know how to attack the ball of yarn? Some behaviors do not need to be learned.

Many animal behaviors are ways that animals act, naturally. They don't have to learn how to behave in these ways. Cats are natural-born hunters. They don't need to learn how to hunt. Spiders spin their complex webs without learning how to do it from other spiders. Birds and wasps know how to build nests without being taught. These behaviors are called inherited.

An **inherited behavior** is any behavior that occurs naturally in all animals of a given species. An **inherited behavior** is also called an **instinct**-behaviors that are inherited from the parent organism. The first time an animal performs an inherited behavior, the animal does it well. The animal does not have to practice the behavior in order to get it right or become better at it. Inherited behaviors are also predictable. All members of a species perform an inherited behavior in the same way. From the examples described above, you can probably tell that inherited behaviors usually involve important actions, like eating and caring for the young.

There are many other examples of **instincts**. For example, did you know that honeybees dance? The honeybee pictured below has found a source of food. When the bee returns to its hive, it will do a dance. This dance is called the waggle dance. The way the bee moves during its dance tells other bees in the hive where to find the food. Honeybees can do the waggle dance without learning it from other bees, so it is an instinct.

When this honeybee goes back to its hive, it will do a dance to tell the other bees in the hive where it found food.

Besides building nests, birds have other instincts. One example occurs in gulls, which are pictured below; one of the chicks is pecking at a red spot on the mother's beak. This inherited behavior causes the mother to feed the chick. In many other species of birds, the chicks open their mouths wide whenever the mother returns to the nest. This inherited behavior, called gaping, causes the mother to feed them.

Left: This mother gull will feed her chick after it pecks at a red spot on her beak. Both pecking and feeding behaviors are instincts. Right: When these baby birds open their mouths wide, their mother instinctively feeds them.

Significance of Inherited Behavior

Inherited behaviors are rigid and predictable. All members of the species perform the behaviors in the same way. Inherited behaviors usually involve basic life functions, such as finding food or caring for offspring. Several examples are shown in Figure to the left. If an animal were to perform such important behaviors incorrectly, it would be less likely to survive or reproduce.

Examples of Inherited Behavior

These inherited behaviors are necessary for survival or reproduction. Can you explain why each behavior is important?

This female graylag goose is a ground-nesting water bird. Before her chicks hatch, the mother protects the eggs. She will use her bill to push eggs back into the nest if they roll out. This is an example of an inherited behavior.

Inherited Behavior in Human Beings

All animals have inherited behaviors, even human beings. Can you think of human behaviors that do not have to be learned? Chances are, you will have a hard time thinking of any. The only truly inherited behaviors in humans are called **reflex behaviors,** an involuntary response to a stimulus. They occur mainly in babies. Like instincts in other animals, **reflex behaviors** in human babies may help them survive.

An example of a reflex behavior in babies is the sucking reflex. Newborns instinctively suck on a nipple that is placed in their mouth. It is easy to see how this behavior evolved. It increases the chances of a baby feeding and surviving. Another example of a reflex behavior in babies is the grasp reflex (Figure below). Babies instinctively grasp an object placed in the palm of their hand. Their grip may be surprisingly strong. How do you think this behavior might increase a baby's chances of surviving?

Learned Behavior

Learning is a change in behavior that occurs as a result of experience. Compared with inherited behaviors, learned behaviors are more flexible. They can be modified to suit changing conditions. This may make them more adaptive than instincts. For example, drivers may have to modify how they drive, a learned behavior, when roads are wet or icy. Otherwise, they may lose control of their vehicle. Animals may learn behaviors in a variety of ways. Some ways are quite simple. Others are more complex.

Do you play a sport? If you play a sport like soccer, then you realize it takes a lot of work. Remember how you didn't know at all what you were doing when you first started? You had rules to figure out and skills to practice. Playing a sport is an example of a learned behavior.

Just about all human behaviors are learned. Learned behavior is behavior that occurs only after experience or practice. Learned behavior has an advantage over inherited behavior: it is more flexible. Learned behavior can be changed if conditions change. For example, you probably know the route from your house to your school. Assume that you moved to a new house in a different place, so you had to take a different route to school. What if following the old route was an instinct? You would not be able to adapt. Fortunately, it is a learned behavior. You can learn the new route just as you learned the old one.

Although most animals can learn, animals with greater intelligence are better at learning and have more learned behaviors. Humans are the most intelligent animals. They depend on learned behaviors more than any other species. Other highly intelligent species include apes, our closest relatives in the animal kingdom. They include chimpanzees and gorillas. Both are also very good at learning behaviors.

You may have heard of a gorilla named Koko. The psychologist, Dr. Francine Patterson, raised Koko. Dr. Patterson wanted to find out if gorillas could learn human language. Starting when Koko was just one year old, Dr. Patterson taught her to use sign language. Koko learned to use and understand more than 1,000 signs. Koko showed how much gorillas can learn.

Think about some of the behaviors you have learned. They might include riding a bicycle, using a computer, and playing a musical instrument or sport. You probably did not learn all of these behaviors in the same way. Perhaps you learned some behaviors on your own, just by practicing. Other behaviors you may have learned from other people. Humans and other animals can learn behaviors in several different ways.

Why don’t cactuses grow in the rain forest, and why aren’t their tropical flowers in the desert?

Adaptation

The characteristics of an organism that help it to survive in a given environment are called **adaptations**. **Adaptations** are traits that an organism inherits from its parents. Within a population of organisms are genes coding for a certain number of traits. For example, a human population may have genes for eyes that are blue, green, hazel, or brown, but as far as we know, not purple or lime green.

Adaptions develop when certain variations occur within a population. The variation may already exist within the population, but often the variation comes from a **mutation**,a random change in an organism’s genes. Some **mutations** are harmful and the organism dies; in that case, the variation will not remain in the population. Many mutations are neutral and remain in the population. If the environment changes, the mutation may be beneficial and it may help the organism adapt to the environment. The organisms that survive pass this favorable trait on to their offspring.

Biological Evolution

Many changes in the genetic makeup of a species may accumulate over time, especially if the environment is changing. Eventually the descendants will be very different from their ancestors and may become a whole new species. Changes in the genetic makeup of a species over time are known as biological **evolution**, the gradual development of something from a simple to a more complex form.

Natural Selection

The mechanism for **evolution** is **natural selection,** a process whereby organisms better adapted to their environment tend to survive and produce more offspring. Traits become more or less common in a population depending on whether they are beneficial or harmful. An example of evolution by **natural selection** can be found in the deer mouse. In Nebraska this mouse is typically brown, but after glaciers carried lighter sand over the darker soil in the Sand Hills, predators could more easily spot the dark mice. Natural selection favored the light mice, and over time, the population became light colored.

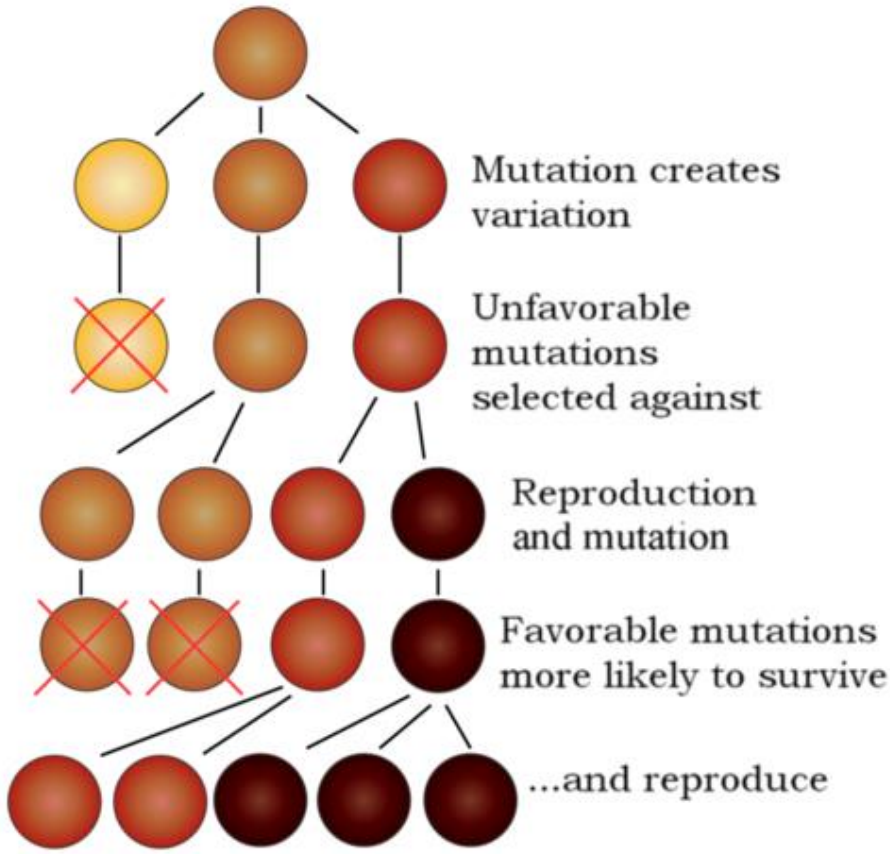
Adaptation and Evolution of Populations

Adaptations and Mutations

- Adaptations are characteristics that help an organism survive in an environment.
    - Adaptations develop when variations in a population occur.
- A mutation is a random change in the genetic makeup of an individual.
    - Mutations can be harmful, helpful, or have no effect to the organism.
    - Favorable mutations are passed down to future generations through reproduction.

Evolution

- Evolution is when the changes in the genetic makeup of a population of individuals accumulate over time.
    - Evolution causes descendants to be much different than their ancestors.
    - Eventually, it can cause a new species to arise.
- Natural selection is the process in which evolution is able to occur.
    - Traits become more or less common in a population depending on how beneficial they are.



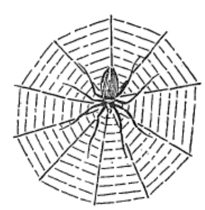
Natural selection driven on both positive and negative variations, and helps organisms adapt and evolve.

Concept Check

- How do adaptations and mutations contribute to the process of evolution?
- Describe the process of natural selection.

Instincts

Instincts are also behaviors that are inherited from the parent organism. These instincts help organisms survive. This explains why salmon migrate upstream to spawn, a cat purrs, a duck swims, a spider spins a web, or a termite rots wood.



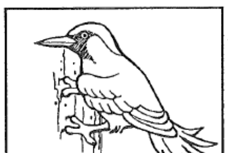
Snowshoe Rabbit

Jackrabbit

Other variations include **specialized structures,** a body part unique to a species for survival in its environment that help organisms to survive in their **environments**, the area in which an organism lives. A snowshoe rabbit has small ears and broad feet. Its smaller ears prevent it from losing body heat, enabling it to stay warmer in its cold northern habitat. Its broad-sized feet are well suited to help it travel over snowy terrain. A jackrabbit lives in the hot, dry areas of the southwest. It has long, large ears and powerful hind feet. These ears provide a large surface area that allows excess heat to escape. The powerful hind legs enable it to outrun predators. These **specialized structures** of a snowshoe rabbit and jackrabbit enable them to live and reproduce in different **environments**.

All birds have a beak but all beaks do not look the same. A goldfinch has a short beak for eating seeds. A woodpecker has a slender beak to get insects from under tree bark. A hawk has a hooked beak for ripping and tearing prey, such as rabbits.

Goldfinch



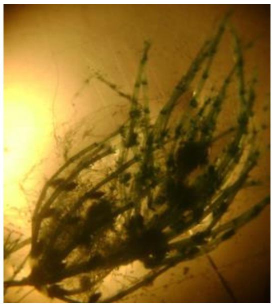
Woodpecker

Hawk

Variations among plants can also help them with **survival,** the continuation of life, advantage. Pine seedlings compete for sunlight, water, and soil nutrients. Fast-growing seedlings are more likely to crowd out their slow-growing neighbors. Most organisms compete for resources such as food, air, water, and space. Variations that make it easier for organisms to find or use a resource are better able to survive.

The environment is constantly changing. Sometimes the changes are gradual, as in climate changes. Other changes may be sudden, such as volcanoes, earthquakes, floods, landslides, or violent storms. When an environment changes, some organisms die. Some organisms move to a new environment. Some have variations for better **survival**. The helpful variations will be inherited by some of the offspring. After many generations, most organisms in that species will have helpful variations. Years ago, when DDT (a poison that kills insects) was used in the environment, a few mosquitos were resistant to DDT. These mosquitos with this variation were better suited to survive in an environment that contained DDT. They lived and produced offspring that DDT could not kill. As a result, the **population**, the number and kind of organisms in an area, of DDT-resistant mosquitoes has grown larger in recent years.

The traits inherited by parents are only a part of who they are. Some actions of organisms are learned behaviors from parent organisms and from their environment. These are behaviors learned during an organism's lifetime. Learned behaviors vary from organism to organism. Calves, following their mothers to the water troughs, will soon learn to get there by themselves when they are thirsty. Dogs learn different ways to let their owners know they want to come inside or go outside the house. Some dogs may scratch at the door while other may sit by the door and whine. Learning is important for all organisms because it allows them to change when the environment around them changes. This ability to change or learn a new behavior will help them survive for many years.



Where did plants come from?

Plants have not always been around on land. For a long time, life was confined to water. The first plants evolved from green algae that looked somewhat like the Chara pictured right.

Plants have adapted to a variety of environments, from the desert to the tropical rain forest to lakes and oceans. In each environment, plants have become crucial to supporting animal life. Plants are the food that animals eat. Plants also provide places for animals, such as insects and birds, to live. From tiny mosses to gorgeous rose bushes to extremely large redwood trees.

Look closely at the petals of this flower.
Do they look different?

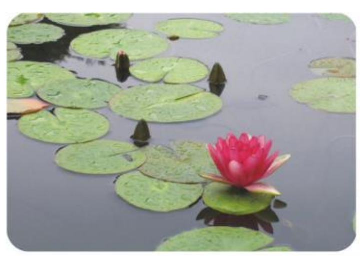
This flower is from an aloe plant. Aloes are succulent plants, which have adaptations that allow them to store water in their enlarged fleshy leaves, stems, or roots. This allows them to survive in arid environments.

Plant Adaptations

Plants live just about everywhere on Earth. To live in so many different habitats, they have evolved adaptations that allow them to survive and reproduce under a diversity of conditions. All plants are adapted to live on land. Or are they? All living plants today have terrestrial ancestors, but some plants now live in the water. They have had to evolve new adaptations for their watery habitat.

Adaptations to Water

Aquatic plants are plants that live in water. Living in water has certain advantages for plants. One advantage is, well, the water. There's plenty of it and it's all around. Therefore, most aquatic plants do not need adaptations for absorbing, transporting, and conserving water. They can save energy and matter by not growing extensive root systems, vascular tissues, or thick cuticles on leaves. Support is also less of a problem because of the buoyancy of water. As a result, adaptations such as strong woody stems and deep anchoring roots are not necessary for most aquatic plants.



Water Lilies

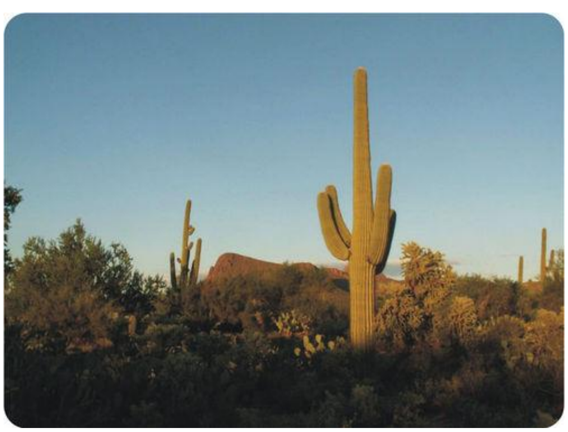
Cattails

Living in water does present challenges to plants, however. For one thing, pollination by wind or animals isn't feasible under water, so aquatic plants may have adaptations that help them keep their flowers above water. For instance, water lilies have bowl-shaped flowers and broad, flat leaves that float. This allows the lilies to collect the maximum amount of sunlight, which does not penetrate very deeply below the water's surface. Plants that live in moving water, such as streams and rivers, may have different adaptations. For example, cattails have narrow, strap-like leaves that reduce their resistance to the moving water (see Figure below). Water lilies and cattails have different adaptations for life in the water. Compare the leaves of the two kinds of plants. How do the leaves help the plants adapt to their watery habitats?

Adaptations to Extreme Dryness

Plants that live in extremely dry environments have the opposite problem: how to get and keep water. Their adaptations may help them increase water intake, decrease water loss, or store water when it is available.

The saguaro cactus pictured below has adapted in all three ways. When it was still a very small plant, just a few inches high, its shallow roots already reached out as much as 2 meters (7 feet) from the base of the stem. By now, its root system is much more widespread. It allows the cactus to gather as much moisture as possible from rare rainfalls. The saguaro doesn't have any leaves to lose water by transpiration. It also has a large, barrel-shaped stem that can store a lot of water. Thorns protect the stem from thirsty animals that might try to get at the water inside.



The saguaro cactus has many adaptations for extreme dryness. How does it store water?

Adaptations to Air

Plants called epiphytes grow on other plants. They obtain moisture from the air and make food by photosynthesis. Most epiphytes are ferns or orchids that live in tropical or temperate rainforests. Host trees provide support, allowing epiphyte plants to obtain air and sunlight high above the forest floor. Being elevated above the ground lets epiphytes get out of the shadows on the forest floor so they can get enough sunlight for photosynthesis. Being elevated may also reduce the risk of being eaten by herbivores and increase the chance of pollination by wind.

Epiphytes don't grow in soil, so they may not have roots. However, they still need water for photosynthesis. Rainforests are humid, so the plants may be able to absorb the water they need from the air. Many epiphytes have evolved modified leaves or other structures for collecting rainwater, fog, or dew. The leaves of the bromeliad shown below are rolled into funnel shapes to collect rainwater. The base of the leaves forms a tank that can hold more than 8 liters (2 gallons) of water. Some insects and amphibians may spend their whole life cycle in the pool of water in the tank, adding minerals to the water with their wastes. The tissues at the base of the leaf are absorbent, so they can take in both water and minerals from the tank.

This elkhorn fern is growing on a rainforest tree as an epiphyte.

The leaves of this bromeliad are specialized to collect, store, and absorb rainwater.

Why would an organism match its background? Wouldn't it be better to stand out? An organism that blends with its background is more likely to avoid predators. If it survives, it is more likely to have offspring. Those offspring are more likely to blend into their backgrounds. Where a river runs into the sea, a special area called an estuary develops. The fresh water from the river mixes with the salty sea water. You can often find mudskippers here (fish that can hop onto land and into trees!)

Mudskippers live in estuaries, but they can hop onto land and into low branches!

Summary

- Plants live just about everywhere on Earth, so they have evolved adaptations that allow them to survive and reproduce under a diversity of conditions.
- Various plants have evolved adaptations to live in the water, in very dry environments, or in the air as epiphytes.

Science Language

- **adaptations-**alteration in the structure or function of an organism or any of its parts
- **environment-**the surroundings in which an organism lives
- **evolution-**gradual development of something from a simple to a more complex form
- **genetics-**the study of heredity and the variation of inherited characteristics
- **inherit-**a characteristic passed on from parents to their young
- **inherited behavior-**set of actions that a living thing is born with and does not need to learn
- **inherited trait-**traits or characteristics passed from parents to offspring through the genes
- **instinct-**behaviors that are inherited from the parent organism
- **learned behavior-**an action that is learned through trial and error or is brought about by the environment
- **mutation-**changing of the structure of a gene
- **natural selection-**organisms better adapted to their environment tend to survive and produce more offspring
- **offspring-**the young of an organism
- **organism-**any living thing that can carry out its life activities on its own
- **parent organisms-**a producer of offspring
- **population-**the number and kind of organisms in an area
- **reflex behaviors-**automatic responses to stimulation
- **specialized structures-**a body part unique to a species for survival in its environment
- **species-**a certain group of plants or animals that can only reproduce among themselves
- **survival-**the continuation of life
- **trait-**characteristics that determine how an organism looks, acts, or functions

- **variations-**differences in the appearance of an inherited trait among members of a group or species

Think Like a Scientist

1. Why doesn't a cow quack and why don't puppies look kittens? And why do children look like their parents?
2. Compare and contrast learned behaviors and inherited behaviors.
3. How do inherited behaviors help organisms survive?
4. How do learned behaviors help organisms survive?
5. Why don't cactuses grow in the rain forest, and why aren't there tropical flowers in the desert?
6. Compare and contrast the adaptations of a cactus and the adaptations of a water lily.
7. How do specialized structures help organism survive in their environment? Provide examples.

Online Activities to Try

- Participate in a Virtual Lab for DNA Extraction on this site.
  http://tinyurl.com/UT5th5-1a
- Review heredity and why offspring look like their parents on this site.
  http://tinyurl.com/UT5th5-1b
- Distinguish between physical traits and inherited traits on this site.
  http://tinyurl.com/UT5th5-1c
- Select how specific adaptations help animals survive in their environments.
  http://tnyurl.com/UT5th5-2a

- Choose among 142 Species of animals and create habitats in which they will survive. Create your own new species from a menu of characteristics. http://tinyurl.com/UT5th5-2b

- Discover various species of endangered, threatened, and extinct animals. Choose which animal species left clues behind in their habitats. http://tinyurl.com/UT5th5-2c