8th Grade Science

for Utah SEEd Standards

Utah State Board of Education

2019-2020

8^{th} Grade

for Utah SEEd Standards

Utah State Board of Education OER
2019-2020

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Students as Scientists

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?

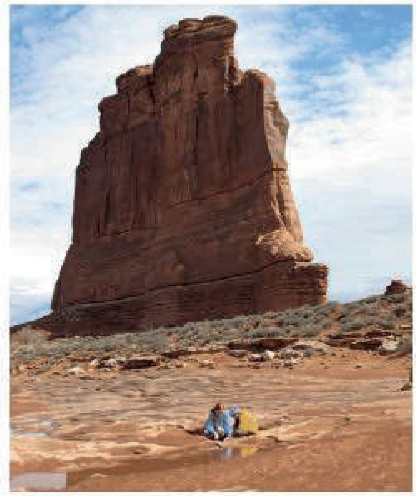
Often when we ask people to imagine this, they draw or describe people with lab coats, people with crazy hair, beakers and flasks of weird looking liquids that are bubbling and frothing. Maybe there's even an explosion. Let's be honest: Some scientists do look like this, or they look like other stereotypes: 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 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 certain stereotype. 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, through painting, religion, music, culture, poetry, and, 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 then you're already thinking with a scientific mind. Of course you are; you're human, after all.

But here is where we really have to be clear. Science isn't just questions and 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?

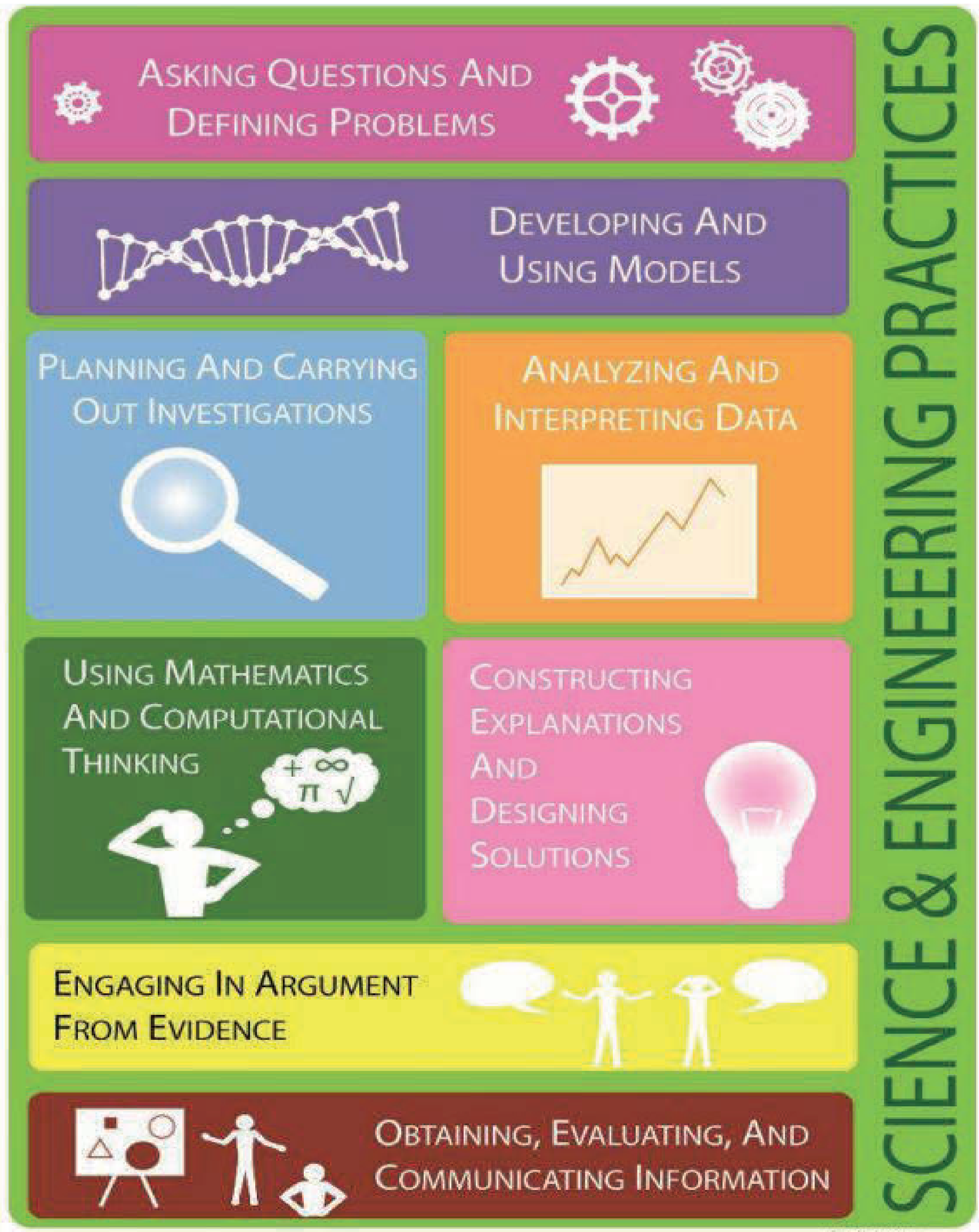
Look. There's a puddle. How often is there a puddle in the desert? The sand is wet and fine; and it makes swirling, layered patterns on the solid stone. There are pits and pockets in the rock, like the one that these two scientists are sitting in, and the gritty sand and the cold water accumulate there. 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

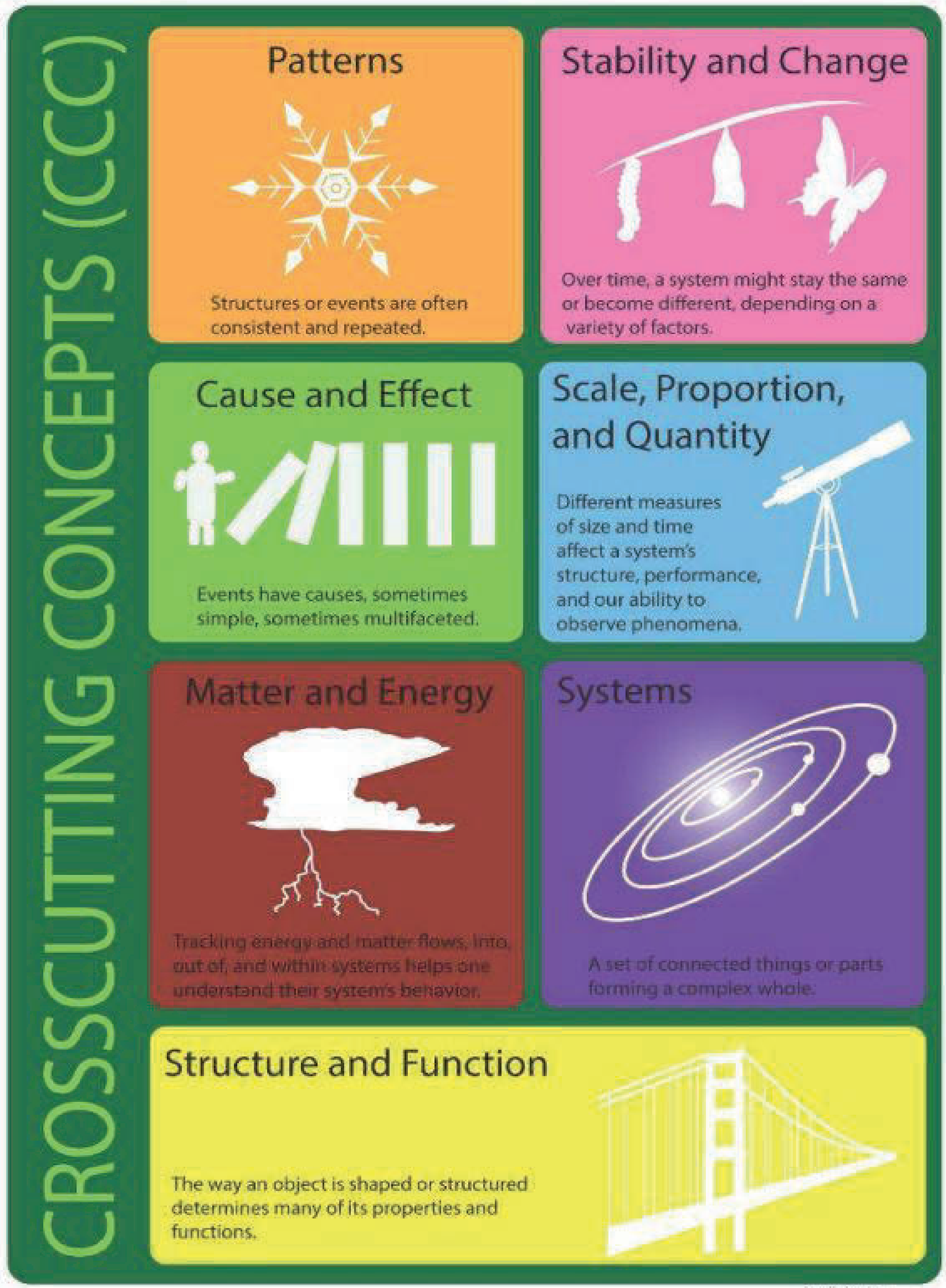
Science and Engineering Practices

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.



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 8th Grade Science Standards. 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: http://go.uen.org/b62

CHAPTER 1

Strand 1: Matter and Energy

Chapter Outline

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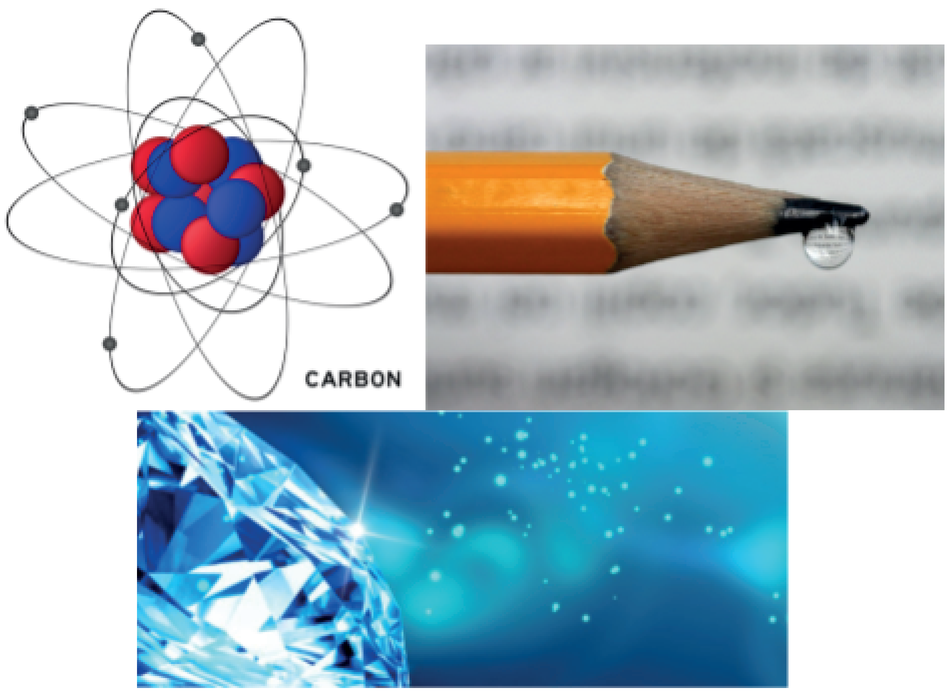
The physical world is made of atoms and molecules. Even large objects can be viewed as a combination of small particles. Energy causes particles to move and interact physically or chemically. Those interactions create a variety of substances. As molecules undergo a chemical or physical change, the number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

1.1 Atoms and Molecules (8.1.1)

Explore this Phenomenon



Pixabay, CC0

1. What do these three things have in common??

2. What are some similarities and differences in the objects?

3. Are these items made of atoms or molecules?

4. What are the similarities and differences between atoms and molecules?

1.1 Atoms and Molecules (8.1.1)

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.

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.

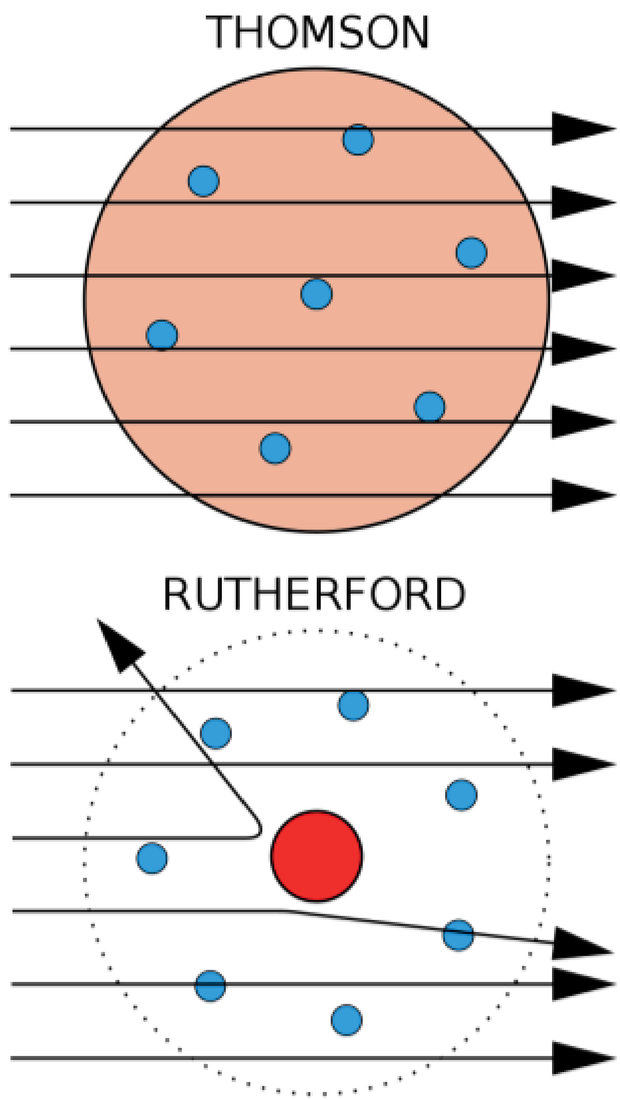
What Are Atoms?

What do you, stars, and a speck of dust have in common? What do a carbon atom, a diamond, and a pencil have in common? The answer is that everything is 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.
- 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.



(Public Domain)

- 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. There are three main types of particles that make up all atoms and they are as follows.

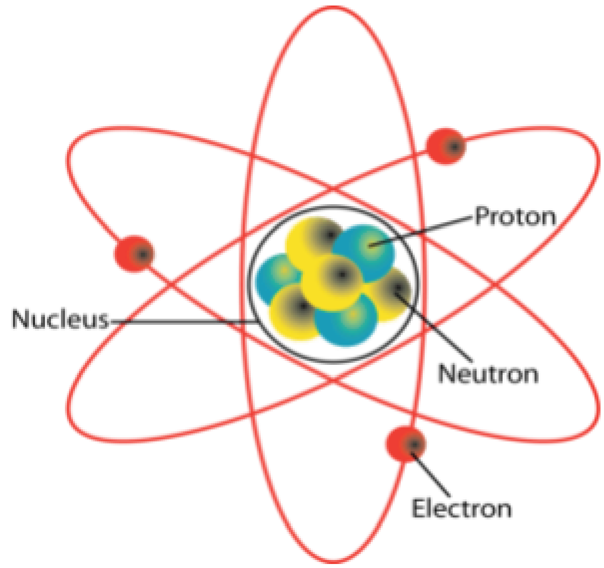
At the center of an atom is a nucleus made up of two types of particles called protons and neutrons.

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.

For a fun way to learn about a remember atomic particles, watch this video! Mr Parr Song on Atomic Particles:



Ck12.org, CC BY-SA

https://www.youtube.com/watch?v=Qfcmzxhga-U

The model in the previous 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.”

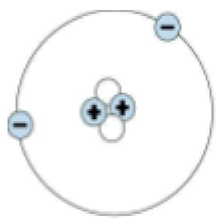
Using our knowledge of an atom, what is accurate and inaccurate about the model shown? The model is very useful in showing us the parts of the atom and their approximate locations. What it fails at is to show the correct scale of atom. For example, the nucleus of an atom is one trillionth the size of the whole atom. The rest of the atom is mostly empty space. Although this model is not completely accurate 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 video link to understand the relative size of the atom and nucleus. http://go.uen.org/aZc

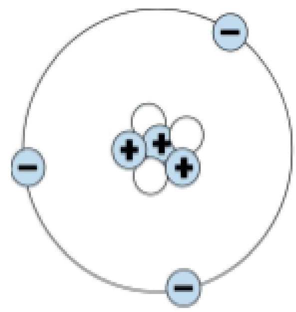
For a virtual lab on building an atom go to:
https://phet.colorado.edu/en/simulation/build-an-atom

Elements

In ancient times, people thought the elements were fire, earth, water, and air, but we now have a much better understanding of elements. Think back again to you and a speck of dust. 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 next figures. A helium atom has two protons, whereas a lithium atom has three protons. Go to the following link for a video to further learn about what elements are. http://go.uen.org/aZd



Helium Atom

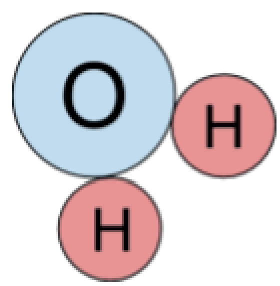


Lithium Atom

CC0

Molecules

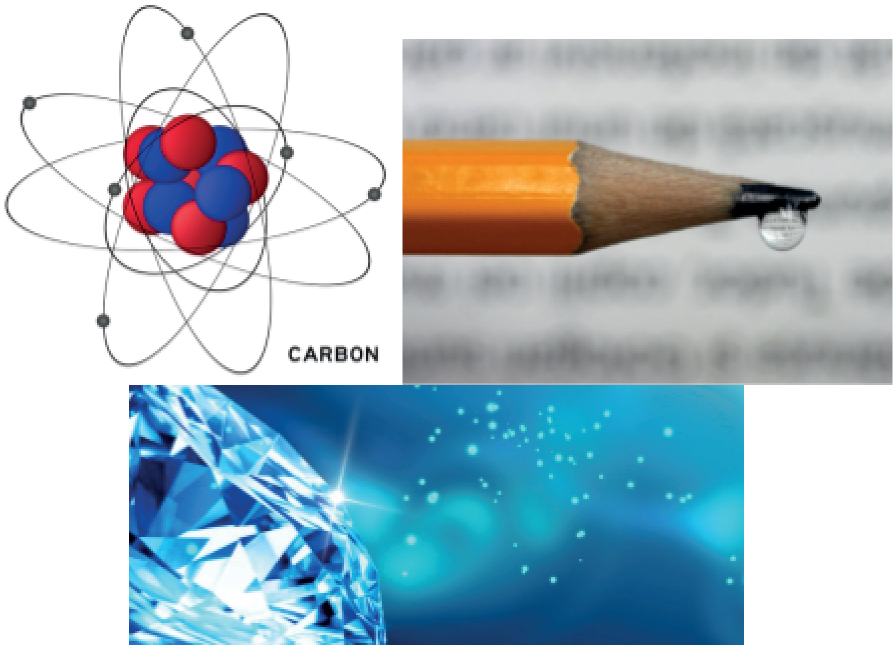
There are only 118 known elements, but there are millions of different substances in our everyday lives. How do we get the millions of substances from just 118 elements? When two or more atoms combine, it makes a molecule. Molecules make up the millions of things our universe is made of. One of the most common molecules we have on Earth is water. It is made of two atoms of hydrogen (H) and one atom of oxygen (O).



A model of a water molecule.
(CC0)

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 of sodium and one atom of chlorine (NaCl) and sugar ($C_6H_{12}O_6$) which is made of six carbons, twelve hydrogens, and six oxygens.

Putting It Together



Pixabay, CC0

Using your knowledge of atoms and molecules, see how your answers have changed.

1. What do these three things have in common?

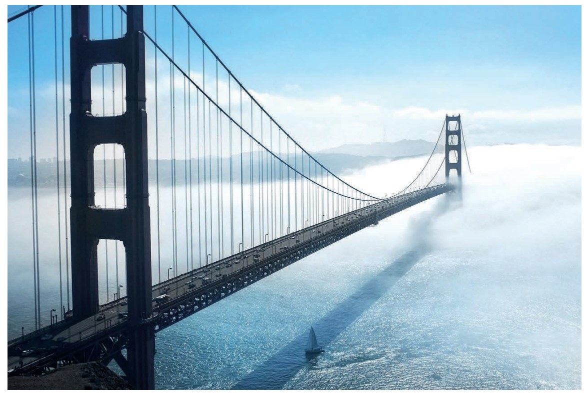
2. What are some similarities and differences in the objects?

3. Are these items made of atoms of molecules?

4. What are the similarities and differences between atoms and molecules?

1.2 Properties of Matter (8.1.2)

Explore this Phenomenon



These objects are made of two different materials, plastic and steel.

1. What are some observation you can make about these two materials?
2. What is similar between them?
3. What is different between them?
4. What can each item be used for?
5. What questions could you ask about why these substances are used for different things?

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.

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.

What is Matter?

Legos, 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. Properties are separated into two different categories. Properties are classified as either chemical properties or physical properties. If you were to describe an object to someone who cannot see or feel the object you would describe the object's properties. Below is a list of some properties you could use to describe matter.

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- 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.

(Public Domain)

Image adapted from
https://www.flickr.com/photos/ilmungo/60154176/,
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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. This is a chemical reaction and so makes new substances like ash, carbon dioxide, and water.

- 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.

The iron in these steel chains has started to rust.
https://pixabay.com/photos/chain-chains-iron-hard-metal-link-109302/, CC0

- Malleability: The ability of a solid to bend or be hammered into other shapes without breaking.
- Other properties include color, odor, shape, etc.

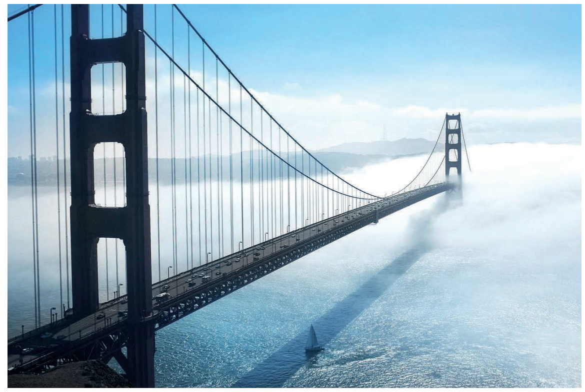
Properties Determine Function

A substance's properties determine its function. A function is the purpose for which something is designed. We can think of function what or how we use something. 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.

DSC_1632 by S.S.K.,https://flic.kr/p/HU8Dh CC BY-NC-ND

You are my Sunshine by Mark Somma.,https://flic.kr/p/HU8Dh CC BY

Putting It Together

Pixabay, CC0

1. Explain how your understanding of the properties of matter has changed.

2. Think of another phenomenon that applies the concept of properties.

3. Explain why there are different uses for these substances based on what you have learned in this section.

1.3 Chemical Reactions (8.1.3)

Explore this Phenomenon

(Pixabay, CC0)

The photo shows a piece of iron that has been outside in the weather and has “rusted”

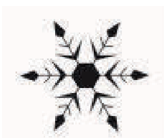
1. What do you observe about the iron’s appearance?

2. How has the piece of iron changed over time?

3. 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 next 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, the gas that fills the bubbles. It's the same gas that gives soft drinks their fizz and that we exhale during breathing..

This girl is pouring vinegar on baking soda. This causes a bubbling "volcano."
(ck12.org, CC BY-SA)

Not all reactions are as dramatic as this "volcano." Some are slower and less obvious. The following video shows examples of chemical reactions. http://go.uen.org/aZq

These chemical reactions all result in the formation of new substances with different properties.
(ck12.org, CC BY-SA)

Signs of Chemical Reaction

How can you tell whether a chemical reaction has occurred? Often, there are clues. Several are demonstrated in the following video http://go.uen.org/aZw (9:57)

To decide whether a chemical reaction has occurred, look for these clues or 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)
- A new odor is produced. (Example: Logs burn and smell smoky.)
- A solid comes out of a solution. This is called the formation of a precipitate. (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 may have 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. The only way to be positive that a chemical reaction has occurred is to know if a new substance has formed.

Reversing Chemical Reactions

Because chemical reactions produce new substances, they often cannot be undone. For example, you can't change a fried egg back to a raw egg. Some chemical reactions 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.

Your cell phone battery provides energy to your cell phone but goes down after a while and needs to be recharged. When you plug it in, it causes the chemical reaction in the battery to reverse so it is then available, once again, to power your phone.

Cooking and Chemistry

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 reactions in the ingredients that result in a new product: bread.

To practice and learn more about chemical reactions, go to this virtual lab: https://phet.colorado.edu/en/simulation/reactants-products-and-leftovers

Putting It Together

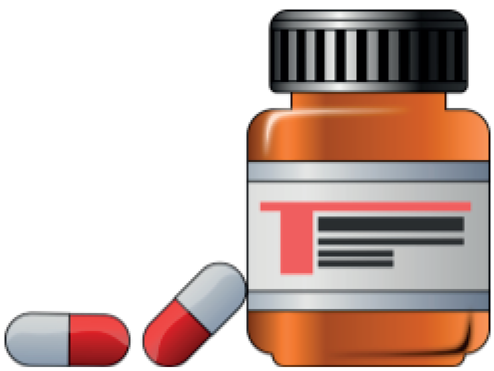
1. Explain your understanding of what is happening to this pipe. How has it changed over time?

2. Think of another phenomenon that applies the concept of the signs of chemical reactions.

3. Explain what is happening to the pipe based on what you have learned in this section.

1.4 Natural vs Synthetic Materials (8.1.4)

Explore this Phenomenon



(Public domain)

(*Digitalis purpurea* by Jcart1534, CC BY-SA)

1. What observations can you make about how do you think the flower and the medicine are related?

2. How are the flower and the medicine different?

3. 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.

(CC0)

(*Diamond Ring* by Jeffrey Beall, https://www.flickr.com/photos/denverjeffrey/8477836008 CC BY-SA)

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 are made of the exact same thing and have the exact 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.In

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 insulin. These people have a condition known as diabetes. Scientists used to get insulin from pigs however it took huge numbers of pigs to make the needed insulin. Scientists have now developed a way to make insulin in the lab synthetically. 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.

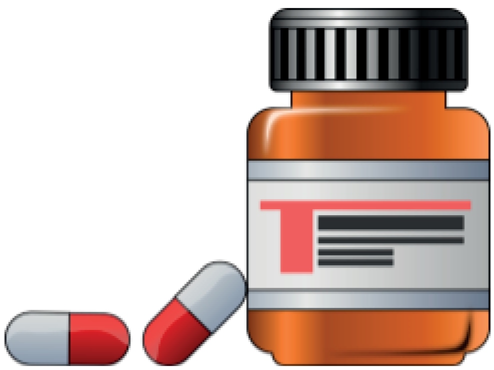
Examples of Synthetic Materials that come from Natural Resources

Revisit the flower and medicine phenomenon. The Foxglove flower, though poisonous if eaten fresh, contains chemicals that are beneficial to society. A medicine can be made from the Foxglove flower that is used to treat heart failure. It increases the force of heart contractions which improves blood flow and and gives the heart more rest time between beats. This medicine 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). Watch the video From DNA to Silly Putty http://go.uen.org/aYT 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 video link http://go.uen.org/aYW and think more about the problems associated with plastic.

Clothing is yet another great example of a synthetic material we use everyday 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 woven into cloth and cotton is grown as a plant. Human-made fabrics include nylon and polyester. These materials are made from petroleum products. Synthetic fabrics are also used in shoes, rain gear, 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. To find out about the properties of different natural and synthetic fabrics, go to this website link: http://go.uen.org/aZH

Putting It Together



(Public domain)

(*Digitalis purpurea* by Jcart1534, CC BY-SA)

1. Explain your understanding of synthetic vs natural substances.

2. Think of another phenomenon that applies natural and synthetic substances.

3. Explain what the connection is between the flower and the medicine based on what you have learned in this section.

1.5 States of Matter (8.1.5)

Explore this Phenomenon

CC0

(*Steaming Teapot* by Indigo Skies Photography, https://www.flickr.com/photos/indigoskies/6785798209 CC BY-SA-ND)

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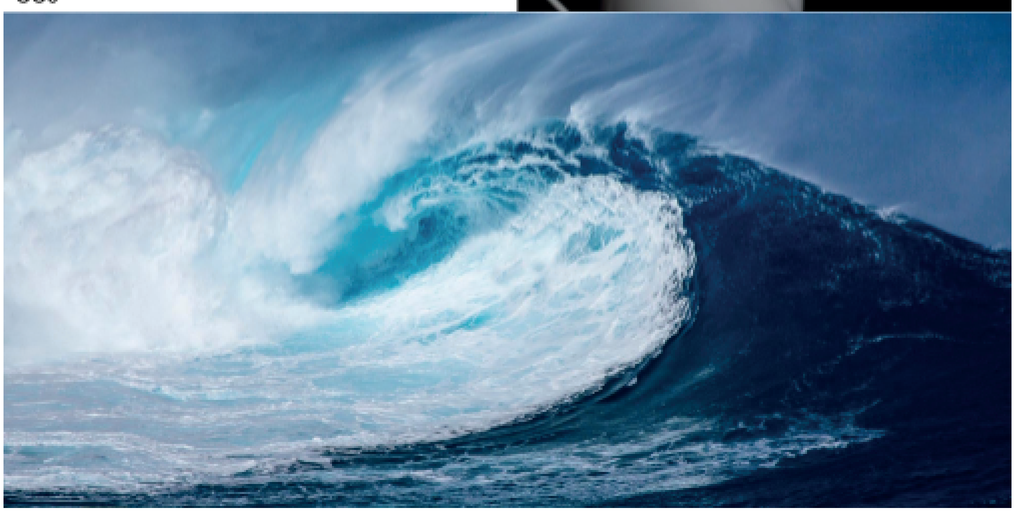


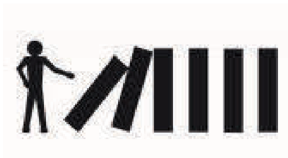
1. What observations can you make about the pictures and how the pictures are connected?

2. What questions can you ask about these different pictures?

3. How can you explain the differences in the pictures?

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.



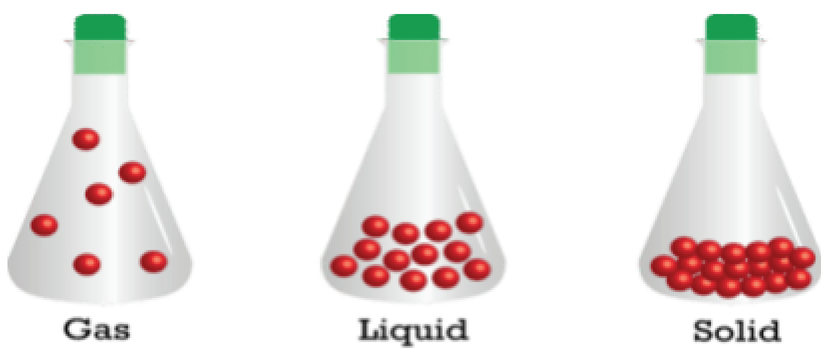
In this section, focus on cause and effect. Observe the effect that adding or removing heat causes on the particle motion, density, and state of pure substances.

Matter and Its States

Matter typically exists in one of three states: solid, liquid, or gas. The state of matter 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 the states of matter. Solids have a definite shape (rigid), 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 up to the limit of the volume), though they do 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 density of the molecules is 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.

Ck12.org, CC BY-SA

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 heat 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 or Removing 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. These effects can be seen also when energy is removed but the effects go in the opposite direction. When energy is removed particle motion decreases and the space between particles decreases. When energy is added or removed the motion of particles and distance between particles changes, but the particles themselves do not change.

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 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 more dense than a volleyball. Although both balls are similar in size, the bowling ball feels much heavier than the volleyball.
(ck12.org, CC BY-SA)

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:

$$Density = \frac{mass}{volume}$$

For example, a book with a mass of 500 g and a volume of 1000 cm^3, the density would be calculated as follows:

$$Density = \frac{500g}{1000\ cm^3} = 0.5g/cm^3$$

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

A: The density of the liquid is: Density=300 g/30 mL=10 g/mL

For information on how to calculate the density of a gas, go to the following video link. http://go.uen.org/aZg

To practice and learn more about phase changes, adding or removing energy and figuring out density, go to this digital lab link: http://go.uen.org/b03

Putting It Together

CC0

(Steaming Teapot by Indigo Skies Photography, https://www.flickr.com/photos/indigoskies/6785798209 CC BY-SA-ND)

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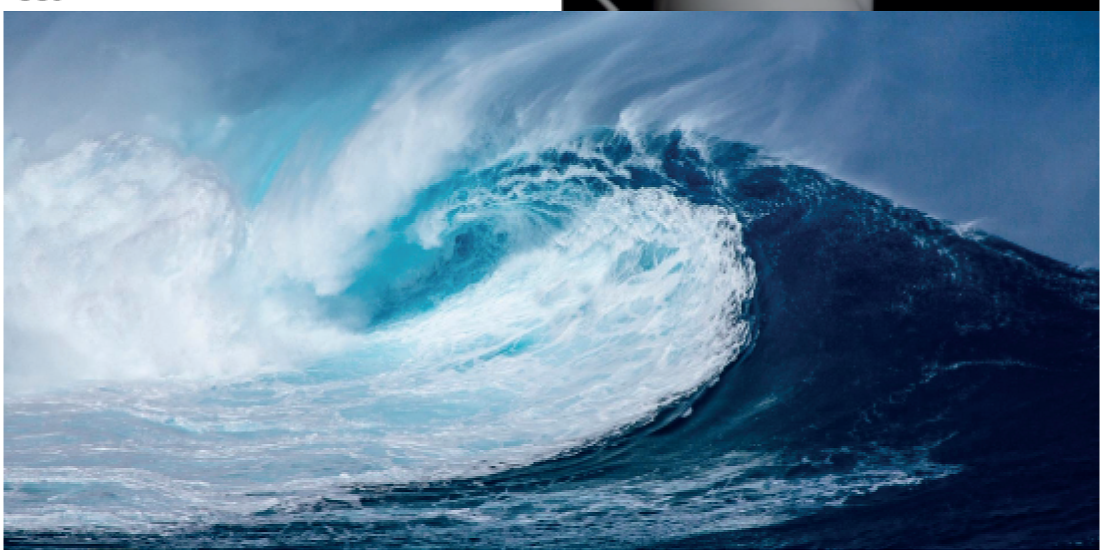


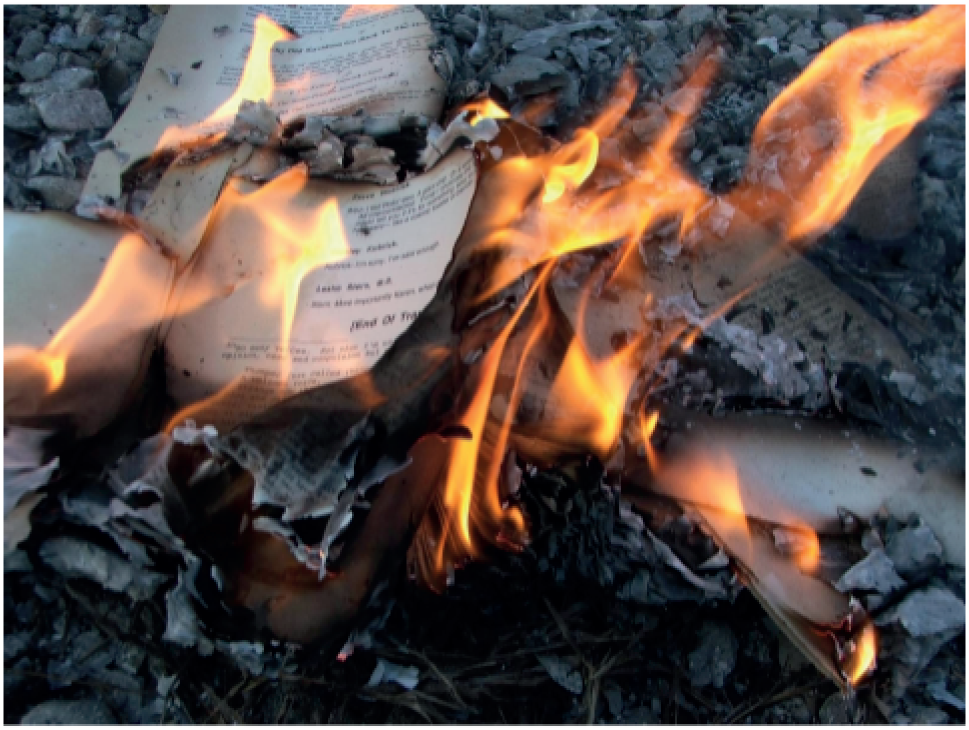
1. Explain how your understanding of what these pictures show has changed.

2. Think of another phenomenon that applies to phase changes.

3. Explain what is going on in the pictures based on what you have learned in this section.

1.6 Conservation of Matter (8.1.6)

Explore this Phenomenon



(*The House of Leaves - Burning 4* by Learning Lark,
https://www.flickr.com/photos/44282411@N04/4141069138

1. What observation can you make about what you already know is happening in this photo?

2. What questions can you ask?

3. 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.

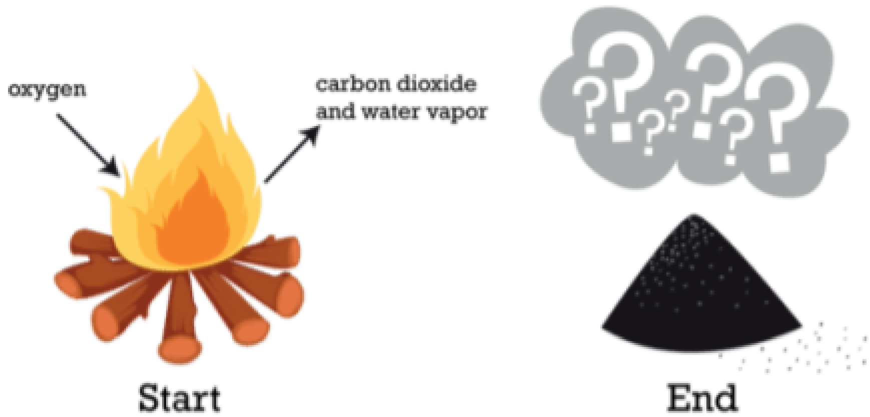
In this section, focus on matter. Observe how matter is conserved; the total number of atoms does not change in a chemical reaction.

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. This is similar to the idea of conservation of mass.

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.

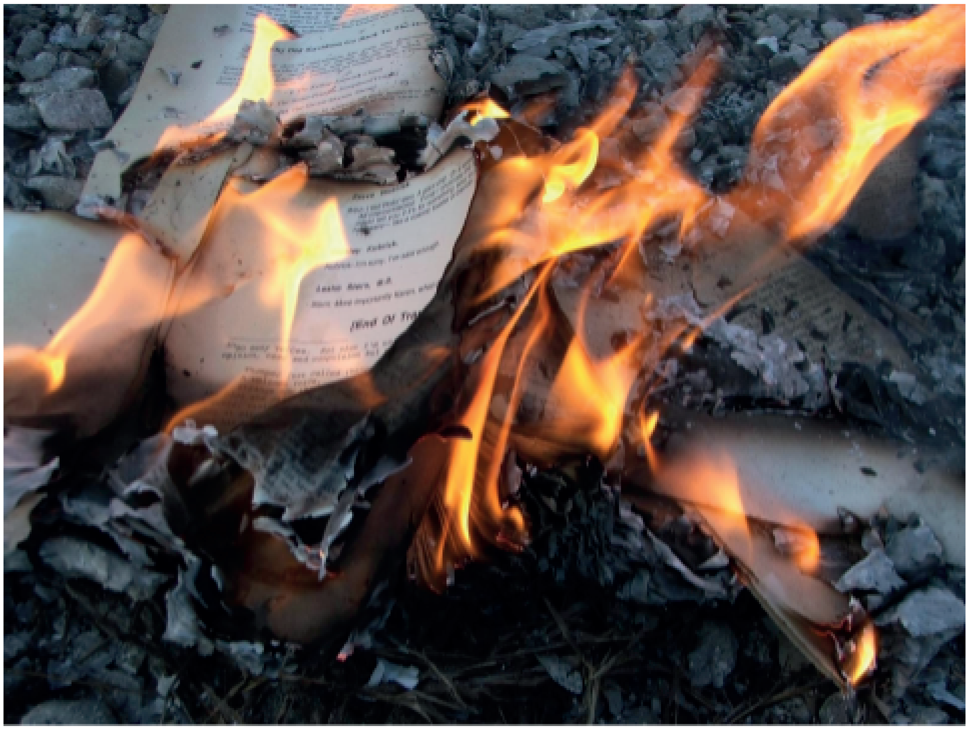


Burning is a chemical process. Is mass destroyed when wood burns?
(ck12.org, CC BY-SA)

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. If matter cannot be created or destroyed, then the matter can only change in some way. 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.

Putting It Together



(*The House of Leaves - Burning 4* by Learning Lark, https://www.flickr.com/photos/44282411@N04/4141069138 CC-BY)

1. Explain how your understanding of conservation of mass has changed.

2. Think of another phenomenon that applies to the concept of conservation of mass.

3. Explain what is going in the picture on based on what you have learned in this section.

1.7 Devices Affecting Phase Change (8.1.7)

Explore this Phenomenon

(Pixabay, CC0)

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 winter. Propose some ideas that will prevent the water in the pipes in your cabin from boiling and freezing.

1. What do you already know that would help in this situation?
2. What do you already know about phase changes in water?
3. What questions can you ask to help explore the situation?
4. How would go about meeting the challenge?

8.1.7: Designing a Device to Affect 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.

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?

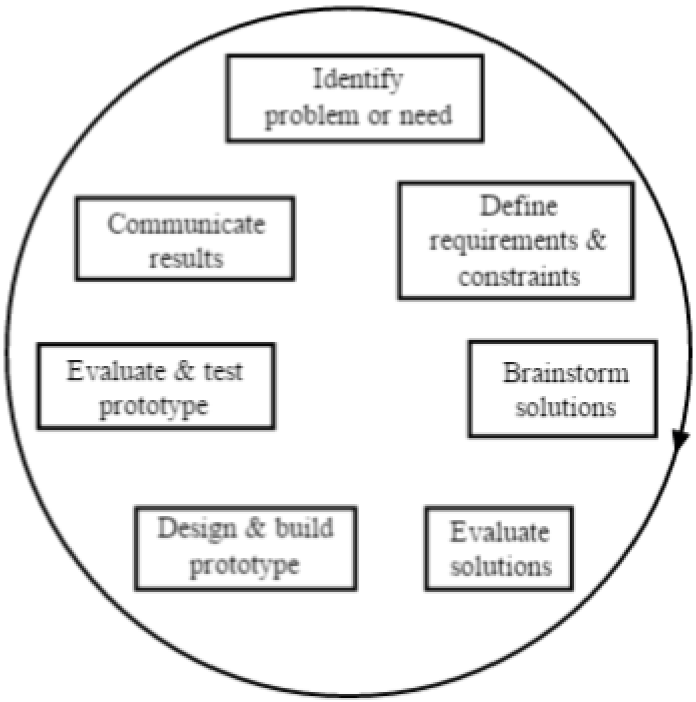
The process used to create and perfect devices is called the engineering design process. This is the way most new technologies are developed. Engineering design is similar to scientific investigation. Both processes rely on evidence and reason and follow a logical sequence of steps to solve problems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



(*Engineering Design Process* by Steve Krause, https://commons.wikimedia.org/wiki/File:Engineering_design_process.svg, CC BY-SA)

Consider the problem of developing something to prevent your pipes from freezing. Many questions would have to be researched in the design process. For example, what is the best type of insulators, what temperature does water boil and freeze at, what insulators are cheap and easy to work with? What are the constraints on the project? Is there a budget limit? Does it have a maximum size or weight that the pipes can hold?

After researching the answers, possible designs are developed. This generally takes imagination as well as reasoning based on what you found out during research. 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.

After testing your model, you will probably need to modify it and retest it until you reach a design that satisfies the need and fits within the constraints. At this point you would share the device you have created with others for production or as a solution to the problem.

In order to engineer a solution to our problem with the pipes in the cabin you should know the difference between thermal conductors and thermal insulators. The following information will give you a brief breakdown of information that could be useful to you.

Thermal Conductors

Conduction is the transfer of thermal energy between particles of matter that are touching. Thermal conduction occurs when particles of warmer matter bump into particles of cooler matter and transfer some of their thermal energy to the cooler particles. Conduction is usually faster in certain solids and liquids than in gases. Materials that are good conductors of thermal energy are called thermal conductors. Metals are especially good thermal conductors because they have freely moving electrons that can transfer thermal energy quickly and easily.

Thermal Insulators

One way to retain your own thermal energy on a cold day is to wear clothes that trap air. That’s because air, like other gases, is a poor conductor of thermal energy. The particles of gases are relatively far apart, so they don’t bump into each other or into other things as often as the more closely spaced particles of liquids or solids. Therefore, particles of gases have fewer opportunities to transfer thermal energy. Materials that are poor thermal conductors are called thermal insulators. Down-filled snowsuits, like those in the next image, are good thermal insulators because their feather filling traps a lot of air.

Another example of a thermal insulator is pictured in the next picture. The picture shows fluffy pink insulation inside the attic of a home. Like the down filling in a snowsuit, the insulation traps a lot of air. The insulation helps to prevent the transfer of thermal energy into the house on hot days and out of the house on cold days. Other materials that are thermal insulators include plastic and wood. That's why pot handles and cooking utensils are often made of these materials. Notice that the outside of a toaster is made of plastic. The plastic casing helps prevent the transfer of thermal energy from the heating element inside to the outer surface of the toaster where it could cause burns.

Putting It Together

(Pixabay, CC0)

1. Explain how your ideas of how you could redesign this cabin have changed.

2. Think of another phenomenon that applies transfer of heat.

3. Explain what causes insulation to be necessary based on what you have learned in this section.

CHAPTER 2

Strand 2: Storing and Transferring Energy

Chapter Outline

(*Roller Coaster* by SouthEastern Star, https://www.flickr.com/photos/southeasternstar/8243458741, CC BY-NC-ND)

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 speed. Energy can travel in waves and may be harnessed to transmit information.

2.1 Energy Speed and Mass (8.2.1)

Explore this Phenomenon

(CC0)

These two trucks run into an empty building. One truck causes more damage to the building than the other.

1. What observations can you make about the trucks?

2. What questions can you ask to determine why one truck causes more damage than the other?

3. How would you explain why one truck causes more damage than the other?

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.

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 you should be very familiar with 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. (image from ck12.org)

Factors Affecting Kinetic Energy

An object's kinetic energy depends on two things, its mass and speed. The greater the mass, more kinetic energy the object has. Speed, which is how fast an object is moving (meters/second), also influences kinetic energy. The greater the speed, 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 due to its mass, the large dump truck or the smaller truck? How would speed affect the truck's kinetic energy?

Kinetic energy can be calculated by using the formula $KE = \frac{1}{2}(mv^2)$. This formula is read as kinetic energy equals one half of the mass times square of the speed.

If we take a closer look at the formula you will be able to see why changes in speed have more of an impact on kinetic energy than changes in mass. Use the space below to explain this phenomenon in your own words.

Putting It Together


(Pixabay, CC0)(Public Domain)

1. Explain how your understanding of kinetic energy has changed.

2. Think of another phenomenon that applies to how mass & speed affect kinetic energy.

3. Explain what the difference in kinetic energy will be for these two trucks based on what you have learned in this section.

2.2 Potential Energy (8.2.2)

Explore this Phenomenon

1. What observations can you make about the climbers in the photo?

2. What questions could you ask to help you explore the amount of energy each one has?

(leader belays the second on Illusion Dweller in Joshua Tree National Park, United States by Jarek Tuszynski, https://en.wikipedia.org/wiki/Rock_climbing#/media/File:Joshua_Tree_-_Illusion_Dweller_10.jpg CC BY-SA)

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. Objects have potential energy because of their position or shape. 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.

(Diving Board 2 by Claire Gillman, https://flic.kr/p/7BbfbV, CC BY)

Gravitational potential

Image by Squeeze from Pixabay, CC0

Potential. If an object has gravitational potential it can fall. Like a diver on a diving board or the skydiver from a plane, anything that is above Earth's surface has the potential to fall because of gravity. The amount of gravitational potential energy an object has depends on the object's mass and its distance above the ground. Between the two previous pictures the skydiver is higher above the earth and so has the greatest gravitational potential energy.

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

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

Elastic Potential

An object's shape can also give it potential energy if when let go it tries to return to its original shape. This kind of potential energy is known as elastic potential. 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.

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. It also required more kinetic energy from you to pull it out farther.

Can you think of other examples of how varying distances change the amount of potential energy involved?

Top of Shambhala, by Jordi Paya
https://flic.kr/p/ch7rqb CC BY-SA

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

Where would it have the least?

How is distance related to the amount of energy?

Putting It Together

1. Explain how your new understanding of potential energy helps explain the amount of energy of the people in this picture.

(leader belays the second on Illusion Dweller in Joshua Tree National Park, United States by Jarek Tuszynski, https://en.wikipedia.org/wiki/Rock_climbing#/media/File:Joshua_Tree_-_Illusion_Dweller_10.jpg CC BY-SA)

2. Think of another phenomenon that applies to potential energy.

3. Explain how potential energy and distance is involved in what the climbers are doing in this picture.

2.3 Energy Transfer (8.2.3)

Explore this Phenomenon

Public Domain,
https://pxhere.com/en/photo/495963

As the boy skates down the ramp, he goes faster, when he skates up the ramp he goes slower.

1. What observations can you make about the skater?
2. What questions can you ask about the skater’s energy?
3. How can you explain what happens to the skater’s kinetic energy?

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.

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

Remember back to the Law of Conservation of Mass that states that matter cannot be created or destroyed. There is a similar law for energy. The Law of Conservation of Energy states that energy cannot be created or destroyed only transformed from one form into another or transferred from one object to another. One of the most common energy transformations 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 the potential energy is released then the object will move and change the potential energy back to kinetic energy.

To investigate how potential and kinetic energy are related in a roller coaster simulator, visit http://go.uen.org/b0tl

Pixabay.com, CC0

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

How could the man regain her potential energy? He 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 his position on the stairs as she climbed. By the time he got to the top of the slide, he 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 transformed to heat energy which is why your hands feel warm. On a normal slide, friction would help convert some of the girl’s kinetic energy to heat energy. As her kinetic energy decreased, she would slow down. Since this is a water slide the water reduces friction, her kinetic energy won’t be converted to heat as much and she can get going much faster.

Putting It Together

Public Domain,
https://pxhere.com/en/photo/495963

1. Explain how your understanding of the energy transfer has changed.

2. Think of another phenomenon that applies to transfer of energy.

3. Explain what happens to the skater’s energy as he skates up and down the hills in the skate park.

4. If the skater dragged his foot on the ground as he skates down the ramp, what will happen to his speed?

5. What would happen to his kinetic energy if he did this?

6. What evidence can you use to support your answer?

2.4 Waves (8.2.4)

Pixabay.com, CC0

When you drop a rock in water, waves form on the surface of the water.

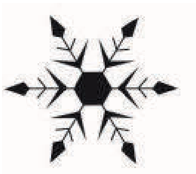
1. What observations can you describe about the waves created by the rock?

2. What questions can you ask that would help explain why this happens?

3. How would 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.



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 everywhere, but what exactly is a wave? Waves have characteristics, properties, and behaviors that can be used to make observations and predictions about what waves can and cannot do. Identifying wave models allows us to understand wave characteristics, properties, and behavior.

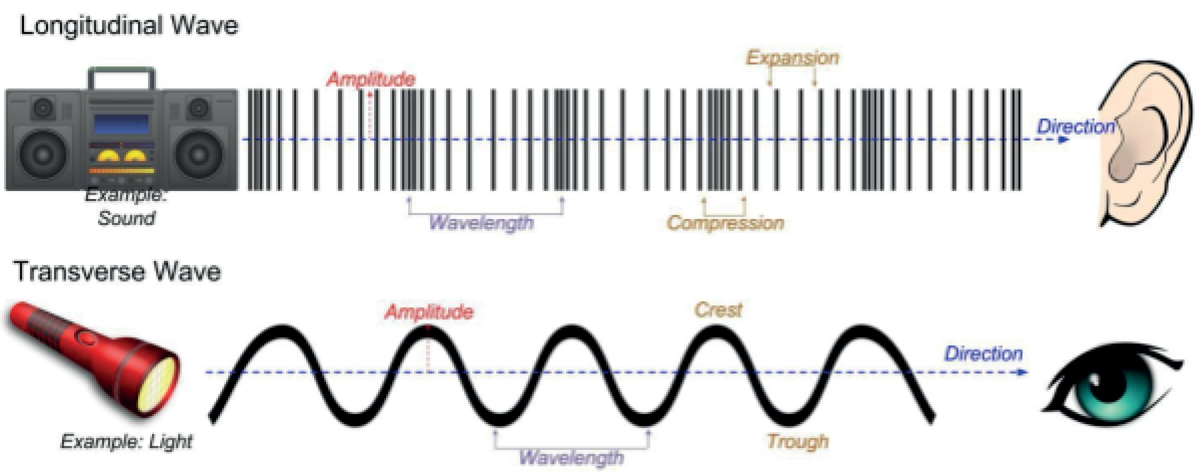
Waves are regular patterns of motion. They transfer energy as they move through various materials like wood, water and even air. The material they transfer energy through is called the medium. Waves do not carry or transfer matter but they do transfer energy from one place to another. When a rock hits 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 the same distance the wave moves.

Pixabay.com, CC0

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 model that represents both the amplitude and the wavelength of a wave.



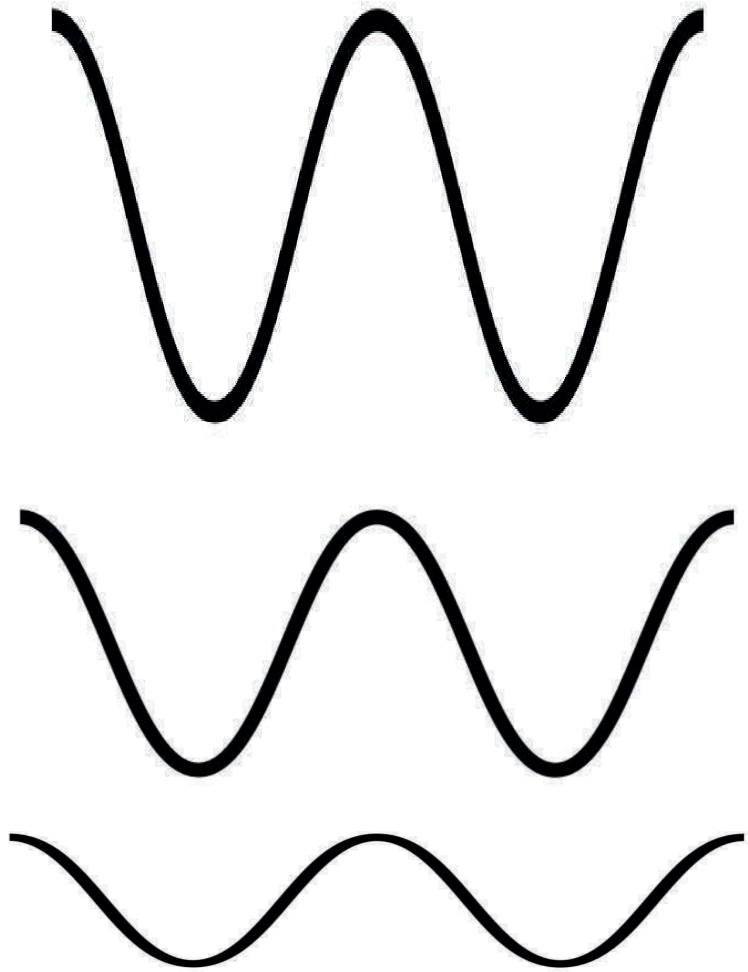
Tracy Poulsen, CC0

Energy and Amplitude

A wave that is transferring more energy will have a larger amplitude than a wave that is transferring less energy. A sound wave with higher amplitude is transferring more energy and will sound louder than a sound wave with lower amplitude.

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 higher amplitude waves and would have a greater amount of energy than the waves caused by the smaller pebble.

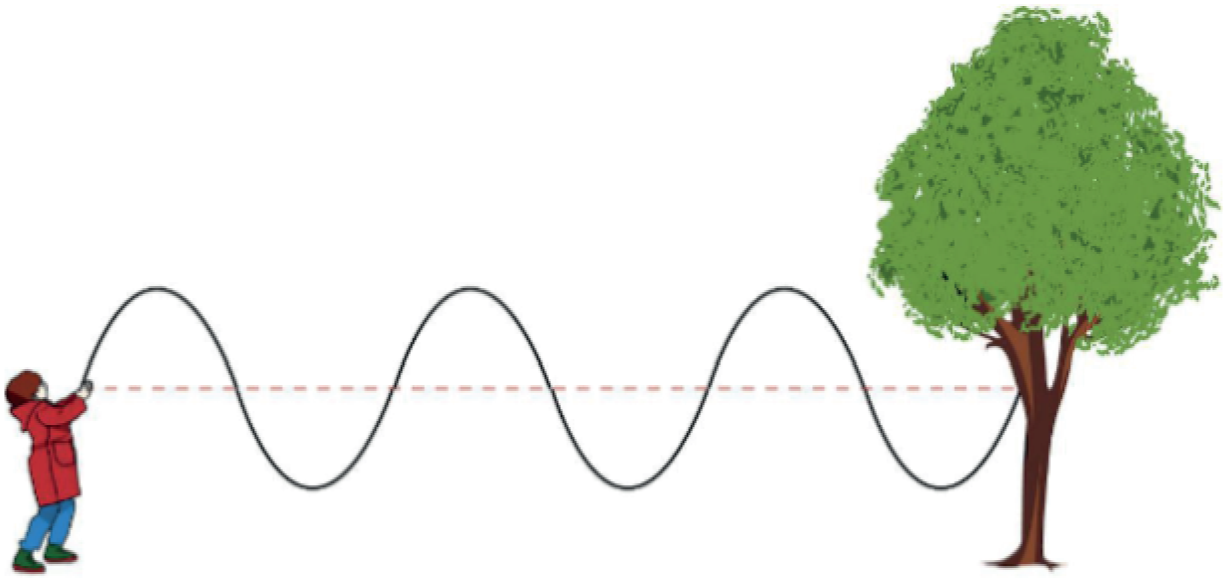
Below are three different sketches of waves. What do you notice that is similar and different about each of the waves in the sketches?



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 investigate how the amplitude of a wave is related to the energy in the wave. The student tied a rope to a tree and then moved the rope up and down at two different heights.



Ck12.org, CC BY-SA

The student found out that the higher you move the rope up and down, the more energy it required, therefore higher amplitude requires more energy.

To investigate how amplitude is related to the energy in a wave, visit the following digital wave simulator. http://go.uen.org/b12

Putting It Together

Pixabay.com, CC0

1. Explain how your understanding of the waves has changed.

2. Think of another phenomenon that applies to the concept of waves.

3. Explain what is going on with the ripples based on what you have learned in this section.

2.5 Waves and Mediums (8.2.5)

Explore this Phenomenon

Rainbow by Ivan,
https://flic.kr/p/apd4Er, CC BY-SA

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

1. What do you already know about light waves and prisms?

2. How do you explain what is happening to the light waves?

3. What questions can you ask about this phenomenon?

8.2.5 Waves and Mediums

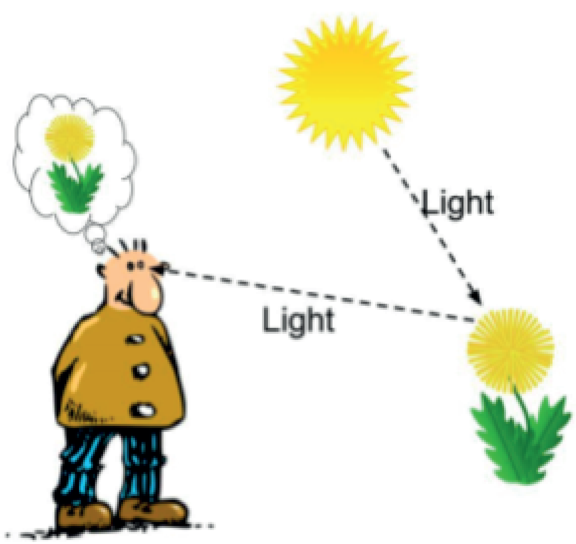
Develop and use a model to describe the structure of waves and how they are reflected, absorbed, or transmitted through various materials. Emphasize both light and mechanical waves. Examples could include drawings, simulations, and written descriptions of light waves through a prism; mechanical waves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

Waves

There are many different types of waves. 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



CC0

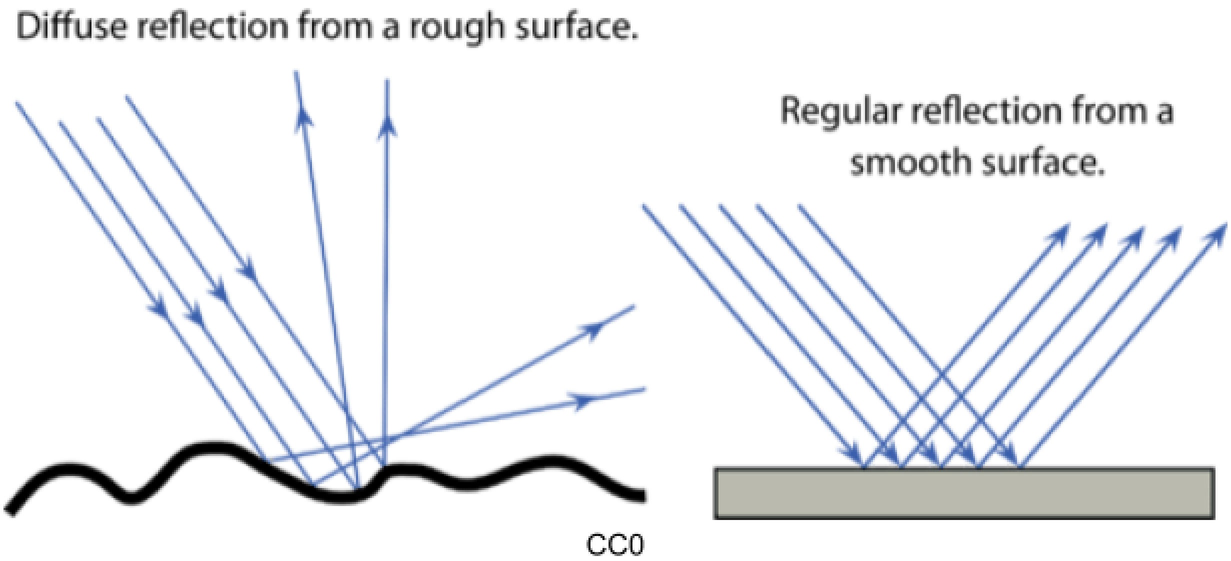
Light waves are a type of wave that help us see. Light waves transfer energy. To understand how light waves help us see, look at the illustration.

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

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 reflect off the objects around you. Which shows your eyes are useless without light.

Reflection of Waves

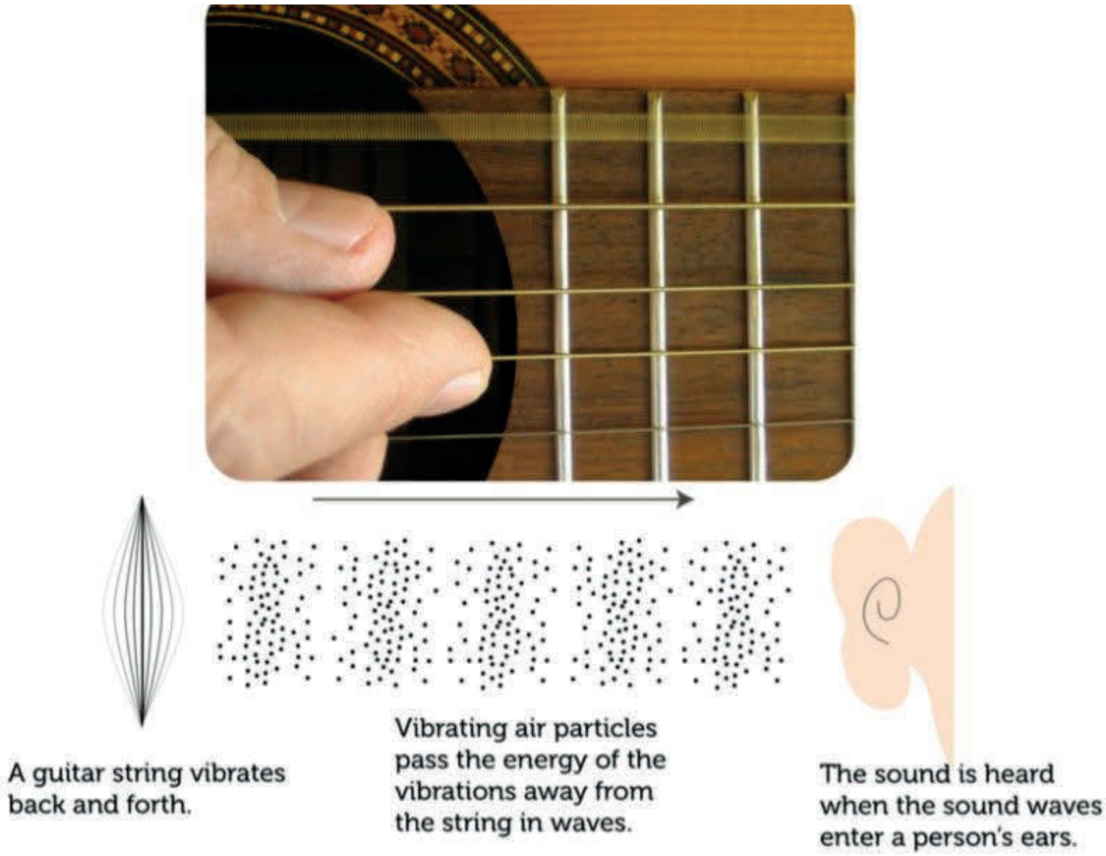
When a light ray strikes a reflecting surface the light ray is bounced back in a different direction (reflected). Sound waves can also be reflected. Echoes are an example of reflecting sound waves.



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.

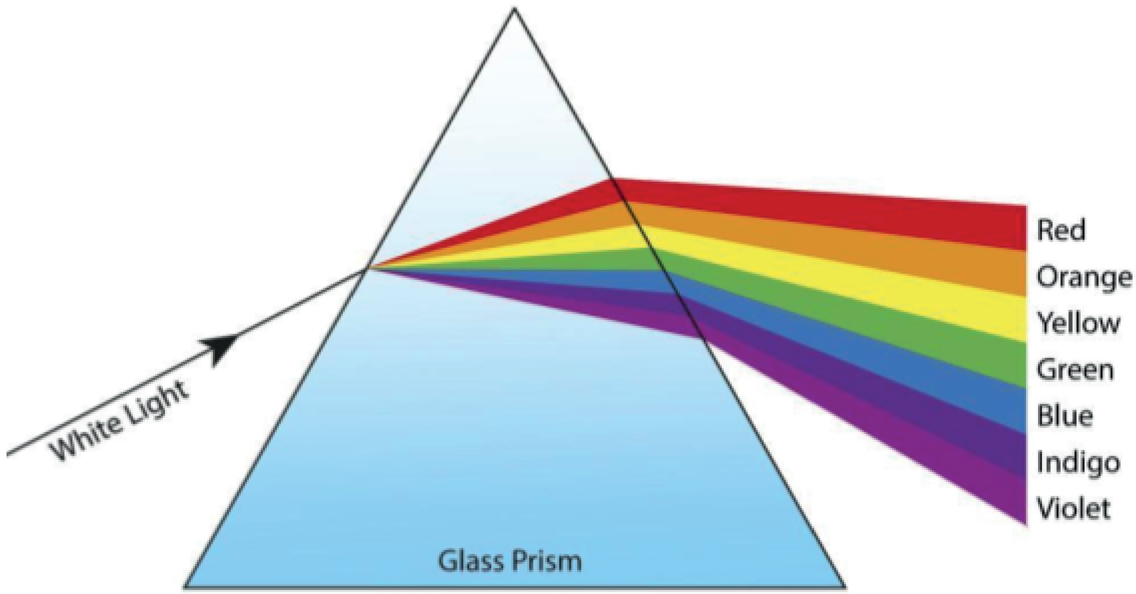
Transmitting Waves

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.

Visit this interactive to investigate how sound waves move through a medium: http://go.uen.org/aZE

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.

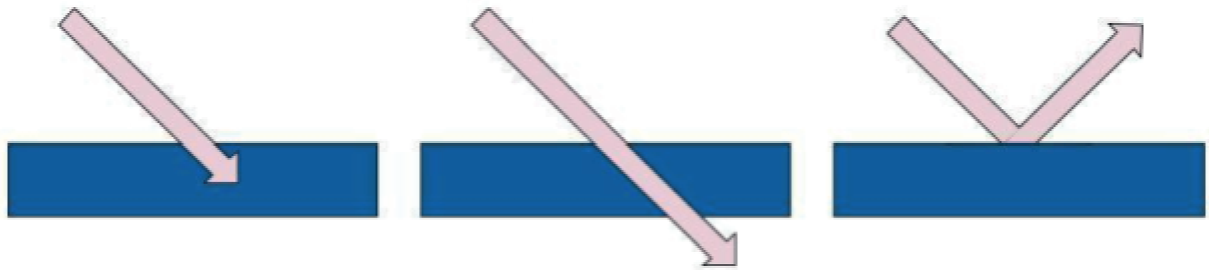


Refraction_Triangular Prism, Siyavula Education https://flic.kr/p/mG4acK
CC-BY

To investigate how light is transmitted through prisms, visit the online simulation at http://go.uen.org/b29

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.



CC0

The image above shows how a wave can be either absorbed, transmitted, or reflected depending on which medium it is traveling through. In some cases, waves can be both transmitted and reflected such as when you can see the display in a store window (transmitted) and also see a reflection of yourself.

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?

Pixabay.com, CC0

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 through air 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 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

Rainbow by Ivan,
https://flic.kr/p/apd4Er, CC BY-SA

1. Explain how your understanding of waves & mediums has changed.

2. Think of another phenomenon that applies waves and mediums.

3. Explain what is going on to create this rainbow based on what you have learned in this section.

2.6 Analog and Digital Signals (8.2.6)

Explore this Phenomenon

Vinyl record LP 10inch by 能無しさん
https://commons.wikimedia.org/wiki/File:Vinyl_record_LP_10inch.JPG

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

1. Why have digital recordings (cd's, mp3s) mostly replaced vinyl records in recent years?

2. How do you think waves are involved for this type of communication?

3. What questions can you ask 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

NPS.gov, Public Domain

Often young students enjoy creating codes to write secret messages with. This is not just a childish past time. The code shown above is believed to have been used by George Washington to send secret messages during the American Revolutionary War.

Signals are not just used by humans, 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.

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?

Pixabay.com CC0

Digital Signals

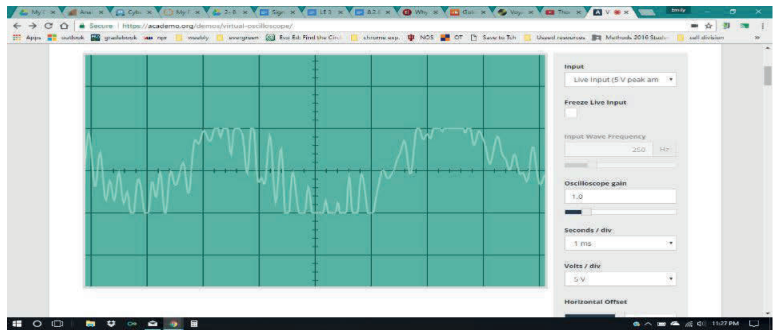
Everything that you see or hear on a computer—words, pictures, numbers, movies and sound--uses digital signals. Digital signals are sent as mathematically coded waves and can be sent over long distances. Once the waves arrive at a receiving station, they are decoded back into information that you can 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

Pixabay.com, CC0

When analog technology is used to record a sound, every part of the sound wave is recorded. The recorded sound waves can be very complex, because the recording device records every sound that it picks up, even background noises that are traveling through the air. The next picture shows an analog wave.



These signals can be changed easily, because when the sound is transmitted and recorded, it is hard for every part of the wave to be recorded exactly the same each time. Any additional background noise could be recorded with it, changing the wave and the sound.

When sounds are recorded digitally, not every part of the sound wave is recorded. Instead, the recording device takes samples of the sound wave, and assigns it to be either a zero or a one. The picture below shows a digital wave.

If the wave is recorded digitally, there are only two values. Since there are only two options for any point on the wave, it is harder to make changes to the wave if the sound is transmitted. Since the wave retains the same values, the sound it encodes remains unchanged.

To make a digital recording, the sound has to be translated into a simpler version. The information takes up less storage space and is less likely to get changed or altered. However, to be able to get any information from the signal, it must be converted back into an analog signal before being transmitted to your ears.

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

- http://go.uen.org/aZn

For more information on analog and digital technologies go to the following website:

- http://go.uen.org/aZk

Putting It Together

Vinyl record LP 10inch by 能無しさん
https://commons.wikimedia.org/wiki/File:Vinyl_record_LP_10inch.JPG
CC BY-SA

1. Explain how your understanding of analog vs digital communications have changed.

2. Think of another phenomenon that applies the concept of analog and digital.

3. Explain why vinyl records are used less now than other forms of digital media based on what you have learned in this section.

CHAPTER 3

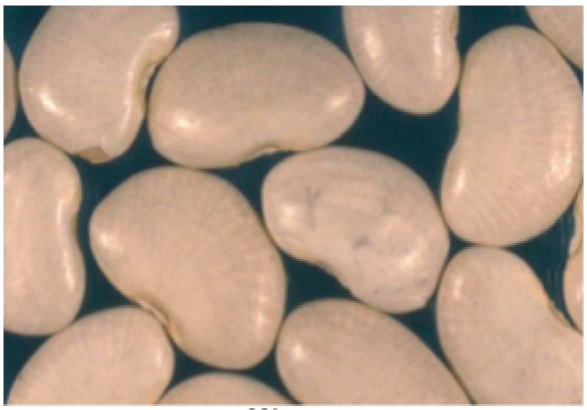
Strand 3: Life Systems

Chapter Outline

Living things use energy from their environment to rearrange matter to sustain life. Photosynthetic organisms are able to transform 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.

3.1 Photosynthesis (8.3.1)

Explore this Phenomenon



CC0

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Video of lima bean growth from seed http://go.uen.org/aZ2

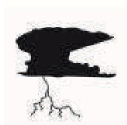
1. What do you already know about how plants grow?

2. Using your prior knowledge, identify what plants need in order to grow?

3. 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.



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

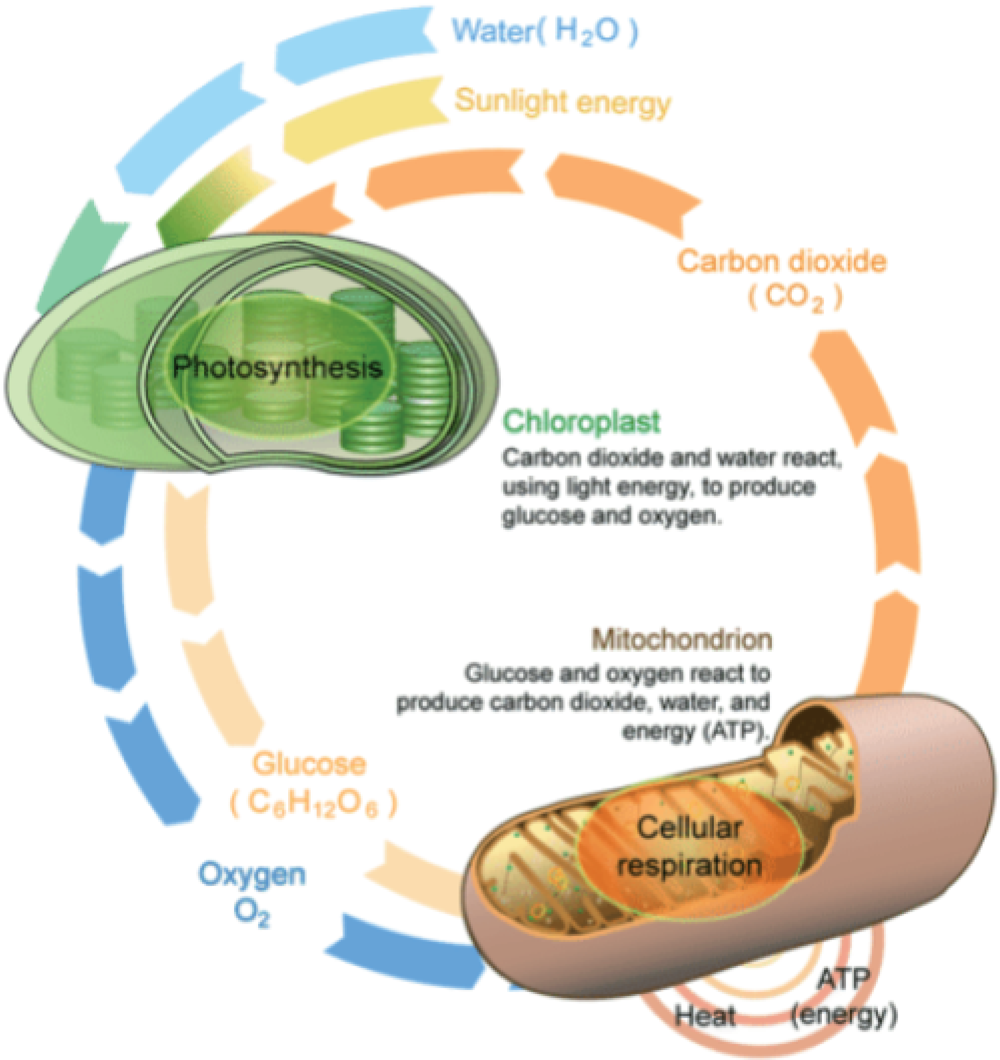
Photosynthesis Reactions: Food from Light

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:

$$6CO_2 + 6H_2O \xrightarrow{\text{with sunlight}} C_6H_{12}O_6 + 6O_2$$

Carbon dioxide, water, with sunlight, glucose, oxygen

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 organisms such as plants make their own glucose, other organisms that don't do photosynthesis are able to get glucose for energy from the food they eat.



Change in matter

Plants through the process of photosynthesis are able to make sugars. Most of a plants body is made of sugars that the plant is able to put together using the materials of carbon dioxide and water. Where does the mass of a giant redwood tree come from?

Photosynthetic Organisms

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

Pixabay.com, CC0

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

NASA, Public Domain

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

Pixabay.com, CC0

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

Putting It Together

1. Explain how your understanding of plant growth and photosynthesis has changed.

2. Think of another phenomenon that deals with photosynthesis.

3. Explain what is going on with plant growth based on what you have learned in this section.

3.2 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.

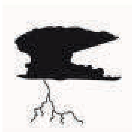
1. What do you feel?

2. What questions do you have about what is coming out?

3. How do you explain what is happening?

8.3.2 Cellular 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 <u>matter</u> 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.

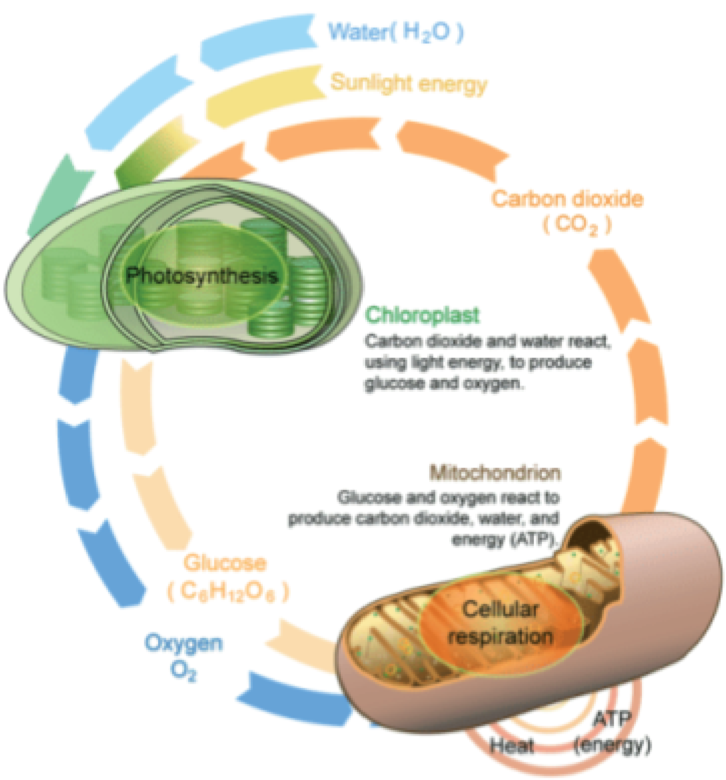


In this section, focus on matter and energy. Within a natural system, the flow of energy drives the motion and/or cycling of matter.

What is Cellular Respiration?

Cellular respiration is how cells of living things, including plants, break down glucose in order to release the chemical energy stored in the sugar. The chemical equation for cellular respiration is:

Glucose + Oxygen → Carbon Dioxide + Water



If you compare this with the last section you will notice it is the opposite of photosynthesis. The forms of energy are different though. Photosynthesis uses light to create chemical energy in sugar, cellular respiration breaks down the chemical energy found in sugars and converts it to mechanical and heat energy for the organism's use.

Why Food is Important

Living organisms need energy to live and they need matter to grow. Cellular respiration provides for both needs. During the digestion of food (carbohydrates, fats, proteins) the molecules are broken down to form new molecules that support growth and/or release energy as matter cycles through the organism. Proteins from your food are broken into smaller pieces and then are used to build up your muscles and to support a complex assortment of cellular functions. The phrase “you are what you eat” is quite true in that the matter in the food you eat becomes the matter that your body is made of. It also means that you are consuming whatever the plant or animal consumed prior to you eating it.

Putting It Together

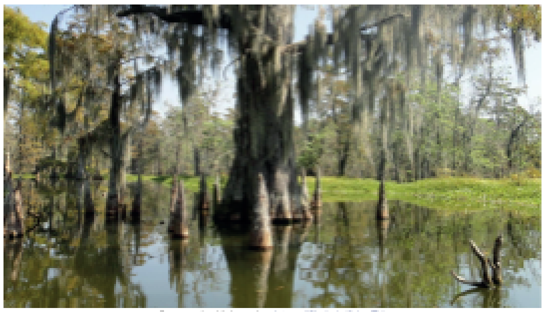
Ck12.org, CC BY-SA

1. Explain how your understanding of cellular respiration has changed.

2. Think of another phenomenon that applies to cellular respiration.

3. Explain what is happening in the picture base on what you have learned in this section.

3.3 The Carbon Cycle and Ecosystems (8.3.3)



Swamp, by Kaleandan https://flic.kr/p/91azTd, CC-BY-NC-ND

CC0

Explore this Phenomenon

Look at the photos.

1. What questions do you have about the scenes?

2. What do you already know?

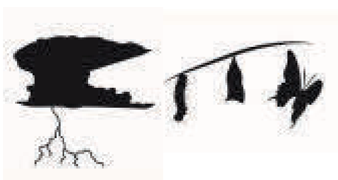
3. How are these two images similar?

4. How are these two images different?

5. How do you explain what is happening?

8.3.3 Carbon Cycle & Ecosystems

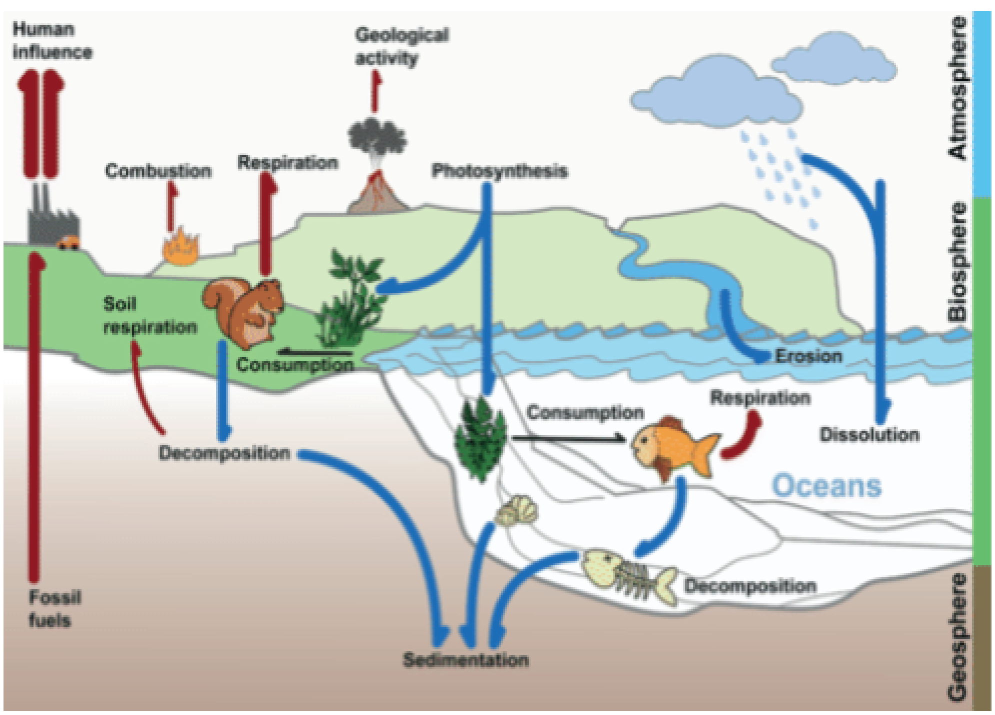
Ask questions to obtain, evaluate, and communicate information about how changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of an ecosystem. Emphasize describing the cycling of matter and flow of energy through the carbon cycle.



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 flow 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?



Ck12.org, CC BY-SA

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.

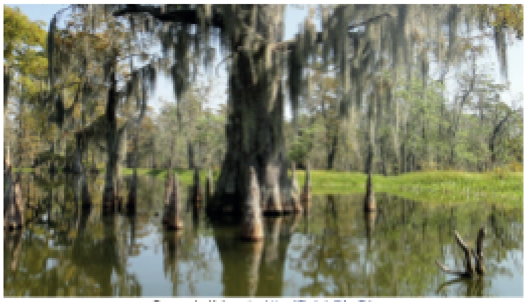
Carbon in Carbon Dioxide

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 during 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 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



Swamp, by Kaleenalan https://flic.kr/p/91szTd,
CC BY-NC-ND

CC0

1. Explain how your understanding of the carbon cycle has changed.

2. Think of another phenomenon that applies to the carbon cycle.

3. Explain what could eventually happen to this swamp based on what you have learned in this section.

3.4 Flow of Energy in Ecosystems (8.3.4)

Explore this Phenomenon

20090130-JDW411, by Jeremy Wheaton
https://flic.kr/p/7gF7UA CC BY-NC-ND

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.

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

2. What do you predict happened when the wolves were removed?

3. 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 energy stored by producers is passed to consumers, scavengers, and decomposers as each organism obtains food.

Food Chain

The set of organisms that pass energy from one organism to the next is described as a food chain in the next figure. 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 plants that grow on dry land. 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 the top predators.

Ck12.org, CC BY-SA

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

Matter Cycles and Energy Flows

Matter cycles, this means that it is used over and over again. In the carbon cycle, matter, in the form of carbon, is recycled again and again. Carbon can move from the atmosphere into both living and non-living things, such as rocks and oceans, and then back into the atmosphere. The big idea is that matter is reused; matter cycles through ecosystems.

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, through 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

20090130-JDW411, by Jeremy Wheaton
https://flic.kr/p/7gF7UA CC BY-NC-ND

1. Explain how your understanding has changed about the of the flow of energy and the cycling of matter in an ecosystem.

2. Think of another phenomenon that applies the concept of the flow of energy in ecosystems.

3. Explain what happened with wolves in Yellowstone 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 after over 70 years of being absent. http://go.uen.org/aZi

CHAPTER 4

Strand 4: Natural Resources

Chapter Outline

Witten - Muttental - Zeche Nachtigall Streckenausabau 01 by Daniel Mennerich, https://flic.kr/p/qkK8J8 CC BY-NC-ND

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.

4.1 Natural Resources and their Geology (8.4.1)

Explore this Phenomenon

Coal Seams by Tim Whitlow,
https://flic.kr/p/7yBouU

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

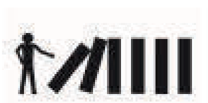
1. What are your observations about the coal in the rock?

2. What questions do you have about the coal?

3. 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.



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.

Natural Resources

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 also have the responsibility to use natural resources in ways which sustain the web – both for ourselves and for all life on the 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 coal doesn'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 rocks in an area are formed determines which mineral resources will be found in that location.

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.

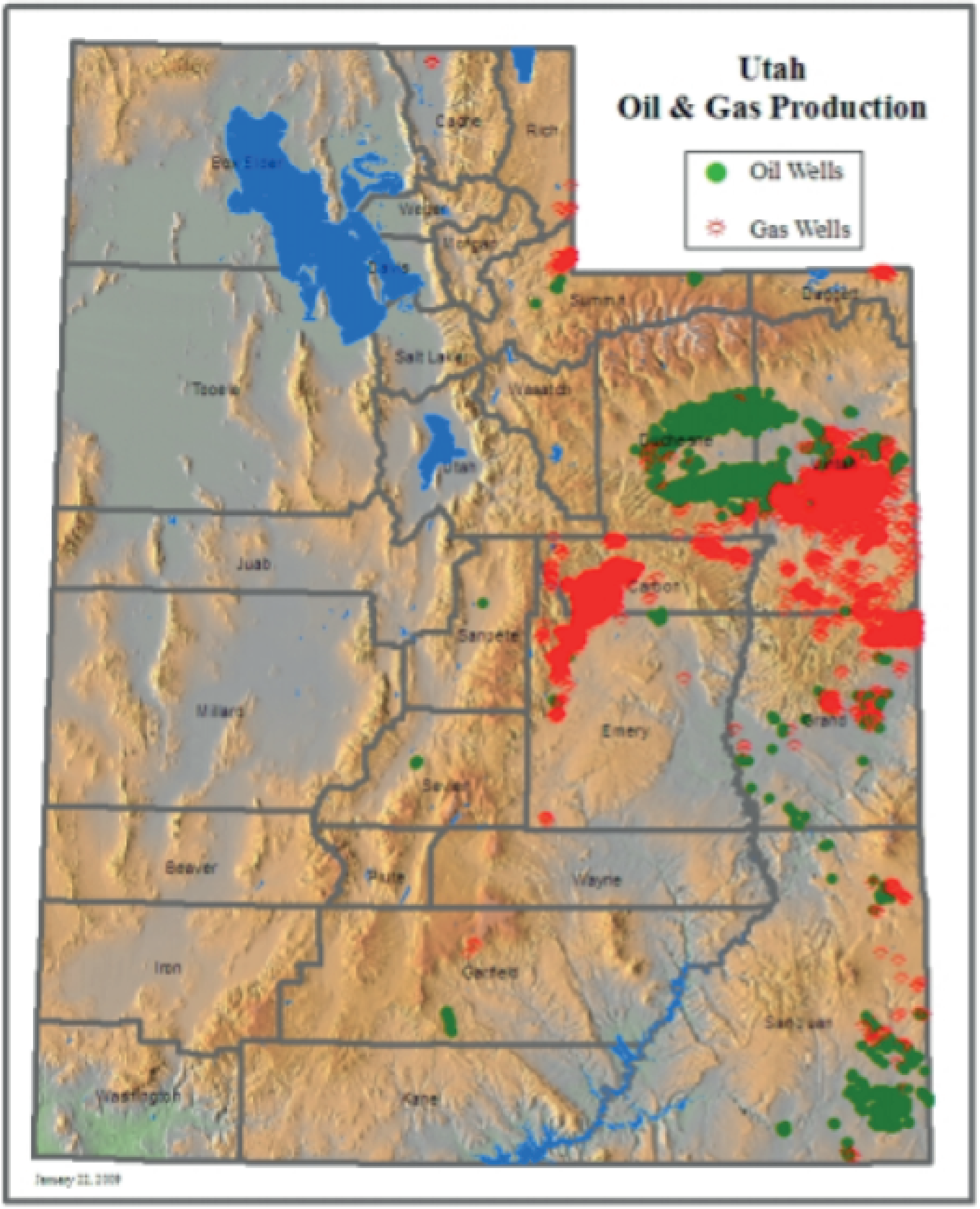
The table below shows some resources and the geological environments where they are usually found.

Resource	**Where it is found**
Metals (gold, silver, iron, copper, lead, zinc, etc.)	Occasionally in, but more often near, volcanic intrusive rocks (cooled at deep levels below Earth's surface), 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 water evaporates.
Uranium	Concentrated in sedimentary rocks but can be found in volcanic or metamorphic rocks.
Fossil fuels (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 (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 tablelands, faults and earthquakes, volcanoes, sedimentary rocks that were deposited in lakes and oceans, and metamorphosed rock. For this reason, Utah has abundant mineral and fossil fuel resources.

Bingham Canyon Mine 宾汉铜矿场 by Miaomao WANG,
https://flic.kr/p/eNh1xj

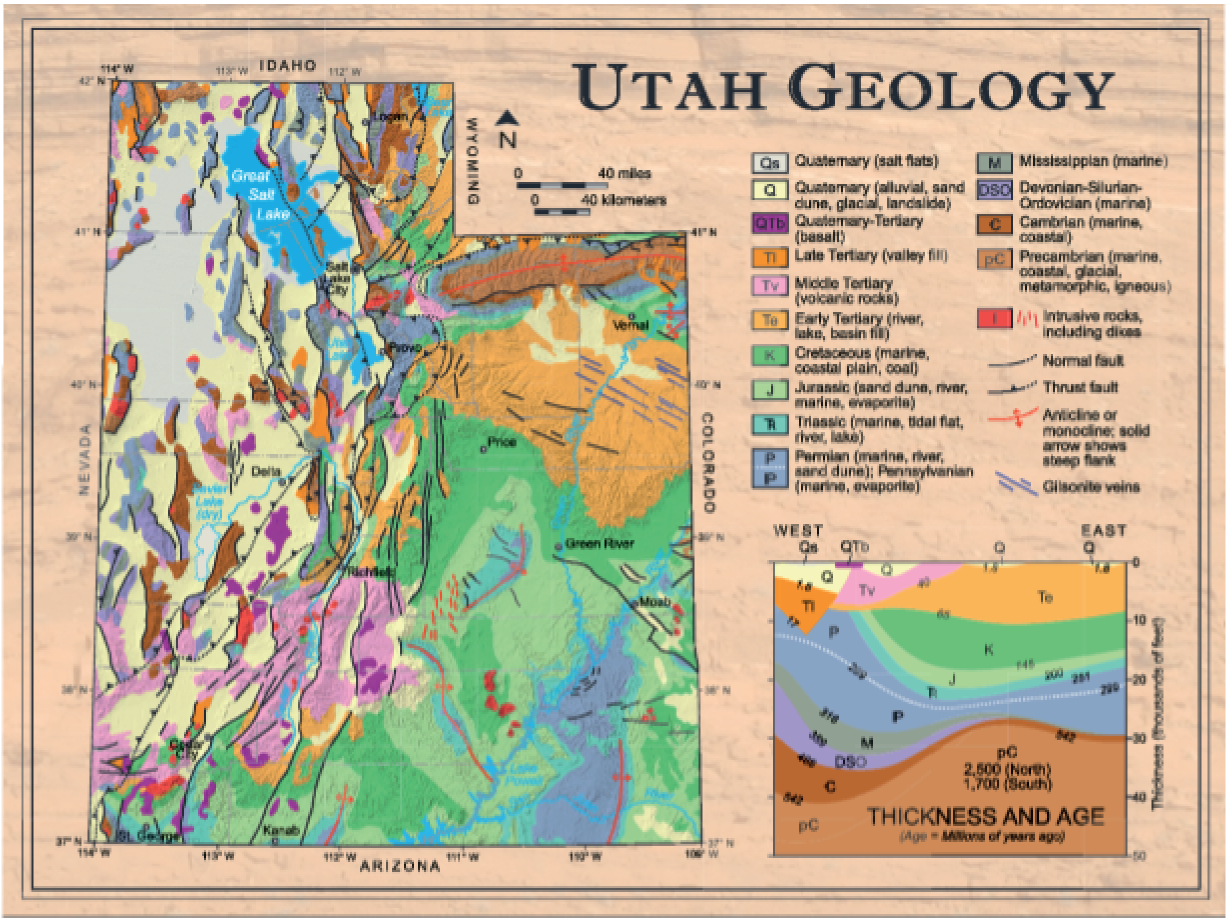
Utah has been a major producer of copper and other metals that are associated with volcanic rocks. They are mostly found in the western half of the state. Coal and oil are found in the eastern half of the state. Other resources that have been mined here include uranium, beryllium, magnesium, molybdenum,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



**Used with permission:*
http://files.geology.utah.gov/maps/geomap/postcards/pdf/utgeo_postcd.pdf

This image shows where oil and gas production occurs in Utah.

The next image is a generalized map of Utah's geology. For a digital colored version of this map go here: http://go.uen.org/aZ9



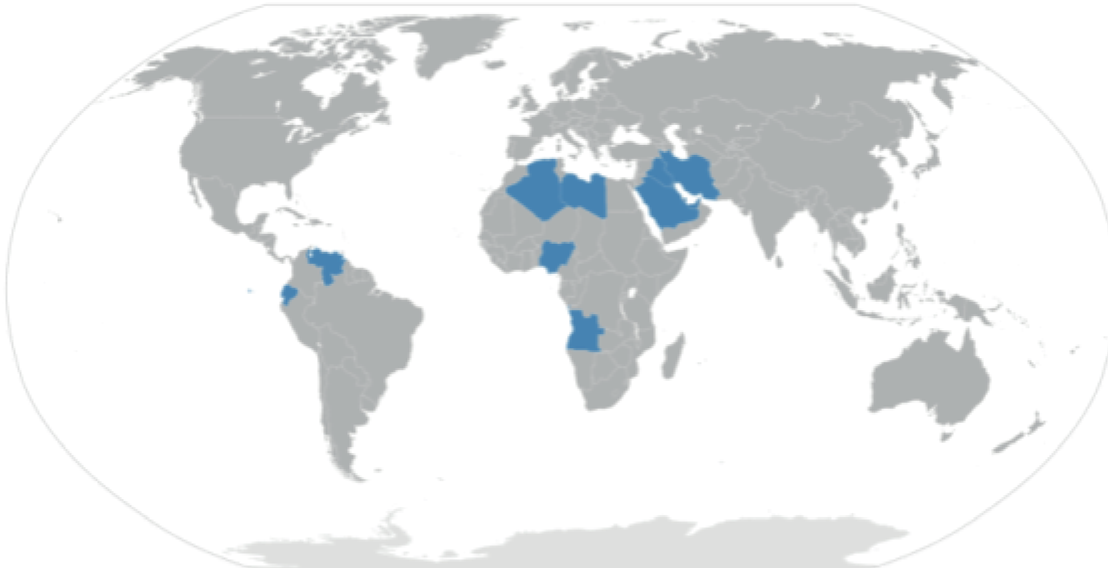
**Used with permission:*
http://files.geology.utah.gov/maps/geomap/postcards/pdf/utgeo_postcd.pdf

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)

Using the information from the resource chart, what kind of resources would you possibly 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.



Public Domain

This image indicates the 12 highest oil producing countries. Some countries have vast oil reserves, some have a less and others do not have any.

Putting It Together

Coal Seams by Tim Whitlow,

Using the photo above, answer the following:

1. Explain how your understanding of natural resources has changed.

2. Think of another phenomenon that applies natural resources.

3. Explain what is going on with the earth and its natural resources based on what you have learned in this section.

4.2 Renewable and Nonrenewable Resources (8.4.2)

Explore this Phenomenon

CC0

NASA - Public Domain
https://earthobservatory.nasa.gov/features/Deforestation

1. What are your observations about what has happened in these photos?

2. What questions do you have about what has happened here?

3. How do you explain what is happening?

4. 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 and you would be right. However, ecosystems and the services they provide are also natural resources that people often don't think of. Natural resources are generally classified as either renewable or nonrenewable.

Renewable resources have an unlimited supply and nonrenewable have a limited supply. Will this planet eventually run out of oil? Almost certainly, but scientists disagree on when the supplies will run out.. . There is a limited supply of oil on our planet and because the rate of usage far exceeds the rate at which the supply can be replenished, fossil fuels is classified as a nonrenewable resource. Wind and water are considered renewable resources because you can't ever run out of them.

Renewable Resources

Renewable resources can be replenished by natural processes about as quickly as humans use them. Sunlight and wind are renewable resources because they cannot be used up. 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 organisms are considered to be renewable. This is because they can reproduce to replace themselves. However, they can be overused 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 however 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.

Pixabay.com, CC0

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.

https://climate.nasa.gov/quizzes/quiz-energy/, Public Domain

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.

Rance tidal power plant by Dani 7C3,
https://en.wikipedia.org/wiki/File:Rance_tidal_power_plant.JPG

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 50 or so years 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.

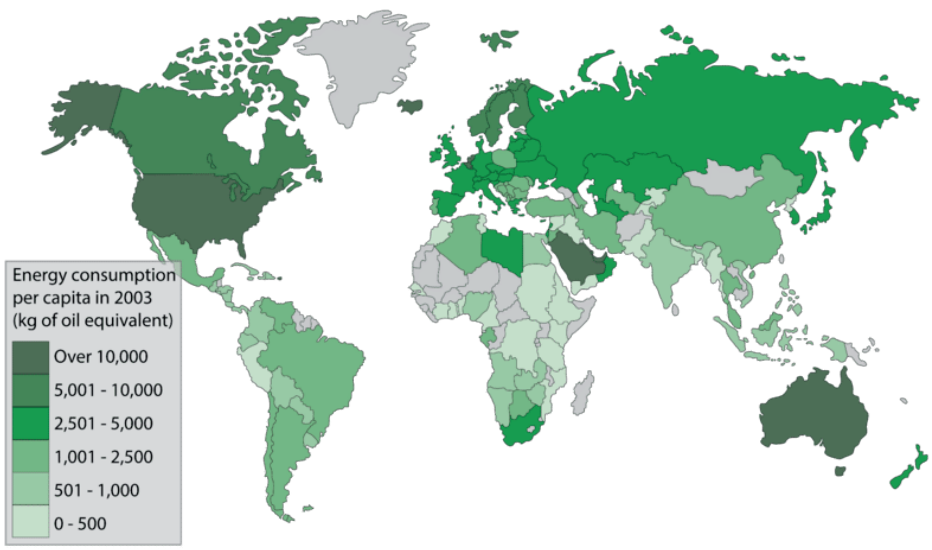
Coal is another nonrenewable resource.

Nuclear power is considered a nonrenewable resource because it uses radioactive elements of which we have a limited supply.

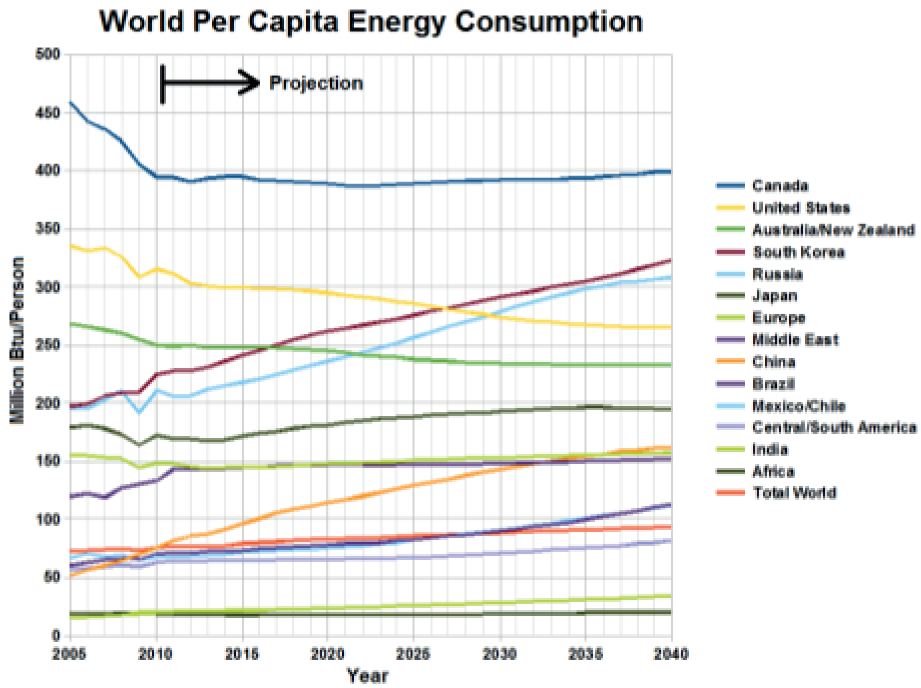
Society's Use of Resources

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.

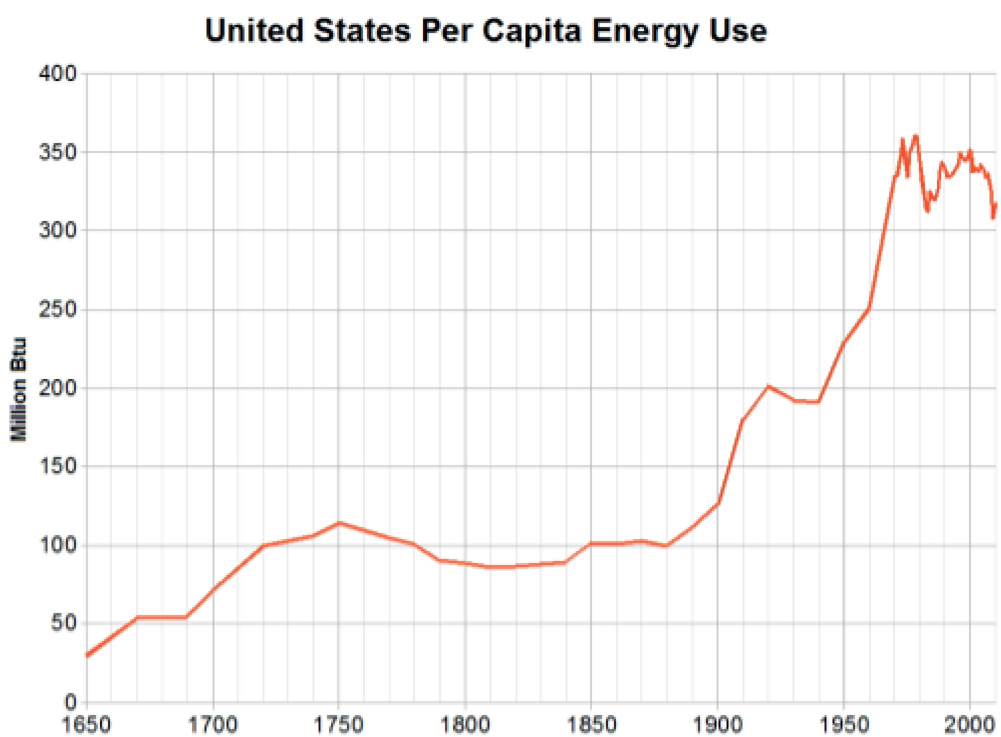
Analyze the graphs and charts to determine the effect of per capita consumption of natural resources on Earth's systems



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



https://upload.wikimedia.org/wikipedia/commons/6/67/World_per_capita_energy_consumption_projection.png, CC0



https://upload.wikimedia.org/wikipedia/commons/5/52/United_States_per_capita_energy_use_1650-2010.png, CC0

Putting It Together

Deforestation in Nigeria by Foreign and Commonwealth Office, https://flic.kr/p/8m8Hja, CC BY-ND

https://pixabay.com/photos/river-dam-energy-electricity-power-3810378/, CC0

Using the photos above, answer the following:

1. Explain how your understanding human use of natural resources has changed.

2. Think of another phenomenon that applies the concept of per capita use of natural resources.

3. Explain what is happening in this picture based on what you learned in this section.

4.3 Problems Caused by Natural Resource Usage (8.4.3)

Explore this Phenomenon

Oiled Bird - Black Sea Oil Spill 11/12/07 by Marine Photobank
https://flic.kr/p/471EuR, CC BY

1. What are your observations about what has happened in this photo?
2. What questions do you have about what has happened here?
3. 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.

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 (reduce) the negative effects, and monitored the results.

Case Study: Oil Spills

Oil spill Mobile - Briefings & Oiled Bird cleaning 077 oiled brown pelican before cleaning by US Fish and Wildlife Service Southeast Region, https://flic.kr/p/8D8MEM CC BY

Oil is an important part of the world's economy. The need for oil requires transport of oil across the ocean. Each time oil is transported we have an increased chance of having an accident where the oil spills. After every oil spill, photos are released of marine organisms covered with oil. Often there are pictures of people trying to clean them. Seabirds are especially vulnerable; they dive into a slick because the surface looks like calmer water. Oil-coated birds cannot regulate their body temperatures and will die. After cleanup, some birds will live and others will not make it.

Large oil spills, like the Exxon Valdez in Alaska in 1989, get a lot of attention, as they should. Besides these large spills, though, much more oil enters the oceans from small leaks that are only a problem locally. For our case study we will take a look at a large oil spill in the Gulf of Mexico.

The Gulf of Mexico Oil Spill

New drilling techniques have allowed oil companies to drill in deeper waters than ever before. This allows us to access oil deposits that were never before accessible, but only with great technological difficulty. The risks from deep water drilling and the consequences when something goes wrong are greater than those associated with shallow wells.

Explosion

Working on oil platforms is dangerous. Workers are exposed to harsh ocean conditions and gas explosions. The danger was never more obvious than on April 20, 2010, when 11 workers were killed and 17 injured in an explosion on a deep water oil rig in the Gulf of Mexico (next image). The drilling rig, operated by BP, was 77 km (48 miles) offshore and the depth to the well was more than 5,000 feet.

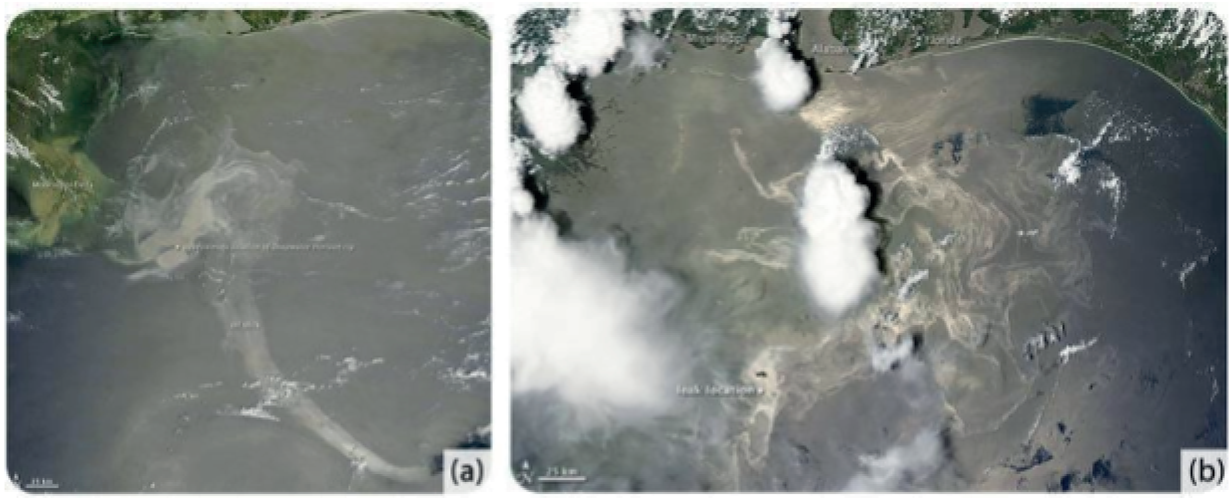
By Coastguard

The U.S. Coast Guard tries to put out the fire and search for missing workers after the explosion on the Deepwater Horizon drilling rig. Eleven workers were killed.

Spill

Two days after the explosion, the drill rig sank. The 5,000-foot pipe that connected the wellhead to the drilling platform bent. Oil was free to gush into the Gulf of Mexico from nearly a mile deep (next image). Initial efforts to cap or contain the spill at or near its source all failed to stop the vast oil spill. It was not until July 15, nearly three months after the accident, that the well was successfully capped.

Estimating the flow of oil into the Gulf from the well was extremely difficult because the leak was so far below the surface. The U.S. government estimates that about 4.9 million barrels entered the Gulf at a rate of 35,000 to 60,000 barrels a day. The largest previous oil spill in the United States was of 300,000 barrels by the Exxon Valdez in 1989 in Prince William Sound, Alaska.

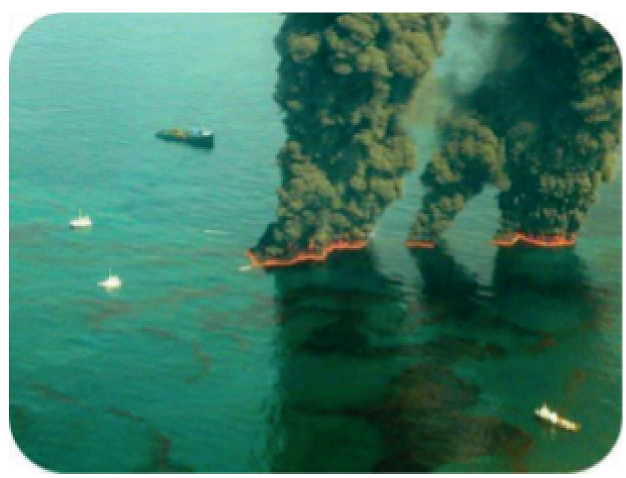


(a) On May 17, 2010, oil had been leaking into the Gulf for nearly one month. The oil is the lighter areas of the water. On that date government estimates put the maximum total oil leak at 1,600,000 barrels, according to the New York Times. (b) The BP oil spill on June 19, 2010. The government estimates for total oil leaked by this date was 3,200,000 barrels.

Cleanup

Once the oil is in the water, there are different methods that have been developed for dealing with it:

1. Removal: Oil is corralled (rounded up or contained) and then burned; natural gas is flared off (next image). Machines that can separate oil from the water are placed aboard ships stationed in the area. These ships cleaned tens of thousands of barrels of contaminated seawater each day.



2. Containment: Floating containment booms are placed on the surface offshore of the most sensitive coastal areas in an attempt to attempt to trap the oil. But the seas must be calm for the booms to be effective, and so were not very useful in the Gulf (next image). Sand berms have been constructed off of the Louisiana coast to keep the oil from reaching shore.

A containment boom holds back oil, but it is only effective in calm water.

3. Dispersal: Oil disperses naturally over time because it mixes with the water. However, such large amounts of oil will take decades to disperse. To speed the process up, BP has sprayed unprecedented amounts of chemical dispersants on the spill. That action did not receive support from the scientific community since no one knows the risks to people and the environment from such a large amount of these harmful chemicals. Some workers may have become ill from exposure to the chemicals.

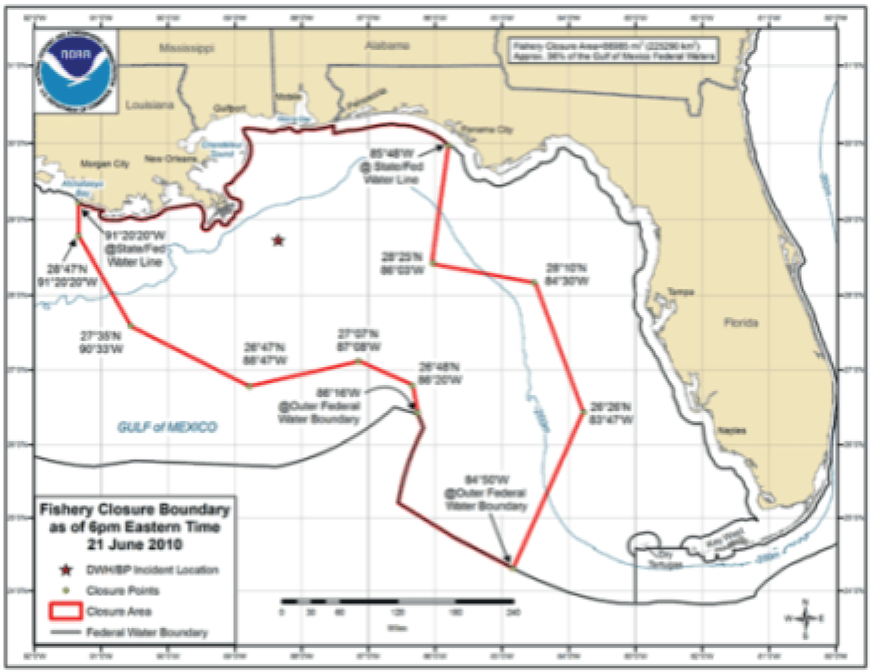
4. Natural clean-up crews: The ocean actually contains bacteria that eat and break down oil. There are usually very few of these bacteria in the ocean however when an oil spill takes place the numbers increase very quickly. The idea of producing these bacteria to release in high quantities in case of a spill is a very real possibility. The only problem is that the bacteria work slowly and there are some chemicals in the crude oil that they still cannot break down.

Plugging the Well

BP drilled two relief wells into the original well. When the relief wells entered the original borehole, specialized liquids were pumped into the original well to stop the flow. Operation of the relief wells began in August 2010. The original well was declared effectively dead on September 19, 2010.

Impact

The economic and environmental impact of this spill will be felt for many years. Many people rely on the Gulf for their livelihoods or for recreation. Commercial fishing, tourism, and oil-related jobs are the economic engines of the region. Fearing contamination, NOAA imposed a fishing ban on approximately one-third of the Gulf (next image). Tourism is down in the region as beach goers find other ways to spend their time. Real estate prices along the Gulf have declined as well.



Public Domain

This was the extent of the banned area on June 21, 2010.

The toll on wildlife is felt throughout the Gulf. Plankton, which form the base of the aquatic food web, are killed by the oil, leaving other organisms without food. Islands and marshlands around the Gulf have many species that are already at risk, including four endangered species of sea turtles. With such low numbers, rebuilding their populations after the spill will be difficult.

Eight national parks and seashores are found along the Gulf shores. Other locations may be ecologically sensitive habitats such as mangroves or marshlands.

Long-Term Effects

There is still oil on beaches and in sediment on the seafloor in the region. Chemicals from the oil dispersants are still in the water. In October 2011 a report was issued that showed that whales and dolphins are dying in the Gulf at twice their normal rate. The long-term effects will be with us for a long time.

Monitoring for future accidents

There are ways to monitor for oil leaks to try and prevent situations early. For example there are special cables that can be placed near a drill and they are able to sense when oil is in the water around it. This can help give an early warning before the leak becomes unmanageable. There are many types of sensors. Some sensors work better than others and some are more expensive than others. There have been situations of leaks however that have not been identified by the monitors at all. There are many rules and regulations in place for oil drills to try and prevent these types of things happening. Special precautions must be taken by companies in order to show that they are taking necessary steps in order to be able to prevent this, or even to stop a spill once it starts.

Putting It Together

Oiled Bird - Black Sea Oil Spill 11/12/07 by Marine Photobank
https://flic.kr/p/471EuR, CC BY

1. Explain how your understanding has changed about possible effects caused by the use of natural resources.

2. Think of another phenomenon where there are effects to the use of natural resources.

3. Explain what happened in this picture based on what you have learned in this section.

4. What ideas do you have about how to solve this problem?

4.4 Global Climate Change (8.4.4)

Explore this Phenomenon

Pixabay.com, CC0

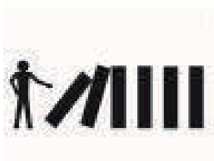
Cocoa-bean by carolann.quart; https://flic.kr/p/6vpRyt CC BY-NC

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 places where they struggle to survive.

1. What are your observations about the cocoa beans and cocoa trees pictured above?
2. What questions do you have about the cocoa beans?
3. 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.



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.

Climate Change

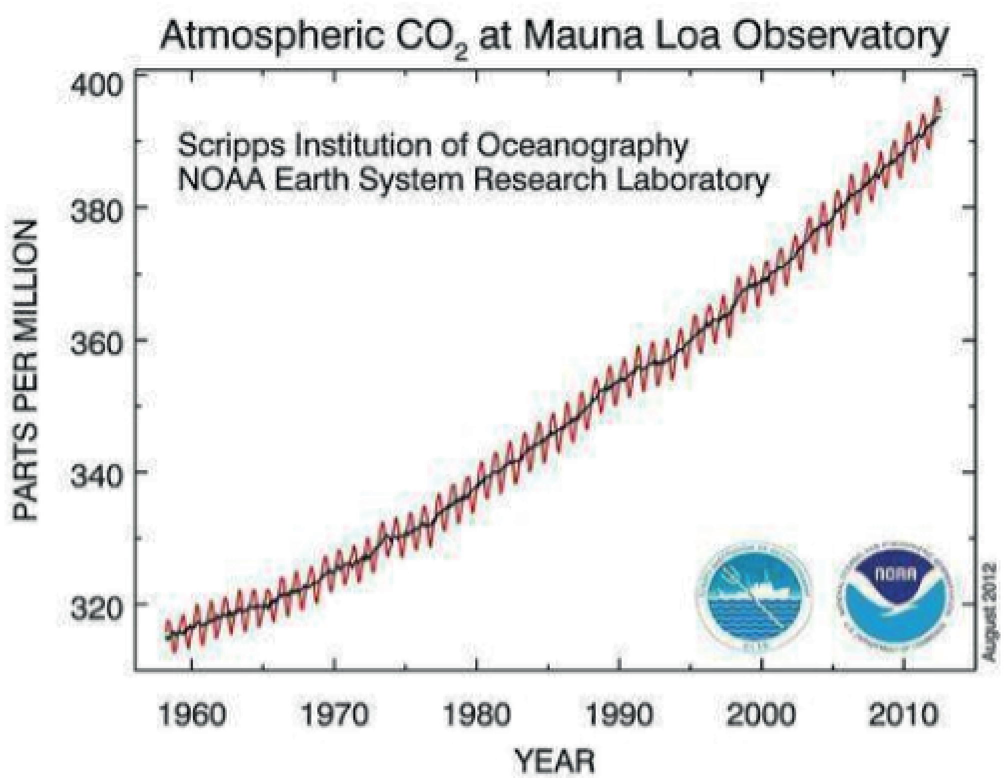
The trees in the phenomenon photo only grow in tropical forests in countries along the equator. They are cocoa trees. The brown seeds that are taken from the seed pods are used to make chocolate. Cocoa trees are sensitive to temperature. If temperatures change in the countries where cocoa trees grow,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

Many lands are good for farming. When rainfall is normal or high, the lands can produce. When rainfall is low, no crops grow. Drought makes land unsuitable for farming. 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 increase global climate increase 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.



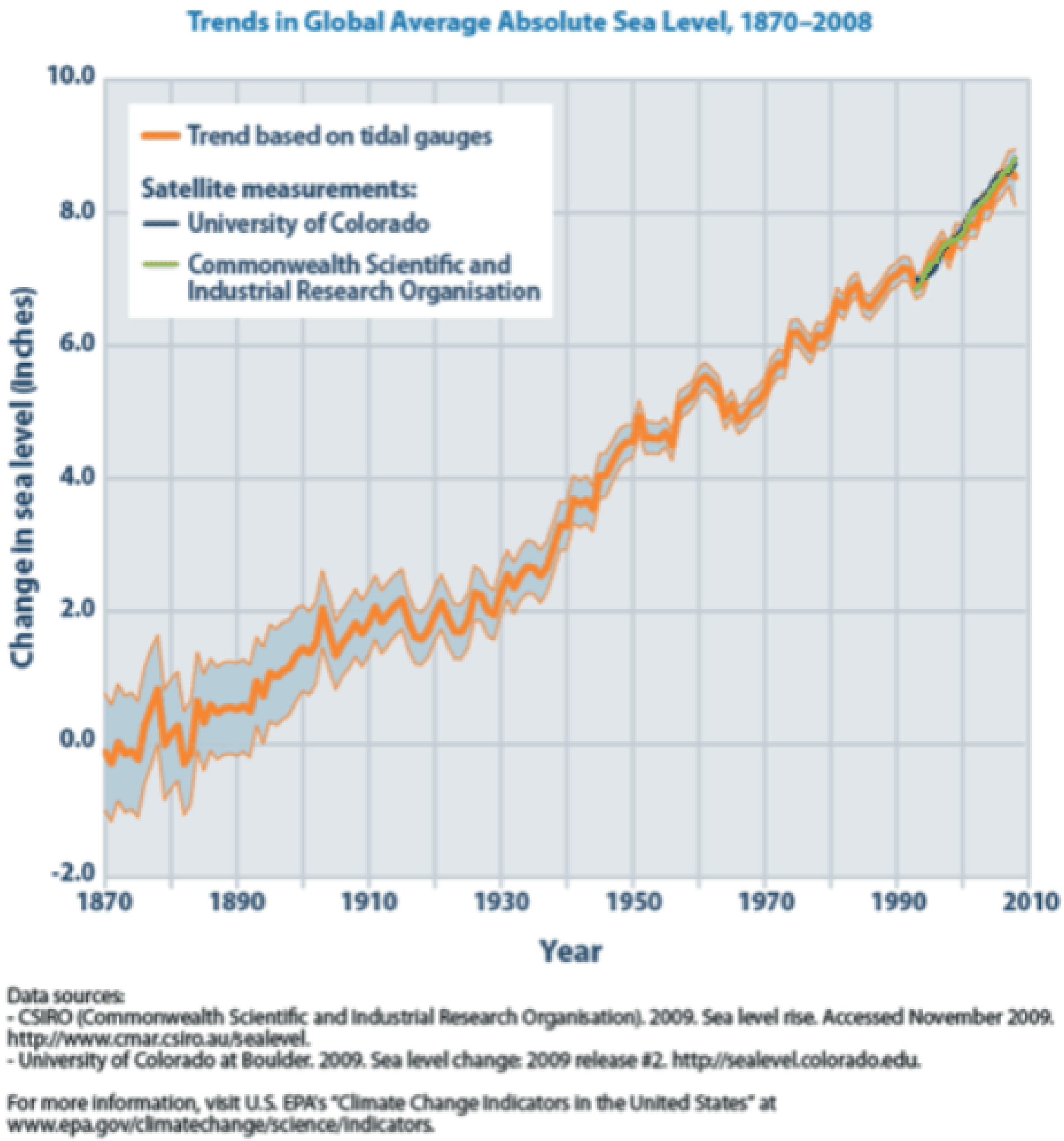
Public Domain

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 (next image).



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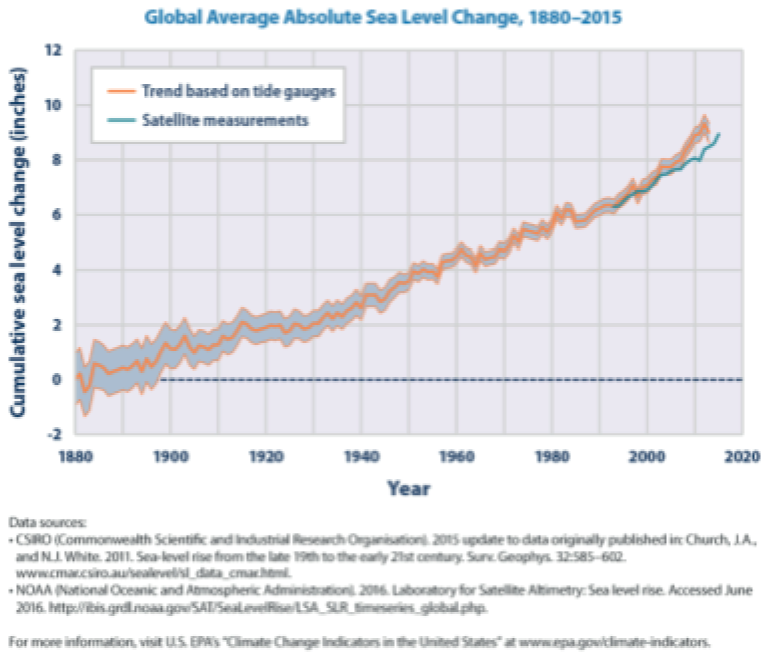

Public Domain

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 next picture.) 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.

NASA, public domain

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

Pixabay.com, CC0

Cocoa-bean by carolann.quart; https://flic.kr/p/6vpRyt CC BY-NC

1. Explain how your understanding of climate change differs from before.

2. Think of another phenomenon that is occurring because of climate change.

3. Explain what is going on to the cocoa trees based on what you have learned in this section.

4.5 Natural Hazards (8.4.5)

Explore this Phenomenon

Ck12.org, CC BY-SA

Cal Memorial Stadium by Dave Schumaker, https://flic.kr/p/jLfuC, CC BY-NC-ND

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

1. What observations can you make about what has happened in these photos?

2. What questions could you ask about what has happened here?

3. 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.

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 intense forces, 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. There are basically two types of natural hazards, geological and atmospheric. Earthquakes, volcanoes, landslides, rock falls, or sinkholes are examples of natural hazards that result from geologic changes. Tornadoes, hurricanes, flooding, avalanches, blizzards, or windstorms are examples of atmospheric natural hazards

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

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Mount St. Helens

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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.

Oops by Brett L., https://flic.kr/p/iC1yU,

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 many small earthquakes around 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 on flat ground. Hurricanes form over warm oceans in the wet 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. Currently scientists are studying animal behavior to gain insight as some species begin to seek higher ground from a earthquake-caused tsunamis, well in advance.

Earthquakes area 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.

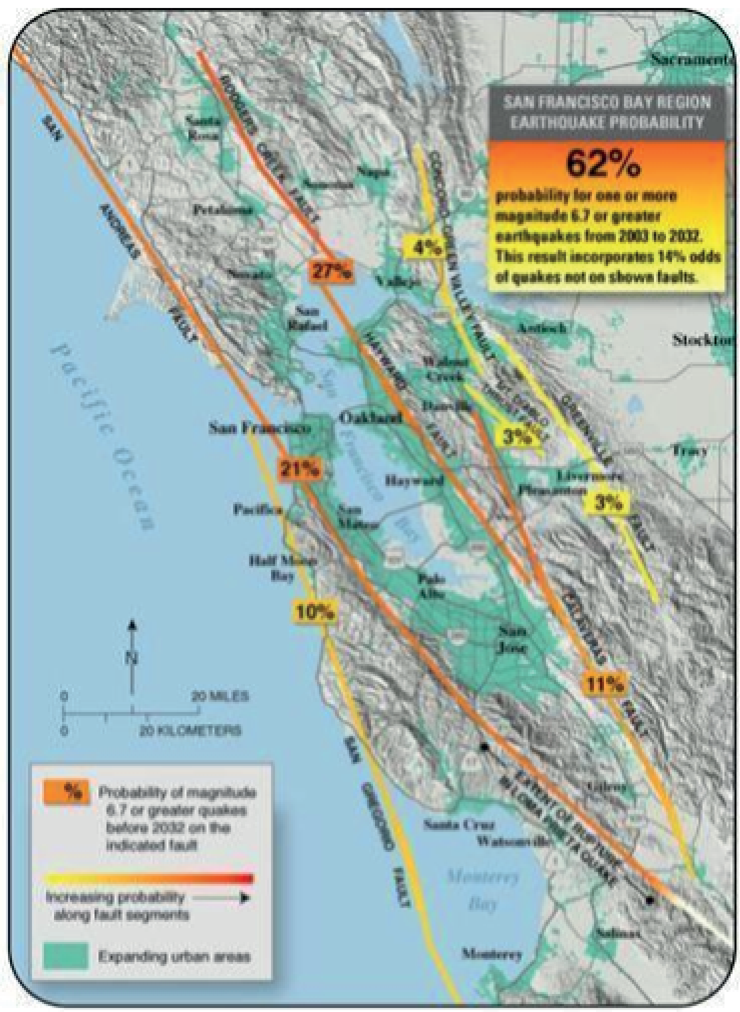
A Good Prediction

Scientists are a long way from being able to predict earthquakes. To be useful, a good prediction must be accurate as to when, where, and how strong the earthquake will be. 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 would be expensive and would cause 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 and 2032.



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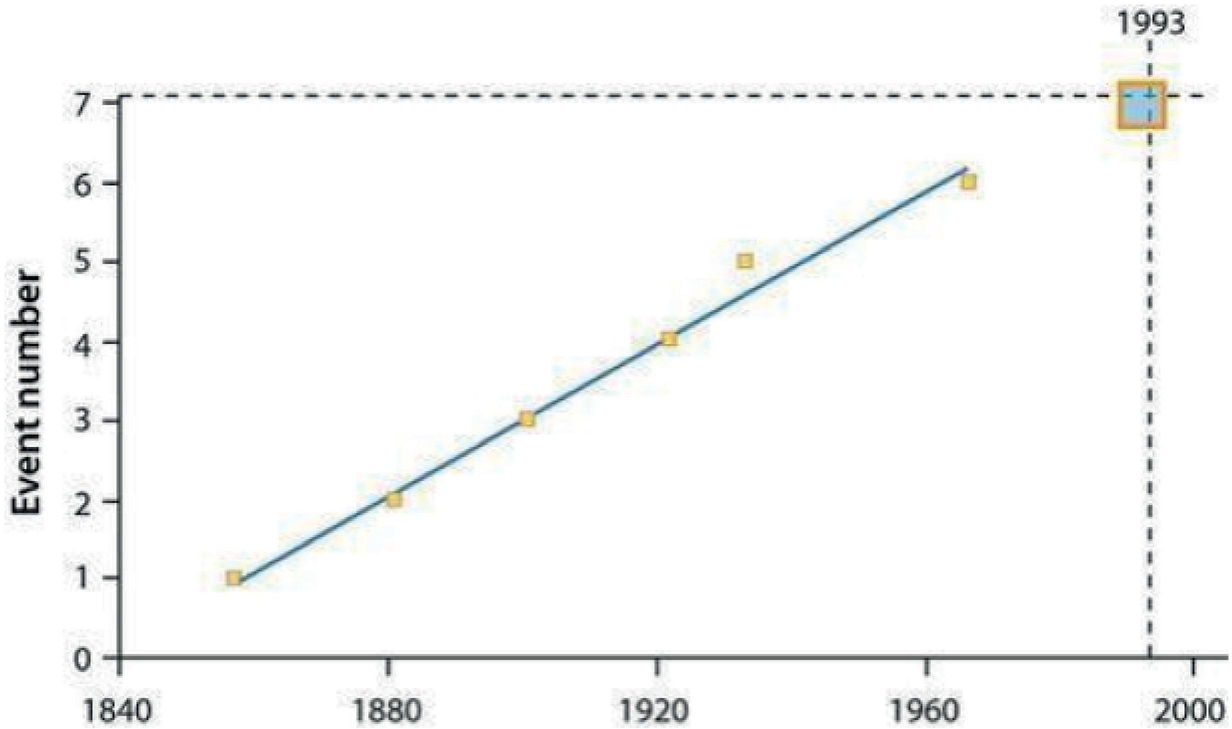
Where an earthquake will occur is the easiest feature to predict. Earthquakes tend to happen where they've occurred before. (See previous image) Scientists know that earthquakes take place at plate boundaries or along major faults in the interior of continents, like the Wasatch Fault.

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 next figure.) But so far scientists cannot predict when quakes will occur, even to within a few years.



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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.

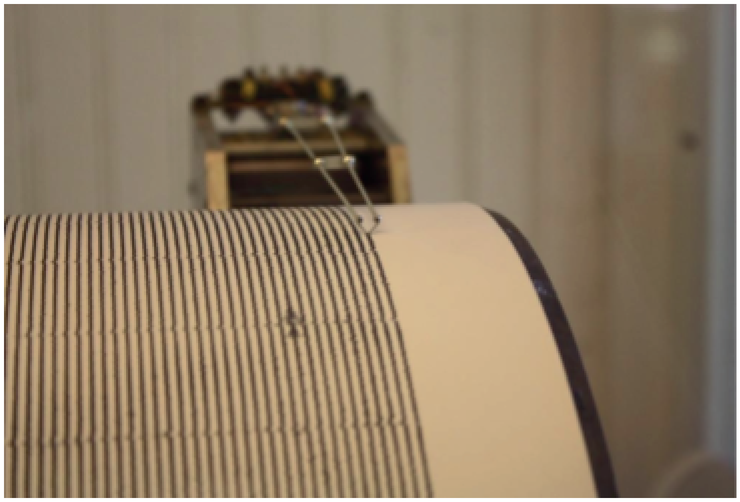
Earthquake Signs

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

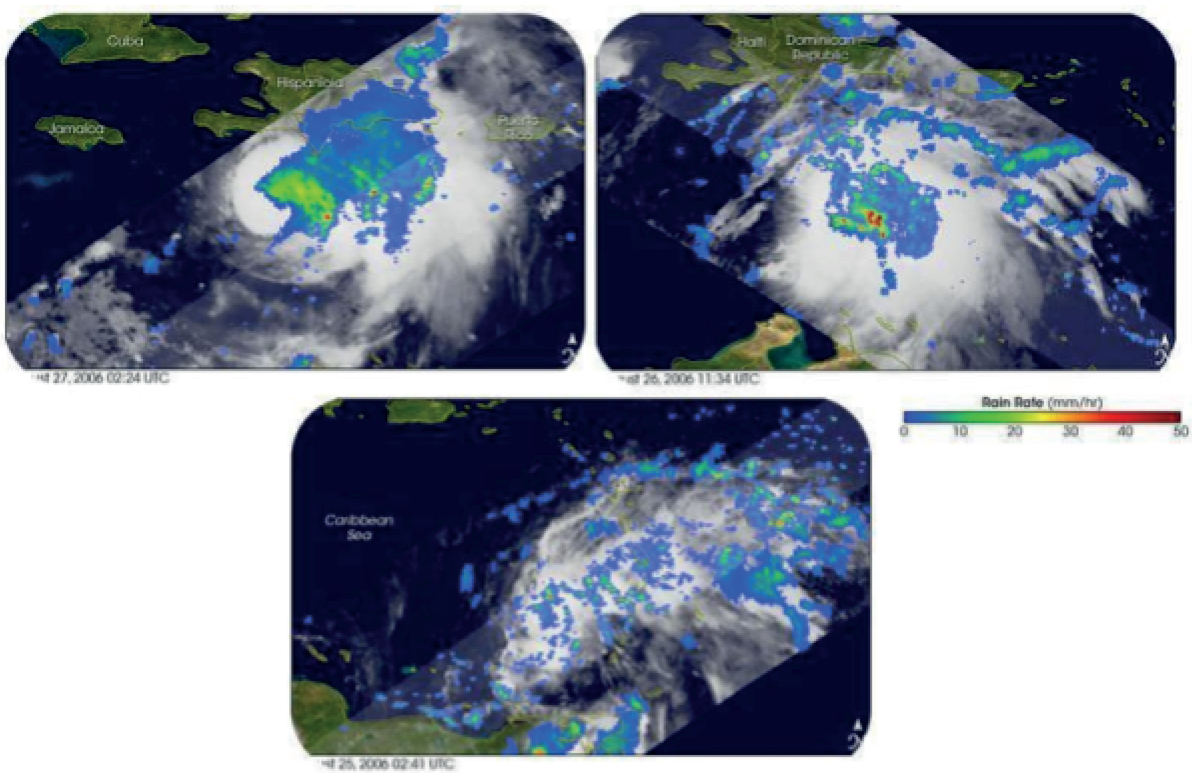
Earthquake prediction is very difficult and not very successful, but scientists are looking for a variety of clues in a variety of locations in an effort to advance knowledge and improve the ability to predict earthquake location, timing, and magnitude.

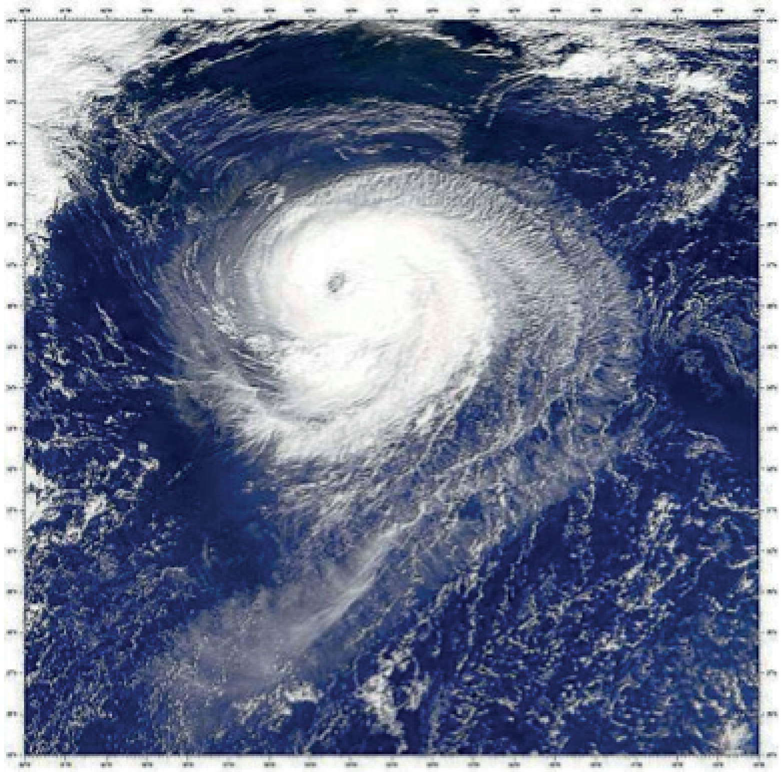
Preventing Natural Hazards from Becoming Natural Disasters

Whether we can predict when disasters will happen or not, there are ways we can prepare for them in areas where they are more likely to occur so that we can possibly reduce the damage to society. Scientists are developing technologies that will help us predict catastrophic natural disasters and mitigate (reduce) their effects.

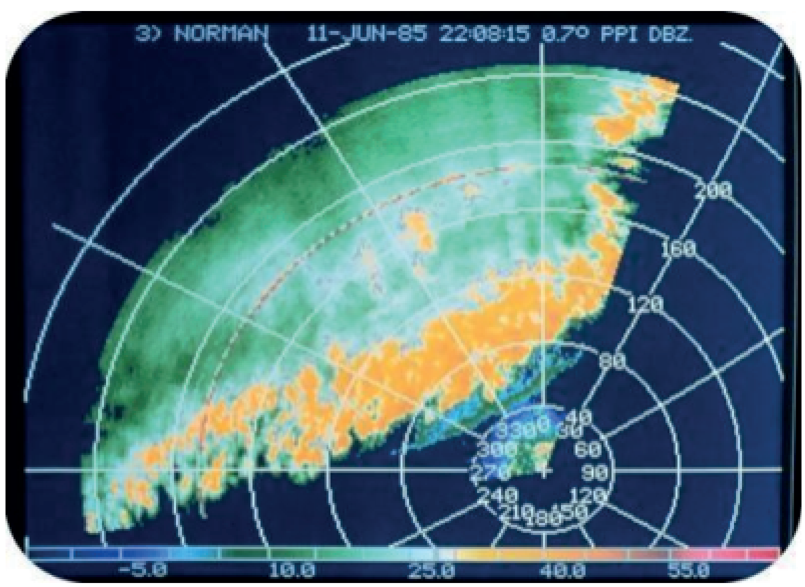


A seismometer is used to measure earthquake activity. These devices help us measure and record the strength of an earthquake while it is happening. They cannot predict an earthquake but by collecting information on earthquakes over time scientists can learn where earthquakes are more likely to happen.





Satellite images can include visual images, infrared heat images or a combination like the previous images 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 hazard is coming. These can be broadcasted over television, radio and cell phones, or using sirens like this one in the picture.

Siren by Al, https://flic.kr/p/8hRX1Z, CC BY-NC

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Tsunamis are long tall waves that are caused when earthquakes happen at sea. 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.

CC0

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.

J.K. Nakata, U.S. Geological Survey

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 or why don't all homes have storm shelters? Cost, of course. More sturdy structures are much more expensive to build. Storm shelters require land space and money to dig and build another structure. So communities must weigh how great the hazard is, what the cost is, and make an informed decision.

Putting It Together

1. Explain how your understanding of natural hazards has changed.

2. Think of another phenomenon where natural hazards occur that we need to mitigate (reduce) the damage caused.

3. Explain what is going on in these pictures based on what you have learned in this section.