# 8th Grade Science

2017-2018

# 8th Grade Science
## for Utah SEEd Standards

UTAH OER DOE
2017-2018

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Printed: January 20, 2017

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# CHAPTER 1

# Using this Book

## Chapter Outline

## 1.1 Credits and Copyright



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We especially wish to thank the amazing Utah science teachers whose collaborative efforts made the book possible. Thank you for your commitment to science education and Utah students!

# 1.2 Students as Scientists

## Making Science

What does science look and feel like?

If you're reading this book, either as a student or a teacher, you're going to be digging into the "practice" of science. Probably, someone, somewhere, has made you think about this before, and so you've probably already had a chance to imagine the possibilities. Who do you picture doing science? What do they look like? What are they doing?

Often when we ask people to imagine this, they draw or describe people with lab coats, people with crazy hair, beakers and flasks of weird looking liquids that are bubbling and frothing. Maybe there's an explosion. Let's be honest: Some scientists do look like this, or they look like other stereotypes: people readied with their pocket protectors and calculators, figuring out how to launch a rocket into orbit. Or, maybe what comes to mind is a list of steps that you might have to check off for your science fair project to be judged; or, maybe a graph or data table with lots of numbers comes to mind.

So let's start over. When you imagine graphs and tables, lab coats and calculators, is that you and what you love? If this describes you, that's great. But if it doesn't — and that's probably true for many of us — then go ahead and dump that image of science. It's useless because it isn't you. Instead, picture yourself as a maker and doer of science. The fact is, we need scientists and citizens like you, whoever you are, because we need all of the ideas, perspectives, and creative thinkers. This includes you.

Scientists wander in the woods. They dig in the dirt and chip at rocks. They peer through microscopes. They read. They play with tubes and pipes in the aisles of a hardware store to see what kinds of sounds they can make with them. They daydream and imagine. They count and measure and predict. They stare at the rock faces in the mountains and imagine how those came to be. They dance. They draw and write and write and write some more.

Scientists — and this includes all of us who do, use, apply, or think about science — don't fit a stereotype because no people fit stereotypes. If we really want to figure out what we all have in common, it turns out that our genetic structure looks a lot like that of a chimpanzee. What distinguishes us from chimpanzees, however, might be that we walk a little more upright, have a little less hair, and make better pizza. (For what it's worth, chimpanzees do really well at many things we think of as "human" skills, such as communicating, fighting, taking care of one another, establishing communities, and using tools.) What really sets us apart as humans is not just that we know and do things, but that we wonder and make sense of our world. We do this in many ways, including through painting, religion, music, culture, poetry, and, maybe most especially, science. Science isn't just a method or a collection of things we know. It's a uniquely human practice of wondering about and creating explanations for the natural world around us. This ranges from the most fundamental building blocks of all matter to the widest expanse of space that contains it all. If you've ever wondered, "When did time start?" or "What is the smallest thing?" or even just "What is color?" or so many other, endless questions, you're already thinking with a scientific mind. Of course you are; you're human, after all. 3 1.2. Students as Scientists www.ck12.org

But here is where we really have to be clear. Science isn't just these questions and their explanations. Science is about a sense of wondering and the sense-making itself. We have to wonder and then really dig into the details of our surroundings. We have to get our hands dirty. Here's a good example: two young scientists under the presence of the Courthouse Towers in Arches National Park. We can be sure that they spent some amount of time in awe of the giant sandstone walls, but here in this photo they're enthralled with the sand that's just been re-washed by recent rain. There's this giant formation of sandstone looming above these kids in the desert, and they're happily playing in the sand. This is ridiculous. Or is it?

How did that sand get there? Where did it come from? Did the sand come from the rock or does the rock come from sand? And how would you know? How do you tell this story?

Look. There's a puddle. How often is there a puddle in the desert? The sand is wet and fine; and it makes swirling, layered patterns on the solid stone. There are pits and pockets in the rock, like the one that these two scientists are sitting in, and the gritty sand and the cold water accumulate there. And then you might start to wonder: Does the sand fill in the hole to form more rock, or is the hole worn away because it became sand? And then you might wonder more about the giant formation in the background: It has the same colors as the sand, so has this been built up or is it being worn down? And if it's being built up by sand, how does it all get put together; and if it's being worn away then why does it make the patterns that we see in the rock? Why? How long? What next?

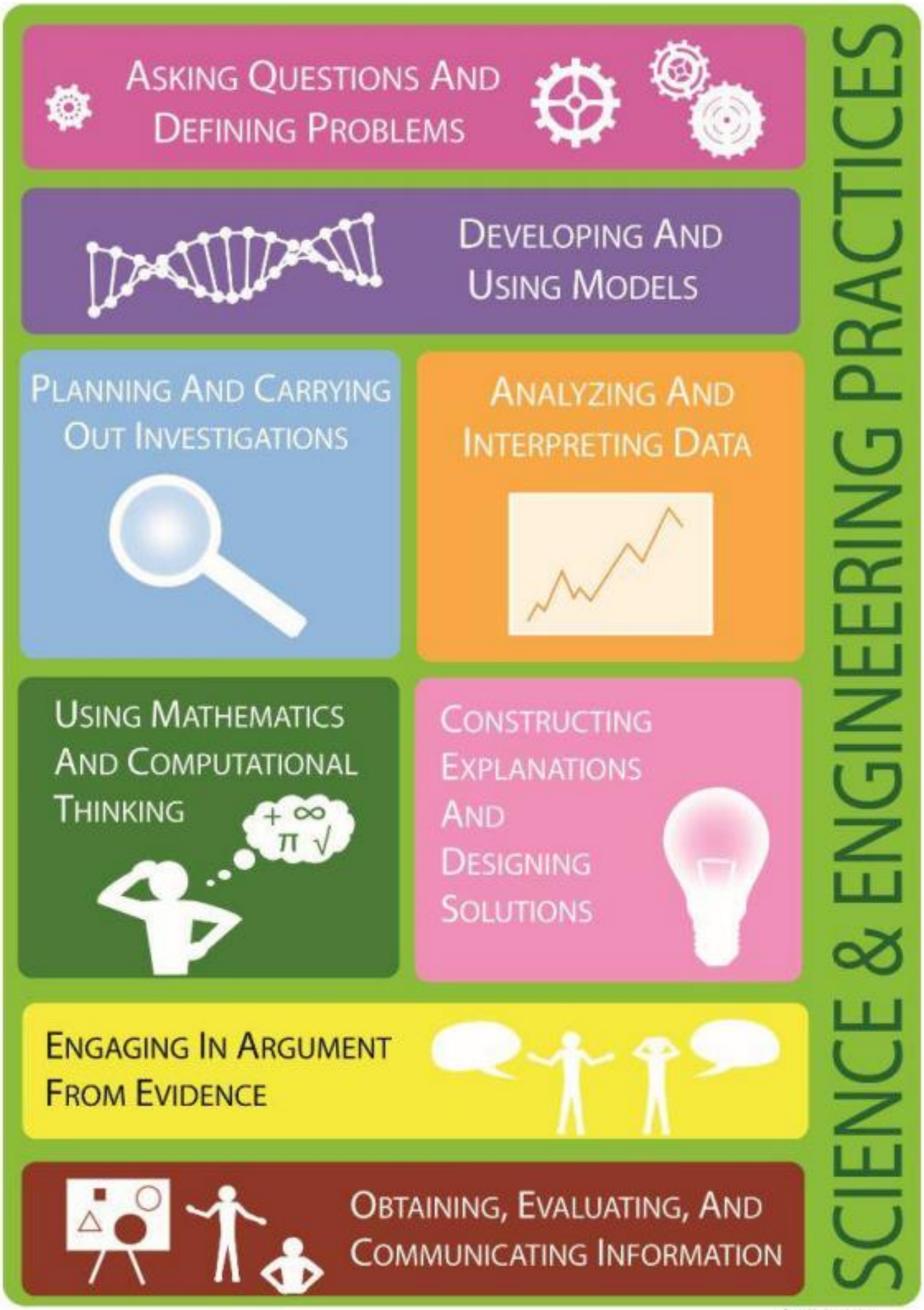
Just as there is science to be found in a puddle or a pit or a simple rock formation, there's science in a soap bubble, in a worm, in the spin of a dancer and in the structure of a bridge. But this thing we call "science" is only there if you're paying attention, asking questions, and imagining possibilities. You have to make the science by being the person who gathers information and evidence, who organizes and reasons with this, and who communicates it to others. Most of all, you get to wonder. Throughout all of the rest of this book and all of the rest of the science that you will ever do, wonder should be at the heart of it all. Whether you're a student or a teacher, this wonder is what will bring the sense-making of science to life and make it your own.

Adam Johnston

Weber State University

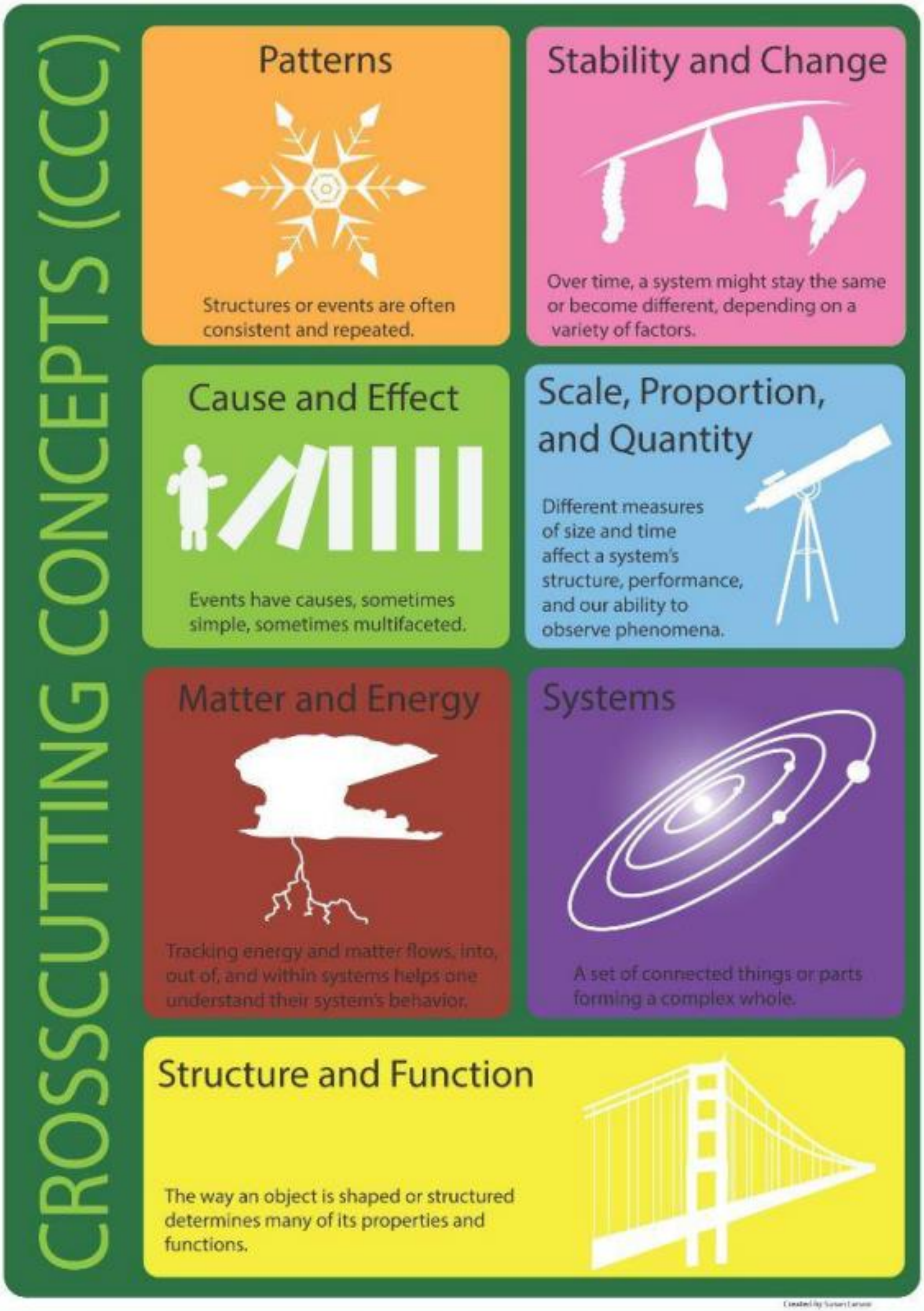
## Science and Engineering Practices

Science and Engineering Practices are what scientists do to investigate and explore natural phenomena.



## Crosscutting Concepts

Crosscutting Concepts are the tools that scientists use to make sense of natural phenomena.



## 1.3 A Note to Teachers

This Open Educational Resource (OER) textbook has been written specifically for students as a reputable source for them to obtain information aligned to the Utah Science with Engineering Education (SEEd) Standards. This book is to be used to support the curriculum created by teachers and not to supplant classroom instruction. It is not intended to describe what content should be taught or even suggest in what order instruction should occur.

This OER textbook has been organized in the same order as the strands and standards of the Utah SEEd Standards. Most standards have their own section starting and ending with a phenomenon that students can use to gather information, reason through their understanding, and communicate their findings using the science and engineering practices. Standards that pair well together may be joined into a single section.

This book is a first iteration for the Utah SEEd Standards and was written and organized by Utah science teachers in a relatively short period of time. The short time available to create this book may mean that there are some grammatical errors or weaknesses in the content. The hope is that as teachers use this resource with their students they keep a record of their suggestions on how to improve the book. Every year, the book will be revised using teacher feedback and with new objectives to improve the book.

If there is feedback you would like to provide to support future writing teams please use the following online survey: https://www.surveymonkey.com/r/SEEdOERFeedback .

# CHAPTER 2

# Strand 1: Matter and Energy

## Chapter Outline



The physical world is made of atoms and molecules. Even large objects can be viewed as a combination of small particles. Energy causes particles to move and interact physically or chemically. Those interactions create a variety of substances. As molecule undergo a chemical or physical change, the number of atoms in that system remains constant. Humans use energy to refine natural resources into synthetic materials.

# 2.1 Atoms and Molecules (8.1.1)

## Explore this Phenomenon

Ink is dropped in a beaker of water. The jar is photographed at 1 minute intervals.

- What do you observe is happening in the jar as time progresses?
- What questions do you have about what is happening in the jar?
- How do you explain what is happening in the jar?

## 8.1.1 Atoms and Molecules

**Develop a model** to describe the scale and proportion of atoms and molecules. Emphasize developing atomic models of elements and their numbers of protons, neutrons, and electrons, as well as models of simple molecules. Topics like valence electrons, bond energy, ionic complexes, ions, and isotopes will be introduced at the high school level.

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In this section, focus on the scale and proportion of atoms and molecules and how they can be understood at various scales by using models to study systems that are too small to observe directly.

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### What Are Atoms?

Have you ever wondered what you and a speck of dust in outer space have in common? The answer is that you and the speck of dust are made of atoms. Atoms are the building blocks of matter. They are what makes up all solids, liquids, and gases. Atoms are extremely small, so small that they cannot be seen by the naked eye. The radius of an atom is well under 1 nanometer, which is one-billionth of a meter. If a size that small is hard to imagine, consider this: trillions of atoms would fit inside the period at the end of this sentence.

### History of the Atom

The history of our understanding of the atom is a classic example of how scientific knowledge changes over time. As one thinker builds on another thinker's ideas and as technology advances, our understanding of how the world works becomes more and more accurate. Consider the following timeline of how people have modeled the atom.

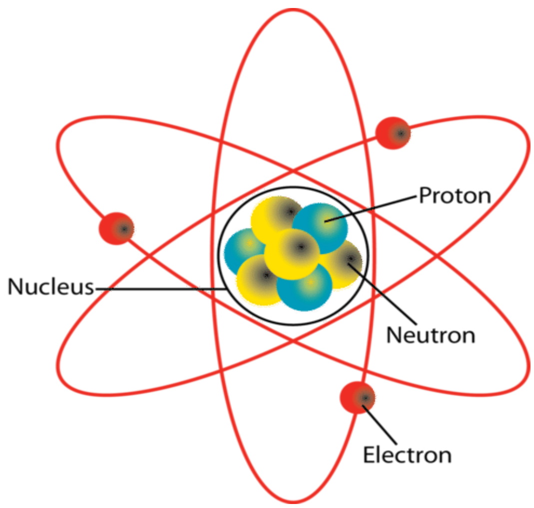
- Around 450 B.C., the Greek philosopher Democritus introduced the idea of the atom. However, the idea was essentially forgotten for more than 2000 years.
- In 1800, John Dalton re-introduced the atom. He provided evidence for atoms and developed atomic theory. His theory was essentially correct. However, he incorrectly thought that atoms are the smallest particles of matter.
- In 1897, J.J. Thomson discovered electrons. He proposed the plum pudding model of the atom. In this model, negative electrons are scattered throughout a "sea" of positive charge.
- In 1911, Ernest Rutherford discovered the nucleus. He later discovered protons as well. Rutherford thought that electrons randomly orbit the nucleus.
- Niels Bohr and Ernest Rutherford, in 1913, represented the atom as a small, positively charged nucleus surrounded by electrons that travel in circular orbits around it, much like planets orbit the sun in the solar system.
- A little later, building on the thoughts of Bohr, Erwin Schrodinger took the understanding of the atom in a new direction when he developed the electron cloud model. The cloud model represents a sort of history of where the electron

has probably been and where it is likely to be going. Imagine that as the electron moves it leaves a trace of where it was. This collection of traces quickly begins to resemble a cloud; the electron cloud.

## Parts of an Atom

Although atoms are very tiny, they consist of even smaller particles. Three main types of particles that make up all atoms are as follows.

- At the center of an atom is a nucleus made up of two types of particles called protons and neutrons.
    - Protons have a positive electrical charge. The number of protons in the nucleus determines what element the atom is.
    - Neutrons are about the same mass as protons but have no charge.
- Electrons, much smaller than protons or neutrons, have a negative electrical charge, move at nearly the speed of light, and orbit the nucleus at certain distances, depending on their energy.

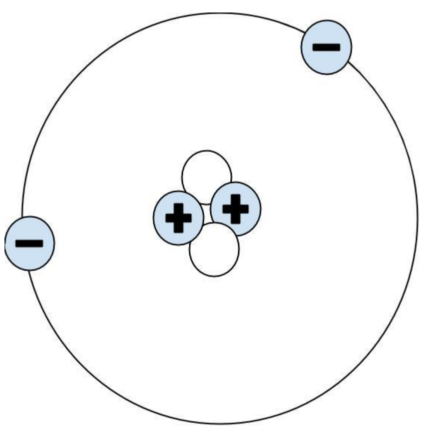



The model in the figure shows how these particles are arranged in an atom. At the center of the atom is a dense area called the nucleus, where all the protons and neutrons are clustered closely together. The protons and neutrons make up almost all of the mass of an atom. The electrons have almost no mass and are constantly moving around the nucleus. Because the protons and electrons have opposite electric charges they attract each other; negative electrons are attracted to the positive nucleus. This force of attraction keeps electrons constantly moving through the otherwise empty space around the nucleus. The number of protons in a neutral atom equals the number of electrons. This makes atoms neutral in charge because the positive and negative charges "cancel out."

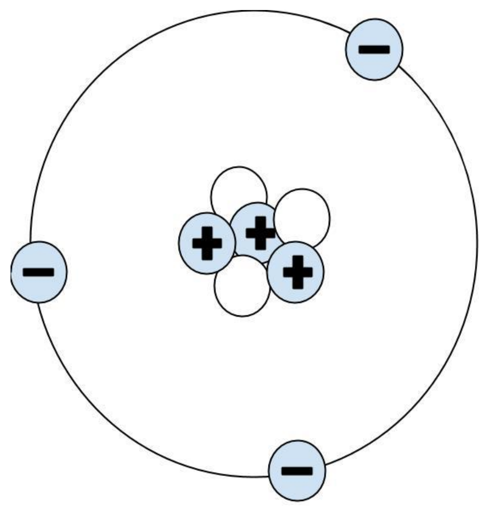
Using our knowledge of an atom, what is accurate and inaccurate about the model shown? The model is very useful in showing us the parts of the atom and their approximate locations. What it fails at is to show the correct scale of atom. For example, the nucleus of an atom is one trillionth the size of the whole atom. The rest of the atom is mostly empty space. Although this model is inaccurate we will frequently see and use it because making an accurate model is impractical given the size and scale of this book. Go to the following link to understand the relative size of the atom and nucleus. https://www.ted.com/talks/just_how_small_is_an_atom

## Elements

Think back again to you and a speck of dust in outer space. We know that we are both made of atoms but it is important to understand that not all atoms are the same. All atoms have the same structure, in that they are made of protons, neutrons, and electrons. What makes one atom different than another atom is that they have different numbers of protons. Atoms with different numbers of protons are called elements; each element has its own unique number of protons in its atoms. Elements are pure substances—such as nickel, hydrogen, and helium—that make up all kinds of matter. Examine the figures. A helium atom has two protons, whereas a lithium atom has three protons. Go to the following link to further learn about what elements are. https://youtu.be/atcrgTH_ul4/



Helium Atom



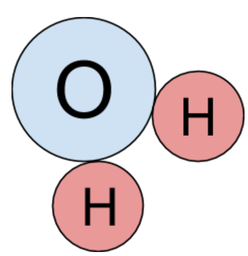
Lithium Atom

## Molecules

When two or more atoms combine, it makes a molecule. Molecules make up the millions of things that make up most of the world. One of the most common molecules we have on Earth is water. It is made of two atoms of hydrogen (H) and one atom of oxygen (O). (See the figure.)

Other common examples of molecules are carbon dioxide which is made of two carbon atoms and one oxygen atom ($CO_2$), salt which is made of one atom each of sodium and chlorine (NaCl) and sugar ($C_6H_{12}O_6$) which is made of six carbons, twelve hydrogens, and six oxygens.

Drawing of a model of a water molecule.

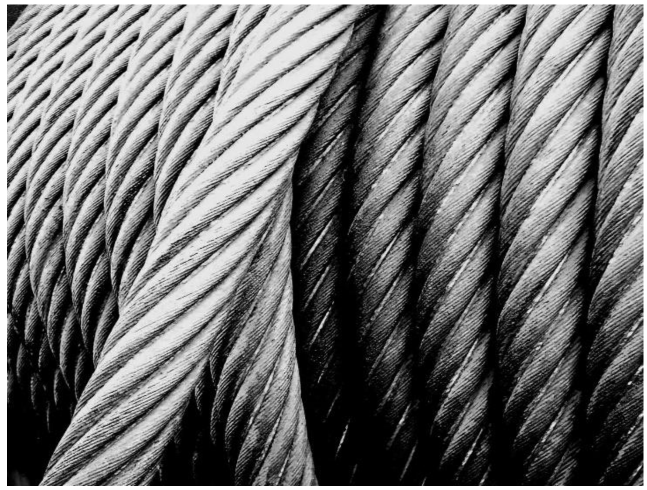


## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.2 Properties of Matter (8.1.2)

## Explore this Phenomenon



Pictured are two different substances, an apple and a steel cable.

- Describe everything you can about these two substances.
- What is the same about the two items?
- What is different about the two items?
- What can these things be used for?
- What questions do you have about why these substances?

## 8.1.2 Properties of Matter

**Obtain** information about various properties of matter, **evaluate** how different materials' properties allow them to be used for particular functions in society, and **communicate** your findings. Emphasize general properties of matter. Examples could include color, density, flammability, hardness, malleability, odor, ability to rust, solubility, state, or the ability to react with water.

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In this section focus on structure and function. Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

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### What is Matter?

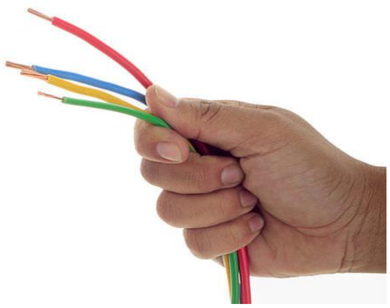
An apple, steel cable, the air you breathe the water you drink--all of it is considered matter. So is the ground beneath your feet. In fact, everything you can see and touch is made of matter. The only things that aren't matter are forms of energy, such as light and sound. Although forms of energy are not matter, the air and other substances they travel through are. So what is matter? Matter is defined as anything that has mass and volume. Mass is the amount of matter in a substance or object. The amount of space matter takes up is its volume.

### Properties of Matter

Look at the picture of the Statue of Liberty. Describe it in as many ways as possible. The things you described are called properties; they are the characteristics of matter. If you were to describe an object to someone who cannot see the object you would describe the object's properties. Below is a list of some properties you could use to describe matter.

- Hardness: Whether or not an object can be scratched by something else. For example, a diamond is the hardest mineral found on Earth and can scratch most everything else. Talc is the softest mineral; it can be scratched by a fingernail.
- State of matter: Whether it is a solid, liquid, or gas.
- Melting and boiling point: This is the temperature at which a substance goes from a solid to a liquid or a liquid to a gas. For example, antifreeze has a higher boiling point and lower freezing point than water, which is useful in a car's engine to keep it from freezing in cold weather or overheating in hot weather.
- Ability to conduct heat or electricity: Some materials conduct electricity and others do not. Aluminum and copper are good conductors, wood and plastic are not.

**Ability to Conduct Electricity**



**Ability to Conduct Heat**

The plastic and the aluminum in the kettle conduct heat differently just as the copper in the wires and the plastic on the outside conduct electricity differently.

- Ability to dissolve in other substances: Some substances dissolve and others do not. Sand does not dissolve in water, sugar does.
- Density: How closely packed the atoms of matter are. A solid rock is denser than water and will sink while wood is less dense than water and will float.
- Flammability: The ability of matter to burn. Wood is flammable; iron is not. When wood burns, it changes to ashes, carbon dioxide, water vapor, and other gases. After burning, it is no longer wood.

- Reactivity: The ability of matter to combine chemically with other substances. Iron is highly reactive with oxygen. When it combines with oxygen, a reddish powder called rust forms. Rust is not iron but an entirely different substance that consists of both iron and oxygen.
- Malleability: The ability of a solid to bend or be hammered into other shapes without breaking.

The iron in these steel chains has started to rust.

- Other properties include color, odor, shape, smell etc.

## Properties Determine Function

A substance’s properties determine the way it is used. This is considered a function. For example, gold is an element with the property of malleability. Malleability means a substance is very flexible; it can be shaped into many different forms. Gold is used as a major source for jewelry because it can be formed into many different shapes.

## Putting It Together

- How has your understanding of these two objects changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on and why there are different uses for these substances based on what you have learned in this section.

# 2.3 Chemical Reactions (8.1.3)

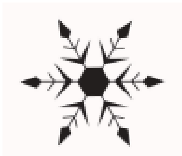
## Explore this Phenomenon

The photo shows a piece of iron that has been outside in the weather.

- What do you observe about the iron's appearance?
- How has the piece of iron changed over time?
- How do you explain what happened?

## 8.1.3 Signs of Chemical Reactions

**Plan and conduct an investigation** and then **analyze and interpret the data** to identify patterns in changes in a substance's properties to determine whether a chemical reaction has occurred. Examples could include changes in properties such as color, density, flammability, odor, solubility, or state.



In this section, focus on patterns. The patterns observed in chemical changes are related to what happens to structures at the atomic level.

### Chemical Reactions

Did you ever make a "volcano," like the one in the figure, 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 reaction. A chemical reaction occurs when matter changes chemically into an entirely different substance with different 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 reactions are as dramatic as this "volcano." Some are slower and less obvious.

The photos and the video show other examples of chemical reactions.

- http://www.youtube.com/watch?v=BqeWpywDuiY (2:54)


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

## Signs of Chemical Reaction

How can you tell whether a chemical reaction has occurred? Often, there are clues. Several are demonstrated in the video below.

- http://www.youtube.com/watch?v=gs0j1EZJ1Uc (9:57)

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

- Gas bubbles are released. (Example: Baking soda and vinegar mixed produce bubbles.)
- Something changes color for a reason other than simply that two colors were mixed. (Example: Leaves turn from green to other colors or eggs turning from clear to )
- 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.)
- A change in energy. (Example: A firework produces heat, light, and sound)

Changes in a substance's properties indicate that a chemical reaction has occurred. When there are changes in properties such as color, density, flammability, odor, solubility, or state it is likely that a chemical reaction has occurred.

## Reversing Chemical Reactions

Because chemical changes produce new substances, they often cannot be undone. For example, you can't change a fried egg back to a raw egg. Some chemical changes can be reversed, but only by another chemical reaction. For example, to undo the tarnish on copper pennies, you can place them in vinegar. The acid in the vinegar reacts with the tarnish. This is a chemical reaction that makes the pennies bright and shiny again. You can try this yourself at home to see how well it works.

## Cooking and Chemistry

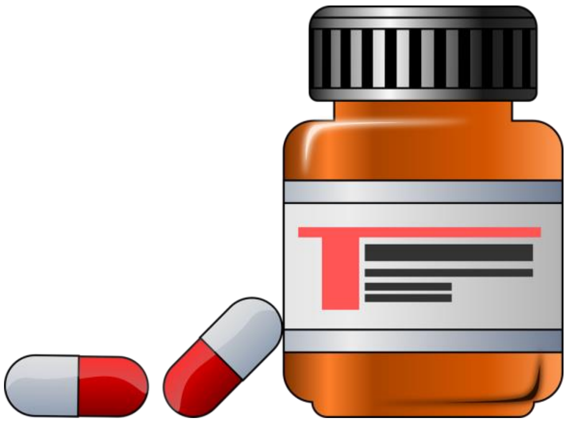
Cooking is a valuable skill that everyone should have. Whether it is fixing a simple grilled cheese sandwich or preparing an elaborate meal, cooking demonstrates some basic ideas in chemistry. When you make bread, you mix flour, sugar, yeast, and water together. After baking, this mixture changes into what we consider bread, a new substance that has different properties than the original materials. The process of baking causes chemical changes in the ingredients that result in a new product: bread.

## Putting It Together

- How has your understanding of what is happening changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.4 Natural vs Synthetic Materials (8.1.4)

## Explore this Phenomenon



- How do you think the flower and the medicine are related?
- How are the flower and the medicine different?
- What questions do you have about the connection between these two?

## 8.1.4 Natural vs. Synthetic Materials

**Obtain and evaluate information** to describe how synthetic materials come from natural resources, what their functions are, and how society uses these new materials. Examples of synthetic materials could include medicine, foods, building materials, plastics, and alternative fuels.

In this section, focus on structure and function. The properties of the synthetic materials, such as how they can be shaped, determine their structure and their structure can be utilized to serve particular functions.

### Natural vs. Synthetic

Many advertisements claim their products are "all natural". Most people understand this to mean that it comes from nature or is made from something that occurs in nature. On the other hand, when people hear that something is "synthetic", you think of things that are made in the lab which is true, synthetic things have been made by mankind.

The diamond on the left above came from a mine. It is natural. The diamond on the right was created in a lab. It is synthetic. The diamond produced in the lab costs about 30% less than the mined diamond. What's the difference between them? These two diamonds have exactly the same composition and exactly the same properties. If you were to look at them under a microscope, they look exactly the same. Many of the materials that occur naturally can be made synthetically by scientists in the lab. If a synthetic material has the same chemical structure as a naturally occurring material, they have the same properties.

Insulin is a compound made by the body that allows our bodies to use the sugar in the food we eat. Some people's bodies don't have the ability to make this important compound. These people have a condition known as diabetes. Scientists used to get insulin from pigs however it took huge amounts of pig to make the needed insulin. Scientists have now developed a way to make insulin in the lab. Chemically, natural insulin and synthetic insulin have the exact same structure and properties. People with diabetes can inject synthetic insulin into their bodies and then their bodies can use sugar just like people who produce insulin naturally. The only difference between natural and synthetic insulin is the process used to make them. Since both forms of insulin are identical in structure and function, one can substitute for the other.

### Examples of Synthetic Materials that come from Natural Resources

Revisit the flower and medicine phenomenon. The Foxglove flower, though poisonous if eaten fresh, contains chemicals that are beneficial to society. Digitalis is a medicine, made from the Foxglove flower that is used to treat congestive heart failure. It increases the force of heart contractions which improves the movement of blood through the heart and gives the heart more rest time between beats. It also corrects abnormal rhythms and helps the body shed excess fluid. Digitalis is a great example of a synthetic material that has been made from a natural resource.

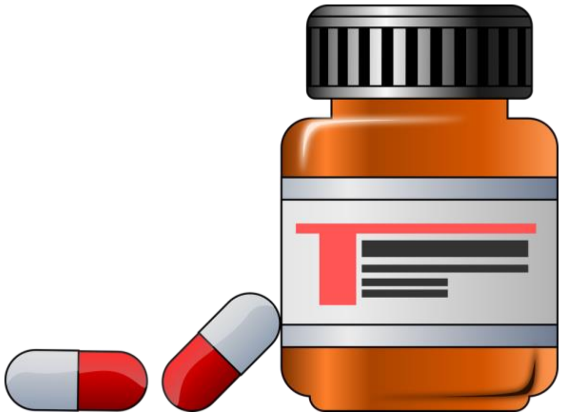
Many other things we use every day are synthetic and are made from natural resources. Let's look at something we use a lot of everyday: plastic. Plastic is, in many ways, an almost ideal substance because it is used for many different things and it is cheap to make. Plastic is mainly made from petroleum (oil) and hydrocarbons in a repeating pattern of molecules stuck together, known as a polymer. Watch the video (link below "From DNA to Silly Putty) to gain a better understanding. Plastics have a downfall though, in that they take a long time to decompose and often become a hazard to other organisms. Watch the Edward Norton clip and think more about the problems associated with plastic.

- From DNA to Silly Putty, the diverse world of polymers - Jan Mattingly http://ed.ted.com/lessons/from-dna-to-silly-putty-the-diverse-world-of-polymers-jan-mattingly

- Edward Norton pleads with you to make the extra effort to conserve our natural resources: http://video.nationalgeographic.com/video/environment/going-green-environment/conservation-in-action/norton-bag-env/

Clothing is yet another great example of a synthetic material we use every day that comes from something natural. The fibers that compose the materials for our clothes are either natural or human-made. Silk and cotton are examples of natural fibers. Silk is produced by silkworms and oven into cloth and cotton is grown as a plant. Human-made fabrics include nylon, orlon, and polyester. These materials are made from hydrocarbons found in petroleum products. Synthetic fabrics are also used in shoes, raingear, and camping items. The synthetic fabrics tend to be lighter than the natural ones and can be treated to make them more water-resistant and durable. Materials originally developed as textiles are finding a wide variety of other uses. Nylon is found in a number of plastic utensils. Because it is strong and lightweight, nylon is a component of ropes, fishing nets, tents, and parachutes.

## Putting It Together



- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.5 States of Matter (8.1.5)

## Explore this Phenomenon

A. Iceberg

B. Waves

C. Steam

- What do you already know about the pictures above?
- What questions do you have?
- What makes the pictures different from each other?

## 8.1.5 The States of Matter

**Develop a model** that uses **computational thinking** to illustrate cause and effect relationships in particle motion, temperature, density, and state of a pure substance when heat energy is added or removed. Emphasize molecular-level models of solids, liquids, and gases to show how adding or removing heat energy can result in phase changes, and focus on calculating the density of a substance's state.

---

In this section, focus on cause and effect. Observe the effect that adding or removing heat causes on the particle motion, density, and state of pure substances.

---

### Matter and Its States

Matter typically exists in one of three states: solid, liquid, or gas. The state of a substance is one of its properties. Some substances exist as gases at room temperature (oxygen and carbon dioxide), while others, like water and mercury metal, exist as liquids. Most metals exist as solids at room temperature. Most elements can exist in any of these three states.

Note: Technically speaking a fourth state of matter called plasma exists, but it does not occur often on earth, so we will omit it from our study here.

Let's do a quick review of state of matter. Solids have a definite shape (rigid), have a definite volume, and the particles are not free to move very much other than just vibrate. Liquids have no definite shape (take the shape of the container), have a definite volume, and the particles are free to move over each other but are still attracted to each other. Gases have no definite shape (take the shape of the container), have no definite volume, and the particles move in random motion with little or no attraction to each other.


The figure represents what the molecules look like in each state of matter.

## The Role of Energy in Changes of State

Suppose that you leave some squares of chocolate candy in the hot sun. A couple of hours later, you notice that the chocolate has turned into a puddle like the one pictured in the photo.

In order for solid chocolate to melt and change to a liquid, the particles of chocolate must gain energy. The chocolate pictured in the photo gained energy from sunlight. When matter changes from one state to another, it either absorbs energy—as when chocolate melts—or releases energy--as when water freezes. For example, if you were to place the melted chocolate in a refrigerator, it would lose energy to the cold air inside the refrigerator. As a result, the liquid chocolate would change to a solid again. When matter changes from one state to another, it is referred to as a phase change. When liquid water turns to ice, it has a phase change from liquid to solid.

## The Effects of Adding Energy

Adding energy is a “cause” that has multiple “effects”. As discussed above, adding heat energy often causes phase changes. Phase changes happen when heat energy is added because heat energy causes particle motion to increase. As particles move faster the space between them increases, which often causes a phase change. The more space that forms between particles will lower the substance’s density.

## How do logs stay afloat in water?

After trees are cut, logging companies often move these materials down a river to a saw mill where they can be shaped into building materials or other products. The logs float on the water because they are less dense than the water they are in. Knowledge of density is important in the categorization and separation of materials. Information about density allows us to make predictions about the behavior of matter.

### Defining Density

Density is an important property of matter. It reflects how closely packed the particles of matter are. When particles are packed together more tightly, matter has greater density. Differences in density of matter explain many phenomena. For example, differences in density of cool and warm ocean water explain why currents such as the Gulf Stream flow through the oceans.

To better understand density, think about a bowling ball and volleyball. Imagine lifting each ball. The two balls are about the same size, but the bowling ball feels much heavier than the volleyball. That's because the bowling ball is made of solid plastic, which contains a lot of tightly packed particles of matter. The volleyball, in contrast, is full of air, which contains fewer, more widely spaced particles of matter. In other words, the matter inside the bowling ball is denser than the matter inside the volleyball.


A bowling ball is denser than a volleyball. Although both balls are similar in size, the bowling ball feels much heavier than the volleyball.

### Calculating Density

As stated, the density of matter is the amount of matter in a given space. The amount of matter is measured by its mass, and the space matter takes up is measured by its volume. Therefore, the density of matter can be calculated with this formula:

$$\text{Density}=\text{mass} / \text{volume}$$

For example, for a book with a mass of 500 g and a volume of 1000 cm3, the density would be calculated as follows:

$$\text{Density}=500\text{ g} / 1000\text{ cm3}= 0.5\text{ g/cm3}$$

Q: What is the density of a liquid that has a volume of 30 mL and a mass of 300 g?

A: The density of the liquid is:

$$\text{Density} = 300\ \text{g}/30\ \text{mL} = 10\ \text{g/mL}$$

For information on how to calculate the density of a gas, go to the following link.

- Density of a Gas Video: https://youtu.be/78K47pDG4qc

## Putting It Together

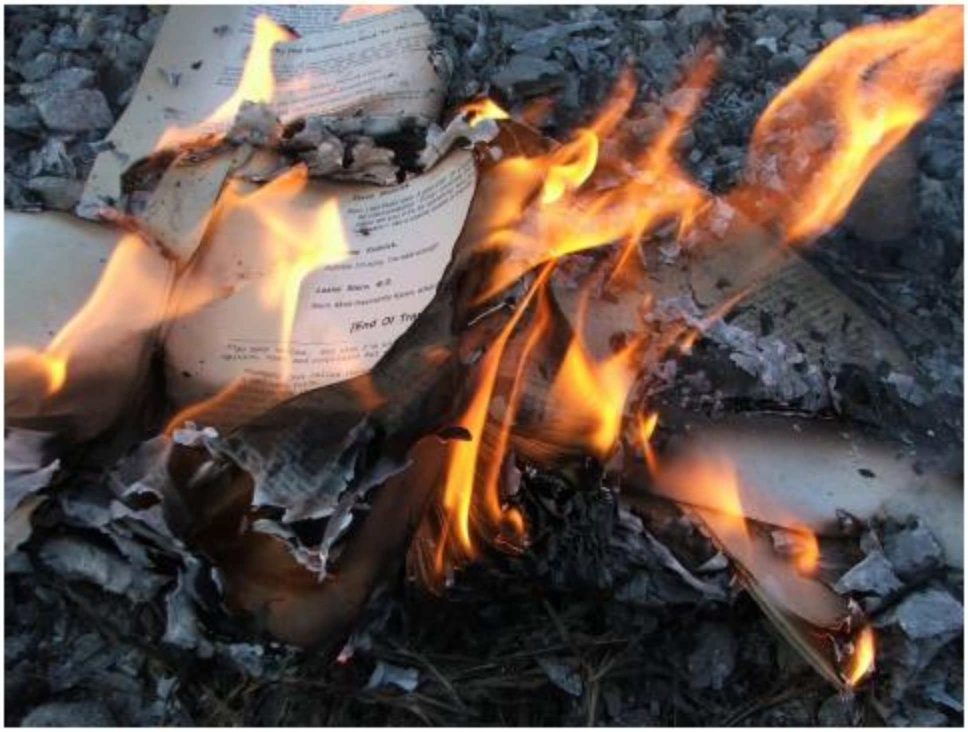
  

A. Iceberg B. Waves C. Steam

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.6 Conservation of Matter (8.1.6)

## Explore this Phenomenon



• What do you already know about what is happening in photo?

• What questions do you have?

• How do you explain what is happening to the atoms in the paper?

## 8.1.6 Conservation of Mass

**Develop a model** to describe how the total number of atoms does not change in a chemical reaction, indicating that matter is conserved. Emphasize demonstrations of an understanding of the law of conservation of matter. Balancing equations and stoichiometry will be learned at the high school level.

---

In this section, focus on matter. Observe how matter is conserved; the total number of atoms does not change in a chemical reaction.

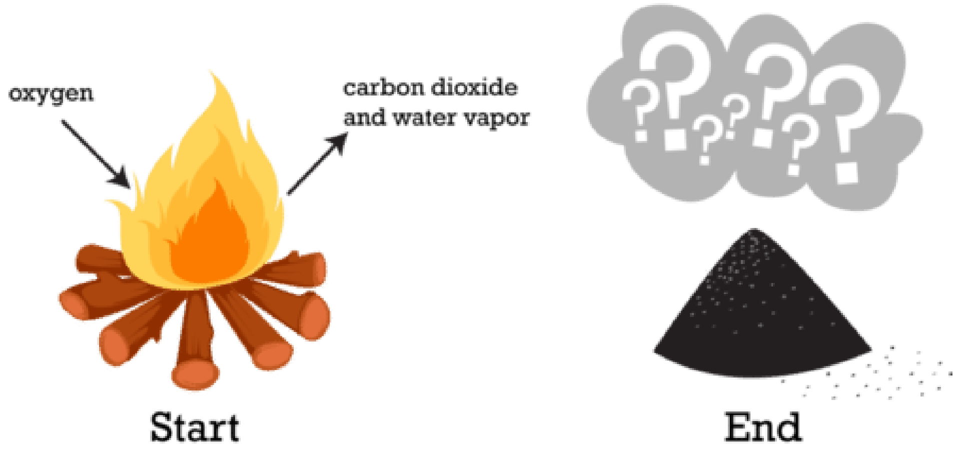
---

### Have you ever lost a screw?

The following situation happens all too often. You take apart a piece of equipment. When you put the equipment back together, somehow you have an extra screw or two. Or you find that a screw is missing that was a there when you started. In either case, you know something went wrong. You should end up with the same amount of material that you started with, not with more or less than what you had originally.

### Conservation of Mass

If you build a campfire 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 is left is a small pile of ashes. What happened to the matter 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.



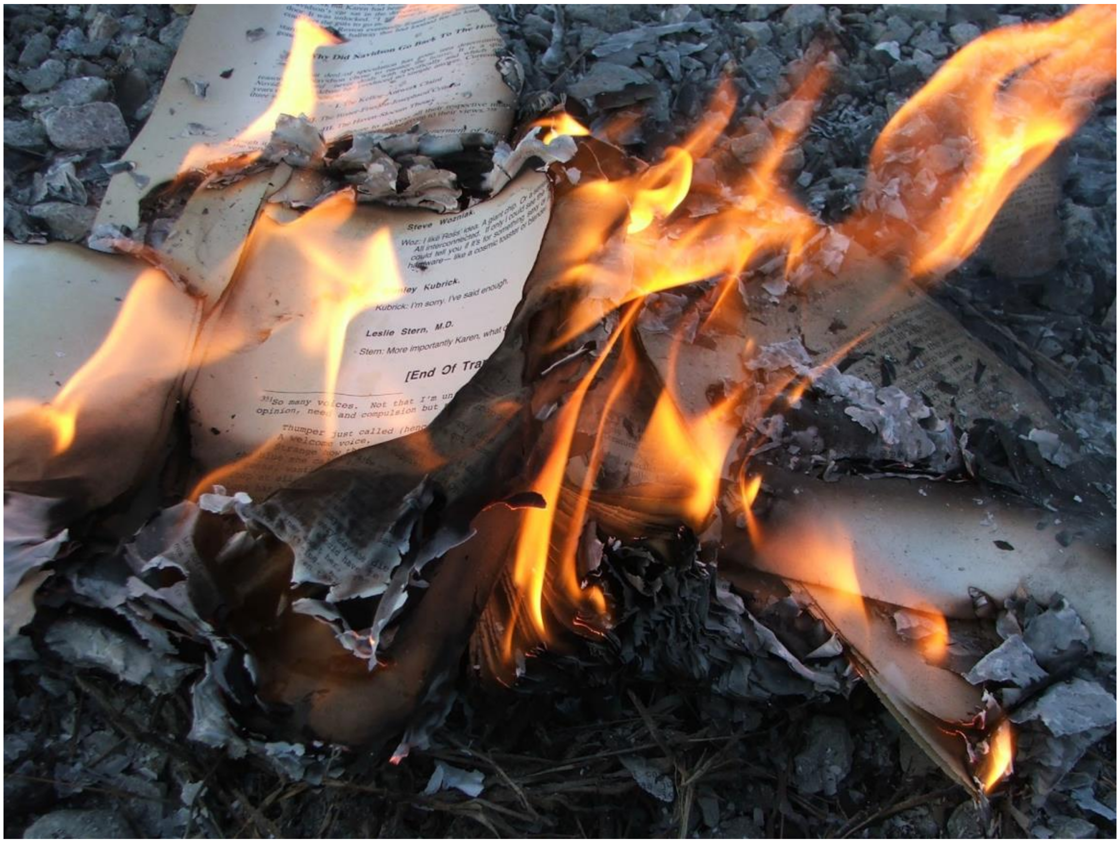

Burning is a chemical process. Is mass destroyed when wood burns?

Assume you measured the mass of the wood before you burned it. Assume you 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 would have the same mass as the wood and oxygen 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 a reaction, the total amount of matter always remains the same. The total mass of the products must be equal to the total mass of the reactants. In other words, mass cannot be created or destroyed during a chemical reaction, but is always conserved.

- 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://www.youtube.com/watch?v=3TsTOnNmkf8.

## Putting It Together




- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.7 Devices Affecting Phase Change (8.1.7)

## Explore this Phenomenon

Pretend that you want to build a cabin in Utah's Uinta mountains. The cabin will get very hot in the summer and very, very cold in the summer. Propose some ideas that will prevent the water in the pipes in your cabin from boiling and freezing.

- What do you already know that would help in this situation?
- What do you already know about phase changes in water?
- What questions do you have?
- How would go about meeting the challenge?

## 8.1.7: Designing a Device to Effect Phase Change

**Design, construct, and test** a device that can affect the rate of a phase change. *Compare and identify the best characteristics of competing devices and modify them based on* ***data analysis*** *to improve the device to better meet the criteria for success.*

---

In this section, focus on energy and matter. Track the transfer of energy as it flows through matter and affects the rate of a phase change.

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### Changing the rate of a phase change

Phase change occurs when matter changes state. For example when water changes from a liquid to a solid, we say its phase has changed. Phase change is a result of a change in energy. One way to affect the rate of a phase change is to change the amount of energy involved. Increasing the amount of energy will increase the rate of phase change and reducing the amount of energy decreases the rate of phase change. Adding heat is a way to increase the energy involved. Using insulation is a way to reduce heat exchange.

Chemicals can also be used to influence the rate of phase change. For example, antifreeze is an additive that lowers the freezing point of a water-based liquid and raises its boiling point.

### What Is the Engineering Design Process?

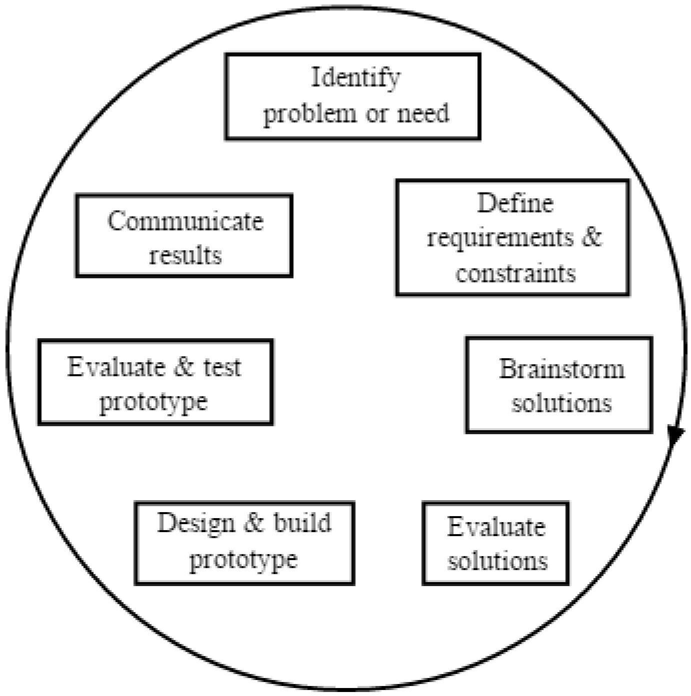
The process used to create and perfect devises is called the engineering design process. This is the way most new technologies are developed. Engineering design is similar to scientific investigation. Both processes rely on evidence and reason and follow a logical sequence of steps to solve problems or answer questions.

The process of designing a new technology includes much more than just coming up with a good idea. Possible limitations, or constraints, on the design must be taken into account. These might include factors such as the cost or safety of the new product or process. Making and testing a model of the design are also important. These steps ensure that the design actually works to solve the problem. This process also gives the designer a chance to find problems and modify the design if necessary. No solution is perfect, but testing and refining a design assures that the device will provide a workable solution to the problem it is intended to solve.

### Steps of the Engineering Design Process

The design process can be broken down into the series of steps shown in the flowchart.

Typically, some of the steps have to be repeated, and the steps may not always be done in the sequence shown.




Consider the problem of developing a solar-powered car. Many questions would have to be researched in the design process. For example, what is the best shape for gathering the sun's rays? How will sunlight be converted to useable energy to run the car? Will a backup energy source be needed? What are the constraints on the project? Is there a budget limit? Does it have a maximum size or weight?

After researching the answers, possible designs are developed. This generally takes imagination as well as sound reasoning. Then a model must be designed and tested. This allows any problems with the design to be worked out before a final design is selected and produced.

**Q:** Assume you want to design a product that lets a person in a wheelchair carry around small personal items so they are easy to access. What questions might you research first?

**A:** You might research questions such as: What personal items are people likely to need to carry with them? What types of carriers or holders are there that might be modified for use by people in a wheelchair? Where might a carrier be attached to a wheelchair or person in a wheelchair without interfering with the operation of the chair or hindering the person? What is the maximum weight it can reasonably be? What materials will be most aesthetically pleasing?

**Q:** Suppose you have come up with a possible solution to the problem described in the previous question. How might you make a model of your idea? How could you test your model?

**A:** First, you might make a sketch of your idea. Then you could make an inexpensive model using simple materials such as cardboard, newspaper, tape, or string. You could test your model by trying to carry several personal items in it while maneuvering around a room in a wheelchair. You would also want to make sure that you could do things like open doors, turn on light switches, and get in and out of the chair without the carrier getting in the way.

After testing your model, you would probably need to modify it and retest it until you reach a design that satisfies the need and fits within the constraints. You could then communicate your results and move on to the next project.

## Putting It Together

- How has your understanding changed on how you could redesign this cabin?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 2.8 References

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3. Michel Craig. Frozen

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5. Diagram of an atom.

6. https://upload.wikimedia.org/wikipedia/commons/1/15/Red_Apple.jpg

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8. Linus Henning. State of Liberty

9. Copper wires can conduct electricity well.

10. Plastic and aluminum in a kettle conduct heat differently.

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18. Timothy Neesam. Newfoundland iceberg, 2007

19. AJC1. Wave

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22. https://upload.wikimedia.org/wikipedia/commons/d/d4/The_House_of_Leaves_-_Burning_4.jpg . 23. https://pixabay.com/p-1208195/?no_redirect .

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# CHAPTER 3

## Strand 2: Storing and Transferring Energy

### Chapter Outline




Objects can store and transfer energy within systems. Energy can be transferred between objects, which involves changes in the object's energy. There is a direct relationship between an object's energy, mass, and velocity. Energy can travel in waves and may be harnessed to transmit information.

# 3.1 Energy Speed and Mass (8.2.1)

## Explore this Phenomenon

- If two trucks were coming at you and you weren't able to move out of the way of both in time which would you rather be hit by, the giant dump truck or the small pickup truck?
- What would be your reasons for making that choice?
- What if the giant truck was going 5 mph and the pickup was traveling 100 mph?
- Why would that make a difference?

## 8.2.1 Energy: Speed and Mass

**Use computational thinking** to **analyze data** about the relationship between the mass and speed of objects and the relative amount of kinetic energy of the objects. Emphasis should be on the quantity of mass and relative speed to the observable effects of the kinetic energy. Examples could include a full cart vs. an empty cart or rolling spheres with different masses down a ramp to measure the effects on stationary masses. Calculations of kinetic and potential energy will be learned at the high school level.

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In this section, focus on scale, proportion, and quantity and cause and effect. Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) coupled with quantity measurements (mass) provide information about the magnitude of an object's kinetic energy. Cause and effect relationships may be used to predict relative amounts of kinetic energy.

---

### Kinetic Energy


What do these four photos have in common?

Energy exists in many different forms, but the one we probably use the most is kinetic energy. Kinetic energy is often thought of as the energy of motion because it is used to describe matter that is moving. The spinning saw blade, flying bee, racing motorcycle, and the flowing water in the photos are moving; therefore, the common factor in all the pictures is kinetic energy.

### Factors Affecting Kinetic Energy

An object's kinetic energy depends on its mass and velocity. The greater the mass, more kinetic energy the object has. Velocity, which is how fast an object is moving (meters/second), also influences kinetic energy. The greater the velocity, the greater the kinetic energy. Think back to the questions you were asked at the beginning of this section about the truck pictures. Which moving truck would have more kinetic energy, the large dump truck or the smaller truck? How would speed affect the truck's kinetic energy?

## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 3.2 Potential Energy (8.2.2)

## Explore this Phenomenon

- What do you observe about the climbers in the photo?
- How would you describe the difference of the energy between the two climbers?

## 8.2.2 Potential energy

**Ask questions** about how the amount of potential energy varies as distance within the system changes. **Plan and conduct an investigation** to answer a question about potential energy. Emphasize comparing relative amounts of energy. Examples could include a cart at varying positions on a hill or an object being dropped from different heights. Calculations of kinetic and potential energy will be learned at the high school level.

---

In this section, focus on energy and matter. The transfer of energy can be tracked as energy flows through a system.

---

### Potential Energy

Potential energy is energy that is stored in an object. The climbers have energy because of their position on the cliff. They used kinetic energy to get to that position. Now the energy is stored in the form of potential energy because of how high up the cliff they are. They have the potential to go down. If they were to fall, their potential energy would be converted to kinetic energy again.

Objects have potential energy because of their position or shape. Like a diver on a diving board or the gymnast on the balance beam, anything that is above Earth's surface has the potential to fall because of gravity therefore it has potential energy. The amount of gravitational potential energy an object has depends on the object's mass and its height above the ground.

How could the child on the sled increase their potential energy?

If the gymnast increased their mass how would that affect their potential energy?

### How does the amount of potential energy vary as distance changes?

Think about climbers on a cliff. If one climber climbed higher than the other, how would the added distance influence the amount of potential energy involved? The higher climber invested more energy climbing to a greater height, therefore there is more potential energy stored in the higher position. If you stretch out a rubber band on a slingshot to a farther distance it will have more potential energy because of the bigger change in shape.

Can you think of other examples of how varying distances change the amount of potential energy involved? What could you do to investigate changes in potential energy?

An object's shape can also give it potential energy. The girl in the photo is giving the elastic band of her slingshot potential energy by stretching it. This is known as elastic potential energy. Stretched rubber bands, inflated balloons, and springs that are uncoiled are examples of objects that have elastic potential energy due to their shape.

What about carts on a roller coaster?

Where on the roller coaster would the cart have the most potential energy?

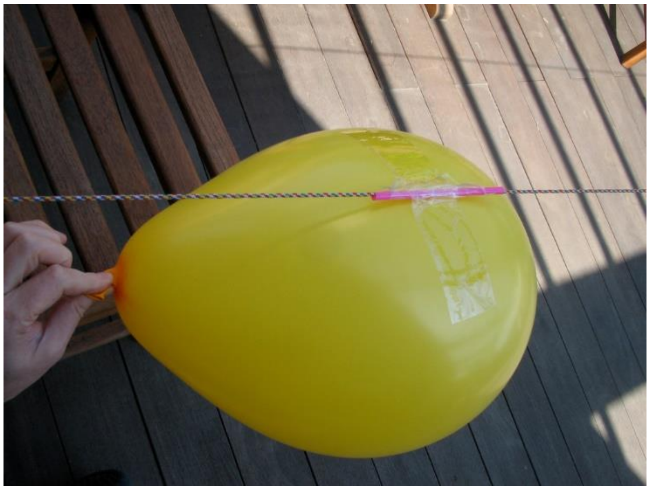
Where would it have the least?

## Putting It Together

- How has your understanding of potential energy in this picture changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 3.3 Energy Transfer (8.2.3)

## Explore this Phenomenon



- What do you observe about the two balloons?

The illustrations show balloon rockets. An inflated balloon is connected to a straw and a string is threaded through the straw. When the air from the balloon is released, the balloon moves rapidly along the string until the balloon is no longer filled with air.

- Assuming the pictures represent a before and after image of the same balloon what evidence do you have that the balloon's energy changed?
- In terms of energy, how do you explain what happened?

## 8.2.3 Energy Transfer

**Engage in argument** to identify the strongest evidence that supports the claim that the kinetic energy of an object changes as energy is transferred to or from the object. Examples could include observing temperature changes as a result of friction, applying force to an object, or releasing potential energy from an object.

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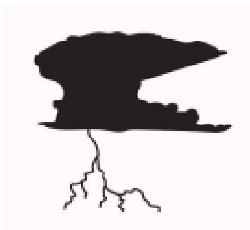


In this section, focus on energy and matter. Energy can be transferred to or from objects and when it is transferred it often changes forms such as kinetic energy to heat energy or potential energy to kinetic energy.

---

### Kinetic-Potential Energy Changes

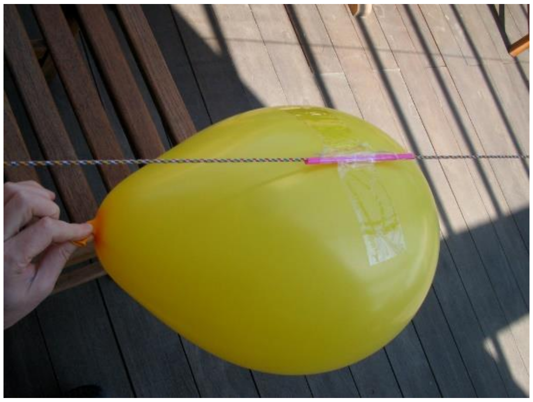
Energy is neither created nor destroyed only transferred from one form into another. One of the most common energy changes occurs between kinetic and potential energy. Kinetic energy is the energy of moving objects. Potential energy is energy that is stored in objects, typically because of their position or shape. Kinetic energy can be used to change the position such as climbing to the top of a slide or shape of an object such as pulling back on a rubber-band, giving it potential energy. Potential energy gives the object the potential to move. If it does move, the potential energy changes back to kinetic energy.

The girl in the photo just finished coming down the water slide. When she was at the top of the slide, she had potential energy. Why? She had the potential to slide into the water because of the pull of gravity. As she moved down the slide, her potential energy changed to kinetic energy. By the time she reached the water, the potential energy had changed to kinetic energy.

How could the girl regain her potential energy? She could climb up the steps to the top of the slide. It takes kinetic energy to climb the steps and this energy would be stored in her position on the stairs as she climbed. By the time she got to the top of the slide, she would have the same amount of potential energy as before.

Friction, which is the resistance of an object to movement, also causes changes in kinetic energy. Rub your hands rapidly together. What do you feel? Friction causes the kinetic energy of the rubbing hands to be converted to heat energy which is why your hands feel warm. On a normal friction would slow the girl down on the slide. Since water reduces friction however on this slide she can get going much faster. As a rule of thumb when there is motion there is some amount of friction occurring as well which causes some of the energy to end up as heat.

## Putting It Together

- How has your understanding of changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 3.4 Waves (8.2.4)

## Explore this Phenomenon

Have you ever thrown a rock in the water in a pond or a lake? When you did a phenomenon like the one in the picture above probably occurred.

- What questions do you have about waves?
- What do you already know?
- How do you explain what is happening?
- What questions do you have about waves?
- What do you already know?
- How do you explain what is happening?

## 8.2.4 Waves

**Use computational thinking** to describe a simple model for waves that shows the pattern of wave amplitude being related to wave energy. Emphasize describing waves with both quantitative and qualitative thinking. Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.

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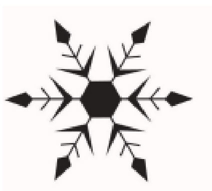


In this section, focus on systems and system models and patterns. Models can be used to understand how energy and matter interact in a wave system. Graphs and charts can be used to identify patterns in data.

---

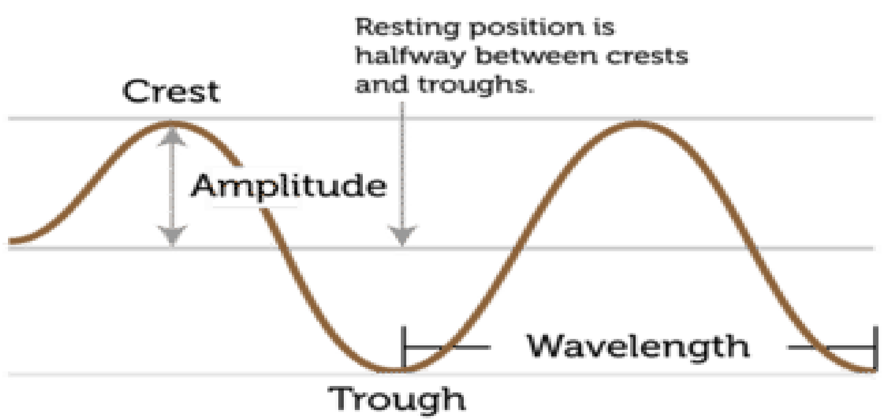
### Waves

Waves are regular patterns of motion. They transfer energy as they move through various materials like wood, water and even air. The material they transfer energy through is called the medium. Waves do not carry or transfer matter but they do transfer energy from one place to another. When a rock hits the water, the kinetic energy from the rock is carried through the water. The ripples provide evidence that energy is being transferred from one place in the water to another, but the actual water molecules do not move this distance.

How does the flag blowing in the breeze resemble a wave?

### Wave Model

Wave amplitude is the maximum distance the particles of the medium move from their resting positions when a wave passes through. The resting position of a particle is where the particle would be if the wave had not traveled through the material. The crest is the highest point of a wave and the trough is the lowest point. Wavelength is the distance from one point on a wave to the same point on the next wave. In the picture it shows a wavelength from the trough to the trough of the next wave. A wavelength however could also be measured from the crest to crest.

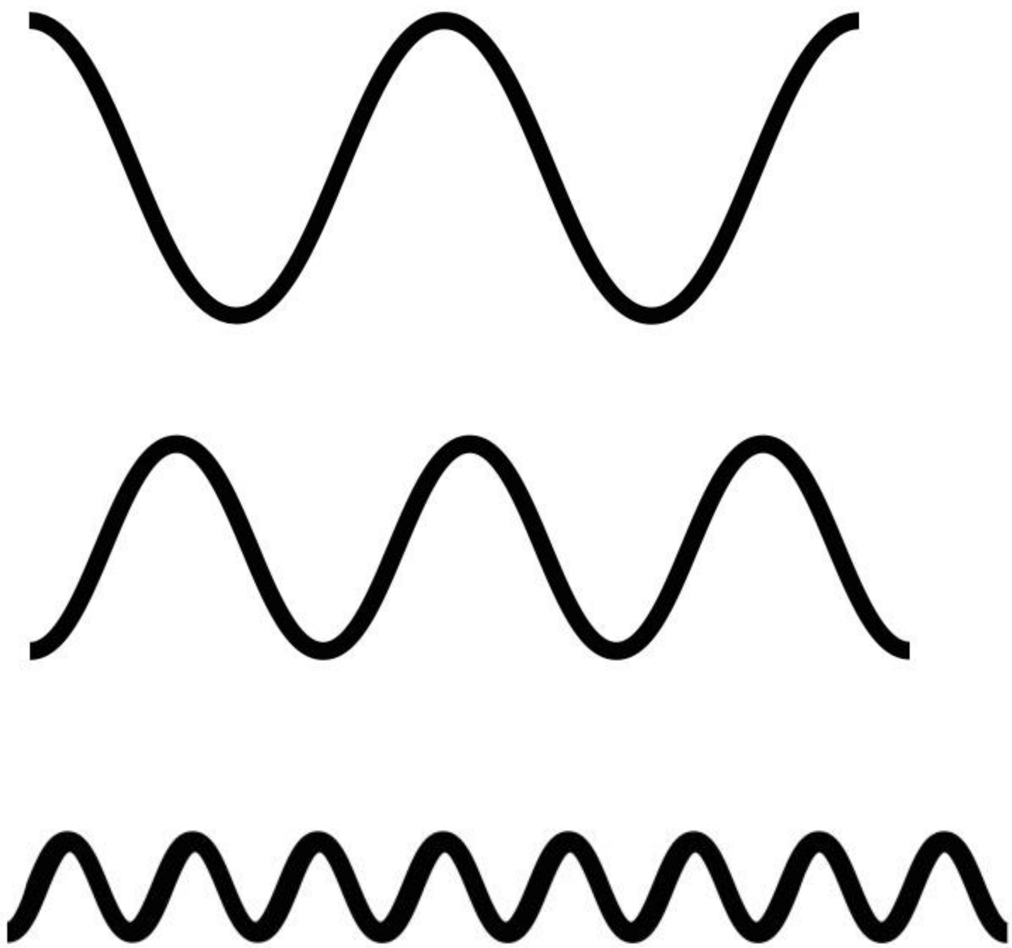



### Energy and Amplitude

The greater the amplitude the “stronger” the wave. The opposite is also true. The exact meaning of "strength" depends on the type of wave. For example, a sound wave with a large amplitude is a loud sound and a light wave with a large amplitude is very bright.

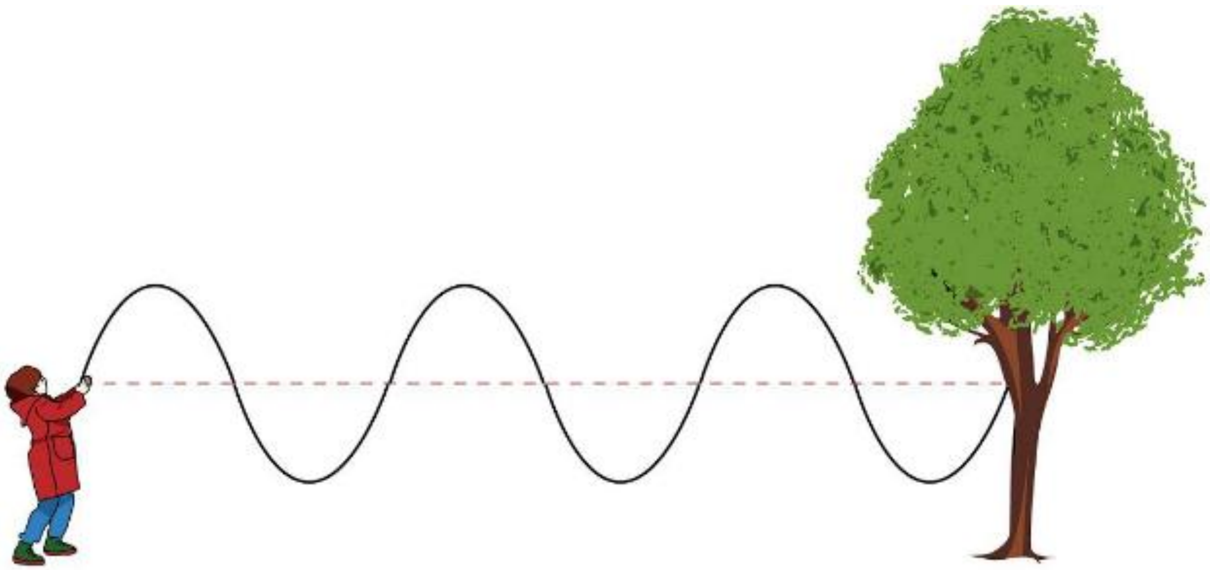
Think back to the original question about the ripples in the picture. The ripples were relatively low-amplitude waves with comparatively little energy because they were caused by a smaller rock. How would the amplitude of the ripples be different if a bigger rock were thrown into the pond? The waves would be a relatively high-amplitude waves and would have a greater amount of energy than the waves caused by the smaller pebble.

Below are three different sketches of waves. What do you notice that is similar and different about each of the waves in the sketches?



- Describe the similarities and differences between the waves using the words amplitude and energy.
- Which wave has more energy?
- Which wave has less?
- How do you know?

A student wanted to use a rope as a model to show that waves can have different amplitudes and wavelengths. The student tied a rope to a tree and then moved the rope up and down at two different speeds.



The faster you move the rope up and down, the more energy that is being transferred to the rope therefore amplitude is higher.

## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 3.5 Waves and Mediums (8.2.5)

## Explore this Phenomenon

On a rainy day you have probably looked outside and seen a rainbow. The picture shows this phenomenon.

- What do you already know about light waves and prisms?
- How do you explain what is happening to the light waves?
- What questions do you have about this phenomenon?

## 8.2.5 Waves and Mediums

**Develop and use a model** to describe the structure of waves and how they are reflected, absorbed, or transmitted through various materials. Emphasize both light and mechanical waves. Examples could include drawings, simulations, and written descriptions of light waves through a prism; mechanical waves through gas vs. liquids vs. solids; or sound waves through different mediums.

In this section, focus on structure and function. Wave structures are altered as they are reflected, absorbed, or transmitted through various materials and as their structure changes their function can also change.

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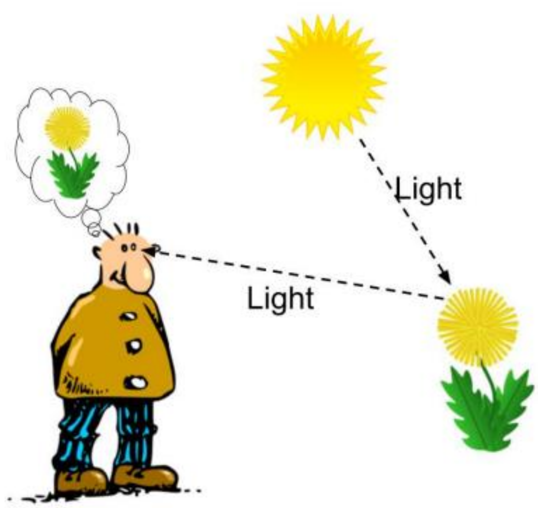
### Waves

Waves come in many shapes and sizes. Light waves transmit energy in the form of light and do not require a medium. Mechanical waves transfer energy through matter by moving particles. Sound waves and water waves are examples of mechanical waves. Waves, both light and mechanical, can be transmitted through various mediums. They can also be reflected and absorbed.

### Waves and Sight

Light waves are a type of wave that help us see. Like water waves, light waves also transfer energy. To understand how light waves help us see, look at the illustration.

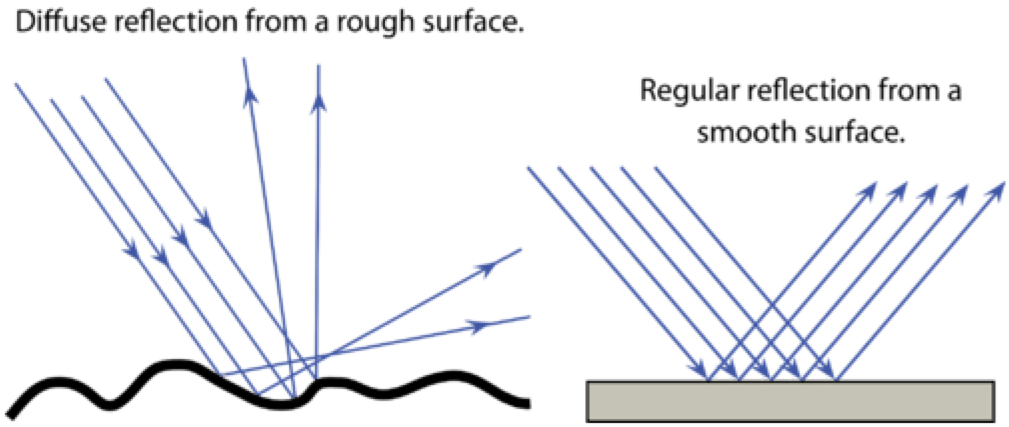



We see an image when waves of light bounce off of the object and enter our eye. In this way, light waves transfer light energy.

Have you ever turned out all the lights in a room and then tried to walk around? You probably noticed it was a little difficult to see things. That is because there are no light waves present to bounce off the objects around you. Which shows your eyes are useless without light.

## Reflection of Waves

When a light ray strikes a reflecting surface the light ray is bounced back in a different direction (reflected). Sound waves can also be reflected. Echoes are an example of reflecting sound waves.

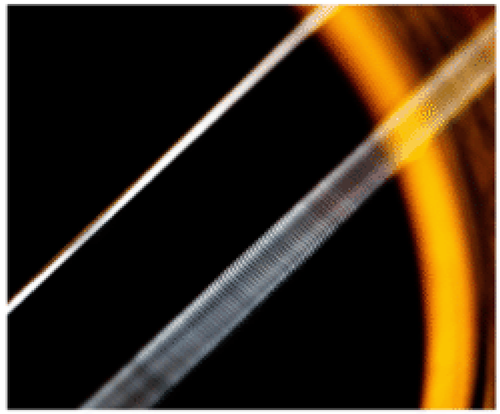


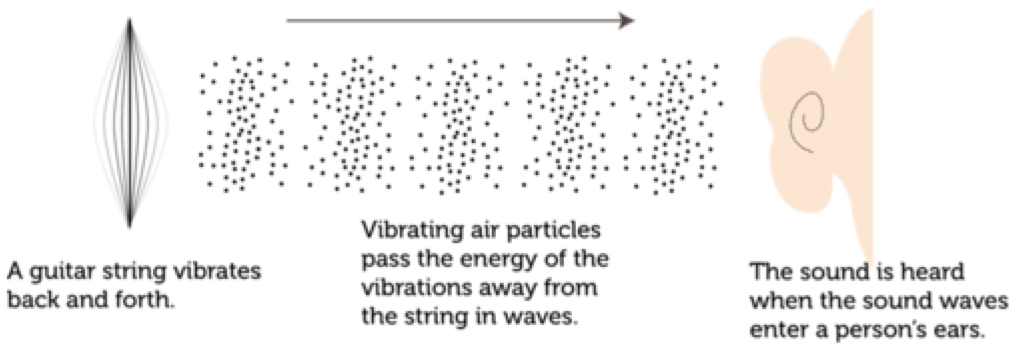

Diffuse reflection makes something look dull where regular reflection makes something look shiny because of the way the light waves are reflected.

## Sound

Sound is defined as the transfer of energy from a vibrating object in waves that travel through matter. Most people commonly use the term “sound” to mean what they hear when sound waves enter their ears.

Sound waves are mechanical waves. Sound waves begin with vibrating matter. Consider a guitar string. Plucking the string makes it vibrate. The diagram shows the wave generated by the vibrating string. The moving string repeatedly pushes against the air particles next to it, which causes the air particles to vibrate. The vibrations spread through the air in all directions away from the guitar string as waves.



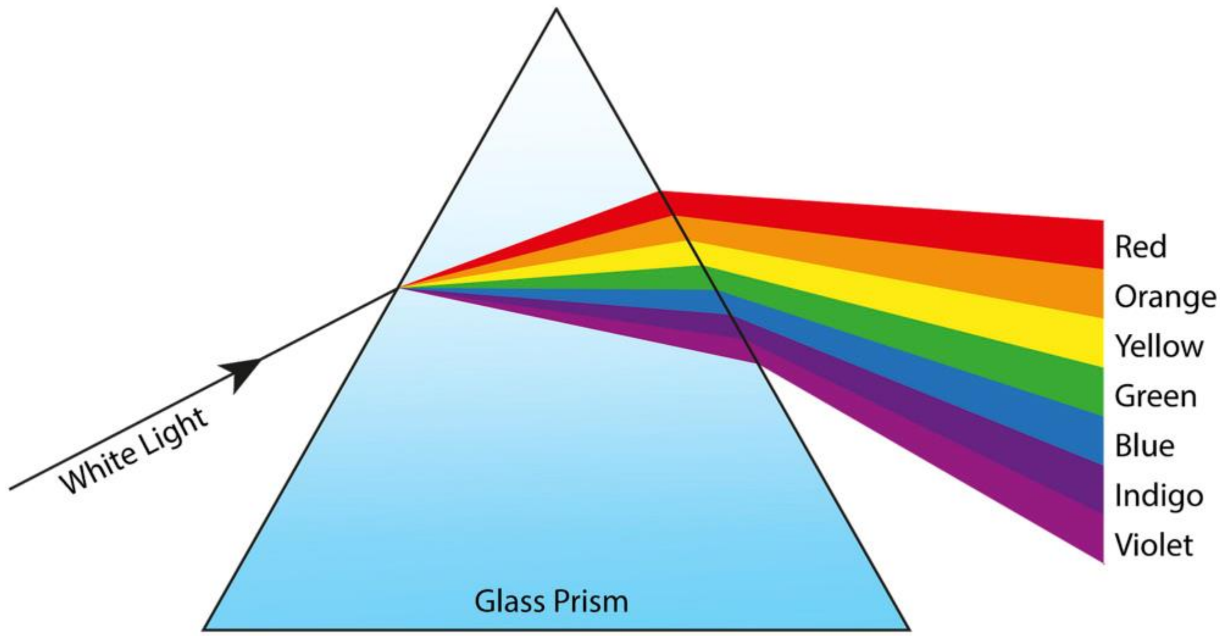



### Transmitting Waves

Most of the sounds we hear reach our ears through the air but sounds can also travel through liquids and solids. If you swim underwater—or even submerge your ears in bathwater—any sounds you hear have traveled to your ears through the water. Some solids, including glass and metals, are very good at transmitting sounds. Foam rubber and heavy fabrics, on the other hand, tend to muffle sounds. They absorb rather than pass on the sound energy.

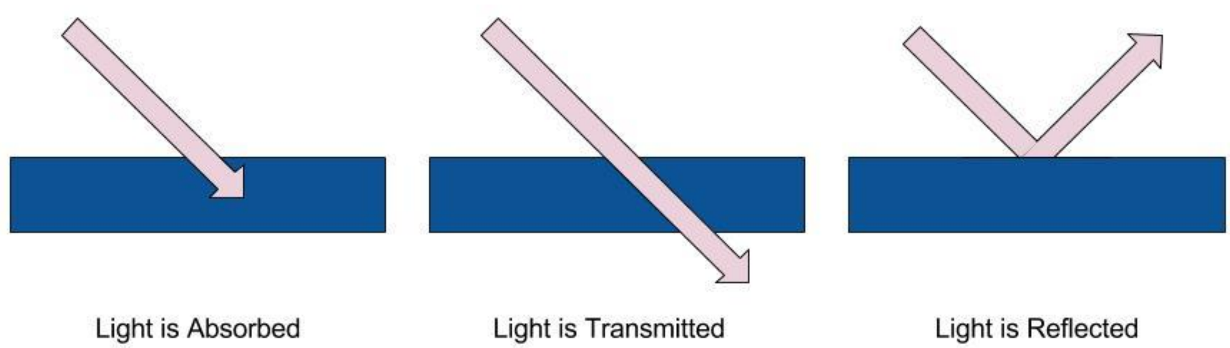
Visible light consists of a range of wavelengths. The wavelength determines the color that the light appears. Light with the longest wavelength appears red and light with the shortest wavelength appears violet. In between is the spectrum of the other colors of light.

A prism, like the one in the figure, can be used to separate white (visible) light into its different colors. A prism is a pyramid-shaped object made of transparent matter, usually clear glass. It transmits light but slows it down. When light passes from the air to the glass of the prism, the change in speed causes the light to bend. Different wavelengths of light bend at different angles. This causes the beam of light to separate into light of different wavelengths. What we see is a rainbow of colors.




### Absorbed Waves

When a wave's energy is transferred to an object, rather than being transmitted through the object or reflected by it, we say the wave has been absorbed. Sound proof walls absorb sound waves. Black material absorbs some of the energy of the sun's light waves which explains why dark materials heat up in the sun.




The image above shows how a wave can be either absorbed, transmitted, or reflected depending on which medium it is traveling through.

### Waves in Everyday Life

Each year there are firework displays all over the United States to celebrate the Fourth of July. Thanks to waves, millions of people are able to enjoy the fireworks displays.

Can you explain why waves are necessary to experience fireworks?

You hear the fireworks because sound waves travel to your ears. You see the fireworks because the light waves are detected by your eyes.

The fireworks can be seen before we hear their sound. Why? Light waves travel faster than sound waves.

Sound waves travel at different speeds, depending on the medium through which they are moving. Have you ever seen a Western movie where the hero puts his ear on the railroad track to determine whether or not a train is coming? Why does he put his ear on the track? Sound waves travel faster through solids than they do through gases. The solid steel railroad tracks transmit the train's rumblings faster than the air does. In general, the more rigid the matter, the faster sound travels through it. Therefore sound travels faster through solids than through liquids and faster through liquids than gases.

Can you think of another example of where you've seen, felt or heard waves?

## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 3.6 Analog and Digital Signals (8.2.6)

## Explore this Phenomenon


Vinyl records, like the one in the photograph, were used to record and play songs in decades past.

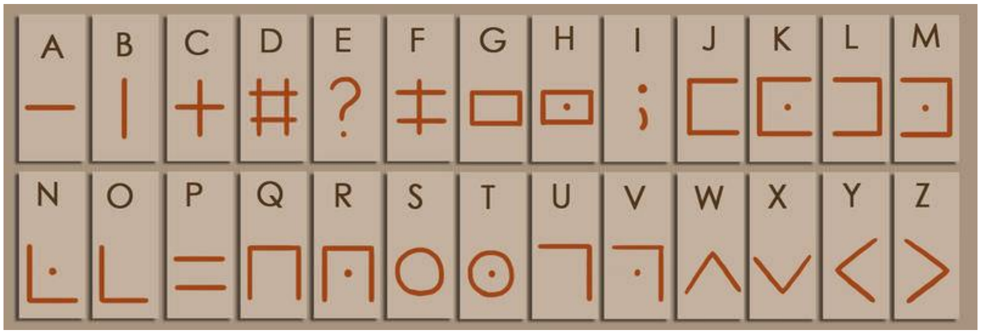
- Why have digital recordings (cd's, mp3s) replaced vinyl records in recent years?
- How do you think waves are used for this type of communication?
- What questions do you have about this phenomenon?

## 8.2.6 Analog Vs Digital Signals

**Obtain and evaluate information to communicate** the claim that the structure of digital signals are a more reliable way to store or transmit information than analog signals. Emphasize the basic understanding that waves can be used for communication purposes. Examples could include using vinyl record vs. digital song files, film cameras vs. digital cameras, or alcohol thermometers vs. digital thermometers.

In this section, focus on structure and function. Structures of waves can make them more or less reliable for the function of storing information.

### Signals




Did you ever make a secret code by assigning each letter of the alphabet a unique symbol? The code shown above is believed to have been used by George Washington to send secret messages during the American Revolutionary War.

Did you know that fireflies talk to each other using light signals from light waves? Firefly lights turn on and off and flash in patterns that are unique. Each blinking pattern is a light signal that helps fireflies communicate.

How do humans communicate over long distances? How does that signal actually get sent and received?

## Analog Signals

In the past, before digital technology was invented, people used only analog signals. Analog signals are representations of actual images, sounds, words. They often use waves to transfer information. Analog signals do not use mathematical codes to transfer information. Examples of analog signals are conversations between people which use the sound waves to transfer the information, film cameras which use light waves to imprint the image on the film and vinyl records which use actual waves/grooves in the plastic to make the sound. Some analog signals are simply an instrument used to make a measurement. For example an alcohol thermometer is used for measuring temperatures and a grandfather clock measures time. Can you think of some other examples of analog signals?

## Digital Signals

Everything that you see or hear on a computer—words, pictures, numbers, movies and sound--uses digital signals. Digital signals are sent as mathematical coded waves and can be sent over long distances. Once the waves arrive at a receiving station, they are decoded back into information that you can understand. In the example of the computer the signal is sent to the speakers which decodes it back into sound or light.


Most of the electronic devices used today, including smartphones, handheld devices, digital thermometers, digital cameras and video game systems, work by transmitting and receiving digital signals in waves. Can you think of other examples of digital signals?

## Comparing Analog Signals and Digital Signals

The following video has two opposing perspectives about analog versus digital from recording engineers.

The following video has two opposing perspectives about analog versus digital from recording engineers:

- http://bit.l y/2h62kC5

For more information on analog and digital technologies go to:

- http://www.explainthatstuff.com/analog-and-digital.html

## Putting It Together


• How has your understanding changed?

• Can you think of another phenomenon that applies these concepts?

• Explain why vinyl records are rarely used based on what you have learned in this section.

# 3.7 References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# CHAPTER 4

# Strand 3: Life Systems

## Chapter Outline



Living things use energy from their environment to rearrange matter to sustain life. Photosynthetic organisms are able to transfer light energy to chemical energy. Consumers can break down complex food molecules to utilize the stored energy and use the particles to form new, life-sustaining molecules. Ecosystems are examples of how energy can flow while matter cycles through the living and nonliving components of systems.

# 4.1 Photosynthesis (8.3.1)

## Explore this Phenomenon

Plants do not need to eat in order to grow. How is this possible?

Video of lima bean growth from seed https://www.youtube.com/watch?v=iZMjBO6A7AE

- What do you already know about how plants grow?
- Using your prior knowledge, identify what plants need in order to grow?
- What questions do you have about how plants grow?

## 8.3.1 Photosynthesis

**Plan and conduct an investigation** and **use the evidence to construct an explanation** of how photosynthetic organisms use energy to transform matter. Emphasize molecular and energy transformations during photosynthesis.

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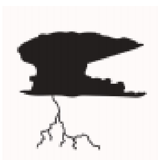

In this section, focus on matter and energy. Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

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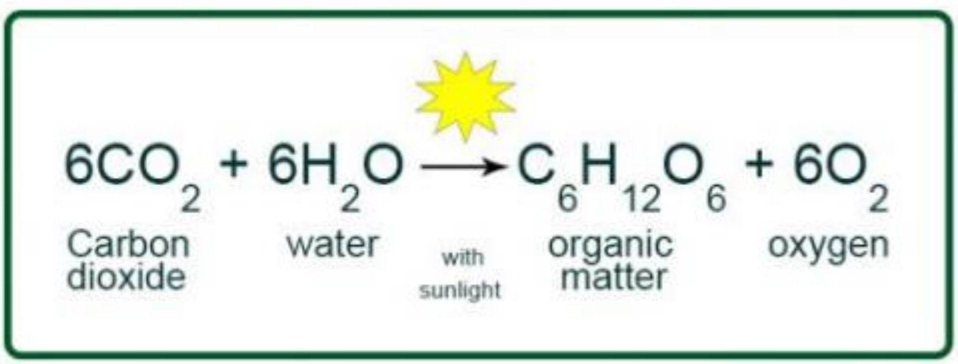
### Photosynthesis Reactions: Food from Light

Most of the energy used by living things comes either directly or indirectly from the sun. That is because sunlight provides the energy for photosynthesis. Photosynthesis is the process by which plants and other organisms, including some types of bacteria, make a sugar called glucose ($C_6H_{12}O_6$). Photosynthesis uses carbon dioxide and water to produce oxygen and glucose. The overall chemical equation for photosynthesis is:




Photosynthesis changes light energy from the sun into chemical energy that is stored by the plant in the form of glucose molecules. Glucose is then used for energy by the cells of the plant. Although photosynthetic organisms such as plants make their own glucose, other organisms that don't do photosynthesis get their glucose from the food they eat.

### Photosynthetic Organisms

The organisms pictured below are photosynthetic organisms because they all use sunlight to make glucose using the process of photosynthesis. In addition to plants organisms that do photosynthesis also include some types of bacteria and algae.

A large amount of photosynthesis takes place in the plants of this lush tropical rainforest.

The green streaks in this very blue lake are photosynthetic bacteria called cyanobacteria.

The green “scum” on this pond consists of photosynthetic algae.

## Putting It Together


Using the photos above, answer the following:

- How has your understanding of plant growth changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 4.2 Respiration (8.3.2)

## Explore this Phenomenon

Take a deep breath, place your hand over your mouth, and breathe out then feel what is on your hand.

- What do you feel?
- What questions do you have about what is coming out?
- How do you explain what is happening?

## 8.3.2 Respiration

**Develop a model** to describe how food is changed through chemical reactions to form new molecules that support growth and/or release energy as matter cycles through an organism. Emphasis is on describing that during cellular respiration molecules are broken apart and rearranged into new molecules, and that this process releases energy.

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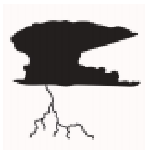

In this section, focus on matter and energy. Matter is conserved because the total number of atoms remains the same when molecules are broken apart and rearranged. Energy is released during this process.

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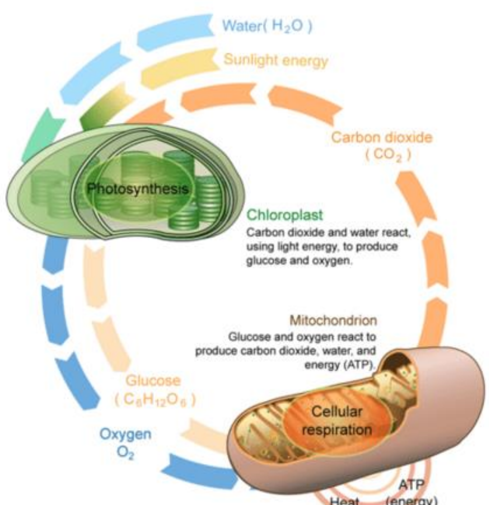
### What is Cellular Respiration?

Cellular respiration is the process in which the cells of living things, including plants, break down glucose with oxygen to produce carbon dioxide and water. The overall chemical equation for cellular respiration is:

**Glucose + Oxygen → Carbon Dioxide + Water**

Notice that this formula is the reverse of photosynthesis. However, the forms of energy involved are different. Where photosynthesis uses light to create chemical energy in sugar in contrast cellular respiration breaks down the chemical energy found in sugars and converts it to mechanical and heat energy used by the organism.




As the figure shows, cellular respiration occurs in the cells of all kinds of organisms, including those that make their own food (producers) as well as those that get their food by consuming other organisms (consumers).

**Q:** How do living things get energy from glucose?

**A:** They break bonds in glucose and release the stored energy in the process of cellular respiration.

## Why Is Cellular Respiration Important?

Living organisms need energy to live and they need matter to grow. Cellular respiration provides for both needs. During cellular respiration food is changed through chemical reactions to form new molecules that support growth and/or release energy as matter cycles through the organism.

## Putting It Together

Using the photo above, answer the following:

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 4.3 The Carbon Cycle and Ecosystems (8.3.3)

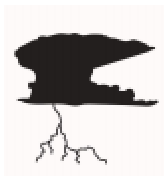
## Explore this Phenomenon

Look at the photo.

- What questions do you have about the scene?
- What do you already know?
- How do you explain what is happening?

## 8.3.3 Carbon Cycle & Ecosystems

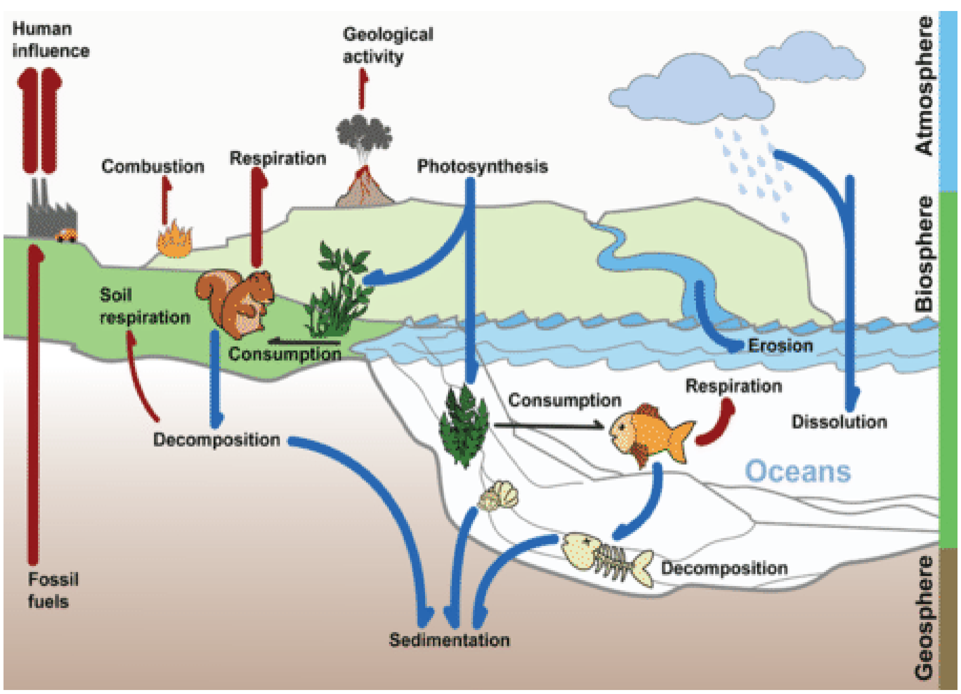
**Ask questions to obtain, evaluate, and communicate information** about how changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of an ecosystem. Emphasize describing the cycling of matter and flow of energy through the carbon cycle.




In this section, focus on stability and change and matter and energy. Small changes in one part of a system might cause large changes in another part and the transfer of energy can be tracked as energy flows through a natural system.

### The Carbon Cycle

Carbon is the element that acts as a building block for many compounds necessary for life. But do organisms make their own carbon? No! Carbon must be recycled from other living organisms, things like sedimentary rocks, the atmosphere, and other parts of the ecosystem. Exactly how does carbon get recycled and move through the ecosystem?




The Carbon Cycle. Carbon moves from one source to another in the carbon cycle.

Flowing water can slowly dissolve carbon in sedimentary rock. This carbon often ends up in the ocean. Once in the ocean carbon can be stored for thousands of years or more. Although oceans and sedimentary rock are major sources for stored carbon, carbon is also stored for different lengths of time in the atmosphere, in living organisms, and as fossil fuel deposits found in the earth. These are all parts of the carbon cycle, which is shown in the figure above.

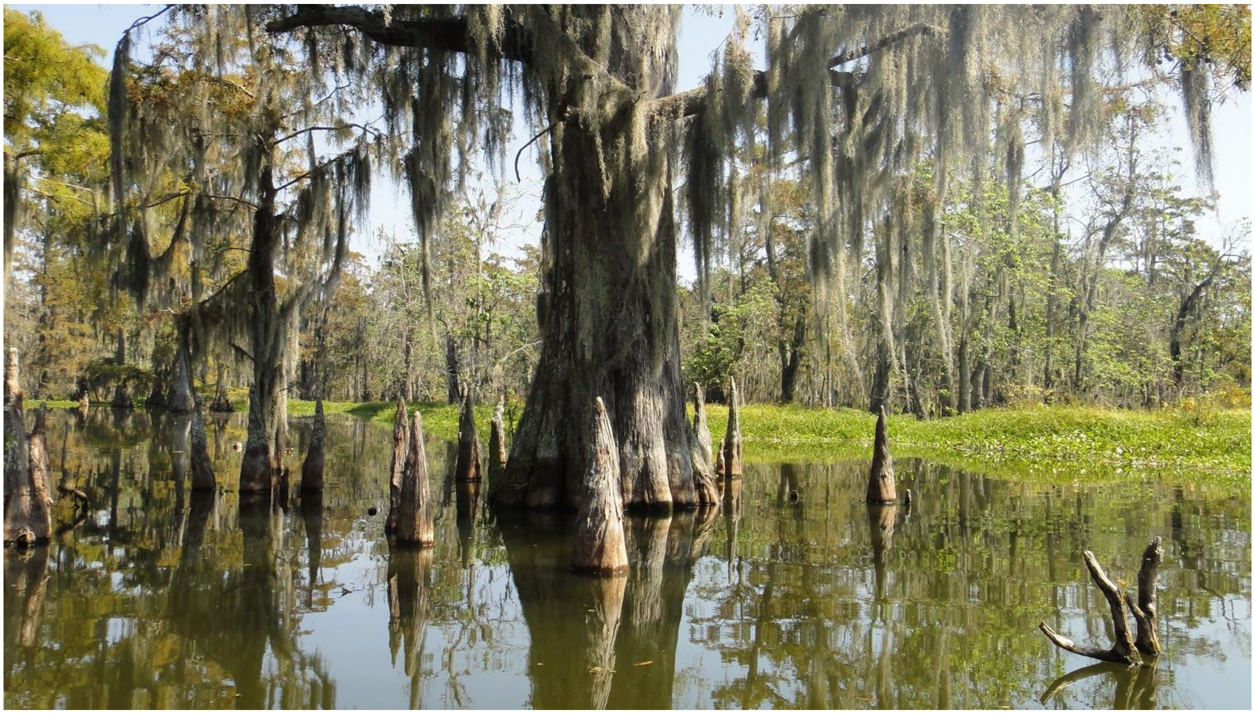
### Carbon in Carbon Dioxide

Carbon cycles quickly between organisms and the atmosphere where carbon exists primarily as carbon dioxide ($CO_2$). Carbon dioxide cycles through the atmosphere by several different processes, including those listed below.

- Living organisms release carbon dioxide as a byproduct of cellular respiration. (Carbon dioxide is breathed out.)
- Photosynthesis removes carbon dioxide from the atmosphere and uses it to make chemicals like glucose.
- Carbon dioxide is given off when dead organisms and other organic materials decompose.
- Burning organic material, such as fossil fuels, releases carbon dioxide.
- Carbon cycles far more slowly through geological (earth) processes. Carbon may be stored in sedimentary rock for millions of years.
- When volcanoes erupt, they release carbon dioxide that was stored in the mantle.
- Carbon dioxide is released when limestone is heated during the production of cement.
- Ocean water releases dissolved carbon dioxide into the atmosphere when water temperatures rise.
- Carbon dioxide is also removed when ocean water cools and dissolves more carbon dioxide from the air.

Because of human activities, there is more carbon dioxide in the atmosphere today than there has been for the past hundreds of thousands of years. Burning fossil fuels has released great quantities of carbon dioxide into the atmosphere. Cutting forests and clearing land have also increased carbon dioxide into the atmosphere. These activities reduce the number of photosynthetic organisms that remove carbon dioxide from the air. In addition, clearing often involves burning, which releases carbon dioxide that was previously stored in plants.

## Putting It Together



- How has your understanding changed of the carbon cycle changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

## Explore this Phenomenon


When Yellowstone National Park was created there was no protection for wolves or other predators. Ranchers were concerned that the wolves were killing livestock and so the government created predator control programs in the early 1900s. Wolves were hunted and killed.

What questions do you have about how the disappearance of wolves affected the ecosystem?

What do you predict happened when the wolves were removed?

What evidence would you collect to verify your prediction?

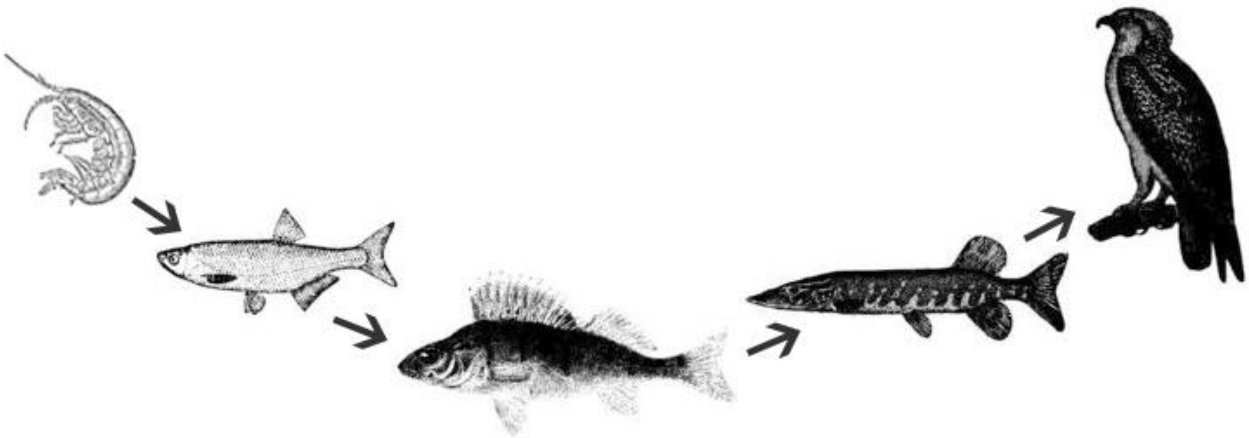
## Flow of Energy in Ecosystems

What is the source of energy for almost all ecosystems?

The sun supports most of Earth's ecosystems. Plants convert light energy from the sun to the chemical energy found in food. The food energy stored by producers is passed to consumers, scavengers, and decomposers.

## Food Chain

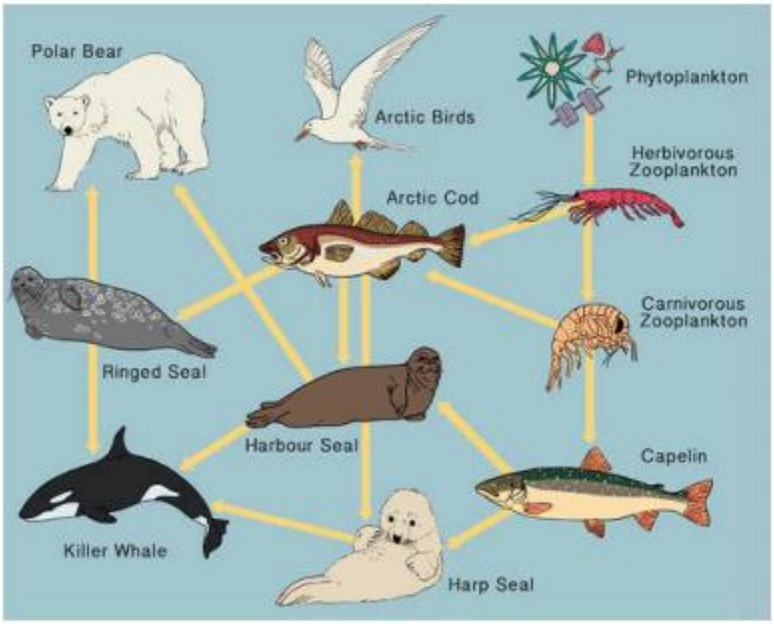
The set of organisms that pass energy from one organism to the next is described as a food chain (See figure below). It is a simplified version of how energy and matter move in an ecosystem. The arrows show the direction the energy and matter move.



## Food Web

A food web recognizes that most organisms eat many different things. Food webs are food chains that interconnect with each other. All organisms depend on two global food webs. The aquatic food web is based on phytoplankton as the producer and the land food web is based on land plants. How are these two webs interconnected? Birds or bears that live on land may eat fish, which connects the two food webs.

Humans are an important part of both of these food webs; we are at the top of a food web since nothing eats humans as a regular source. That means that humans are top predators.




This image shows a food web of the Arctic Ocean. Which organisms would be affected if you took out the artic cod? How would those organisms be affected?

## Matter Cycles and Energy Flows

Matter cycles which is to say that it is used over and over again. In the carbon cycle, matter, in the form of carbon, is recycled again and again and again as it moves from the atmosphere into living things and back into the atmosphere or into rocks or into the oceans. The big idea is that matter is reused; it cycles.

Energy does not cycle. It is converted from one form to another but it is not recycled. The energy that comes from the sun does NOT return to the sun; it is not recycled. Instead energy flows which is to say that it moves from one form to another. In the carbon cycle energy flows from the sun through plants as chemical energy into animals and eventually into the atmosphere in the form of heat.

## Disrupting the Cycle and Flow

Actions have consequences; causes have effects. John Muir said, "When we try to pick anything out by itself, we find it hitched to everything else in the universe."

Nothing in Nature exists in isolation!

Changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of that ecosystem. Consider a forest that has been clear cut which means that all of the big trees were removed. The cycling of carbon through that forest ecosystem would be significantly impacted; it would influence both the ecosystem’s living and nonliving components. The living things that relied on the trees for food would be denied their carbon and energy source and the carbon in the atmosphere would increase as a result of decreased photosynthesis.

## Putting It Together


Using the photo above, answer the following:

- How has your understanding changed of the flow of matter and energy changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what happened with wolves in Yellowstone on based on what you have learned in this section.

Go to this website to watch a video of what happened at Yellowstone when the wolves were reintroduced.

- https://www.youtube.com/watch?v=1UQBHNznzmU

# 4.4 References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# CHAPTER 5

# Strand 4: Natural Resources

## Chapter Outline



Interactions of matter and energy through geologic processes have led to the uneven distribution of natural resources. Many of these resources are nonrenewable and per-capita use can cause positive or negative consequences. As energy flows through the physical world, natural disasters can occur which affect human life. Humans can study patterns in natural systems to anticipate and forecast future disasters and work to mitigate the outcomes.

# 5.1 Natural Resources and their Geology (8.4.1)

## Explore this Phenomenon

One of the main natural resources found in Utah is coal. The black layers in this sedimentary rock are seams of coal.

- What are your observations about the coal in the rock?
- What questions do you have about the coal?
- Can you explain how the coal formed?

## 8.4.1 Natural Resources and their Geology

**Construct a scientific explanation** based on evidence that shows that the uneven distribution of Earth's mineral, energy, and groundwater resources is caused by geological processes. Examples of uneven distribution of resources could include Utah's unique geologic history that led to the formation and irregular distribution of natural resources like copper, gold, natural gas, oil shale, silver and uranium.

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In this section, focus on cause and effect. Cause and effect relationships may be used to predict the uneven distribution of resources by geologic processes.

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### Natural Resources

In Standard 8.1.4 you learned the difference between natural and synthetic materials. Natural resources are substances constructed by nature that help to support life on Earth. Humankind is one species in an extensive web which includes the Earth's resources and all life. Without question, we are a unique species. We have the power to change that web in ways no other species can. We have the responsibility to use natural resources in ways which sustain the web – for ourselves and for all life on this planet.

Distribution of Resources

- Think about all of the natural resources that are found in the United States.
- How many natural resources can you name?
- Are there parts of the US that have more resources than others?
- Coal is a major resource found in the United States but is it found in every state?
- Why do some states like West Virginia and Utah have abundant coal deposits while a large state like California has little to none?

Over millions of years, plant material growing in bogs and swamps gets buried, compacted, and altered as organisms die and build up. This is the process that forms coal. Swampy areas don't occur everywhere. In dry areas they don't form at all. Because of this you will not find coal everywhere on earth's surface. Utah and West Virginia have coal because millions of years ago Utah and West Virginia had extensive swamps and bogs.

Resources are not equally distributed across the earth. Some areas have access to many varied resources while others have few to none. The distribution of many natural resources depends on the geology of the area.

### Mineral and Fossil Fuel Resources and Geology

The natural resources that our society uses form in very specific environments. The way the rocks in an area formed determines the mineral resources that are found there.

Mineral and fossil fuel resources fall into a few main groups.

- Metals: including iron, lead, gold, silver, copper, zinc and others
- Fossil fuels: coal, oil, and natural gas
- Other minerals: gemstones, salt, gypsum, phosphate, etc.
- Building materials: stone for buildings, gravel for roads, asphalt

Water resources are also dependent on the geology of an area. Water will only collect in and flow through certain types of rocks.

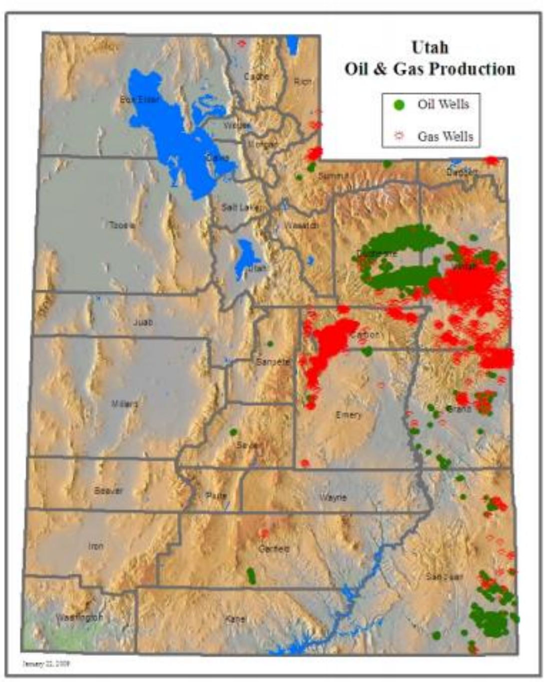
The table below shows some resources and the geological environments where they are usually found.

| **Resource** | **Where it is found** |
|---|---|
| Metals<br>(gold, silver, iron, copper, lead, zinc, etc.) | Occasionally in, but more often near, volcanic intrusive (cooled deeper in the earth) rocks, faults, metamorphic rocks, and sometimes sedimentary rocks. |
| Salt, calcite, gypsum | Sedimentary minerals; these form when elements dissolved in water are left behind by water or are deposited when the water evaporates. |
| Uranium | Concentrated in sedimentary rocks but can be found in volcanic or metamorphic rocks. |
| Fossil fuels<br>(oil, natural gas, coal, oil shale/sands) | Form in sedimentary rocks. This happens as plants, animals, sediment, and bacteria are buried, compacted, and altered by heat and pressure. |
| Precious gems | All rock types. Most are found in igneous or metamorphic. |
| Building Materials<br>(gravel, building stone, clay, sand, asphalt) | Anywhere there is rock. Most rocks can be useful in some way or another as building materials. |
| Water | Groundwater aquifers: porous rock, fractured rock and spaces between soil particles |

We live in a state with a very diverse geologic history. We have mountains and valleys, flat table lands, faults and earthquakes, volcanoes, sedimentary rocks that were deposited in lakes and oceans, and metamorphosed rock. Because of this Utah has abundant mineral and fossil fuel resources.

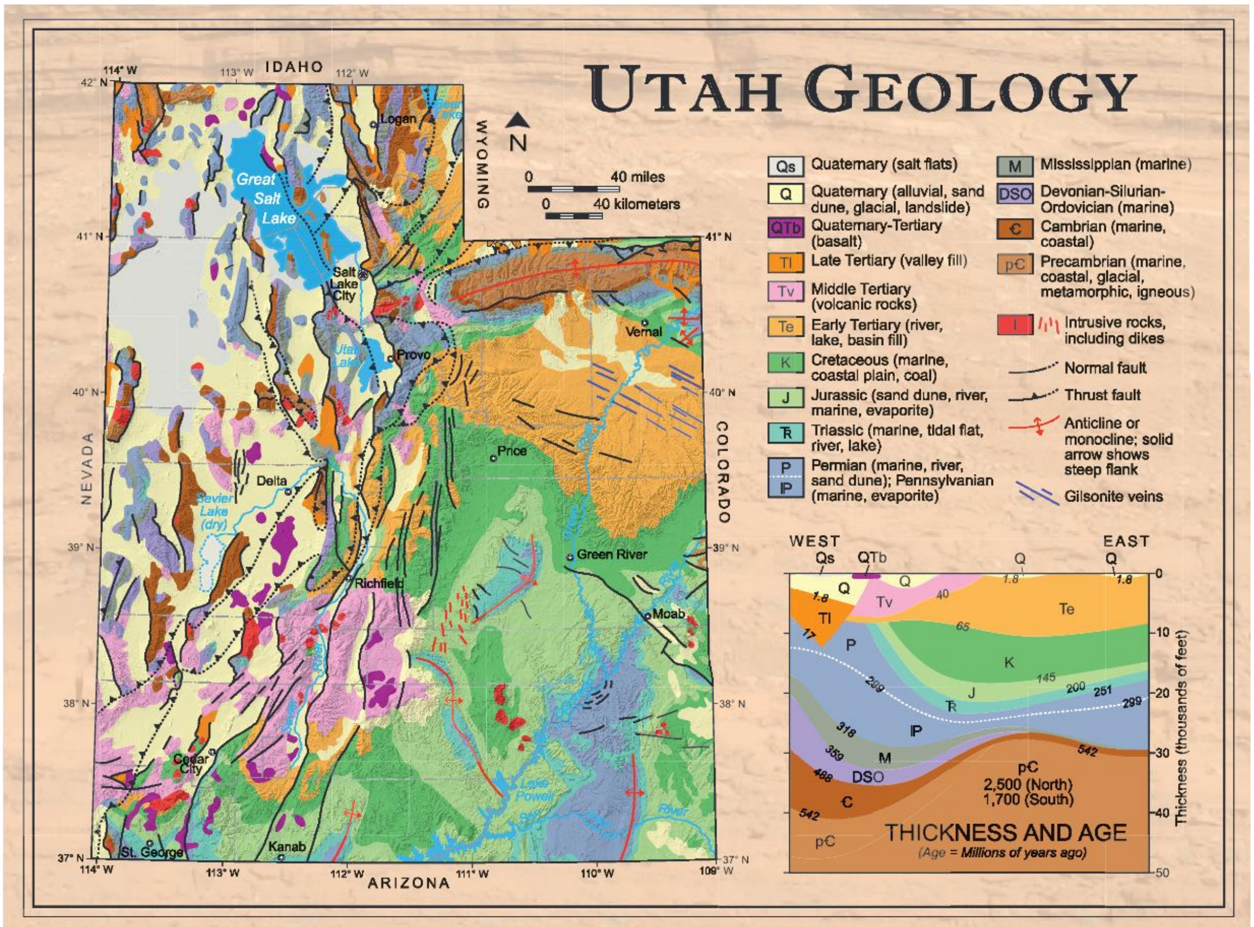
Utah has been a major producer of copper and other metals that are associated with volcanic rocks. There are mostly found in the western half of the state. Coal and oil are found in the eastern half of the state. Other resources that have been mined here include uranium, beryllium, magnesium, molybdenum, potash, salt, magnesium, chloride, and gilsonite.

Bingham Canyon Copper Mine in Salt Lake Valley



Below is a generalized map of Utah's geology. For a colored version of this map go here: http://files.geology.utah.gov/maps/geomap/postcards/pdf/utgeo_postcd.pdf

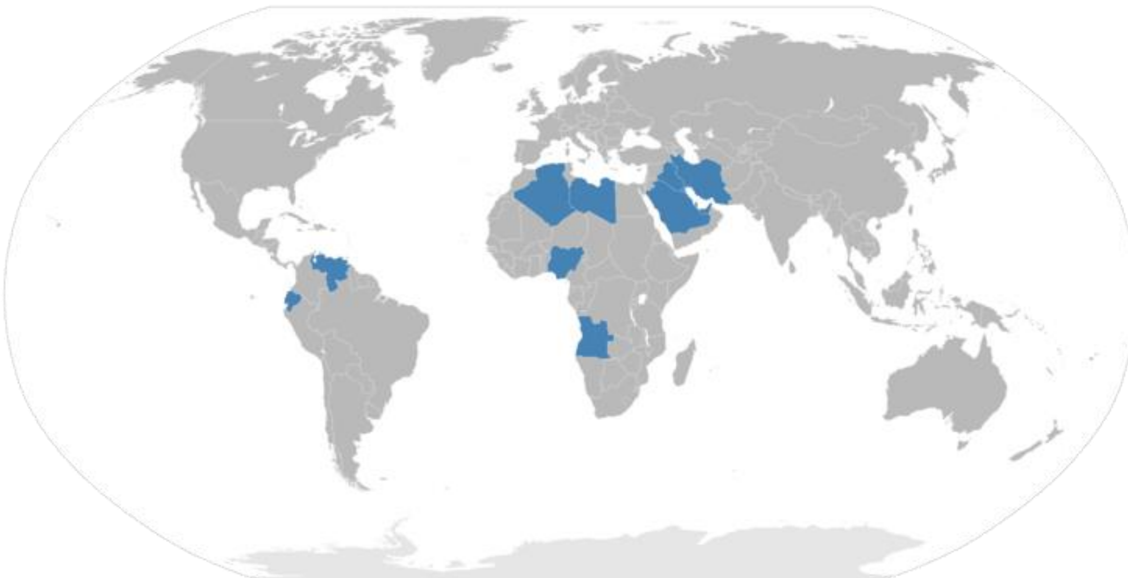
See if you can find the following geologic features on the map.




- Volcanic rocks (red, purple and pink areas)
- Sedimentary rocks deposited in lakes and oceans (grey, orange and blue rocks)
- Metamorphic rocks (dark brown)
- Loose sediment that has filled valley floors (light tan)
- Earthquake faults (solid or dotted black lines)

What kind of resources would you expect to find in each of these areas?

On a worldwide scale these patterns are repeated. Some countries have many resources available to them while others have few. Large countries have a resource advantage because more land means more possible resources. Small countries often struggle to provide resources for their people and have to maintain good relations with their neighbors so that they can trade for resources they lack.



The 12 highest oil producing countries. Some countries have vast oil reserves. Others do not have any oil.

## Putting It Together

Using the photo above, answer the following:

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 5.2 Renewable and Nonrenewable Resources (8.4.2)

## Explore this Phenomenon


- What are your observations about what has happened in these photos?
- What questions do you have about what has happened here?
- How do you explain what is happening?
- What evidence do you have to support your explanation?

## 8.4.2 Use of Natural Renewable and Nonrenewable Resources

**Engage in argument supported by evidence** about the effect of per capita consumption of natural resources on Earth's systems. Emphasize that these resources are limited and may be non-renewable. Examples of evidence include rates of consumption of food and natural resources such as freshwater, minerals, and energy sources.

In this section, focus on cause and effect. Cause and effect relationships may be used to predict the effect of per capita consumption of natural resources on Earth's systems.

### Natural Resources

A natural resource is something supplied by nature that helps support life. When you think of natural resources, you may think of minerals and fossil fuels. However, ecosystems and the services they provide are also natural resources. Natural resources are generally classified as either renewable or nonrenewable.

Renewable or nonrenewable, what's the difference? That's like asking the difference between having an endless supply and having a limited supply. Will this planet eventually run out of oil? Probably. Because there is a limited supply and because the supply cannot be readily replenished, oil is a nonrenewable resource. Wind and water are considered renewable resources because you can't ever run out of wind and water is recycled through the water cycle.

### Renewable Resources

Renewable resources can be replenished by natural processes as quickly as humans use them. Sunlight and wind are renewable resources because they will not be used up. (See figure.) The rising and falling of ocean tides is another example of a resource in unlimited supply. Metals and other minerals are renewable too. They are not destroyed when they are used and can be recycled. In a dry state like Utah, water is always a concern. It is a renewable resource because it is always being replenished through the water cycle but because we have a limited supply each year we have to be careful with how much we use.

Can we use up all of our sunlight?

No, we have a limitless supply of sunlight. That makes it a renewable resource.

Living things are considered to be renewable. This is because they can reproduce to replace themselves. However, they can be over-used or misused to the point of extinction. To be truly renewable, they must be used in a way that meets the needs of the present and also preserves the resources for future generations. The food we grow on farms and in gardens is renewable. Every year we can plant new crops to replace those we use. Some scientists consider individual trees renewable because once they are cut down they can be replanted and grow again within a few decades. Entire forests are considered nonrenewable because when they are cut down an entire ecosystem is affected, not just the trees.

The following are examples of renewable energy resources:

- Solar power. Panels use solar cells to convert sunlight into electricity. (See figure.)

These solar panels convert sunlight into electricity.

- Wind power. Windmills transform wind energy into electricity. Currently wind is used for less than 1% of the world's energy needs but wind energy is growing fast. Every year, 30% more wind energy is used to create electricity.

Wind is a renewable resource. Wind turbines like this one harness just a tiny fraction of wind energy.

- Hydropower. The energy of moving water is used to turn turbines (similar to windmills) or water wheels that generate electricity. This form of energy produces no waste or pollution however it can cause destruction of habitat if dams are created for this purpose.

Hydropower plant.

- Geothermal power. The natural flow of heat from the Earth's core is used to produce steam. This steam turns turbines which generate electricity.
- Biomass. Biomass production involves using organic matter ("biomass") from plants to produce energy. Using corn to make ethanol fuel is an example of biomass generated energy.

- Tides. Waves in the ocean can also turn a turbine to generate electricity. This energy can then be stored until needed.

Dam of the tidal power plant in the Rance River, Bretagne, France

### Nonrenewable Resources

Nonrenewable resources are natural resources that exist in fixed amounts and can be used up. Examples include fossil fuels such as petroleum, coal, and natural gas. These fuels formed from the remains of plants over hundreds of millions of years. We are using them up far faster than they could ever be replaced. At current rates of use, petroleum will be used up in just a few decades and coal in less than 300 years. Nuclear power is also considered to be a nonrenewable resource because it uses up uranium, which will sooner or later run out. It also produces harmful wastes that are difficult to dispose of safely.

Could we all run out of gasoline?

Yes, we will use up all our gasoline eventually. Gasoline is produced from oil. Oil deposits were formed over hundreds of millions of years. They cannot be quickly replenished. Oil is an example of a nonrenewable resource.

Coal is another nonrenewable resource.

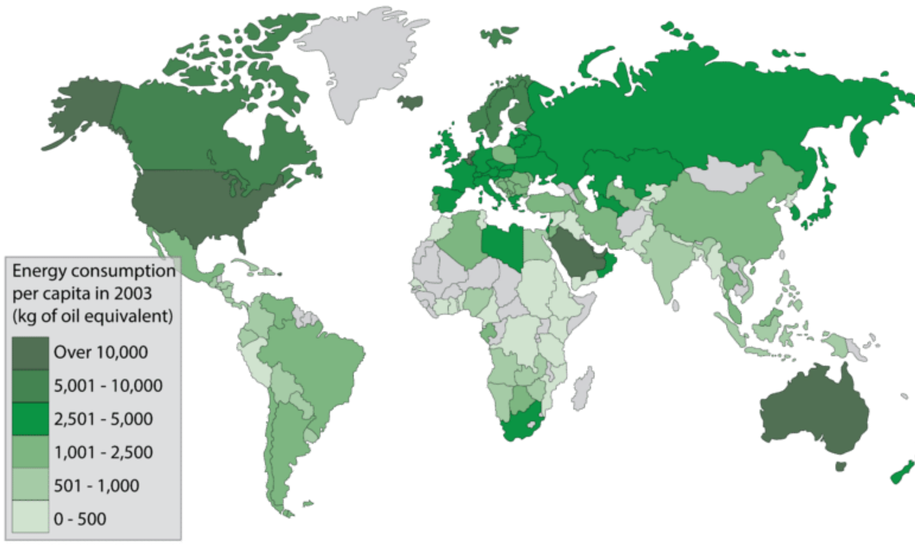
Nuclear power is considered a nonrenewable resource because it uses radioactive elements of which we have a limited supply. Aerial photo of the Bruce Nuclear Generating Station near Kincardine, Ontario.

## Society's Use of Resources

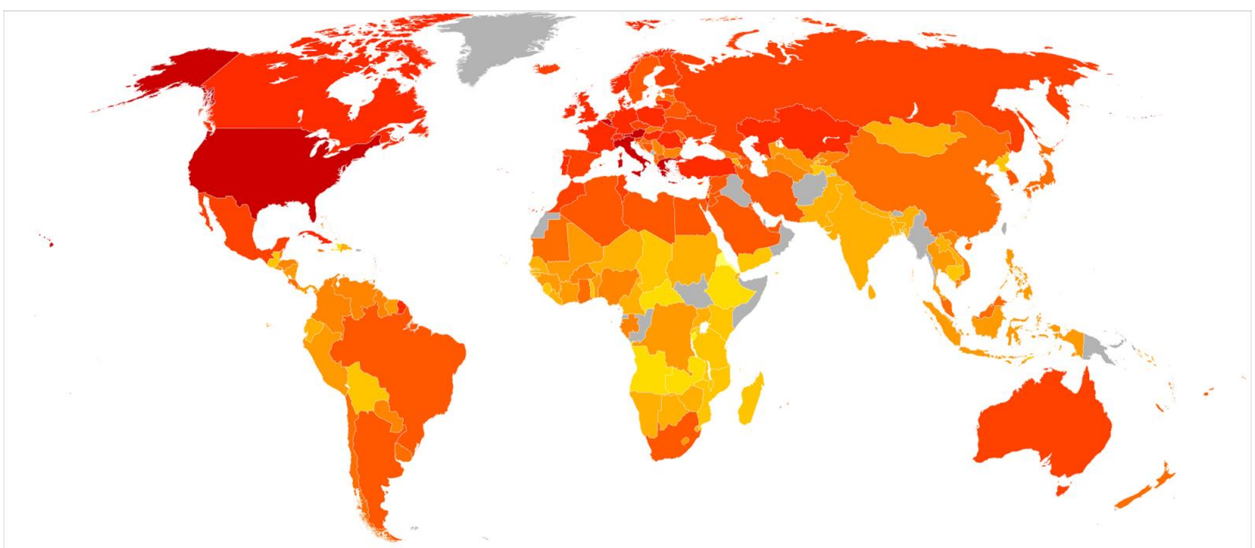
Many times when we discuss resources, power is a main concern. As a society we have become very dependent on power for transportation, hospitals, heating and cooling our homes, light, entertainment, and preserving our food. Population growth, especially in developing countries, should make people think about how fast natural resources are being consumed. Governments around the world should seriously consider these issues.

Developing nations will also increase demands on natural resources as they build more factories. Improvements in technology, use of renewable energy sources and conservation of resources could all help to decrease the demand on nonrenewable resources.

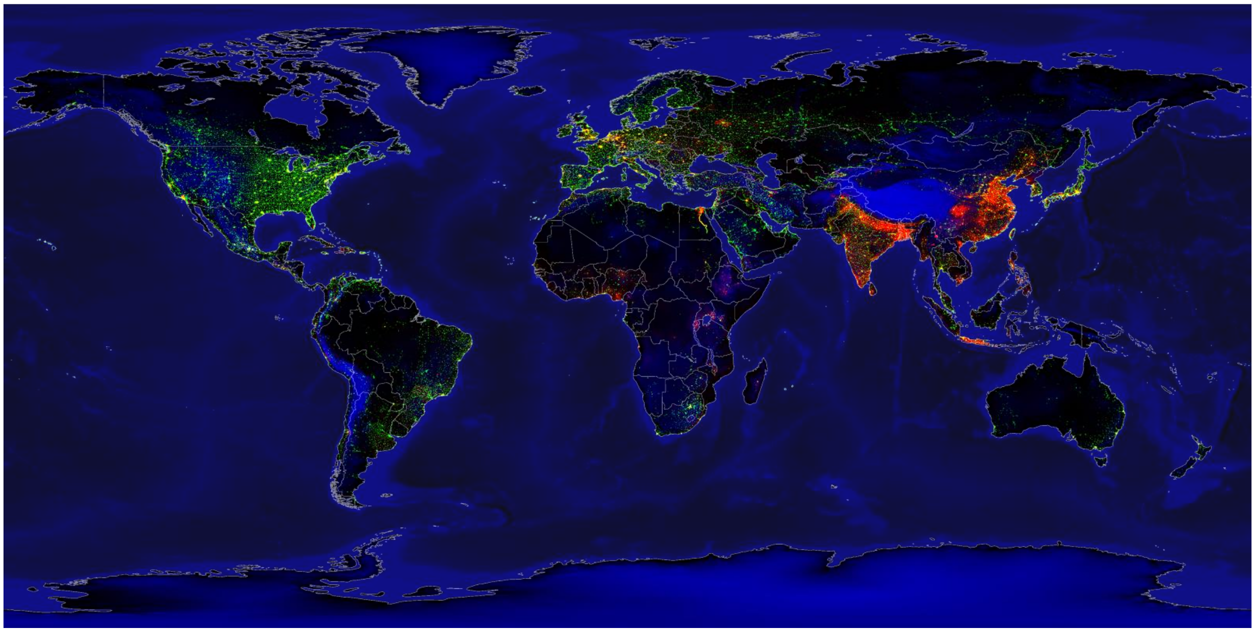
Analyze the graphs and charts to determine the effect of per capita consumption of natural resources on Earth's systems



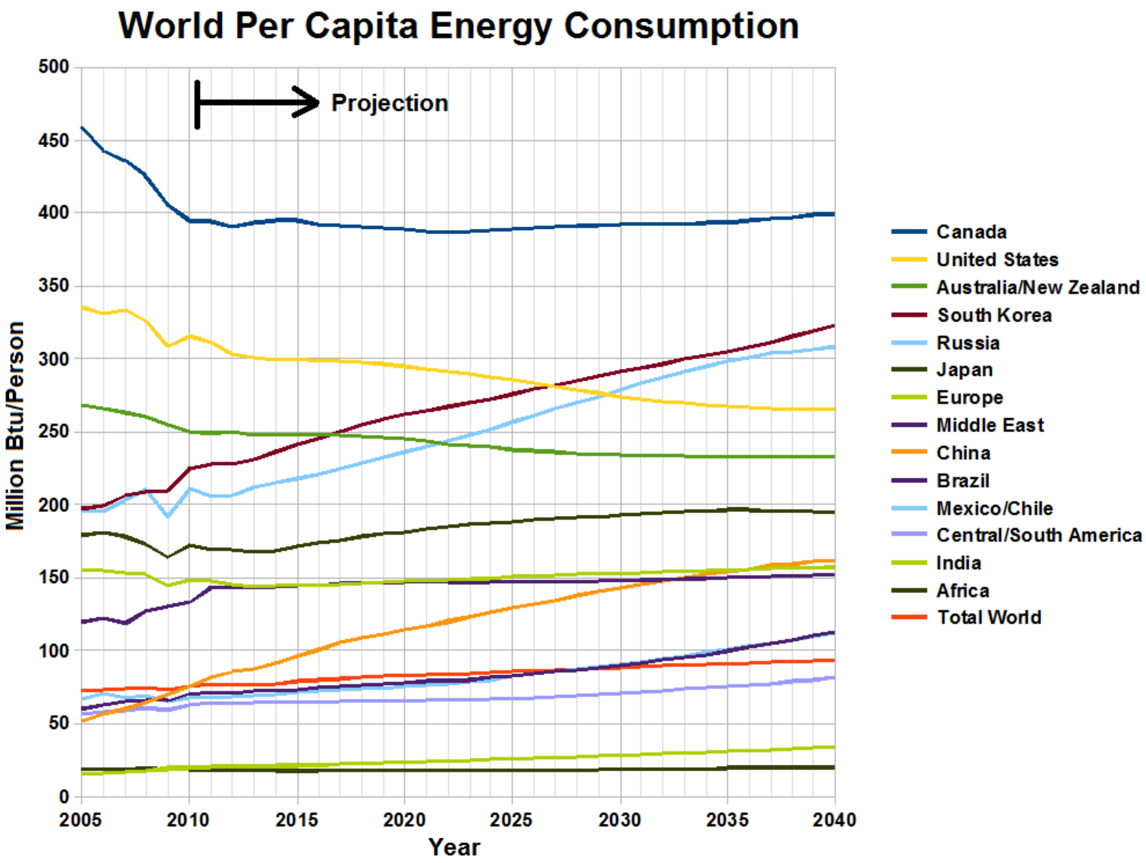

Per capita energy consumption (2003) shows the unequal distribution of wealth, technology, and energy use.

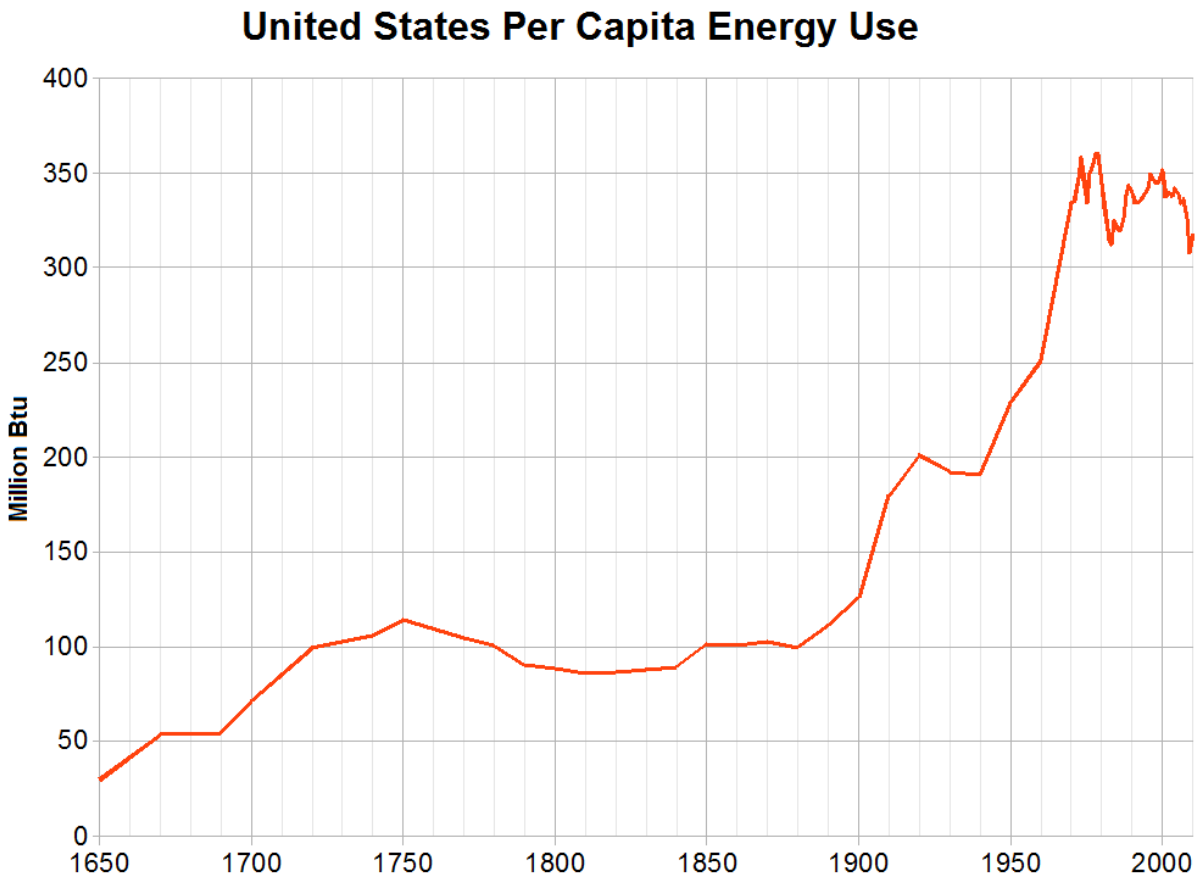


Map of average daily dietary energy availability per capita in 2006–2008.



Earth Lights vs. Population




United States Per Capita Energy Use
Million Btu
400
350
300
250
200
150
100
50
0
1650
1700
1750
1800
1850
1900
1950
2000

## Putting It Together

Using the photos above, answer the following:

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.
- What evidence do you have to support your explanation?

# 5.3 Problems Caused by Natural Resource Usage (8.4.3)

## Explore this Phenomenon

- What are your observations about what has happened in this photo?
- What questions do you have about what has happened here?
- How do you explain what is happening?

## 8.4.3 Solutions for Problems Caused by Natural Resource Usage

**Design a solution** to monitor or mitigate the potential effects of the use of natural resources. **Evaluate** competing design solutions *using a systematic process to determine how well each solution meets the criteria and constraints of the problem*. Examples of uses of the natural environment could include agriculture, conservation efforts, recreation, solar energy, and water management.

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In this section, focus on cause and effect. Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

---

### Conserving Natural Resources

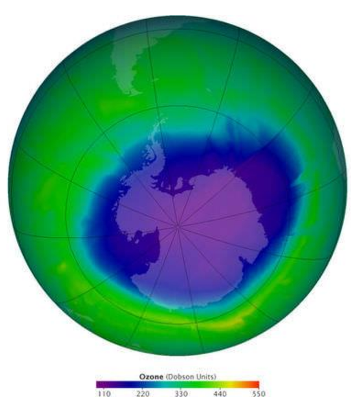
Natural resources must be conserved and protected so that people in developed nations maintain a good lifestyle and people in developing nations have the ability to improve their lifestyles. To do this, people are researching ways to find renewable alternatives to non-renewable resources.

Below is one example of a way that people have tried to solve a problem that resulted from of our use of resources. They recognized the problem, proposed a way to mitigate the negative effects, and monitored the results.

### Case Study: Healing the Ozone Layer

What's destroying the ozone layer? When ozone is in the upper atmosphere it protects our planet from dangerous radiation from the sun. Most ozone loss it taking place over the South Pole and Antarctica. This is the location of the ozone hole. The ozone hole is a region in the stratosphere where there is less ozone than normal. (See figure.) The ozone layer is also thinner over the Northern Hemisphere.

The main cause of the hole in the ozone is chlorofluorocarbons (CFCs). Scientists discovered that these human-made chemicals destroy ozone molecules in the upper atmosphere. In the past, CFCs were widely used in spray cans, refrigerators, and many other products.



### Effects of Ozone Loss

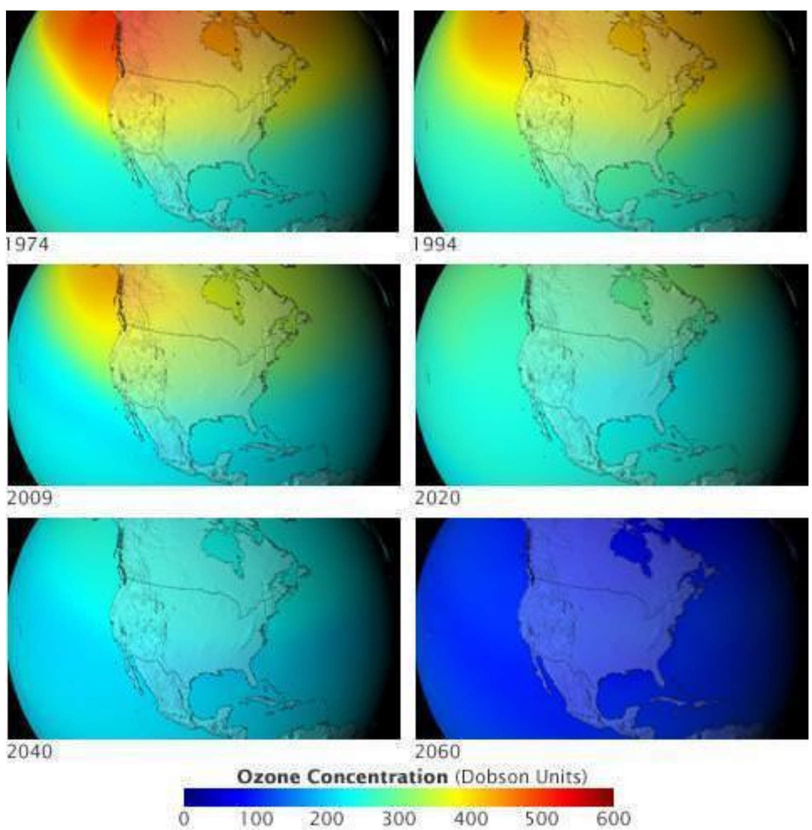
With less ozone in the stratosphere, more UV rays reach the ground. More UV rays increase skin cancer rates. Just a 1 percent loss of ozone causes a 5 percent increase in skin cancer. More UV rays also harm plants and phytoplankton. As a result, they produce less food. This may affect entire ecosystems.

### Protecting the Ozone Layer

The Montreal Protocol is a worldwide agreement on air pollution. It was put into place after people realized the problem with CFC's The Protocol focuses on limiting the use of CFCs. It was signed by many countries in 1987 and it controls almost 100 chemicals that can damage the ozone layer. Its goal was to return the ozone layer to its previous state.

### Ozone Recovery

The Montreal Protocol has been effective in controlling CFCs. By 1995, few CFCs were still being used. But the ozone hole kept growing for several years after that because of the CFCs already in the atmosphere. It peaked in 2006. Since then, the situation has improved. The Montreal Protocol is a shining example of how nations can come together to solve a global environmental problem. The 2006 ozone hole was the largest on record. The holes are beginning to get a bit smaller; the 2012 and 2013 holes were relatively small.



## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.
- What ideas do you have about how to solve this problem?

# 5.4 Global Climate Change (8.4.4)

## Explore this Phenomenon

Cocoa beans grow in a very specific climate range. Unfortunately the range they live in is changing. Places where cocoa beans used to grow easily are now struggling to grow.

- What are your observations about the cocoa beans and cocoa trees pictured above?
- 
- What questions do you have about the cocoa beans?
- What do you think may be causing the change?

## 8.4.4 Global Climate Change

**Analyze and interpret data** on the factors that change global temperatures and their effects on regional climates. Examples of factors could include agricultural activity, changes in solar radiation, fossil fuel use, and volcanic activity. Examples of data could include graphs of the atmospheric levels of gases, seawater levels, ice cap coverage, human activities, and maps of global and regional temperatures.

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In this section, focus on stability and change and cause and effect. Stability might be disturbed either by sudden events or gradual changes that accumulate over time, such as changing global temperatures. Cause and effect relationships may be used to predict the effect of global temperature changes on regional climates.

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### Climate Change

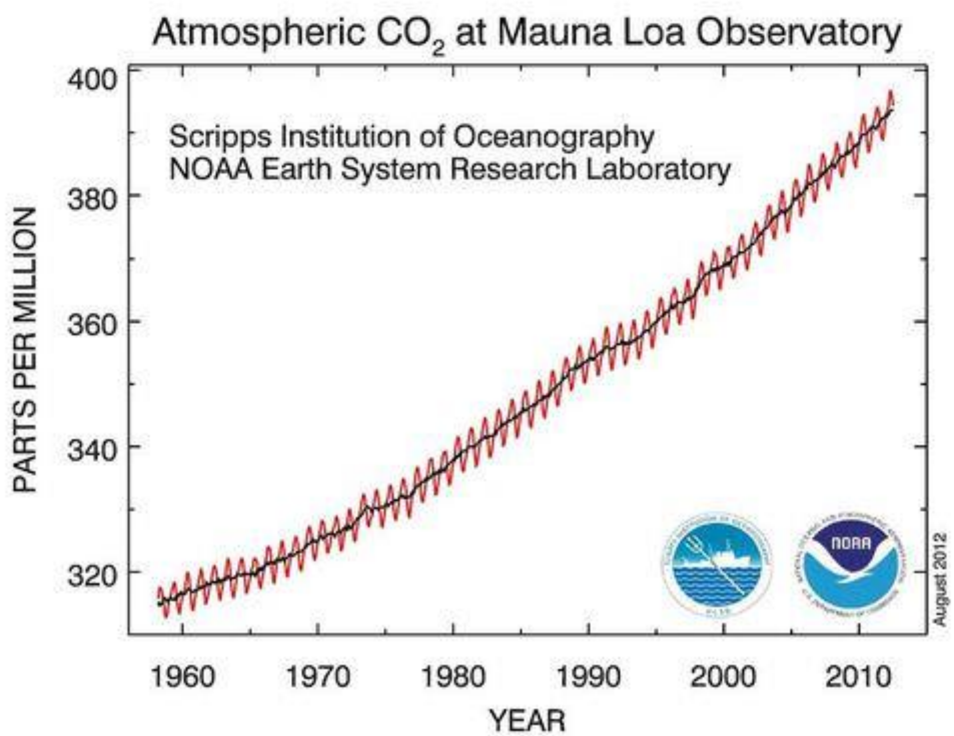
The trees in the phenomenon photo only grow in tropical forests in countries along the equator. They are cocoa trees. The brown seeds that are taken from the seed pods are used to make chocolate. Cocoa trees are sensitive to temperature. If temperatures change in the countries where cocoa trees grow, the ability of the trees to survive there will be threatened.

Many lands are marginal for farming. When rainfall is normal or high, the lands can produce. When rainfall is low, no crops grow. Drought makes marginal lands unsuitable for farming. Drought can also make good lands more difficult to farm. Changes in rainfall patterns will increase as temperatures warm.

### Causes of Climate Change

The average global temperature has been rising since the end of the Pleistocene which was about 11700 years ago, with some ups and downs, of course. Rising temperatures are natural for this time period. But natural causes cannot explain all the warming that's been happening in recent decades. There is some other factors at work.

Recent global warming is due mainly to human actions. The actions involve releasing greenhouse gases into the atmosphere. Remember that greenhouse gases keep the atmosphere warm and that carbon dioxide is a greenhouse gas. When fossil fuels are burned carbon dioxide is released into the atmosphere. The more carbon dioxide in the atmosphere, the more effectively the atmosphere traps heat. In other words, an increase in greenhouse gases leads to a greater greenhouse effect. The result is increased global temperatures. The graph shows the increase in atmospheric carbon dioxide since 1960.

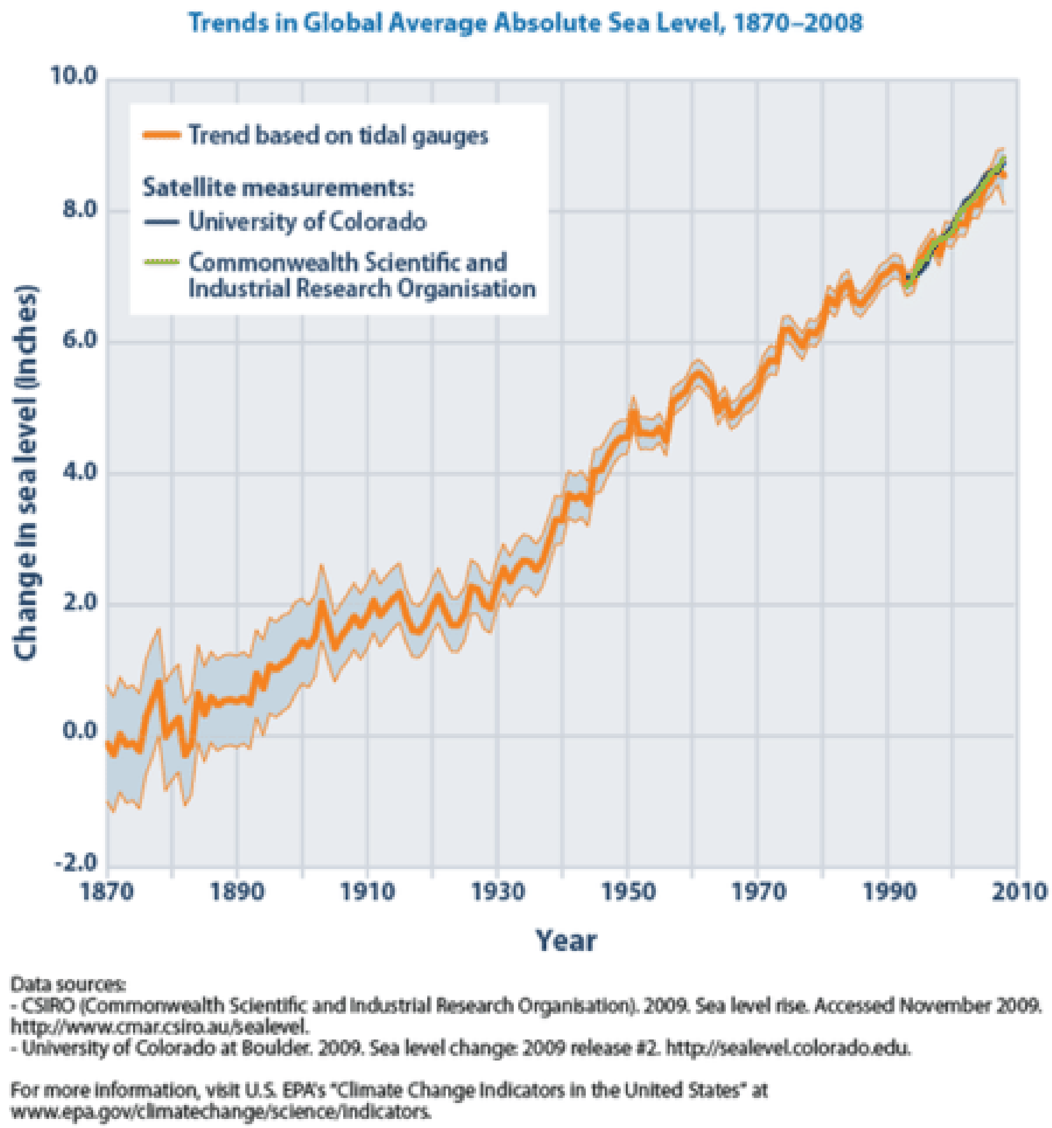



How much more carbon dioxide was in the air in 2010 than in 1960?

Burning forests also releases carbon dioxide into the atmosphere. Other human activities also release greenhouse gases into the atmosphere. For example, growing rice and raising livestock both release methane, another greenhouse gas, into the atmosphere.

## Effects of Climate Change

Already many effects of global warming are being seen. As Earth has warmed sea ice has melted. This has raised the level of water in the oceans (See image below).




The overall trend in sea level since 1870; it has risen about 9 inches.

The extent of Arctic sea ice in summer has been decreasing rapidly. The ice pictured is the sea ice minimum in 2011 (See below). The line that traces outside the pictured ice is the median minimum ice for 1979–2000. Notice how much smaller the ice coverage was in 2011 compared to the normal 1979-2000 average.


The sea ice minimum for 2011 was the second lowest on record.

For more information about global climate change, visit NASA's Climate Change website. http://climate.nasa.gov/ Click on "Facts" in the upper right corner for data on evidence, causes, effects, and scientific consensus related to global climate change.

## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

# 5.5 Natural Hazards (8.4.5)

## Explore this Phenomenon

These are photos of the California Memorial Stadium at the University of California, Berkeley.

- What are your observations about what has happened in these photos?
- What questions do you have about what has happened here?
- How do you explain what is happening?

## 8.4.5 Natural Hazards

**Analyze and interpret** patterns of the occurrence of natural hazards to forecast future catastrophic events and investigate how data are used to develop technologies to mitigate their effects. Emphasize how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow prediction, but others, such as earthquakes, may occur without warning.

---

In this section, focus on patterns. Graphs, charts, and images can be used to identify patterns in data.

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The Hayward Fault passes directly beneath both end zones at California Memorial Stadium, the home of football at the University of California, Berkeley. The site probably looked flat and easy to build on in 1922 before knowledge of earthquake faults was very advanced. Scientists now know that the Hayward Fault shifted in 1868. Since the fault moves every 140 years on average, East Bay residents and geologists are working to prepare for the inevitable event. To make the stadium safe for workers, players, and fans, the stadium is being renovated in a $321 million project involving 10 miles of steel cables, silicone fluid-filled shock absorbers, concrete piers, 3 feet of sand, plastic sheeting, and stone columns.

### Natural Hazards

We live on a planet that is constantly changing. These changes can lead to problems for the humans who live here. The rocks we stand on provide a solid surface for our buildings and roads. They seem steady but over time they slowly shift and move. The atmosphere we breathe allows us to live but the constant cycling of air and water sometimes releases more force that we would like, causing damage to lives and structures.

A natural hazard is an event that occurs in nature that has the potential to cause harm to humans or their property. Events that are a result of the geology of an area, for example earthquakes, volcanoes, landslides, rock falls, or sinkholes are examples of natural hazards. Also included are hazards that are a result of atmospheric phenomena such as tornadoes, hurricanes, flooding, avalanches, blizzards, or windstorms.

Tornadoes such as the one in the photo happen most often in areas with frequent thunderstorms and flat land.


Strong tornadoes can level entire neighborhoods.

Mount St. Helens is a volcano in Washington State that erupted in 1980. Over 230 square miles were covered in debris from the volcano.


Lava flows like these in Hawaii often cover land that has been used by humans for homes and roads.

Steep slopes and cliffs often fail, causing mud, rocks and debris to fill valleys and cover homes and roads.

### Predicting Natural Hazards

Sometimes we can predict when natural hazards will happen. Volcanic eruptions are often preceded by small earthquake swarms on the volcano. By mapping tornadoes and hurricanes we have realized that there are patterns in their occurrences. Some things are generally present when they occur. Tornadoes happen when a mass of cold air collides with a mass of warm air. Hurricanes form over oceans in the warm, moist tropics and then move northward with the prevailing winds. Landslides and rock falls happen on steep, unstable slopes, usually when there is a lot of water present.

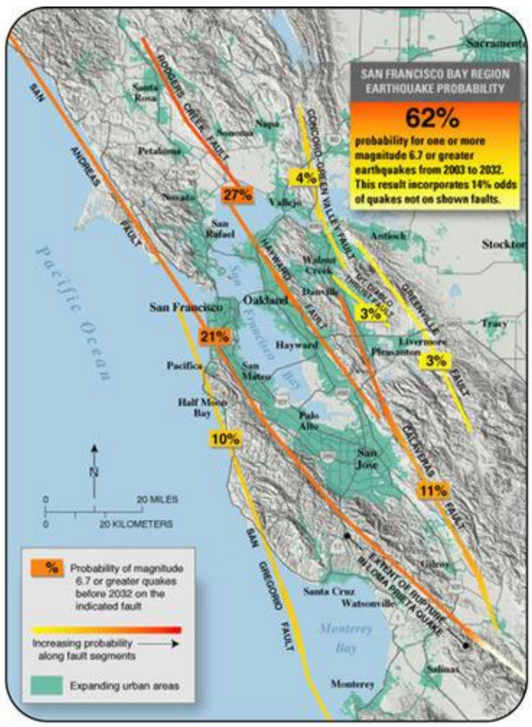
Some natural hazards, like earthquakes, are nearly impossible to predict. This is a very real problem for Utah. Utah is crossed by many active faults and earthquakes happen daily in Utah. Most are too small to feel though many of these faults are capable of very large earthquakes.

## A Good Prediction

Scientists are a long way from being able to predict earthquakes. To be useful, a good prediction must be detailed and accurate. Where will the earthquake occur? When will it occur? What will be the magnitude of the quake? Currently scientists are not able to answer these questions in regards to earthquakes.

Detailed and accurate predictions can be very useful. With a good prediction authorities could get people to evacuate. An unnecessary evacuation is expensive and causes people not to believe authorities the next time an evacuation is ordered.

### Where?

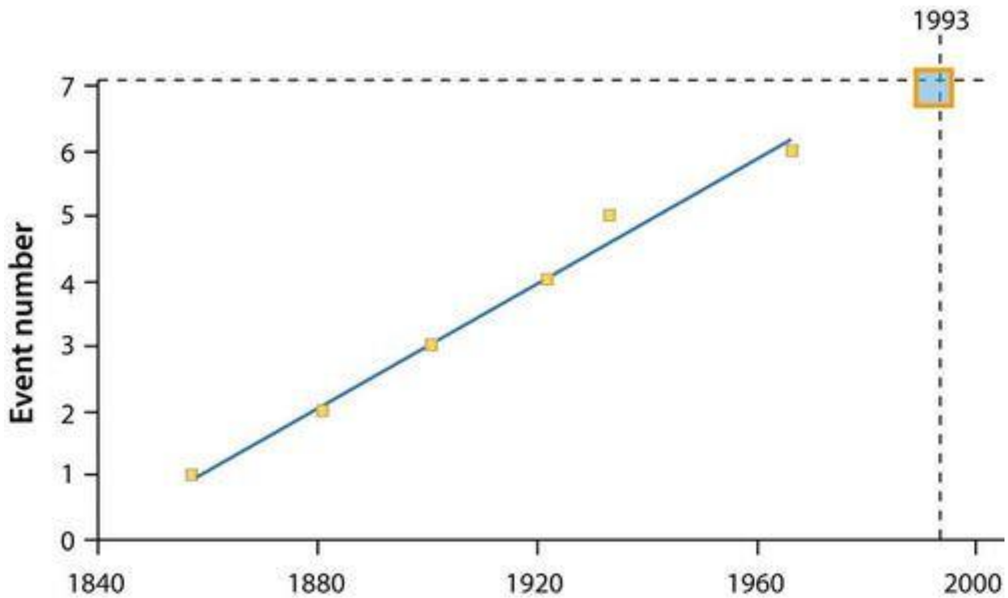



The probabilities of earthquakes striking along various faults in the San Francisco area between 2003 (when the work was done) and 2032.

Where an earthquake will occur is the easiest feature to predict. Earthquakes tend to happen where they've occurred before. (See figure.) Scientists know that earthquakes take place at plate boundaries or along major faults in the interior of continents, like the Wasatch Fault.

### When?

When an earthquake will occur is much more difficult to predict. Since stress on a fault builds up at the same rate over time, earthquakes should occur at regular intervals. (See figure.) But so far scientists cannot predict when quakes will occur, even to within a few years.




Around Parkfield, California, an earthquake of magnitude 6.0 or higher occurs about every 22 years. So seismologists predicted that one would strike in 1993, but that quake came in 2004 - 11 years late.

### Earthquake Signs

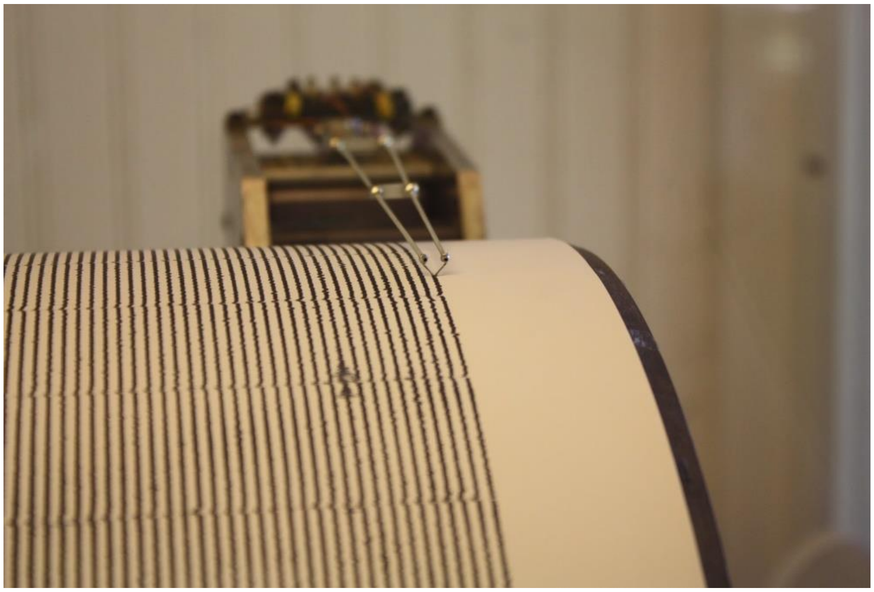
Occasionally we can guess that an earthquake is coming because there are signs that sometimes occur before a large earthquake. For example, small quakes, called foreshocks, sometimes occur a few seconds to a few weeks before a major quake. However, many earthquakes do not have foreshocks, and small earthquakes are not necessarily followed by a large earthquake.

Earthquake prediction is very difficult and not very successful, but scientists are looking for a variety of clues in a variety of locations in an effort to advance knowledge and improve the ability to predict earthquake location, timing, and magnitude.

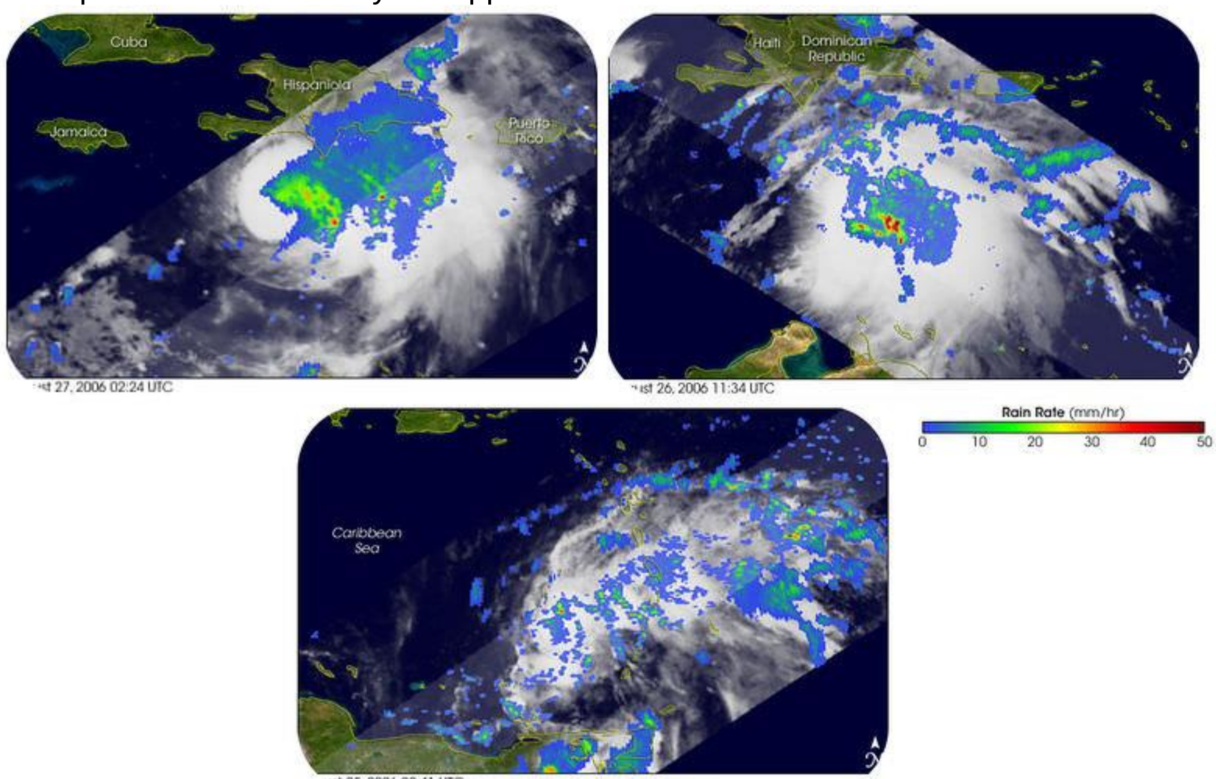
### Preventing Natural Hazards from Becoming Natural Disasters

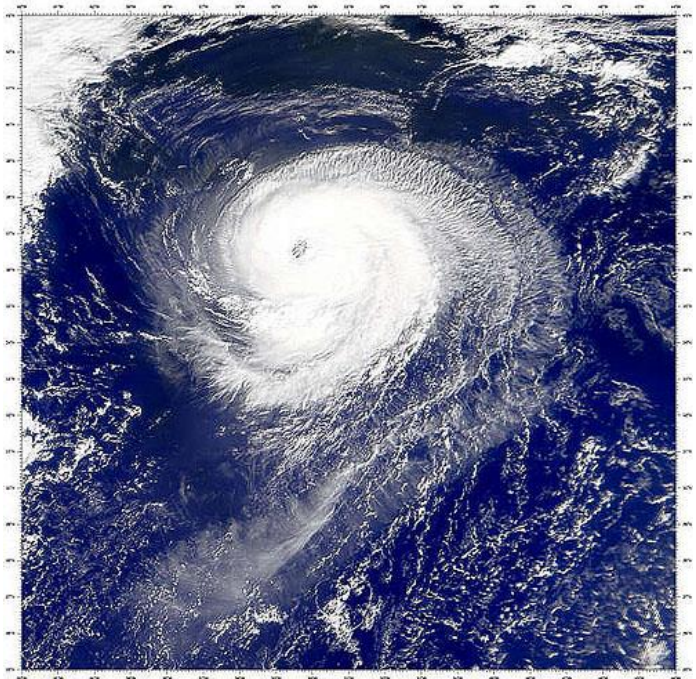
Whether we can predict when disasters will happen or not, there are ways we can prepare for them in areas where they are likely to occur so that we can reduce their negative effects on society.

Scientists are developing technologies that will help us predict catastrophic natural disasters and mitigate their effects.

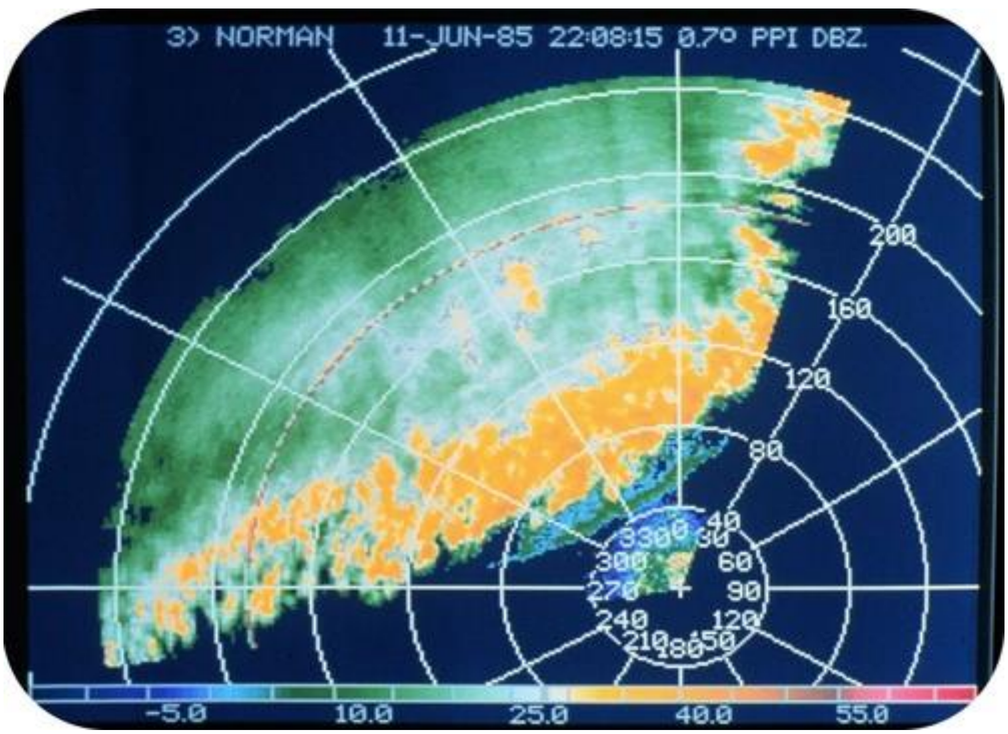


A seismograph is used to measure earthquake activity. Seismometers help us measure the strength of an earthquake while it is happening. They cannot predict an earthquake but by collecting information on earthquakes over time scientists can learn where earthquakes are more likely to happen.





Satellite images can include visual images, infrared heat images or a combination like the images above to track severe weather like hurricanes or ash from volcanic eruptions.




This is a radar image of a line of thunderstorms. Doppler radar bounces radio waves off objects like clouds to determine their location, movement, and intensity.

Many communities that are at risk for natural hazards put warning systems in place to communicate to their residents when a disaster is coming. These can be broadcasted over television, radio and now cell phones, or using sirens like these.

Tsunami buoys are placed far out in oceans to measure ocean waves. When they detect a tsunami approaching they send a warning signal to coastal areas.

Avalanche control. When snow builds up on mountain ridges and is at risk of falling and becoming an avalanche, technicians will clear the area of people and blast the snow with small explosions to trigger avalanches intentionally.

In areas where earthquakes are likely, buildings are now designed with features that will help them withstand the earthquake.

- Skyscrapers and other large structures built on soft ground must be anchored to bedrock, even if it lies hundreds of meters below the ground surface. They are also built to sway with an earthquake wave.
- The correct building materials must be used. Houses should bend and sway. Wood and steel are better than brick, stone, and adobe, which are brittle and will break.
- Large buildings can be placed on rollers so that they move with the ground.
- In a multi-story building, the first story must be well supported.
- Old buildings may be retrofitted to reinforce their structures.

The first floor of this San Francisco building is collapsing after the 1989 Loma Prieta earthquake.

### Cost Considerations

Why aren't all structures in zones at risk for natural disasters constructed for maximum safety? Cost, of course. More sturdy structures are much more expensive to build. So communities must weigh how great the hazard is, what different building strategies cost, and make an informed decision.

## Putting It Together

- How has your understanding changed?
- Can you think of another phenomenon that applies these concepts?
- Explain what is going on based on what you have learned in this section.

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36. Radar view of a line of thunderstorms
37. Al. Siren
38. Al. Siren
39. Photographer: Lesley Urasky, Rawlins HS, Rawlins, WY Credit: NOAA Teacher at Sea Program. Tsunami Warning Buoy being secured for maintenance.
40. Washington State Dept of Transportation. Avalanche control above SR 410 Chinook Pass
41. Building collapsing after the Loma Prieta Earthquake

# Student Notes

# Utah Science with Engineering Education Standards