8th Grade Science

for Utah SEEd Standards

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Utah State Board of Education OER

AUTHOR

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

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.

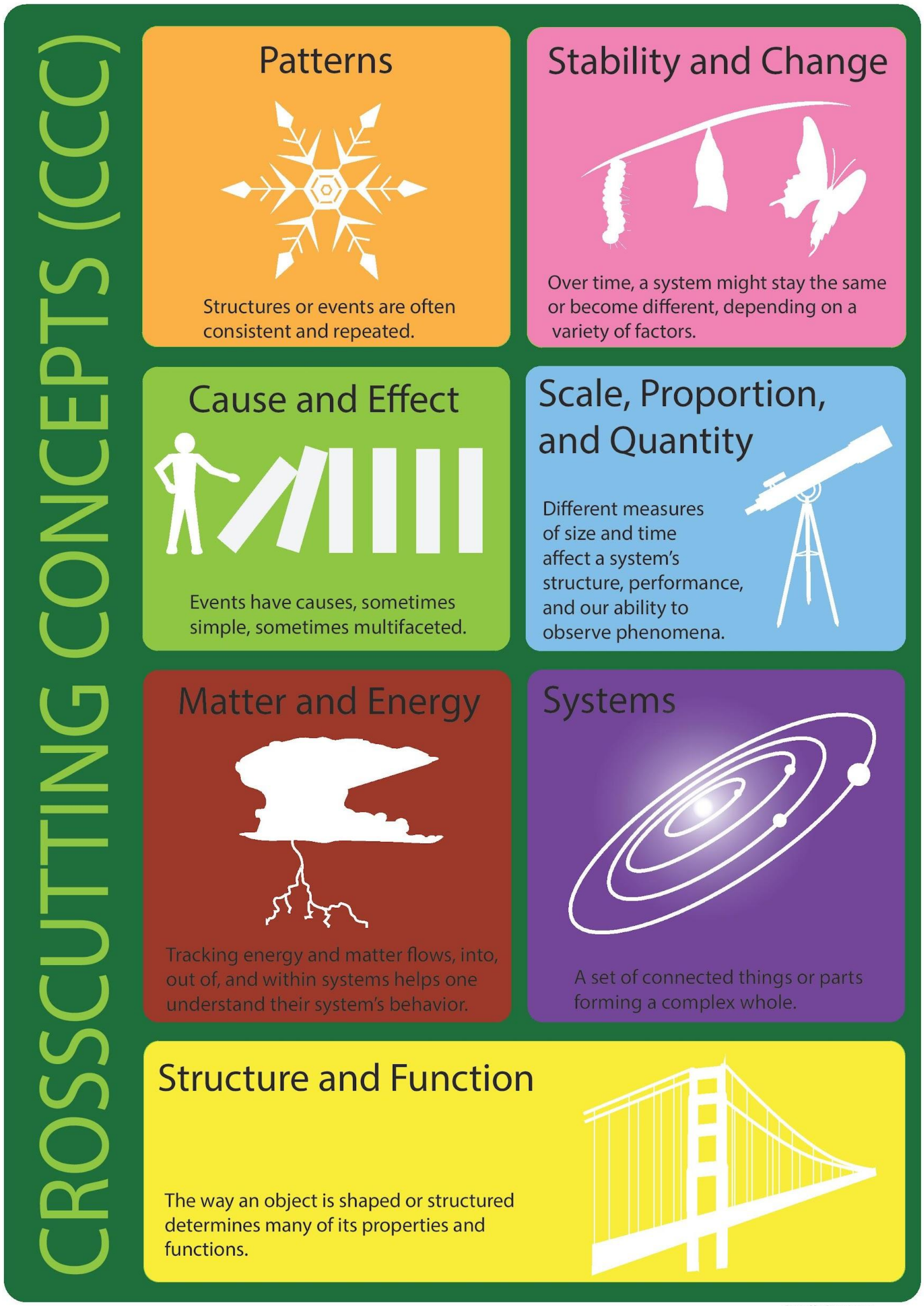
Adam Johnston
Weber State University

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.



What is involved in Engineering Design?

Engineering is a creative process where each new version of a design is tested and then modified, based on what has been learned up to that point. This process includes a number of components:

1. Identifying the problem and defining criteria and constraints.
2. Generating ideas for how to solve the problem. Engineers use research, brainstorming, and collaboration with others to come up with ideas for solutions and designs.
3. Use criteria and constraints to evaluate possible design solutions to identify the one(s) that best address these parameters for the problem in context
4. Build and test the prototypes. Using data collected, the engineer analyzes how well prototypes meet the given criteria and constraints.
5. Suggest or make improvements to prototypes to optimize the design.

In the Science with Engineering Education (SEEd) Standards, specific engineering standards generally involve two types of tasks:

1. If the standard includes the idea of designing, then the design process will contain components of defining the problem (along with identifying the criteria and constraints), developing many possible solutions, and optimizing a solution (e.g., determining a best solution for the situation based on the criteria and constraints, testing the solution, refining the solution).
2. If the standard includes the idea of evaluating, then the design process will contain components of defining the problem (along with identifying the criteria and constraints) and optimizing a solution. The idea of developing many possible solutions is not included because various solutions will be provided. The idea of evaluating then means determining a best solution from the provided solutions for the situation based on meeting the criteria and constraints requirements.

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CHAPTER 1

Strand 1: Matter and Energy

Chapter Outline

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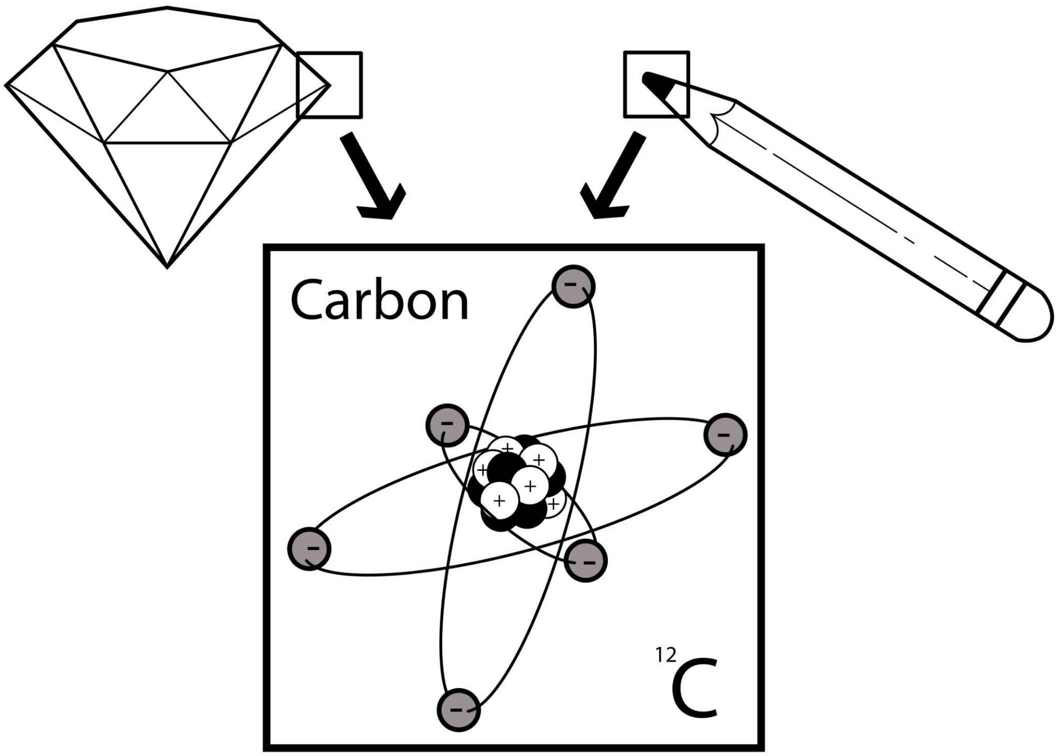
Everything is made of atoms and molecules, even large objects. Energy causes these particles to interact, which can create a variety of substances. As molecules undergo different kinds of changes, the number of atoms remains constant. Humans use energy to turn natural resources into synthetic materials.

1.1 Atoms and Molecules (8.1.1)

Phenomenon

Look at the pencil and diamond. If you could look close enough at the graphite in the pencil or the diamond, you would see what is shown below.



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Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What do you notice that the diamond and graphite in the pencil have in common?

2. What do you notice about the size and scale of what makes Carbon?

3. What do you notice about the proportion of the different parts that make Carbon?

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. (PS1.A

In this section, focus on the scale and proportion of atoms and molecules and how they can be understood using models.

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. Atoms are extremely small, so small that they cannot be seen. The radius of an atom is well under 1 nanometer, which is one-billionth of a meter. A size that small is hard to imagine, consider this: trillions of atoms would fit inside the period at the end of this sentence.

Discovering the Atom

If atoms are too small to see, how do we know about them? Scientific discoveries take time and a complete understanding is often built over time with one discovery helping lead to the next. Below shows some of how this happened for our current model of atoms.

- Around 450 B.C.,the Greek philosopher Democritus introduced the idea that the world was made of something too small to see.
- In 1897, J.J. Thomson discovered atoms have parts with positive and negative charges. His model showed negative electrons mixed with positive charges.
- In 1911, Ernest Rutherford discovered most of the mass was clustered in the center with a positive charge. Negative electrons were on the outside. This was clarified further in 1913 when Rutherford & Neils Bohr recognized electrons were moving.
- In 1926 Erwin Schrodinger took the understanding of the atom further by showing a more accurate motion of the electrons. Rather than specific paths like an orbit, they move so fast in multiple directions they form more of a cloud.
- In 1932 Charles Chadwick discovered the neutral charged neutron in the center with the protons which allowed a more complete model of the atom to be made.

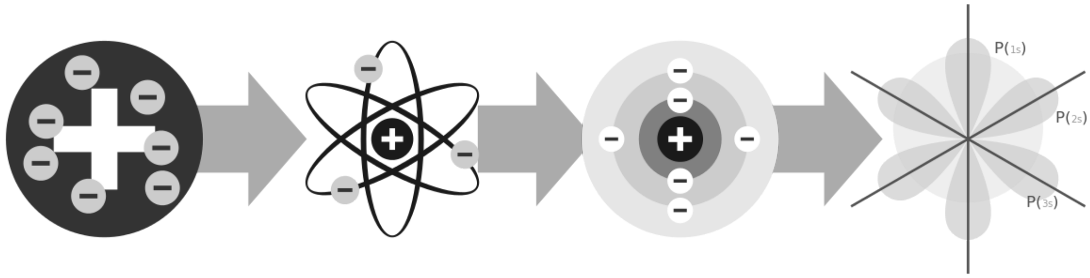
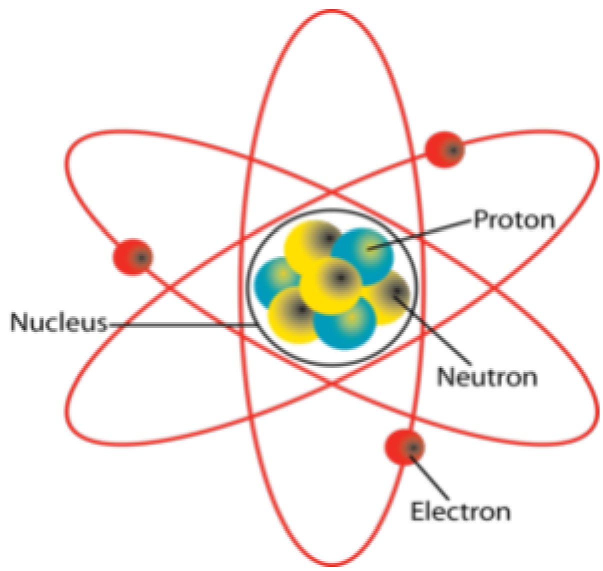


Image by Ville Takanen;
https://commons.wikimedia.org/wiki/File:Evolution_of_atomic_models_infographic.svg; CC BY

Parts of an Atom

Although atoms are very small, scientists were able to identify that even our small atoms are made of even smaller particles. There are three main types of particles that make up all atoms.

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



Ck12.org, CC BY-SA

Protons have a positive electrical charge. The number of protons in the nucleus determines what element the atom is.

Neutrons are about the same size and mass as protons but have no charge.

Electrons are much smaller and have a negative charge. They move at nearly the speed of light, and move around the nucleus.

The model in the previous figure shows how these particles of an atom are arranged. At the center of the atom is a dense area called the nucleus, where all the protons and neutrons are clustered very closely together. The opposite charges of the parts give the structure and motion to the atom.

The protons and neutrons are extremely large compared to the electrons, the nucleus makes up almost all of the mass of an atom. The number of protons in a neutral atom equals the number of electrons.

Using your 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 atoms.

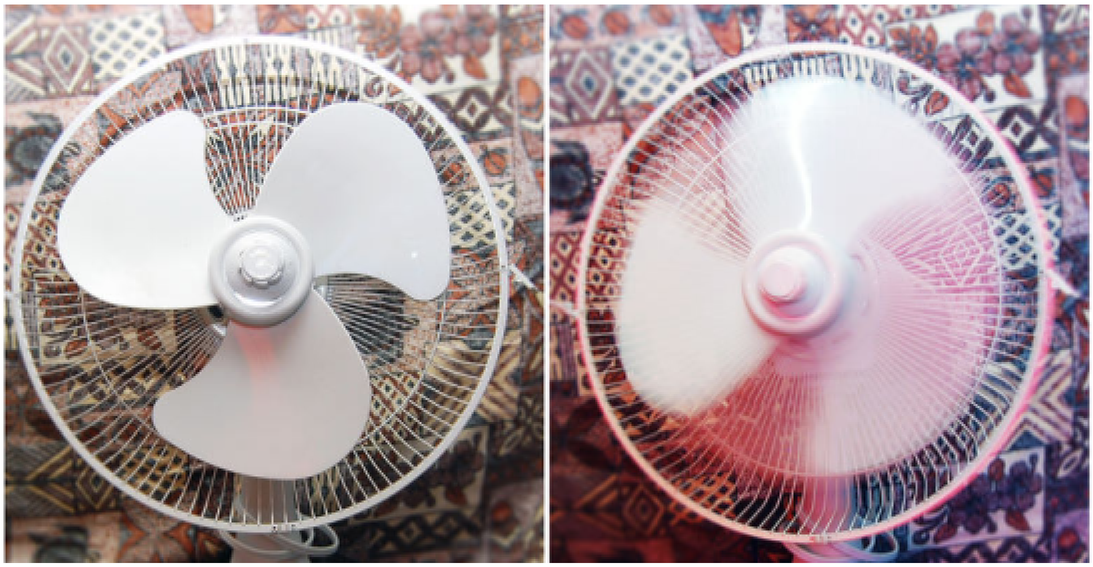


Image by Robert Lopez; CK-12 Foundation; CC BY-NC 3.0

For example, the distance between nucleus and the electrons is much greater. The nucleus is only 1 trillionth of the actual atom, making an atom mostly empty space. Considering the size and scale of this book, it would be difficult to show effectively. This model also doesn't show the proper motion of electrons. Kind of like how you can't see the individual fan blades when on, electrons move in a cloud rather than specific orbits.

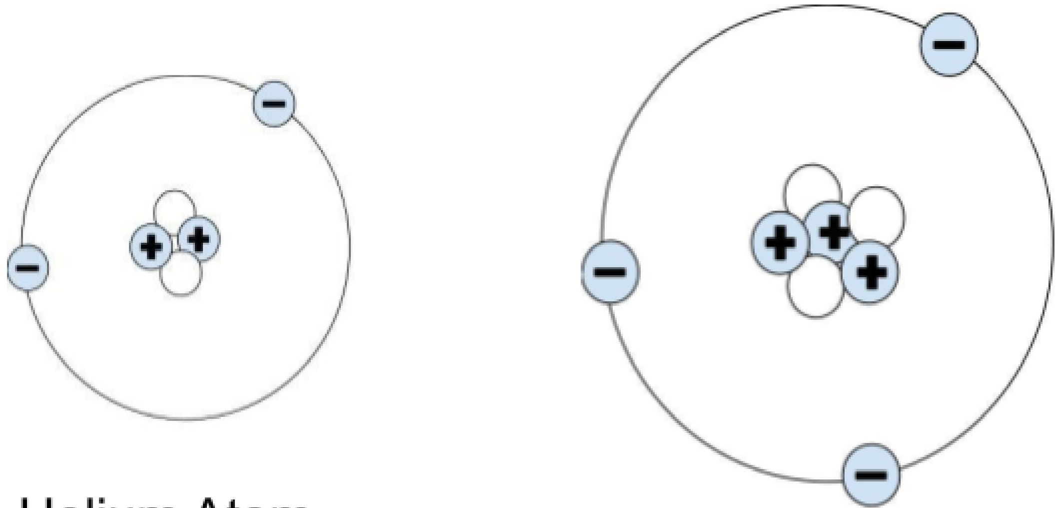
Although the model of the atom is not completely accurate we will frequently see and use it because of what it does show effectively.

(For more opportunity to investigate atoms search online for simulations that allow you to 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 are made of protons, neutrons, and electrons. What makes one atom different from 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. Examine the next figures. A helium atom has two protons, where a lithium atom has three protons. Elements are pure substances that make up all kinds of matter based on the number of protons they contain. Some examples of elements would include nickel, hydrogen and helium.



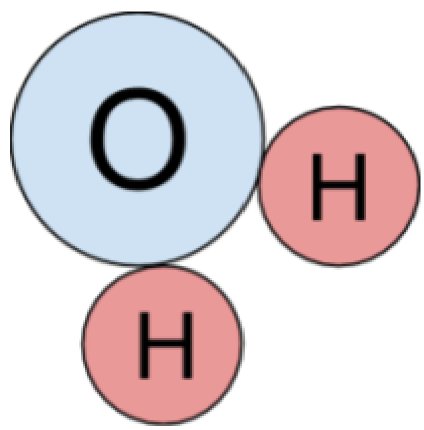
Helium Atom

Lithium Atom

CC0

Molecules

There are only 118 known different elements, but there are millions of different substances in our everyday lives. How do we get 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) connected.



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. Some molecules can be made of more than one of the same element like oxygen which is made from two oxygen atoms (O_2) or ozone made from three oxygen atoms (O_3).

Putting It Together

Look at the pencil and diamond. If you could look close enough at the graphite in the pencil or the diamond, you would see what is shown below.

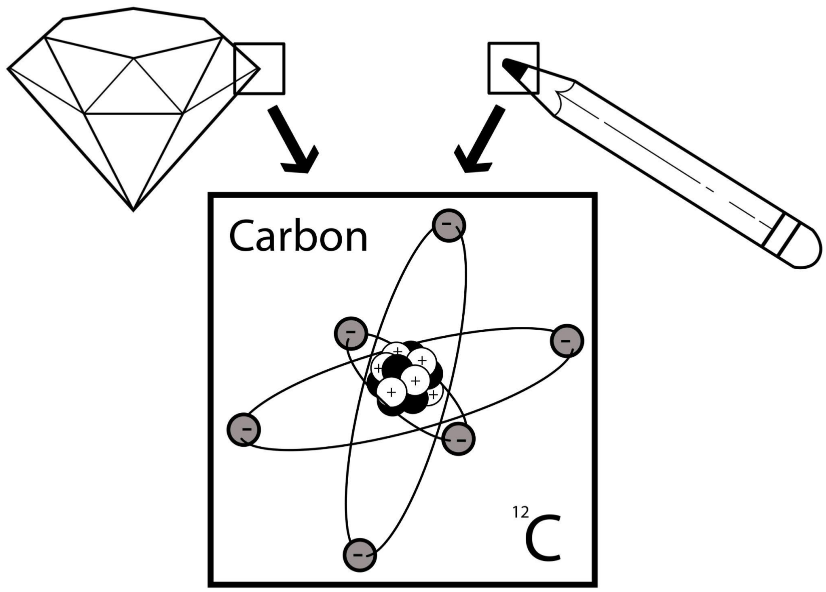


Image by authors; CC0

Focus Questions:

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

1. What do the diamond and graphite in the pencil have in common?

2. What do you notice about the size and scale of what makes carbon?

3. What do you notice about the scale & proportion of the different parts that make carbon?

4. Is the graphite & diamonds made of atoms or molecules?

Final Task:

Select an element and make a model that best represents the scale and proportion of the atom's parts. Then draw a model of a molecule that contains that element, which shows the correct proportion of each element in that molecule.

1.2 Properties of Matter (8.1.2)

Phenomenon

Crayons, birthday candles, letter seals, coatings on cheese, waterproofing leather all use wax but for different purposes.


Image by (Left) Danielle Kellogg; https://flic.kr/p/3eXkCb; CC BY-SA
(Center) WolfBlur; pixabay.com; CC0
(Right) Simon Lesley; https://flic.kr/p/5N8tA7; CC BY-ND

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What are 5 characteristics of wax?

2. What characteristics of wax do you think allow it to be used for these different purposes?

3. What additional characteristics of wax would be helpful to understand how it is able to be used for specific functions?

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. (PS1.A)

In this section, focus on structure and function. Consider how properties of different materials make it so we can design structures to serve different functions.

What is Matter?

Legos, steel cable, the air you breathe, the water you drink--all of it is considered matter. In fact, everything you can see and touch is made of matter. So what is matter? It is the stuff all things are made of (atoms & molecules). 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

Pixabay, CC0

Look at the picture of the Statue of Liberty. Describe what it is made of to someone who cannot see or feel it. The things you described are called properties; they are the characteristics of matter. All matter has a unique combination of properties that make it different from other types of matter. Below is a list of some properties you could use to describe matter.

- **Odor:** Odor is also called smell. We use our sense of smell to detect odors that might be produced by a particular substance. Sulfur has the unpleasant odor of rotting eggs, where carbon monoxide is completely odorless.
    - **Question:** What is a product you use because of its odor?

- **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. Chalk has a very low hardness; it can be scratched by a fingernail.

  - **Question:** What is a way we can use chalk because of its low hardness?

- **State of matter:** Whether the substance is a solid, liquid, or gas. At room temperature oxygen is a gas, water is a liquid, and aluminum is a solid.
  - **Question:** What is a way we can use water because it is a liquid?

- **Solubility:** Ability to dissolve in another substance: Some substances dissolve and others do not. Sand does not dissolve in water, sugar does.
  - **Question:** What is a way we can use sand because it does not dissolve in water?

- **Color:** The color of a substance. Some substances have specific distinct colors like gold, while others like oxygen are colorless.
  - **Question:** What is a way we can use gold because of its color?

- **Reactivity:** The ability of matter to combine chemically with other substances.
  - Iron is highly reactive with oxygen. When iron combines with oxygen, a reddish powder called rust forms. Rust is not iron but an entirely different substance that has molecules made of both iron and oxygen.
  - Water is very reactive to sodium, when a small amount of water is added to a small amount of sodium, it reacts explosively.
    - **Question:** When cooking, many ingredients are chosen because of their reactivity or non-reactivity with other ingredients. What is a cooking ingredient that gets used because of its reactivity?

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

- **Density:** The amount of mass of a substance compared to its volume. It shows how closely packed the atoms or molecules of matter are. A solid rock's particles are more dense than water and will sink while wood is less dense than water and will float.
    - **Question:** What is a way we can use wood because of its density compared to water?

- **Melting and boiling point:** This is the temperature at which a substance goes from a solid to a liquid (Melting Point) or a liquid to a gas (Boiling Point). 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.
    - **Question:** The melting point of milk Chocolate is 86°F/30°C. What is a way we can use milk chocolate, knowing its melting point?

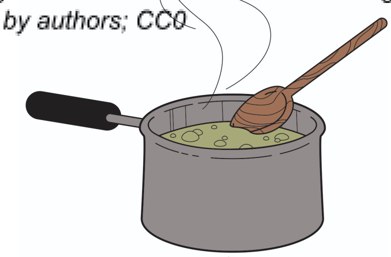
- **Flammability:** The ability of matter to burn. Wood is flammable; iron is not.
    - **Question:** What is a way we can use iron because it is not flammable?

- **Malleability:** The ability of a solid to bend or be hammered into other shapes without breaking. Gold is very malleable so it can be made into foil/leafing for art and food. The wood of a pencil is not malleable, it will break.
    - **Question:** Aluminum is very malleable, what is a way we can use aluminum because of its malleability?

- **Ability to conduct heat or electricity:** Some materials conduct electricity and others do not. Aluminum and copper are good conductors of both heat & electricity, wood, rubber, and plastic are not.
    - **Question:** What is a way we can use rubber because it does not conduct electricity?

Copper wire conducts electricity while the plastic coating does not.
Image by papazachariasa; pixabay.com; CC0

The aluminum in the pan conducts heat well, allowing the heat to transfer to the food and helping with the cooking. However, the rubber handle and wooden spoon do not, making them safe to handle while cooking.
Image by authors; CC0



- **Other properties** include crystal shape, shininess, transparency, magnetism, etc.

Properties Determine Function

A substance's properties determine the function it can be used for.   We can think of function as what or how we use something. For example, aluminum is a shiny gray metal that is very malleable. It also has a low density, is non-toxic, and high thermal & electrical conductivity. It has a low reactivity to most other substances. Because of these properties, aluminum is very useful in a wide range of products including: cans, foils, kitchen utensils, window frames, airplane parts, telescope mirrors, furniture and much more.

Putting It Together

Crayons, birthday candles, letter seals, coatings on cheese, waterproofing leather all use wax.

Focus Questions:

1. Using what you learned, describe the properties of wax.

2. Which property(s) of wax allow it to be used for crayons?

3. If wax had the hardness of a diamond, how would the function of a crayon be affected?

4. Which property(s) of wax allow it to be used as a waterproofing for leather?

Final Task:

Choose an item you can see from where you are sitting. Explain one of its functions and identify the property(s) that allow it to be used for that function.

1.3 Chemical Reactions (8.1.3)

Phenomenon

This paper has been changed multiple ways. It has been folded, torn and burned and looks different after each change.

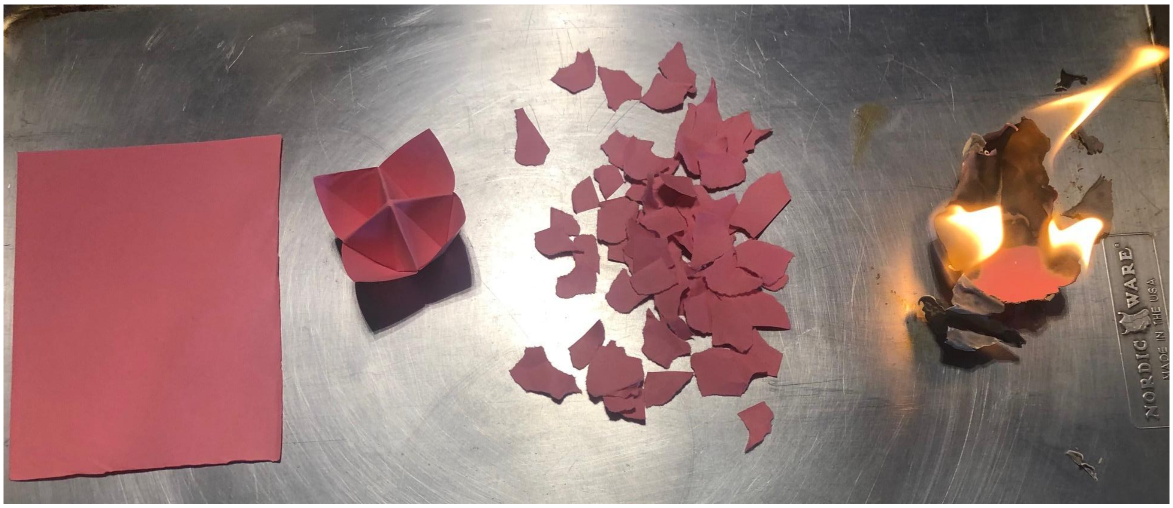


Image by authors; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

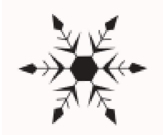
1. What are some properties that have stayed the same?

2. What are some properties that have changed?

3. Do you think the paper that turned black is still paper, or a different substance?

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 if a chemical reaction has occurred. Examples could include changes in properties such as color, density, flammability, odor, solubility, or state. (PS1.A, PS1.B)



In this section, look for the patterns observed in chemical reactions that provide evidence that there has been a new substance formed.

What is a Chemical Reaction

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. Not all reactions are as dramatic as this "volcano." Some are slower and less obvious.

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

Signs of Chemical Reaction

How can you tell whether a chemical reaction has occurred? Often, there are clues.

- **New substance forming**. This means there is new or different matter (molecules) that has formed from the original matter. Example: plants take in carbon dioxide and turn it into oxygen molecules.

A new substance is the only way to be positive that a chemical reaction has occurred. This can sometimes be difficult to determine so we often have to look for other clues. To help decide whether a chemical reaction has occurred, look for these other common clues or signs:

- **A change in energy.** Example: A firework produces heat, light, and sound. Vinegar and baking soda will get cold.
- **Bubbles of a new gas are released.** Example: Baking soda and vinegar mixed produce bubbles that contain a new gas.
- **Something changes color** for a reason other than simply that two colors were mixed. Example: Leaves turn from green to red or cooked eggs turning from clear to white.
- **A new odor is produced.** Example: Logs burn and make a smoky smell.
- **A solid comes out of a solution**. This is called the formation of a precipitate. Example: When acid is added to milk it makes cottage cheese.
- **Extreme or unusual property changes**: Any other property that is extremely different than it was before can be a sign of a change. This could be changes in density, flammability, or like pennies going from shiny to dull. The more extreme or unusual, the more likely there have been new substances formed as a result of a chemical reaction.

Image by Enotovyj; pixabay.com; CC0

These changes in properties only indicate that a chemical reaction may have occurred. Remember, the only way to be positive that a chemical reaction has happened is to find if a new substance has formed. The reason other properties change is because the new substance(s) have different properties than the original substance(s).

Because new substances are formed, chemical reactions cannot be undone. For example, you can't unbake a cake. Some chemical reactions can be returned to the original substance, 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 new chemical reaction that makes the pennies bright and shiny again. You can try this yourself at home to see how well it works.

(An internet search for videos that show signs of a chemical reaction could be helpful.)

Leaves turn color in the fall because of chemical changes in the leaves.

When you fry an egg, the heat changes it into different substances with different properties. For example, the clear liquid part turns into a white solid.

Some of these copper pennies are bright and shiny. Others are dark and dull. The dull pennies have tarnished. Their copper has combined with oxygen in the air to form a new substance with different properties.

The logs in this campfire are slowly burning down to ashes. The ashes are composed of different substances than the logs. They have a different color and texture than wood.

These chemical reactions all result in the formation of new substances with different properties.

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 many different properties than the original materials. The process of baking causes chemical reactions in the ingredients that result in a new product with new properties (like color, taste, density & texture): bread.

(images obtained from pixabay.com; CC0

Putting It Together

This paper has been changed multiple ways. It has been folded, torn and burned and looks different after each change.

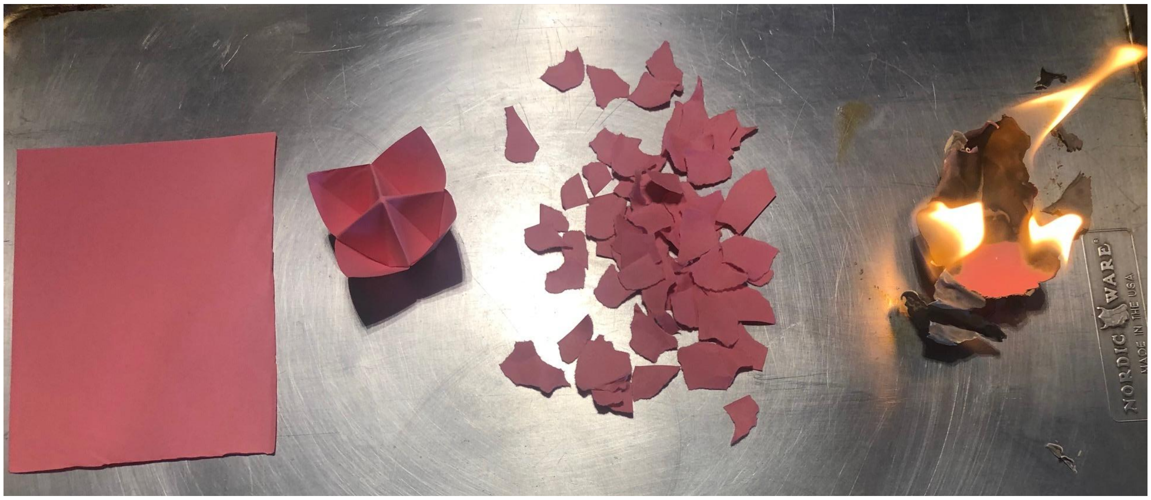


Image by authors; CC0

Focus Questions:

1. Which of the changes to paper result in a chemical reaction? What patterns support this?

2. Which of the changes to paper have NOT resulted in a chemical reaction? What patterns support this?

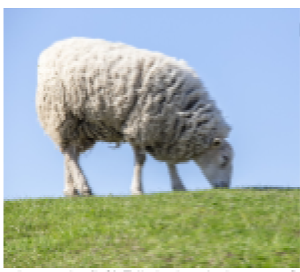
Final Task:

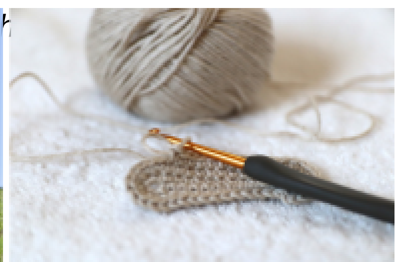
Explain another way you could change paper? Explain the properties that are different and use those patterns to provide evidence of whether or not a chemical reaction has occurred.

1.4 Natural vs Synthetic Materials (8.1.4)

Phenomenon

You look at the tag on one of your shirts and see that it says 100% cotton, another one of your shirts says 100% wool.





Images by (left) Erik_karits; pixabay.com; CC0; (center) Sato-Imo; pixabay.com; CC0; (right) Jen Kim; https://flic.kr/p/7fV28q; CC BY-NC-ND

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. If wool is sheep fur, how can it be what your sweater is made of?

2. If cotton is a plant, how can it be what your shirt is made of?

3. What does the sheep, yarn, and sweater have in common?

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 new materials could include medicine, foods, building materials, plastics, and alternative fuels. (PS1.A, PS1.B, ESS3.A)

In this section focus on when humans change the structure of the molecules in natural resources they create synthetic materials with new properties which changes the function the resources and synthetic materials can be used for.

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 a science lab which is true, synthetic things have been made by mankind.

Looking at the following images identify which you think are synthetic materials and which you think are natural resources.

Cotton plant

Synthetic or natural?

Cotton balls for makeup

Synthetic or natural?

Wood

Synthetic or natural?

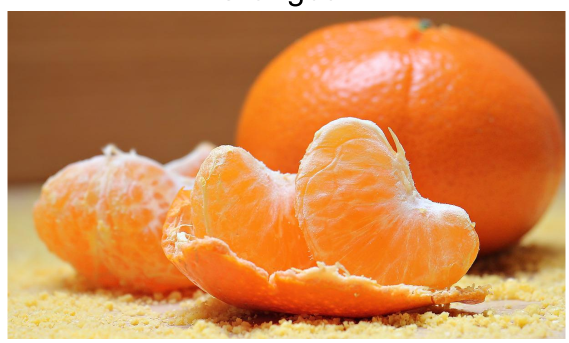
Vinyl Flooring

Synthetic or natural?

Vitamin C Tablets

Synthetic or natural?

Oranges

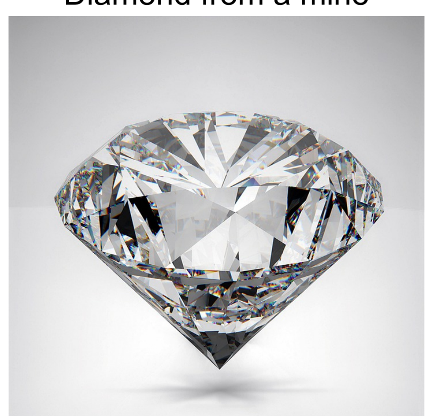


Synthetic or natural?

Diamond made in a lab

Synthetic or natural?

Diamond from a mine



Synthetic or natural?

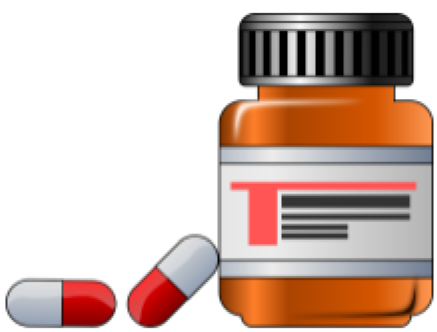
All pictures from pixabay.com; CC0

Synthetic Materials vs Natural Resources

The diamond on the left was created in a lab. It is synthetic. The diamond on the right above came from a mine. It is natural. The diamond produced in the lab costs about 30% less than the mined diamond. What's the difference between them? These two diamonds have the same properties and are made of the exact same thing: carbon, 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.

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.

Synthetic Materials come from Natural Resources



(Public domain)

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

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 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. Even though they are synthetic, they 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 indoors and outside, and it is cheap to make. Plastic is mainly made from petroleum (oil). Plastics have a downfall though, in that they take a long time to decompose and often become a hazard to other organisms.

Clothing is 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 (synthetic). Silk and cotton are examples of natural fibers. Silk is produced by silkworms and woven into cloth and cotton is grown as a plant which is also woven into cloth. Human-made fabrics include nylon and polyester. These materials are made from petroleum (oil) products. Synthetic fabrics are often 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 water-resistant and more durable. Nylon has also been used to make things besides fabric.Because it is strong and lightweight, nylon is a component of ropes, fishing nets, tents, utensils and parachutes.

Putting It Together

You start looking at other tags and labels on items you use and notice more variety like 50% Cotton 50% Polyester.

Picture by Author

Focus Questions:

1. Explain your understanding of synthetic vs natural substances.

2. What natural resource does the synthetic polyester in the shirt come from?

3. Based on what you learned in this section, explain what the connection is between the sheep fur and a sweater.

4. What is a function we can use the polyester cloth for differently than the natural material of oil it came from?

Final Task:

Think of another example of a functional (useful) synthetic material, identify what it is used for and the natural resources it comes from.

1.5 States of Matter (8.1.5)

Phenomenon

You notice that the steam from a hot pool, cup of coffee, steam engine, & factory steam towers always move up.

Yellowstone Hot Pool | Factory steam Tower | Hot Coffee | Steam Engine

Images from pixabay.com; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. Why do you think steam always moves up?

2. What would change if these were cooled instead of warmed up?

3. If you could zoom in to the particles of the steam and the warm liquid what would they look like? Draw a model of how you think the particles would be similar and different?

Model of Steam particles	Model of warm liquid particles

8.1.5 The States of Matter

Develop a model that uses **computational thinking** to illustrate the 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 on calculating density of a substance's state. (PS3.A)

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

At room temperature, matter exists in one of three states: solid, liquid, or gas. The state of matter of a substance is one of its properties. Some substances at room temperature are gases like oxygen and carbon dioxide, while others, like water and the metal mercury, are liquids. Most metals, like silver and gold, are solids at room temperature.. Each of the states of matter have unique characteristics in how the particles move and how close the particles are, which also affects volume and shape. A fourth state of matter called plasma exists, but it does not occur often on earth, so we will not study it here.

The Role of Energy in Changes of State

Although we are familiar with elements in one state of matter, like oxygen as a gas and iron as a solid, elements can exist in any of these three states.

If substances can be in any state of matter, What causes them to change from one form to the next?

Suppose that you leave a chocolate candy bar in the car on a hot day. A couple of hours later, you notice that the chocolate has turned into a puddle.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 the heat in the car. If you were to place the melted chocolate in a refrigerator, it would lose heat energy to the 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 matter goes through a phase change, it either absorbs energy—as when chocolate melts—or releases energy--as when chocolate freezes back to solid.

The Effects of Adding or Removing Energy

As heat is added or removed causing a phase change, the temperature of the substance will also change. Changing energy is a “cause” that has multiple “effects” other than changing the temperature. 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 causing a phase change. These effects are seen when energy is removed. 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.

The changes that occur when heat is added are called melting, vaporizing (boiling or evaporating), and sublimation. Changes that occur when heat is removed are freezing and condensation. There is no such thing as cold being added, only heat being removed.

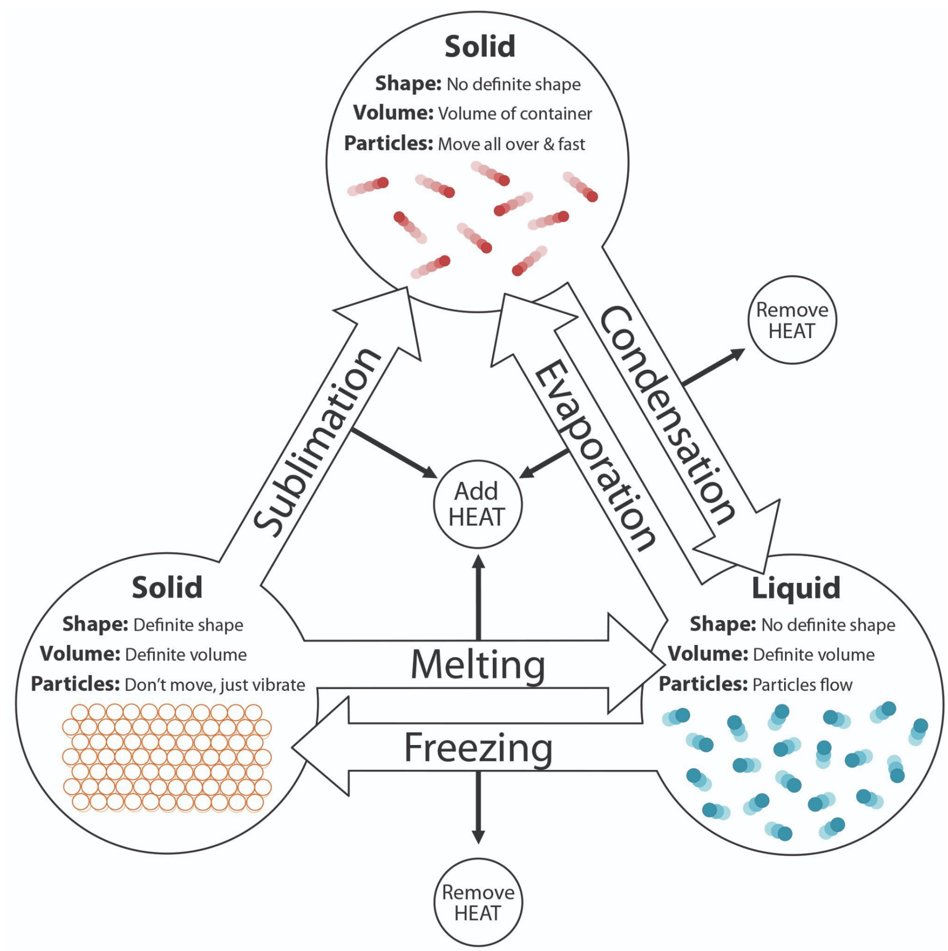


Image by authors; CC0

Defining Density

The spacing between particles changes when heat is added or removed. This is known as density. When particles are packed together more tightly, matter has greater density. The more particles are spread, the more space forms between particles, lowering the substance's density. Differences in density of matter explain many phenomena like why a helium balloon floats in air and rocks sink in water. Differences in density of cool and warm ocean water also 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. The volleyball, in contrast, is full of air, which contains fewer, more widely spaced particles of matter that are a gas. 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)

Draw a model showing the particles inside the bowling ball and the volleyball. Can you show differences in density, particle motion, and state?

Bowling Ball	**Volleyball**

Does your bowling ball model have labels and visuals that show that the inside is a solid with very dense (closely packed particles, that stay put? Does your volleyball model show the inside is a gas with particles that have a lot of space between particles (low density) and moving throughout the space?

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 measure of volume volume. Therefore, the density of matter can be calculated with this formula:

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

For example, if the bowling ball above has a mass of 5,897 g and a volume of 5,269 cm^3, the density would be calculated as follows:

$$Density = \frac{5{,}897g}{5,269\ cm^3} = 1.1\ g/cm^3$$

PRACTICE:
Question: What is the density of the volleyball that has a mass of 260 g and a volume of 5060 cm^3?

Answer: The density of the volleyball is: $Density = \frac{260g}{5{,}060\ cm^3} = 0.05\ g/cm^3$

Although the most common label for density is g/cm^3, always use the mass unit over the volume unit. For example if the volume of the volleyball was in mL, it would have a density of 260 g ÷ 5,060 mL = 0.05 g/mL. If the bowling ball was weighed in pounds and its volume cubic inches, it would have a density of 13lbs ÷ 323 in^3 = 0.0025 lb/in^3

Putting It Together

You notice not only the steam coming from a hot liquid moves up, but the bubbles forming in boiling water also move up.

Yellowstone Hot Pool

Factory steam Tower

Hot Coffee

Steam Engine

Bubbles in boiling water

By Marco Fidele; https://flic.kr/p/61dTJ1; CC BY-NC-ND

Focus Questions:

1. Why do steam above hot water & gas bubbles in boiling water always move up?

2. Do you think anything would change if heat was removed from the liquids instead of warmed?

3. If you could zoom in to the particles of the steam and the warm liquid, draw a model of how you think the particles would be similar and different (motion, temperature, density & state)?

Model of warm liquid particles	**Model of warm steam particles**	**Model of gas bubbles in boiling water**

Final Task:

Describe your own example of a phase change. Identify what caused the phase change to occur and draw a model before and after to show the effect of the change on the particles of the substance.

1.6 Conservation of Matter (8.1.6)

Phenomenon

Image by Maklay62; pixabay.com; CC0

Natural Gas, mostly methane, is used for this stove. It burns and you can cook your food. You ask your parents where the gas comes from. They tell you it is hooked up to the house and you pay a bill every month for the amount you use.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What is happening to the atoms that are in methane (CH_4)

2. Has the type and amount of atoms before the burning and after the burning changed?

8.1.6 Conservation of Matter

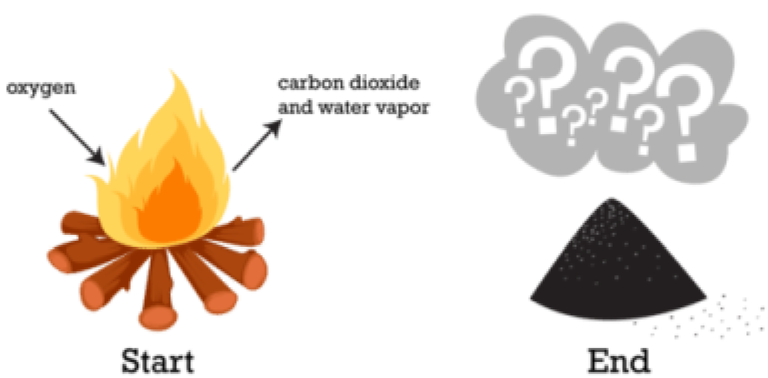
Develop a model to describe how the total number of atoms does not change in a chemical reaction, indicating that matter is conserved. Emphasize demonstrations of an understanding of the law of conservation of matter. Balancing equations and stoichiometry will be learned at the high school level. (PS1.B)

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

Conservation of Matter

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 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 matter.

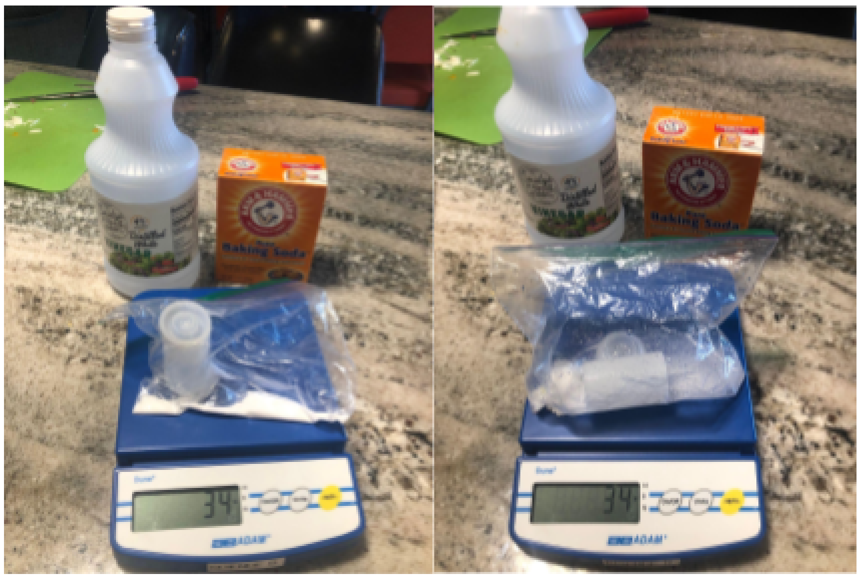
If you build a campfire you start with a large stack of sticks and logs. As the fire burns, the stack slowly shrinks. By the end of the evening all that is left is a small pile of ashes. What happened to the matter you started with? Was it destroyed by the flames? It may seem that way, but in fact the 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)

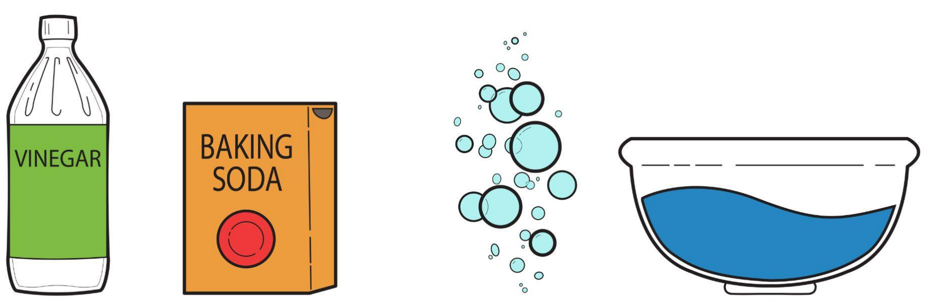
All of the matter that used to be in the wood was changed into the gases and ash. This example illustrates the law of conservation of matter. The law states that matter cannot be created or destroyed. If matter cannot be created or destroyed, the matter only rearranges to form different substances. Because matter is only rearranged, the total amount of matter always remains the same. The total mass of the products (substances after a reaction) must be equal to the total mass of the reactants (substances before a reaction).

A simple experiment can be done with vinegar & baking soda. In this experiment, vinegar and baking soda were placed in a sealed bag and the mass was 34g. With the bag still sealed, the vinegar was allowed to mix with the baking soda. Once the reaction was finished, the mass was taken again: the mass was 34g. New things, like carbon dioxide bubbles were made inflating the bag, but the total mass did not change. How does this happen?



Before **After**

Image by authors; CC0



$$C_2H_4O_2 + NaCHO_3 \longrightarrow CO_2 + NaC_2H_3O_2 + H_2O$$

Vinegar, Baking Soda, Carbon Dioxide, Sodium Acetate, Water

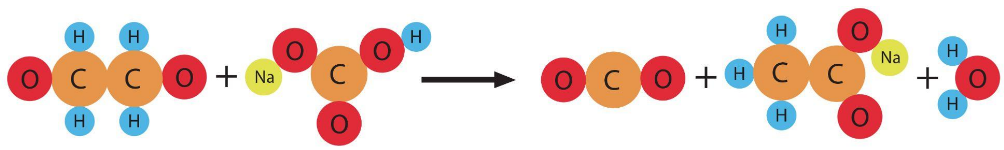
If you were able to keep track of all the atoms that were in the vinegar and the atoms that made the baking soda you would see that the atoms rearranged to make carbon dioxide bubbles, water and sodium acetate molecules.

The chemical equation shown below is a model that helps us see the rearrangement that takes place during the reaction. During a chemical reaction the atoms of the reactants rearrange to make the products. Nothing is created or destroyed. This is why the total mass before the reaction will equal the total mass after the reaction.

If you have building blocks and take them apart and build something new, would you be surprised that the mass of your first object was the same as the new one you built? No, you are dealing with the exact same blocks their mass will not change just because you arranged them differently. This is what happens with a chemical reaction. The type and amount of atoms stay the same, they are just rearranged to different molecules. Which is why a new substance is the most important evidence of a chemical reaction.

Use the model below for the vinegar and baking soda reaction to prove that matter is conserved during the reaction:

- Count the total amount of each type of atom for the reactants and then the products. Record in the table below.



$$C_2H_4O_2 + NaCHO_3 \longrightarrow CO_2 + NaC_2H_3O_2 + H_2O$$

Vinegar | Baking Soda | Carbon Dioxide | Sodium Acetate | Water

Image by authors; CC0

Products	Reactants
____Total Na atoms ____Total O atoms ____Total C atoms ____Total H atoms ____Total of all Atoms	____Total Na atoms ____Total O atoms ____Total C atoms ____Total H atoms ____Total of all Atoms
Was matter conserved? Explain:	

The reactants and products both have a total of 3 Carbon (C) atoms, 5 Hydrogen (H) atoms, 5 Oxygen (O) atoms, and 1 Sodium (Na) atom. This makes a total of 14 atoms that make both the products and the reactants showing that the same type and amount of matter is in both the products and the reactants.

Putting It Together

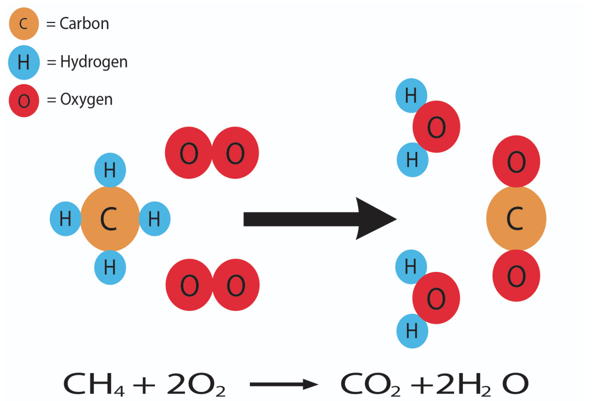


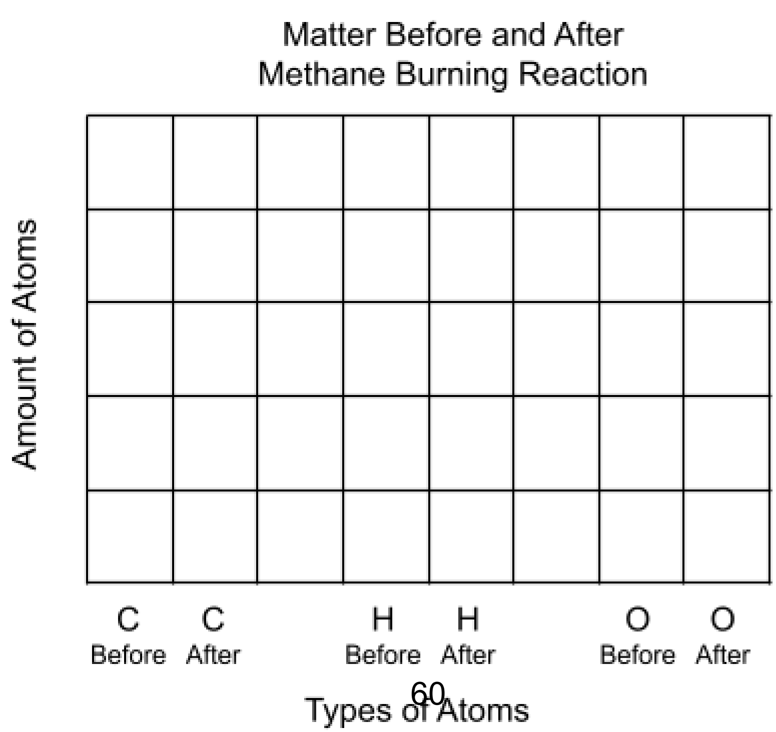
Image (left) from pixabay.com; CC0. Image (right) by authors; CC0

If you could look closely at what the particles of the methane in natural gas are doing when burning on the stove, you would see the reaction shown on the right.

Focus Questions:

1. Has the type and amount of atoms before the burning and after the burning changed?

2. Use the model above of the chemical reaction to fill in the chart below to provide evidence that matter is conserved when methane burns.



3. Which is a better model to represent matter being conserved? Explain.

Model 1: A student made models of molecules using gumdrops and toothpicks. When showing a reaction happening they ate some gumdrops and replaced them with pencil shavings to show that some substances are destroyed and new substances appear.	**Model 2:** A student made models of molecules using legos. When showing the molecules going through a reaction they took apart the legos and put them back together to make new molecules.

Final Task:

How could you use Legos or beads to make a model to show matter being conserved in the methane reaction?

1.7 Devices Affecting Phase Change (8.1.7)

Authentic Situation

Imagine you want to build a cabin in Utah's Uinta Mountains. The cabin will get very cold in the winter. If left without heat for an extended period of time, the water pipes inside the cabin can freeze and burst.

(Pixabay, CC0)

Observations & Wonderings

What is the problem in this situation?

What are possible criteria (positive outcomes) to this situation?

What are constraints (limitations) with finding a solution?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What do you already know about phase changes that would help you in this situation?

2. What questions can you ask to understand this situation better?

3. How might you 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, based on* ***data analysis****, and modify them to improve the device to better meet the criteria for success. (PS1.B, PS3.A, ETS1.A, ETS1.B, ETS1.C).*

In this section, focus on energy and matter. Evaluate energy flow through different materials to control the rate of a phase change.

Engineering Design

This is an engineering standard. Refer to page 10 to read about engineering design. Which type of engineering task is utilized in this SEEd Standard?

Changing the rate of a phase change

Phase change occurs when energy is added or removed and the matter changes state. For example when water changes from a liquid to a solid, we say its phase has changed. 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, which limits heat energy transferring, 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.

Frozen Pipes

Consider the problem of developing something to prevent your pipes from freezing in the winter. Many questions would have to be researched in the design process. For example, what is the best type of insulator, what temperature does water 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 (heat) 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 pink fiberglass insulation inside the attic of a home. Like the feather down 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

Imagine you want to build a cabin in Utah's Uinta Mountains. The cabin will get very cold in the winter. Propose some ideas that will prevent the water in the pipes in your cabin from freezing.

(Pixabay, CC0)

Focus Questions:

1. Which do you think would be the best first thing to try? Explain.
2. Which would be the least effective to try? Explain
3. What data would be helpful to collect in deciding if your solution is effective??
4. Explain how your ideas of how you could redesign this cabin have changed.

Final Task:

Design an experiment to test the 2 methods that would be most effective to prevent water from freezing. Explain the benefits of each method. What data would you need to collect to be able to compare the best characteristics of each.

CHAPTER 2

Strand 2: Storing and Transferring Energy

Chapter Outline

(*Roller Coaster* by SouthEastern Star, https://flic.kr/p/dyrT5Z; CC BY-NC-ND)

Objects can store and transfer energy within a system. 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 also travel in waves and may be used to transmit information.

2.1 Energy Speed and Mass (8.2.1)

Phenomenon

You are given a baseball bat, a wiffle ball and a baseball. As you try to hit both of these as far as possible you notice that even when you hit both with the same amount of force the baseball will always go farther than the wiffle ball. You can also throw the baseball farther than you can the wiffle ball even though they are the same size.

Image (left) by SocialButterflyMMG (right) by KeithJJ; pixabay.com; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What is the difference between the two balls that would cause the baseball to always go farther?

2. If you change how fast you throw or hit the baseball how would that affect the distance it goes?

8.2.1 Energy: Speed and Mass

Use computational thinking to **analyze data** about the relationship between the mass and speed of objects to 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. (PS3.A, PS3.C)

Focus on how the quantity of mass and speed has an effect on the amount of kinetic energy of an object.

Kinetic Energy

What do these four photos have in common?

Credit: *Bees: Nick O'Doherty; Motorcycle: Sean Rozekrans; River: Ryan Mcdonald; Saw: Courtesy of Mass Communication Specialist 3rd Class Chelsea Mandello, U.S. Navy*
Source: *Bees: https://flic.kr/p/eWRvNs; Motorcycle: http://www.flickr.com/photos/fruitbit/7842739156; River: https://flic.kr/p/2o9x8c; Saw: https://flic.kr/p/diuLhJ*

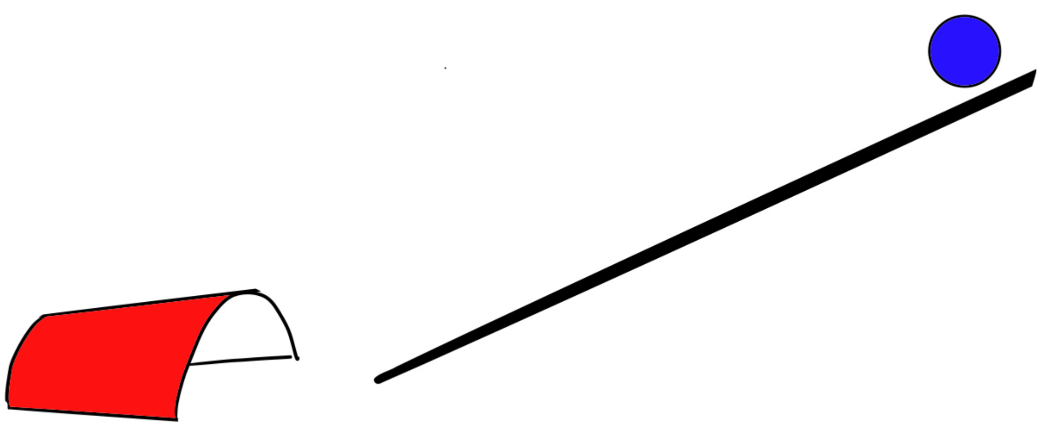
Energy exists in many different forms, but the one you should be very familiar with is kinetic energy. Kinetic energy is often thought of as the energy of motion because it is used to describe matter that is moving. The spinning saw blade, flying bee, racing motorcycle, and the flowing water in the photos 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, the 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. Kinetic energy is proportional to the mass of the moving object and grows with the square of its speed.

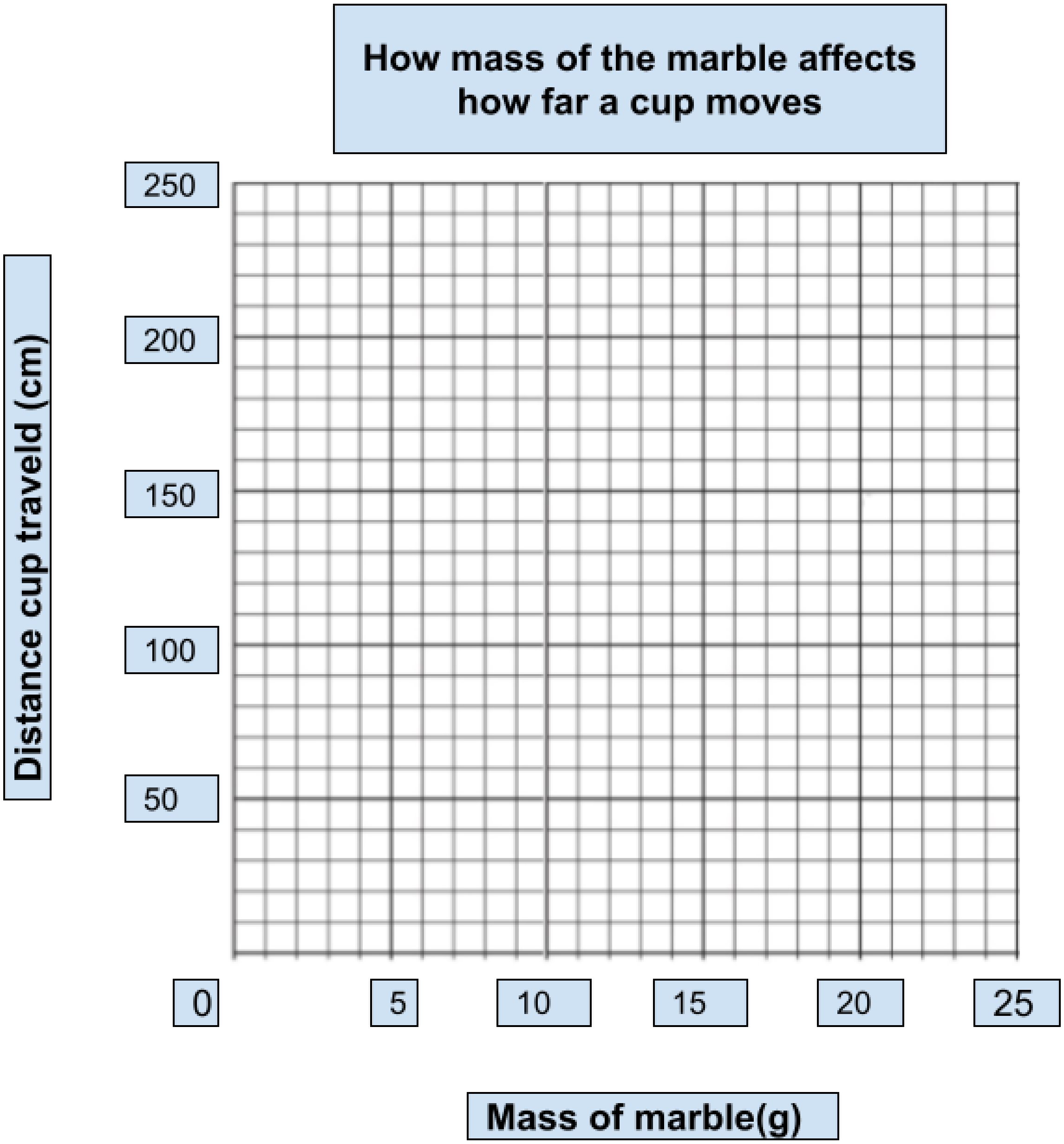
Investigation How Mass affects Kinetic energy

You can test how mass affects the amount of kinetic energy in an object by running an experiment. If you roll three balls of the same size, a heavy glass marble, a lighter plastic marble and an even lighter styrofoam ball, down a ramp and into a paper cup you can measure how far the paper cup moves. Since Kinetic energy is the energy of movement if the cup moves farther it means that the marble had more kinetic energy. Look at the data in the experiment below



Material marble is made of	Styrofoam	Plastic	Glass
Mass of the marble	0.2 grams	9.5 grams	20.4 g
Distance the cup moved	0cm	107cm	208cm

Graph the data on the chart on the next page.



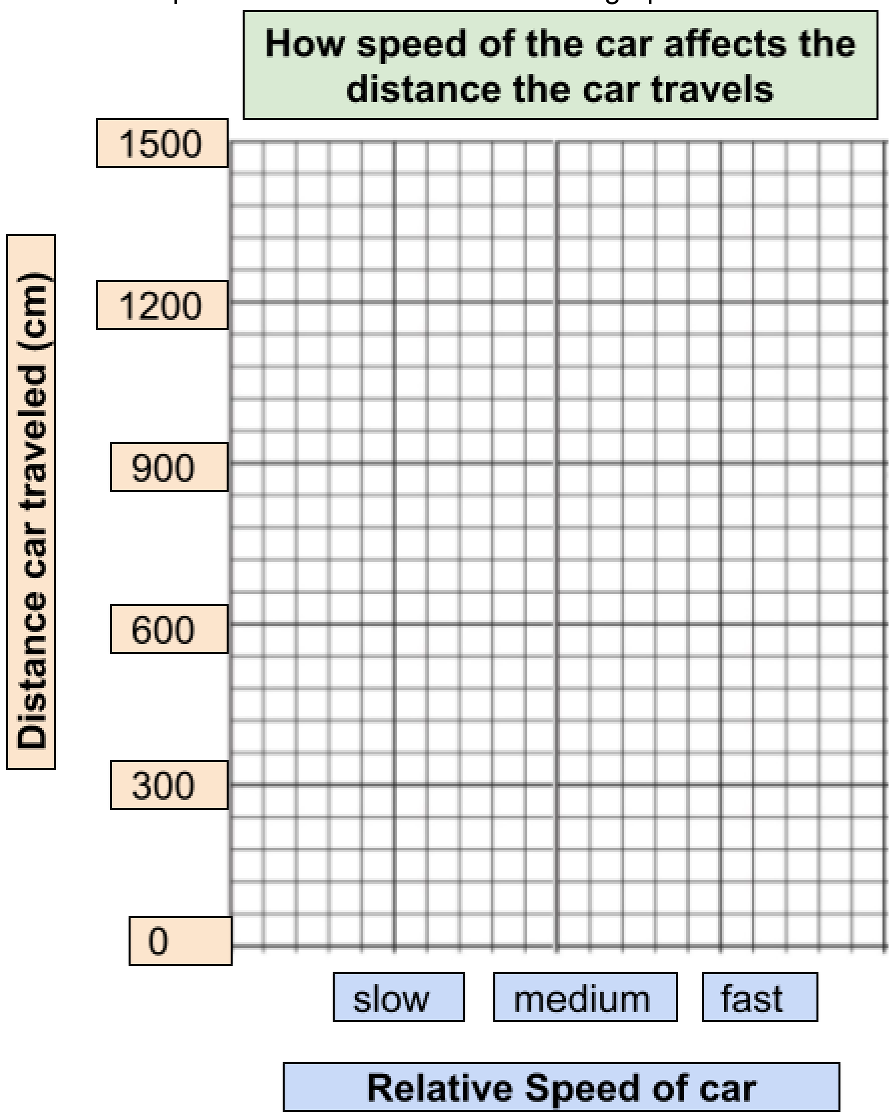
Is there a pattern to the data? As the mass of the marble increases what happens to the distance the cup moves? The Glass marble has more mass than the styrofoam ball and you will notice that when they hit the cup the more massive glass marble causes the cup to move farther. This evidence supports the claim that moving objects with more mass have more kinetic energy because the more massive marble caused the cup to move more.

Investigation How Speed Affects Kinetic Energy

You can also test how speed affects an object's kinetic energy by rolling a toy car at different speeds and measuring how far it is able to travel at each speed.

Speed of the Car	Slow	Medium	Fast
1st Distance car moved	250cm	882cm	1450 cm

Graph the data from the table on the graph below.



Is there a pattern to the data? As the speed of the car increases what happens to the distance the car moves? The data from this experiment supports the claim that objects with more speed have more kinetic energy because when the car was going faster it also went the farthest distance.

Putting It Together

You measure the mass of both of the balls and identify that the baseball definitely has a much larger mass than the wiffle ball does. You try hitting another ball with a similar mass to the baseball and it goes about the same distance.

Image (left) by SocialButterflyMMG (right) by KeithJJ; pixabay.com; CC0

Focus Questions:

1. How does the amount of mass of the wiffleball and the baseball affect the distance they move?

2. How would the relative speed you throw the ball affect the distance they go?

3. How is the amount of kinetic energy related to the distance the ball goes?

Final Task

Construct an explanation using the data you analyzed in the chapter to explain the relationship between the mass and speed of an object and the effect that has on the amount of kinetic energy the object has.

2.2 Potential Energy (8.2.2)

Phenomenon

Snowboarding is a sport that involves speed and movement. However the snowboard itself doesn't provide any energy. If you put a snowboard on and stand in your living room you are not going to go anywhere but one of the fastest snowboarding speeds was clocked at a speed of 126mph.

Image by Scros; pixabay.com; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What types of energy are involved with the snowboarder going down the hill?

2. How could the snowboarder change the amount of speed and movement he has?

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. (PS3.A, PS3.B)

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

Potential Energy

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

Potential energy is energy that is stored in an object. Objects have potential energy because of their position or shape. A diver has potential energy because of their above the pool. They use kinetic energy (movement) to get to that position by walking up the steps to the diving board. 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 dive into the water, their potential energy would be converted to kinetic energy again as they fall.

Gravitational potential

Image by Squeeze from Pixabay, CC0

If an object has gravitational potential it can fall. Like the diver on the diving board or the skydivers jumping from a plane, anything that is above Earth's surface has the potential to fall because of gravity pulling it toward the earth. The amount of gravitational potential energy an object has both 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 they have the greatest gravitational potential energy compared to the diver.

Elastic Potential

An object's shape can also give it potential energy. For example, if an object tries to return to its original shape when let go. This kind of potential energy is known as elastic potential. The individual in the photo is giving the elastic band of the slingshot potential energy by stretching it. This is known as elastic potential energy. Stretched rubber bands, inflated balloons, and springs that are compressed or uncoiled are examples of objects that have elastic potential energy due to their shape and the fact that these objects tend to bounce back to their original shape.

Ck12.org, CC BY-NC-SA

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

Which climber in the picture has more potential energy and which has less?

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?

(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)

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?

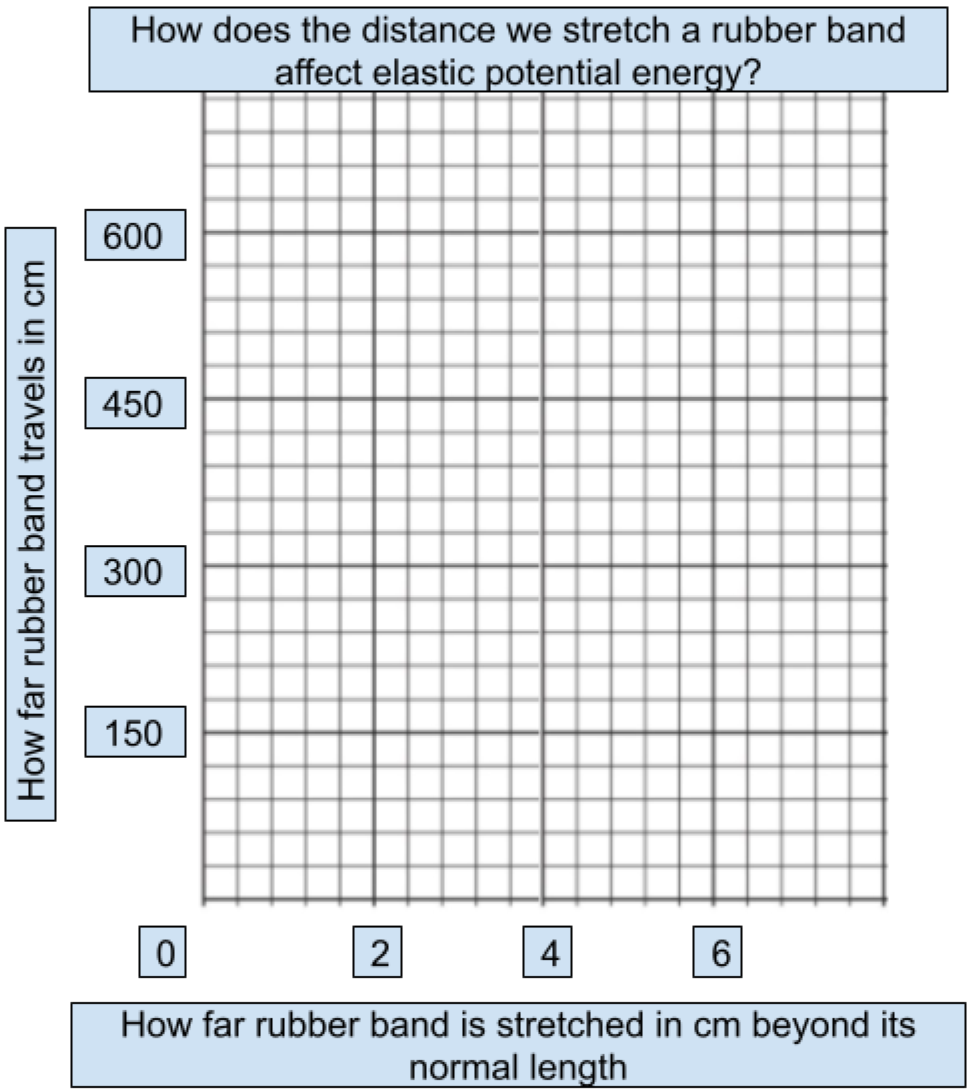
Where would it have the least?

How is distance related to the amount of energy?

Investigating: How Distance and object is stretched affects the Elastic Potential energy

You can run an investigation on how distance will affect the amount of energy an object has by finding a rubber band and some rulers. Take the rubber band and stretch the rubber band out to different lengths. After stretching it out each time, release the rubber band and measure how far the rubber band moves. The more potential energy stored in the rubber band the more kinetic energy it will turn into which means the more potential energy the farther the rubber band will go. Below is some data that was collected by a student doing this experiment. If you have access to the supplies try running it yourself. Use the blank graph to graph the data. Use the graph to explain how the distance the elastic is stretched affects the amount of potential energy in the rubber band.

How much the rubber band was stretched beyond its normal size	Rubber band stretched **2 cm**	Rubber band Stretched **4 cm**	Rubber band stretched **16 cm**
Distance the rubberband moved	180cm	210cm	420cm
Your data			



Was there a pattern in how far you stretched the rubber band compared to how far it went?

What does this tell you about how the distance in a system affects the amount of potential energy stored in an object?

Putting It Together

Observing more about the speed and movement of a snowboarder you can observe at a ski resort that those who are snowboarding down a small hill do not get as much speed as someone who goes to the top of the mountain.

Image by Scros; pixabay.com; CC0

Focus Questions:

1. What type of energy did the snowboarder have when they got off the ski lift at the top of the hill?

2. What energy transfer happened in order to get the snowboarder moving?

3. How does distance affect the amount of energy the snowboarder has?

Final Task:

Draw a model that explains how the snowboarder gets the energy to move down the hill at such high speeds, where it gets that energy from. Explain how the snowboarder could increase their overall energy.

2.3 Energy Transfer (8.2.3)

Phenomenon

This individual at the skate part moves up and down the ramps. As they skate down the ramp, they go faster, when they skate up the ramp they go slower.

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

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What types of energy is involved in the skater moving back and forth?
2. How is the skater’s energy changing as they move?
3. What is causing the skater to speed up and slow down?

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. (PS4.A).

In this section, focus that energy is 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

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 movement. 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 of an object such as lifting a toy car to the top of a ramp or changing the shape of an object such as pulling back on a rubber-band, both of these situations give the object 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 you can search online for a skate park simulator or a roller coaster simulator.)

Pixabay.com, CC0

The person in the photo just finished coming down the water slide. When they were at the top of the slide, they had potential energy. Why? They had the potential to slide down into the pool of water because of the pull of gravity. As they moved down the slide, their potential energy they had at the top of the slide changed to kinetic energy. By the time they reached the water, the potential energy had all changed to kinetic energy.

How could they get that potential energy back? They could climb up the steps to the top of the slide. This would require kinetic energy as they move their legs to climb the steps and this energy would be stored in their position on the stairs as they climbed. By the time they got to the top of the slide, they would have the same amount of potential energy as the time before. This potential energy would then be released as kinetic energy as they went down the slide.

Friction & Energy Transfer

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 slider's kinetic energy to heat energy. As their kinetic energy decreased, they would slow down. Since this is a water slide, the water reduces friction, their kinetic energy won't be converted to heat as much and they can get going much faster.

Putting It Together

You notice that not only when they go up and down they speed up and slow down but when they are going up and down the halfpipe they do not need to push themselves with their foot but when they go on the flat cement they have to propel themselves forward using their foot.

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

Focus Questions:

1. How does energy transfer affect the speed of the skater?

2. What energy transfers are taking place?

3. What would happen to the energy if they were dragging their foot along the ground as they went back and forth?

Final Task:

Construct an argument from evidence explaining what is happening to the skater’s energy as they move up and down the hills in the skate park. You can use a diagram to help explain your reasoning.

2.4 Waves (8.2.4)

Phenomenon

When you drop a rock in water, waves form on the surface of the water. At first the waves are taller and farther apart, then as they get farther from the center the waves become not as tall and closer and closer together.

Pixabay.com, CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. How do you think energy is involved in what is happening?

2. What patterns in the waves do you notice?

3. Why do the waves become smaller and shorter as they spread out?

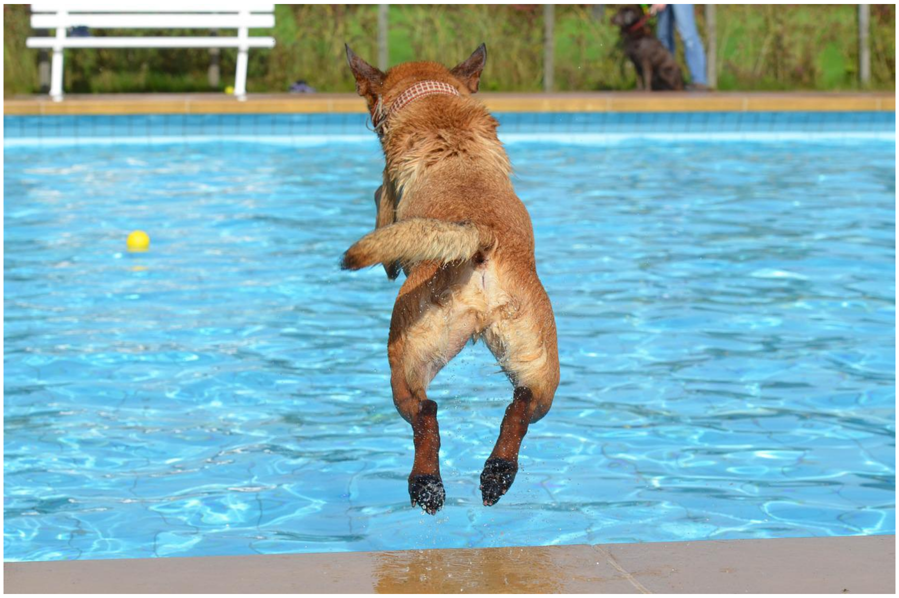
8.2.4 Waves

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. (PS4.A)

Focus on models of a system to understand how energy and matter interact in a wave system. Use models like graphs and charts to identify patterns in data.

Waves

Waves are everywhere: radio waves, ocean waves, microwaves, but what exactly is a wave? Waves are regular patterns of motion. They transfer energy as they move through various materials like wood, water, and even air. The matter that waves 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 someone jumps into the water, the kinetic energy from the person 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. Instead the water molecules really just move up and down in a circular motion.



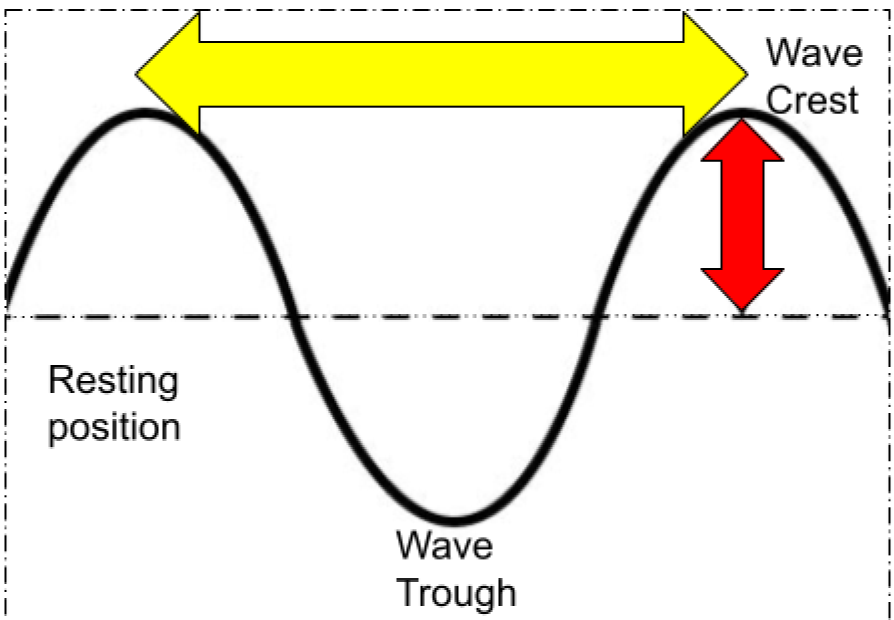
When the dog jumps in the pool his kinetic energy will cause the water to create waves that will transfer the energy to the edges of the pool

Image by 825545, pixabay.com; CC0

Wave Model

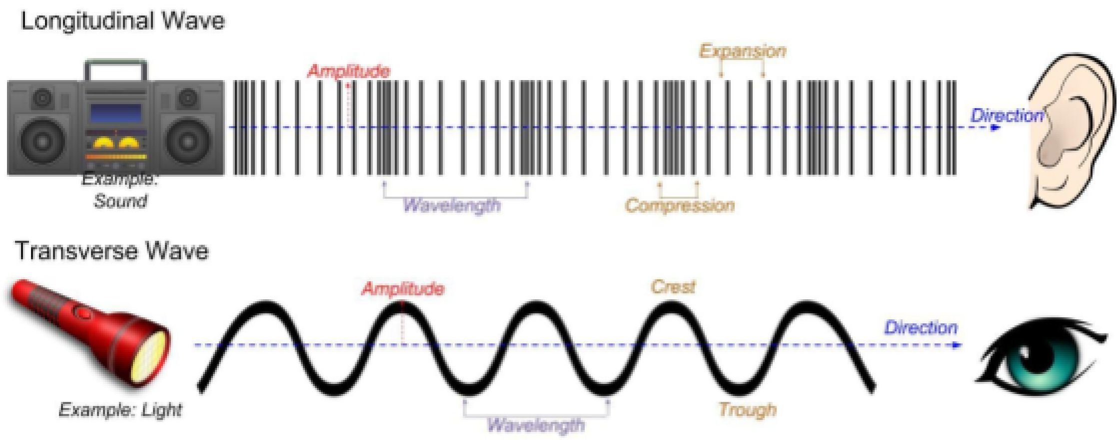
There are three main ways to describe a wave. You can describe its amplitude (height), its wavelength (how far apart the waves are spaced from each other), or the frequency (how quickly the wave is occurring in a period of time).

The exact scientific definition of a 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.
Label the arrows in the diagram below which is amplitude and which represents wavelength.



Types of Wave Movement

There are two types of ways that waves travel and transfer energy, longitudinal and transverse. The difference between the two is the direction that the particles vibrate in comparison to the direction that the wave is traveling.

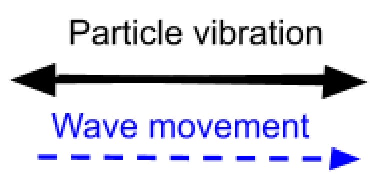


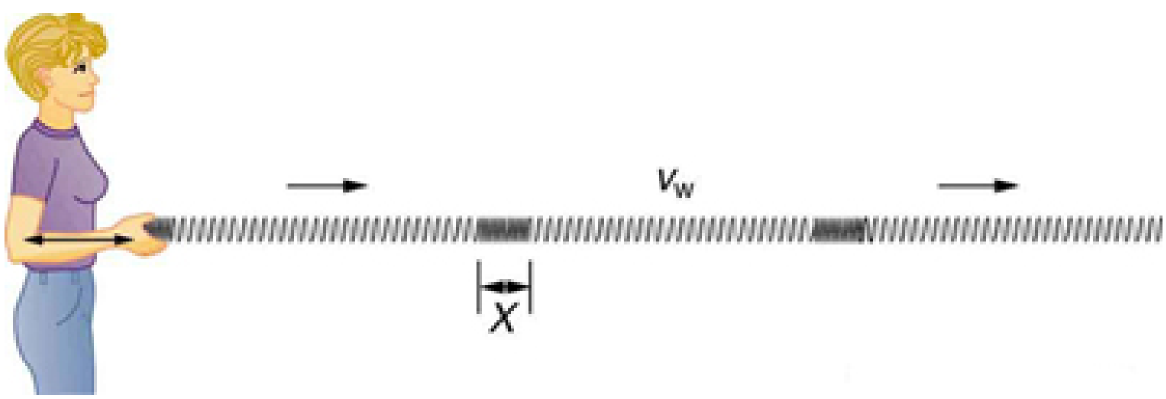
Tracy Poulsen, CC0

This is a model that represents both the amplitude and the wavelength of a wave for both transverse and longitudinal waves

Investigation of Longitudinal waves

A longitudinal wave is when the particles of the medium and the wave itself move in the same direction. An example of this would be if you stretched out a slinky and moved the end of it toward the other end of the slinky. This is the way that sound waves travel.





This image represents a longitudinal wave. In this image the X represents the amplitude and the V_w represents the wavelength.

Image by OpenStax College; https://commons.wikimedia.org/wiki/File:WelleLong.jpg; CC BY-SA

Get a slinky and have one person hold it on one end with you on the other. Without moving the slinky side to side, quickly push your end of the slinky a few inches toward the person holding the other end then pull it back. This may be easier if you are resting the slinky on a table. What you are making here is a longitudinal wave.

Did you see the section of the slinky compress and move down the slinky toward the other person? This is a longitudinal wave traveling along the slinky. The medium, slinky, is moving in the same direction as the wave motion.

Changing the amplitude: In order to change the amplitude this time instead of moving the slinky only a few inches move it as far as your arm will reach forward and back.

What was different this time?

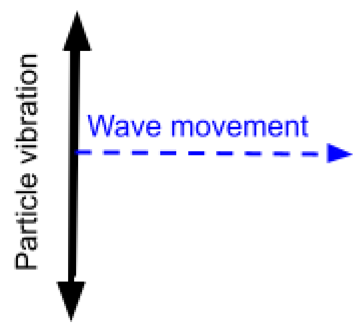
Which required more energy compressing it slightly (low amplitude) or compressing it more (high amplitude)?

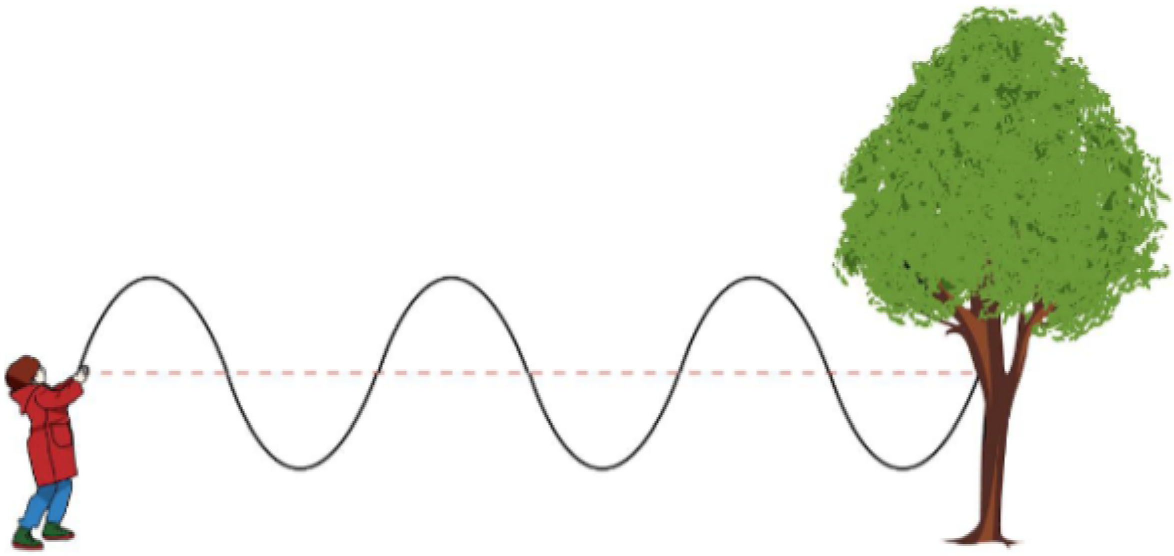
Changing the wavelength: In order to change the wavelength this time you can move it a few inches enough that you can see the wave but do it repeatedly so that you can see the waves moving along the slinky together. In order to change the wavelength you need to change how quickly you are moving. Keep the amount you move the slinky the same but repeat those movements more quickly or more slowly and notice the difference in the wavelength between waves. The closer the waves are together, the shorter the wavelength.

Did shorter or longer wavelengths require more energy to make?

Investigation of Transverse waves

The other type of wave is a transverse wave. The particles in a transverse wave move at right angles (or perpendicular) to the direction of the wave see image above. This means if the wave is moving forward the particles are moving up and down. An example of this would be an ocean wave or light waves.





Ck12.org, CC BY-SA

Take a rope and either tie it to something that won't move or have someone hold the opposite end. Hold the jump rope relatively tight and move the rope up and down a few inches to create a wave.

Did you see the bump in rope move along the rope toward the tree? This is a transverse wave moving along the rope. The rope is moving up and down but the wave moves away from you. The medium, the rope, is moving opposite of the wave motion.

<u>Changing the amplitude:</u> This time instead of moving the rope only a few inches up and down, move it as far as your arm will reach.

What was different this time?

Did higher or lower amplitude require more energy to make?

<u>Changing the wavelength:</u> This time you can move it a few inches enough that you can see the wave but do it repeatedly so that you can see the waves moving along the rope together. In order to change the wavelength you need to change how quickly you are moving. Keep the amount you move the rope the same but repeat those movements more quickly or more slowly and notice the difference in the wavelength between waves. The closer the waves are together, the shorter the wavelength.

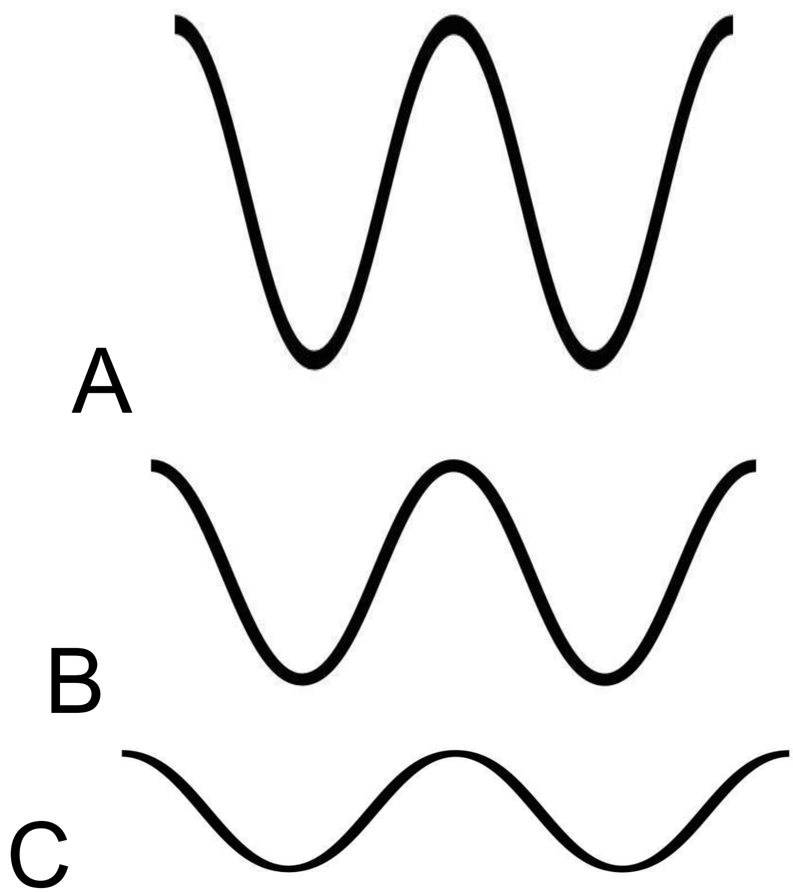
Did shorter or longer wavelengths require more energy to make?

Energy and Amplitude

A wave that is transferring more energy will have a larger amplitude than a wave that is transferring less energy. The greater energy is moving the particles in the medium a greater distance up and down. A sound wave with higher amplitude is transferring more energy and will have a louder sound than a sound wave with lower amplitude which will be quieter. A light that has a higher amplitude will shine brighter and have more energy than a light with a lower amplitude that glows dimmer.

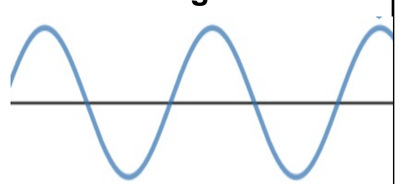
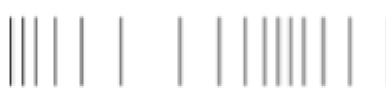
Think back to the original question about the ripples in the picture. The ripples were relatively low-amplitude waves with comparatively little energy because they were caused by a smaller rock. How would the amplitude of the ripples be different if a more massive rock with more kinetic energy were thrown 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. This is because greater mass will transfer more kinetic energy to the water, which creates a greater amplitude.

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

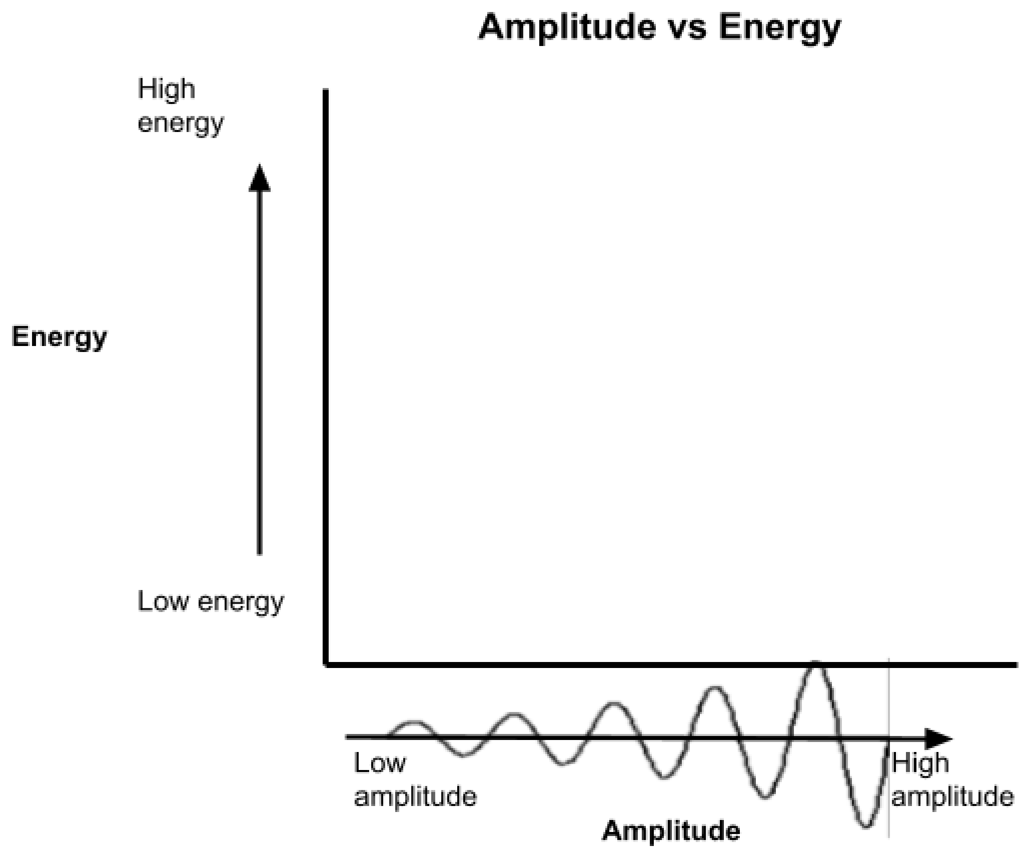


- Describe the similarities and differences between the waves using the words amplitude wavelength and energy.
- Which wave has more energy?
- Which wave has less?
- How do you know?

The graph below shows how amplitude affects both light and sound. Louder sound has a higher amplitude and requires more energy to produce than a quiet sound. If you are talking to a friend it requires much less energy to whisper to a friend sitting next to you than it would to yell the same conversation across the room. In light a brighter amplitude makes a brighter light. An example of this you may be familiar with is that if you have the screen on your computer or phone turned up to its highest it is going to use up the battery more quickly than it would if you dimmed the screen.

Amplitude	Energy level	Amplitude: Sound Wave	Amplitude: Light Wave
High amplitude	High energy	**Loud**  More squished compressions	**Bright**  Taller waves
Low amplitude	Low energy	Quiet  Less squished compressions	Dim  Shorter waves

Based on what you understand now about how higher amplitude carries more energy a wave has, graph a line representing the direct relationship between the amplitude of a wave and the energy the wave has.



(To investigate more about how amplitude is related to the energy in a wave search online for a “wave simulator.”)

Putting It Together

Instead of just dropping the rock into the water this time you throw it at the water. The waves this time are much taller than before. You try again only this time you throw the rock with all your might. Again the waves coming out from your rock are even larger than before.

Pixabay.com, CC0

Focus Questions:

1. What causes the waves in the water to happen when you drop in the rock?
2. What patterns did you see in the amplitude as you increase the kinetic energy of the rock by throwing it harder each time?
3. What do the patterns in the size of the waves tell you about the amount of energy as the waves move away from where the pebble dropped?

Final Task:

Construct an explanation to explain the wave patterns formed when you drop a rock in the water. Be sure to include an explanation of how energy, amplitude and a medium are involved in making the waves.

2.5 Waves and Mediums (8.2.5)

Phenomenon

Sitting in your house, you turn and look through a glass window and see a caterpillar on the porch. On your way outside you walk by the glass mirror and see your reflection. Once outside the sunlight hurts your eyes so you put on sunglasses to block out the sun. You then take the magnifying glass lying on the porch and take a closer look at the caterpillar. You suddenly realize that you just used four pieces of glass all for different purposes.

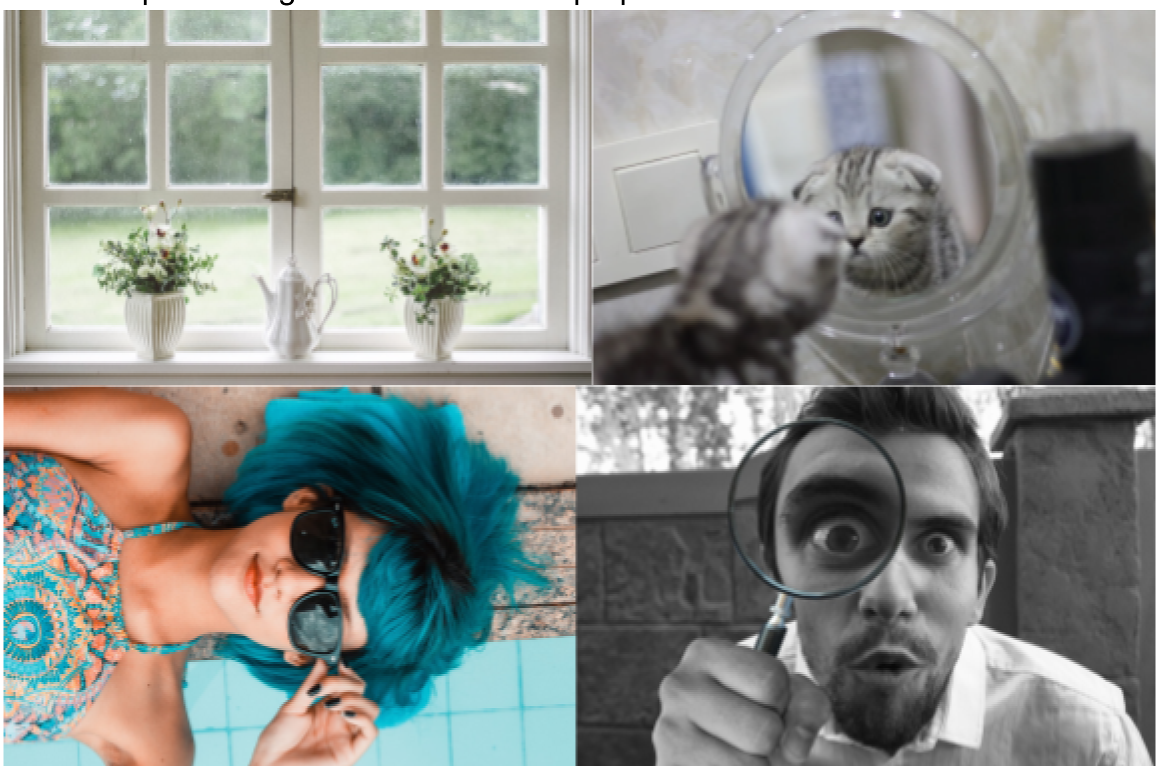


Image by (top left) Stocksnap, (top right) maratius78, (bottom left) danielsampaoineto, (bottom right) Tumiso; pixabay.com; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. Why do each of the types of glass affect the light differently?

2. Knowing what you do about waves, what do you think the medium of the glass did to the structure of the waves as it passed through?

3. How does that medium affect the wave so that it can be used for that particular purpose or function

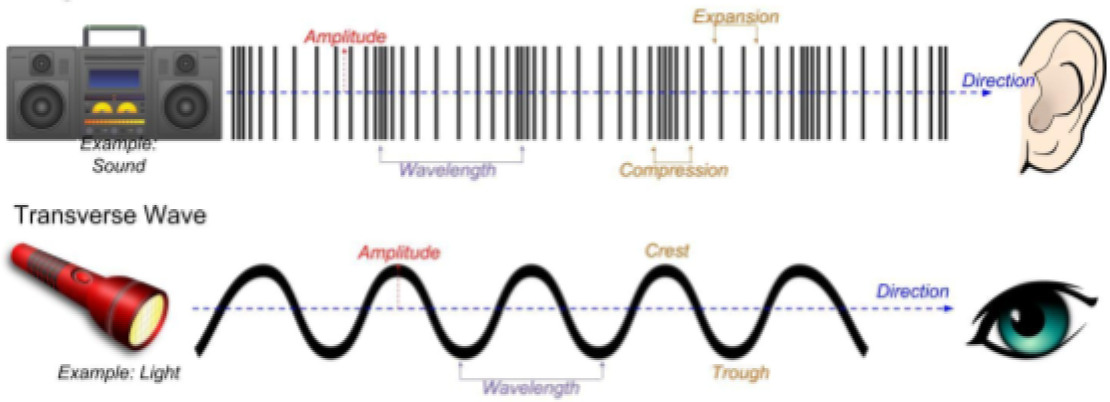
8.2.5 Waves and Mediums

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. (PS4.A, PS4.B)

Focus on wave structures and how they are altered as they are reflected, absorbed, or transmitted through different materials and how the change of the wave structure affects the function of that wave.

Types of Waves

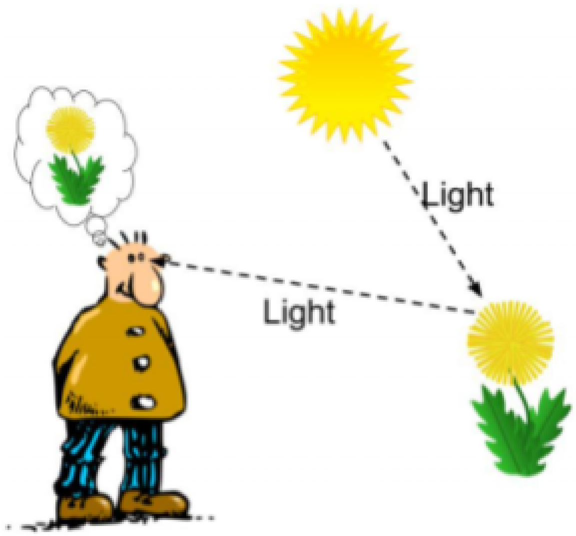
There are two main types of waves. Light waves (also known as electromagnetic waves) transmit energy in the form of light and do not require a medium. Mechanical waves transfer energy through matter by moving particles and so must have a medium present in order to transfer energy. Sound waves and water waves are examples of mechanical waves. Waves, both light and mechanical, can be transmitted through various mediums. They can also be reflected and absorbed. Light waves move as transverse waves and mechanical waves can move as either transverse or longitudinal waves.



Tracy Poulsen, CC0

Waves and light

Light waves are the waves that allow us to see. Light waves transfer energy. To understand how light waves help us see, look at the illustration.



CC0

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.

A light's brightness is controlled by the amplitude of the wave whereas the wavelength determines the color of the light. Lightwaves with the longest wavelength appear red and light with the shortest wavelength appears violet. In between these two is the spectrum of all the other colors of light that goes in the order of the rainbow red, orange, yellow, green blue indigo and violet.

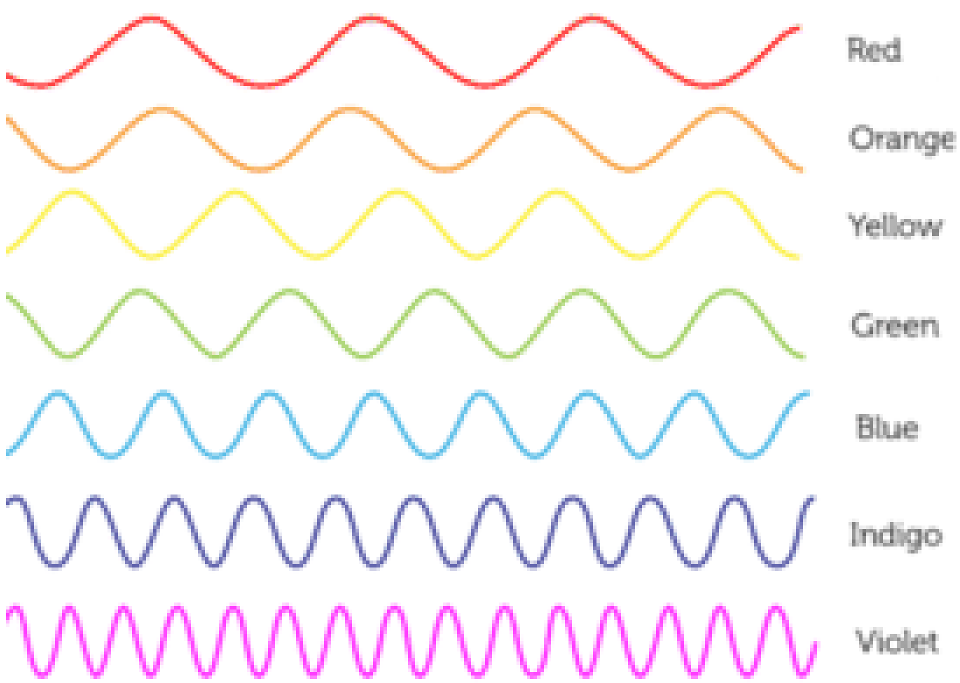


Image by Christopher AuYeung; CK-12 Foundation; CC BY-NC 3.0

Waves and 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 and vibrate their eardrum.

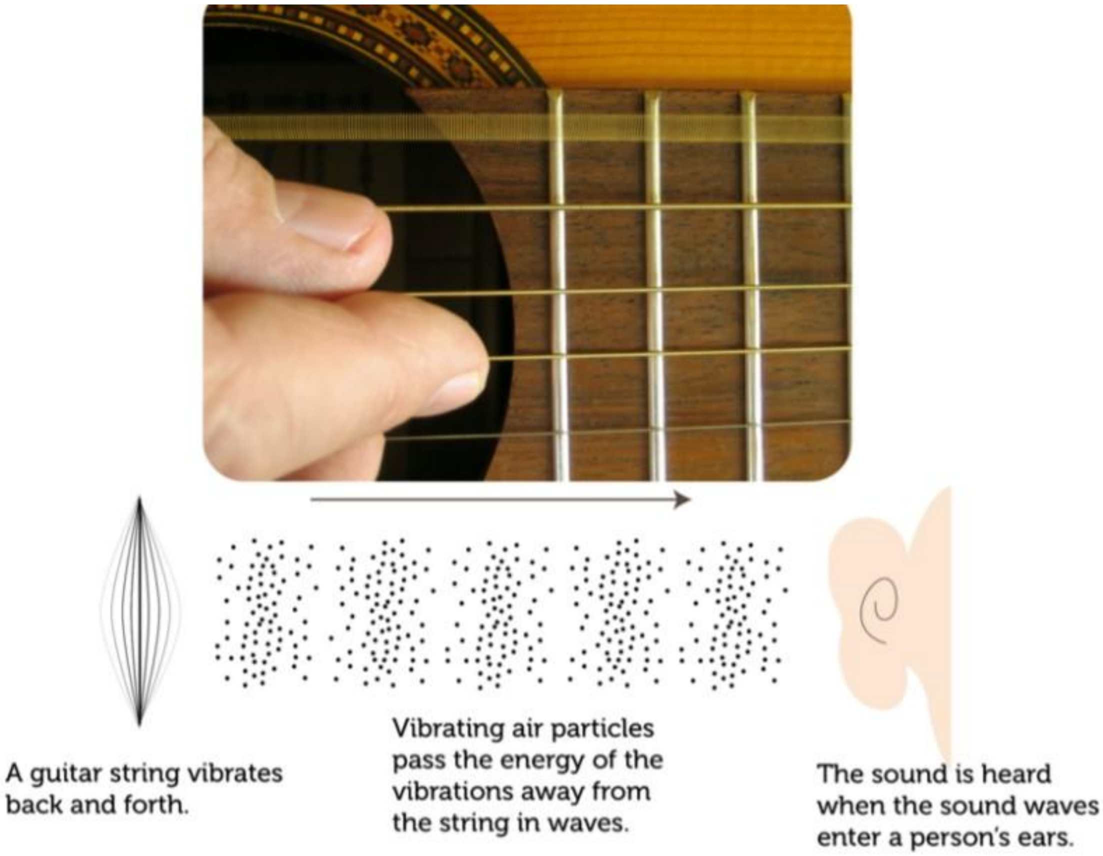
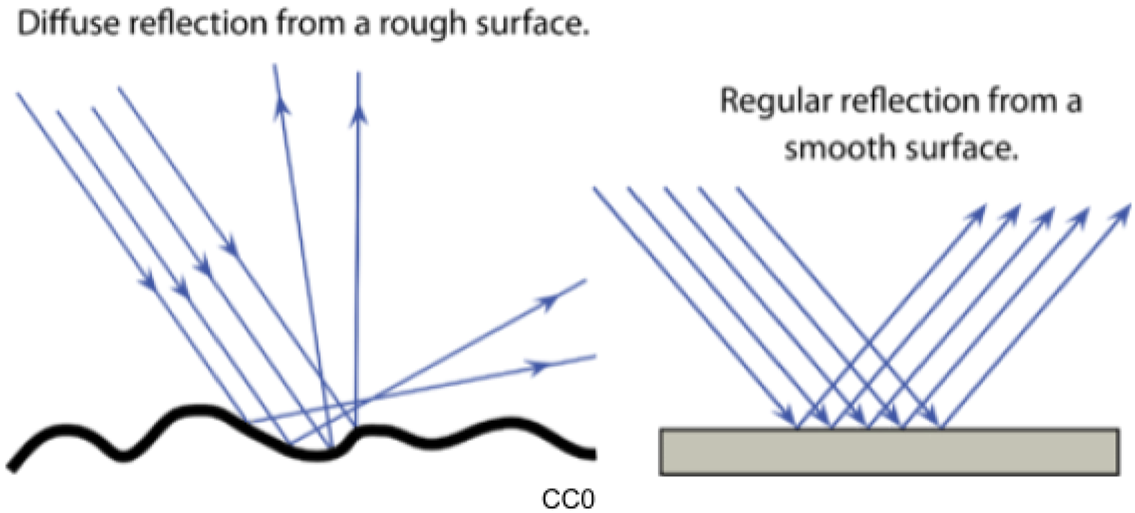


Image by CK-12 Foundation; Curriculum Materials License

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. Once the wave hits your ear, the energy vibrates your eardrum. Your brain interprets the vibration patterns as sound.

Reflection of Waves

When a light ray strikes a reflecting surface like a mirror 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.



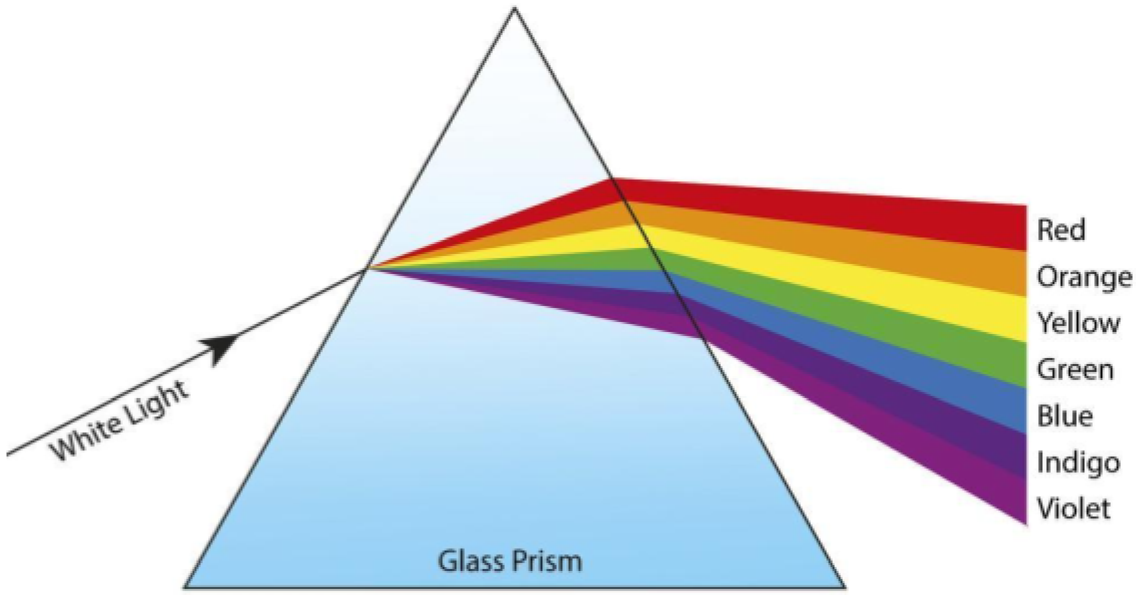
Uneven reflection, like the image on the left, makes something look dull. Even reflection, like the image on the right, makes something look shiny and reflects an image like a mirror.

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. We will talk more about absorption of waves later. Transmission of sound and light occurs when the wave travels through a medium.

Refracting Waves

Refraction is the bending of light due to the change in its speed when it moves from one medium to another. A prism, like the one in the figure below, can be used to separate white (visible) light into its different wavelengths using refraction. The prism transmits light through, but also 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 because they have different amounts of energy. This causes the beam of light to separate into light of different wavelengths. What we see is a rainbow of colors.

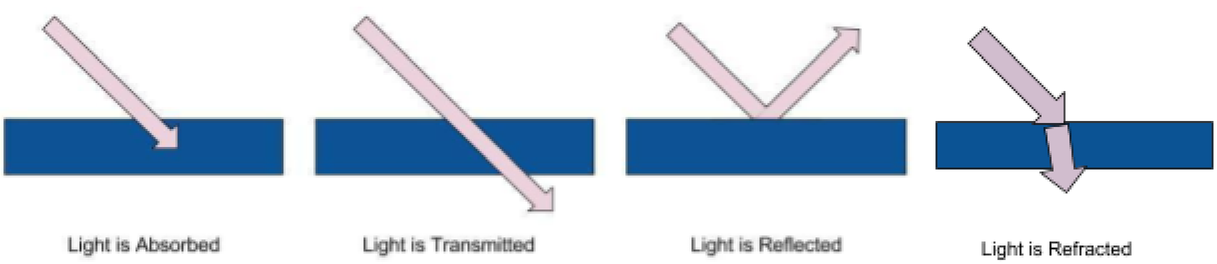


Refraction_Triangular Prism, Siyavula Education *https://flic.kr/p/mG4acK* CC-BY

When light waves refract they don't always bend into the different colors to make a rainbow. Sometimes we use glass to bend the waves to make an image larger for us to see more detail like in a microscope or a telescope. Refraction is also used in contact lenses or glasses so that we can bend the light so that it focuses on the correct location in our eye and makes a clearer image.

Absorbed Waves

Sometimes a wave will not be able to reflect off a medium or be transferred through a medium. Instead the wave is stopped and absorbed by the medium. When waves are absorbed by an object the energy is changed into heat energy. For example sound proof walls absorb sound waves and turn the sound energy into heat which explains why they make it quieter. Black pavement absorbs the sun's light waves and turns it into heat which explains why the road's asphalt is so much hotter than a sidewalk on a summer day.



CC0

The image above shows how a wave can be either absorbed, transmitted, reflected or refracted 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) through the glass and also see a reflection of yourself.

Waves in the World Around Us

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 transmit through the air to your ears. You see the fireworks because the light waves transmit through the air and are detected by your eyes. The different wavelength structures of light allow you to see a variety of different colors.

The fireworks can be seen before we hear their sound. This is because light waves travel faster through the medium of air than sound waves. Because sound waves are mechanical waves they travel at different speeds, depending on the medium through which they are moving.

Speed of Sound Waves Through Mediums

Image by tama66; pixabay.com; CC0

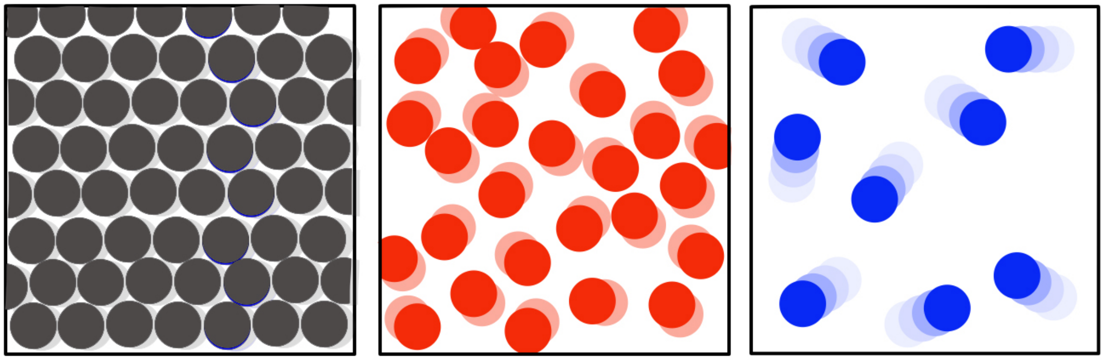
In old westerns many times the outlaws trying to rob the oncoming train would put their ear to a railroad track to see if a train was coming. They would be able to hear the train through the train tracks long before they could hear it through the air. The reason this works is because sound waves travel faster through solids than they do through gases. Sound waves are passed on because of molecules bumping into the next molecule.

Below is a chart that shows the speed of sound traveling through different substances.

Substance	Speed of Sound
Air at 25°C	346 m/s
Water at 25°C	1498 m/s
Steel	5200 m/s

Question: Which phase does sound travel through the slowest?

If you remember back to learning about solids liquids and gases the solids are more dense and so the molecules are closer together compared to liquids or gases. Since the molecules are farther apart in a gas, it takes longer for the wave's energy to pass the vibrations from one molecule to the next so it takes longer to move the sound along. When sound travels through a solid the molecules are closer together when they start to vibrate it easily passes on the vibration to the next. This causes the sound waves to be passed along more quickly.



Solid Liquid Gas

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.

Putting It Together

Sitting in your house, you turn and look through a glass window and see a caterpillar on the porch. On your way outside you walk by the glass mirror and see your reflection. Once outside the sunlight hurts your eyes so you put on sunglasses to block out the sun. You then take the magnifying glass lying on the porch and take a closer look at the caterpillar. You suddenly realize that you just used four pieces of glass all for different purposes.

Image by (top left) Stocksnap, (top right) maratius78, (bottom left) danielsampaoineto, (bottom right) Tumiso; pixabay.com; CC0

Focus questions

1. How did each of the types of glass affect the light wave hitting them?
    - sunglasses
    - magnifying glass
    - mirror glass
    - window glass

2. How does the structure of the different types of glass affect the light differently?

Final Task

Construct a model for each of the types of glass that shows what the wave does when it contacts the medium.

Sunglasses	Glass Mirror
Magnifying glass	Glass Window

2.6 Analog and Digital Signals (8.2.6)

Phenomenon

Left: Vinyl record LP 10inch by 能無しさん https://commons.wikimedia.org/wiki/File:Vinyl_record_LP_10inch.JPG CC BY-SA
Center: by Republica; pixabay.com; CC0
Right: by sweetlouise; pixabay.com; CC0

Vinyl records, like the one in the photograph, were used to record and play songs starting in the 1940s. Later CDs were introduced and were extremely popular until eventually telephones and cellular devices became all you needed to listen to music. The sound quality has changed as the way of storing the music has changed. When you put in a vinyl record you will often hear static as you play the music or the music may not even play correctly because the vinyl record is scratched or warped from heat. When you listen to a CD you don't have issues with static but it can still be scratched and so you may have issues with it reading the CD correctly. Both of these issues are not a problem with an electronic device when listening to music. You can't damage the files by scratching it and the static is not an issue as long as you have a good set of headphones.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What are the differences between the three ways of storing music?

2. Why do you think storing digital recordings on (cd's, mp3s) have mostly replaced vinyl records in recent years?

3. How do you think the structure of the waves in the three different devices is different from each other?

4. How do you think the structure of the wave has any affect on the quality of the sound transmitted?

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. (PS4.C)

The different analog or digital structures of waves can affect their reliability for the function of storing information.

Signals

NPS.gov, Public Domain

Codes are something that has fascinated people for as long as humans could write. Sometimes students will create codes so that no one can read secret notes but themselves or you will find codes in mystery books. While it may just seem fun, signals and codes have been used throughout history to prevent information from falling into the wrong hands. For example, 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 patterns of signals from light waves emitted from their bodies. 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, only analog signals were used to transmit information. 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.

Pixabay.com CC0

Can you think of some other examples of analog signals?

Digital Signals

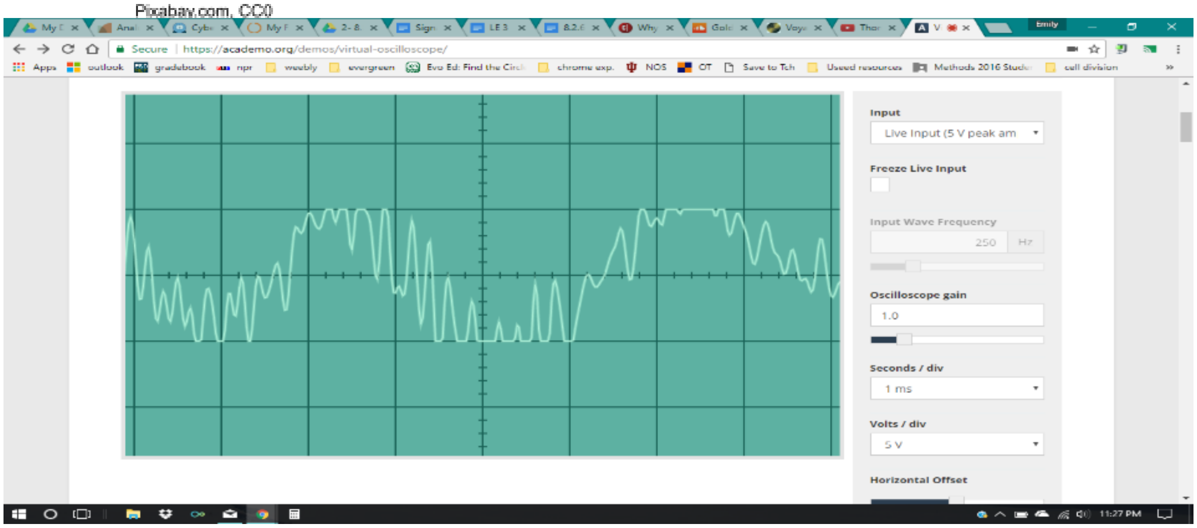
Everything that you see or hear on a computer—words, pictures, numbers, movies and sound--uses digital signals. Digital signals are sent as mathematically coded waves. They can be sent over long distances. Once the waves arrive at a receiving station, they are decoded back into information that you can understand. In the example of the computer, the signal will be sent to the screen which has it decoded back into an image that you will recognize or the code of digital sound files will be sent to your speakers where they will be decoded back into sound.

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

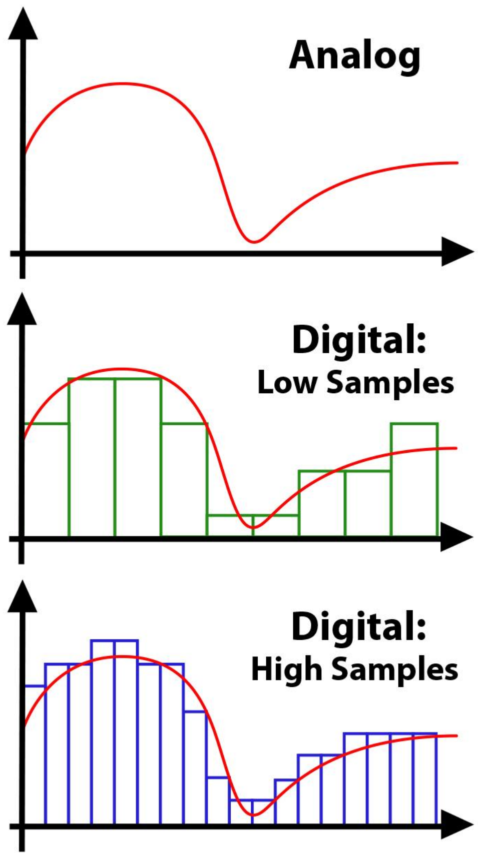
When analog technology is used to record a sound, every part of the sound wave is recorded. The recorded sound waves can be very complex, because the recording device records every sound that it picks up, even background noises that are traveling through the air. The next picture shows an analog wave.



When you are recording analog sounds it is easy for the recorded sounds to be slightly different than the actual soundwave. This is 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.

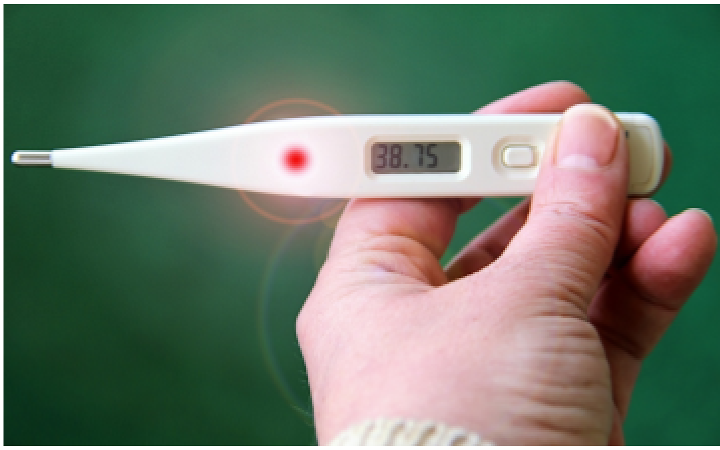
When sounds are recorded digitally, not every part of the sound wave is recorded. Instead, the recording device takes samples of the sound wave at certain periods and only records the information at that moment vs an analog wave that is recording at every moment.

The diagram below shows the difference between an analog and a digital wave. The analog wave is smooth and rounded because it is constantly recording the information where the digital recording only records information periodically and doesn't include the full wave. This would seem like it was a bad thing however because the digital wave is simpler it is easier to copy it or transmit it without there being mistakes in the copy. In digital copies the wave is not affected by any outside source and so the wave's code stays the same and the sound file will remain unchanged.



Low sampling will record the information less often than high sampling where analog records the samples constantly.

If you were asked to remember a series of numbers would it be easier to remember 6 values accurately or 6000. Since digital is only a sampling of all of the information it is only storing and transmitting a smaller number of values compared to analog which is storing and transmitting an infinite number of values. Take the thermometer for example. The liquid in the alcohol thermometer moves up constantly with a temperature rise, showing every temperature change to the smallest degree that you may not even notice. Digital thermometers only increase at set values like 98.6 to 98.7. There are values for the temperature between 0.6-0.7, but the information is not stored or transmitted by the digital thermometer.



Above: Digital thermometer by guvo59
Right: adapted from image by AVAKAphoto
Pixabay.com; CC0

The structure of analog storing every tiny piece of information requires a lot more space to store that information and also makes it more likely that flaws or interference are also stored. The structure of digital storing only samples takes up less storage space and easier to filter out flaws or interference, making it more reliable.

Vinyl records are an analog recording, the pattern of all vibrations of sound is carved on the plastic. When played, the carvings recreate the vibrations from the carvings. The amount of space required to store this much information is why you would only be able to have 44 minutes of songs on an analog vinyl record but digital CDs could have 75-80 minutes of songs. Since only the samples are carved on the disc as holes, more can be stored. Depending on the amount of samples taken during the recording, CDs can hold up to 100-150 songs. Since the digital information is carved on a disc, the disc can still be damaged when being handled and used. Electronic devices like phones and MP3 players can store digital code inside the device, which reduces the chances of the code being affected by use. How much electronic devices hold depends on storage. For example, 64 GB of storage can hold about 14,000 songs. These digital devices allow the signals to be stored and transmitted reliably over and over. 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. Streaming music over wifi is very similar, the code made from the samples is transmitted over wifi to the electronic device which converts it back to analog sound for you to be able to hear.

Putting It Together

Left: Vinyl record LP 10inch by 能無しさん https://commons.wikimedia.org/wiki/File:Vinyl_record_LP_10inch.JPG CC BY-SA
Center: by Republica; pixabay.com; CC0
Right: by sweetlouise; pixabay.com; CC0

Focus Questions

1. Which of these music storage devices uses analog signals and which use digital signals?

2. Why has the music industry moved towards using digital files over analog?

3. How does the structure of the wave affect the reliability of storing or transmitting (playing) the music?

Final Task

Construct an argument based on evidence of the structure of analog and digital waves as to why digital signals are better for copying, storing, and transmitting information.

CHAPTER 3

Strand 3: Life Systems

Chapter Outline

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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 chemical energy and use the particles to form new, life-sustaining molecules and energy to perform daily functions. Ecosystems are examples of how energy can flow while matter, like carbon, cycles through the living and nonliving components of systems.

3.1 Photosynthesis (8.3.1)

Phenomenon

Lima bean seeds are about the size of your index fingernail. When planted, they grow to large plants several feet tall.

(Left) CC0; (Right) by University of Delaware; https://flic.kr/p/fuLk16; CC BY

(You can do a online search for time lapse videos of lima bean growth)

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What do you already know about what plants need to grow?

2. What kind of energy is necessary for plants to grow?

3. Where does the matter come from to allow the small seed to turn into the larger plant?

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. (PS3.D, LS1.C)

In this section, focus on matter and energy. Discover &/or explain how photosynthetic organisms use energy to drive the cycling of matter.

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 algae and some types of bacteria.

Image by GregMontani; pixabay.com; CC0

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

Pixabay.com, CC0

The green "scum" on this pond consists of photosynthetic algae

NASA, Public Domain

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

Discovering Photosynthesis

Where does the mass of a giant redwood tree come from? Often, people think a tree's mass comes from the soil. In the early 1600s a Belgian scientist named Jan Baptista van Helmont did a 5 year experiment with a willow tree. He weighed the dry tree and the soil at the beginning and only added water. After 5 years, he weighed the tree and the soil again. The tree had gained a lot of mass, but the soil had lost almost no mass

If the tree was not getting the mass from the soil, where was it coming from? He concluded that it was the water. We now know that the carbon dioxide from the air is the other essential piece to make the glucose molecules that can build the majority of the plant.

In the late 1770s Joseph Priestley performed experiments with candles and mice in jars. He discovered that candles in a jar would burn much longer when there was also a plant in the jar, showing that the plant helped fix the “injured” air. Though he didn’t understand at the time, he was showing the plant removed carbon dioxide produced by the candle and replaced it with oxygen.

In 1779 Jan Igenhousz repeated Priestley's experiments and followed this up by showing that the plant was more efficient when in sunlight. He also used water plants to prove the plant would produce oxygen bubbles on the leaf in light and no bubbles were made when it was placed in the shade.

These were just the start of the many experiments that helped us with what we know now about how photosynthetic organisms work.

Adapted from image by CK12 Foundation; CC-BY

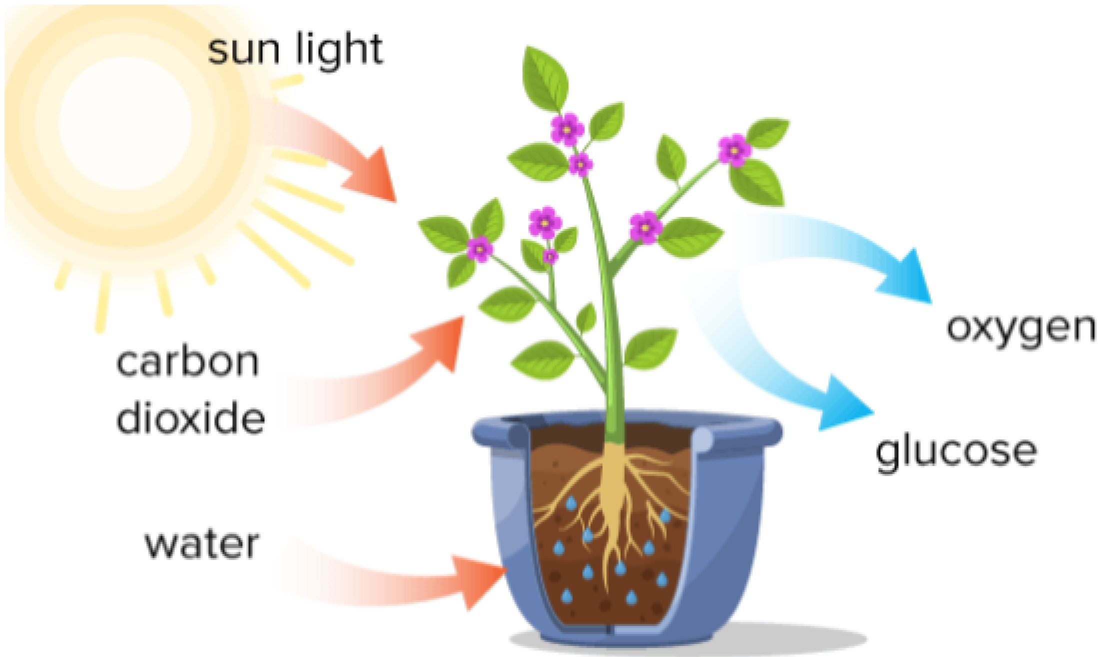
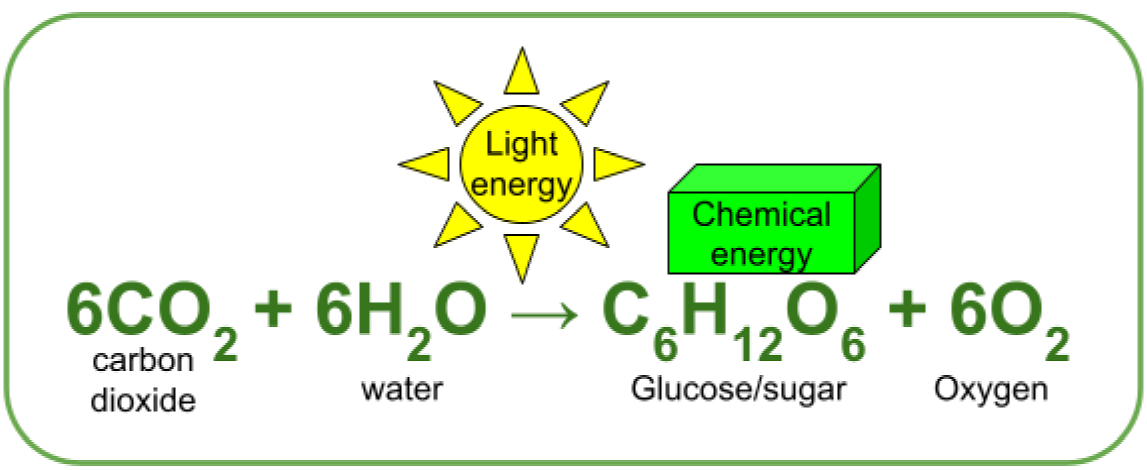


Image by CK-12 Foundation; CK-12 Curriculum Materials License

Photosynthesis: Changes in Matter & Energy

Most of the energy used by living things comes either directly or indirectly from the sun. Photosynthesis uses the sun's energy to make sugars like glucose ($C_6H_{12}O_6$) that the plant is able to put together using the carbon dioxide and water gathered from its environment. Plants, algae and some bacteria use the glucose for energy by the cells, this works because the energy from the sun is stored as chemical energy in the form of the glucose molecule. The matter from photosynthesis is also used to help build most parts of the plant, like the trunks, stems, leaves, fruit, etc. Oxygen is also produced and typically leaves the same way carbon dioxide gets in.

The chemical equation for photosynthesis is:

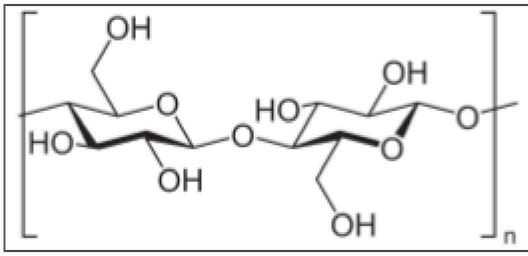


$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

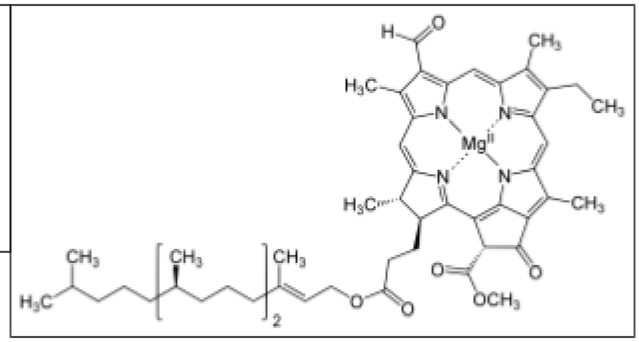
The Building Blocks of Plants

The plant uses some glucose for energy, what happens to the rest of it? Molecules from photosynthesis provide the matter needed to build other parts of the plant, like cellulose and chlorophyll.

Cellulose



Chlorophyll



(Top) by NEUROtiker; public domain;
(Right) by Yikrazuul; public domain

All parts of the plant have a base of hydrogen, carbon, and oxygen that are acquired through photosynthesis. The sun provides the energy for the reactions that allow the plants to transform matter (carbon dioxide & water) into the molecules they need to grow.

Putting It Together

Lima bean seeds are about the size of your index fingernail. When planted, they grow to large plants several feet tall.

(Left) CC0; (Right) by University of Delaware; https://flic.kr/p/fuLk16; CC BY

Focus Questions:

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

2. What kind of energy transfer takes place during photosynthesis?

3. Where does the matter come from to allow the small seed to turn into the larger plant?

Final Task:

How could you set up an experiment to prove that a plant actually needs water, carbon dioxide, or sunlight to transform matter and grow? What evidence would you look for to see if your experiment worked?

3.2 Respiration (8.3.2)

Phenomenon

When you don't eat, especially before exercising, you notice that you don't feel well. Often you feel weak, shaky and light headed. When you eat well, you don't notice those problems.

Image by gianyasa; pixabay.com; CC0

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What do you think makes you feel weak and shaky when you don’t eat?

2. Where do you think you get the energy to be able to do daily activities and exercise?

3. What do you think would happen if you were not able to get access to the energy?

4. What are two types of matter you need to have access to energy?

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. (PS3.D, LS1.C)

In this section, focus on matter and energy. Organisms use chemical reactions to rearrange matter to usable forms and release energy to support life.

Energy

Everything alive needs energy. Plants are producers which means they are able to get the energy they need from the sun and do photosynthesis and store it as chemical energy in the molecules of glucose they produce. Animals on the other hand cannot just stand in the sun to get their energy, they are consumers. They must eat food in order to get the energy they need.

Once the stored chemical energy is inside of an organism either because they made their own glucose or because they ate it, they need to be able to release the energy in order to use it.

Cellular respiration is how cells of all living things, including plants, break down glucose in order to release the stored chemical energy. They need two things in order to do this. One they need the glucose they are going to break down and two they need oxygen. Oxygen is the key for being able to release the stored energy from the glucose.

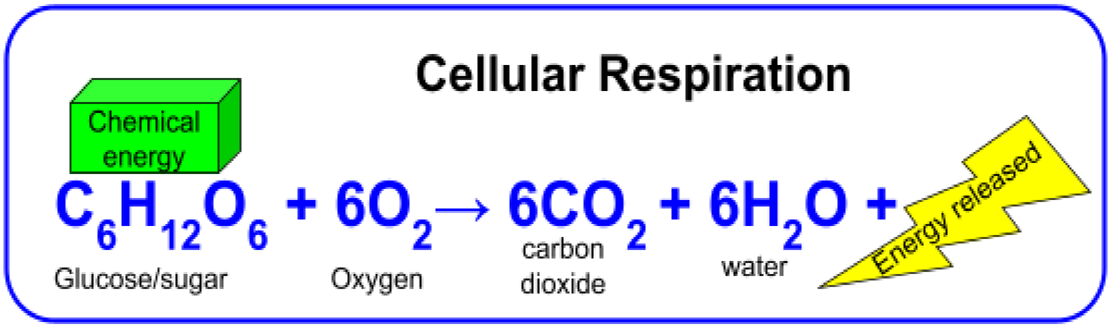
How do you get the oxygen and glucose you need for cellular respiration? We have to breathe to get the oxygen and eat to get the glucose. Even decomposers like mushrooms have to get the oxygen and glucose from the environment to survive.

Image by Shana Chappa; CC BY

Image by JillWellington; pixabaycom; CC0

We often think about oxygen as being important for staying alive. It's easy to overlook the importance of glucose. Glucose is where the chemical energy is stored. Without this energy source, we would not be able to have energy to even blink our eyes or chew our food. The process of respiration allows the organism to release the chemical energy to forms that it can use. During cellular respiration three things are released; energy, carbon dioxide, and water. Energy is what we need from respiration. Organisms get rid of the waste matter, like the carbon dioxide and water by breathing it out. If you breathe slowly on your hand, you can actually feel the water you breathe out.

Cellular Respiration: Changes in Matter & Energy



If you compare this with the photosynthesis reaction you will notice it is the opposite. The matter is the same, but forms of energy are different. Photosynthesis uses light to create chemical energy stored in the sugar glucose, while cellular respiration breaks down the chemical energy found in sugars and converts it to energy for the organisms use. In many animals, the energy is then converted to mechanical and heat energy. This usable energy allows the organism to do things like use muscles to walk around or pump their heart and transport nutrients from one place to the next.

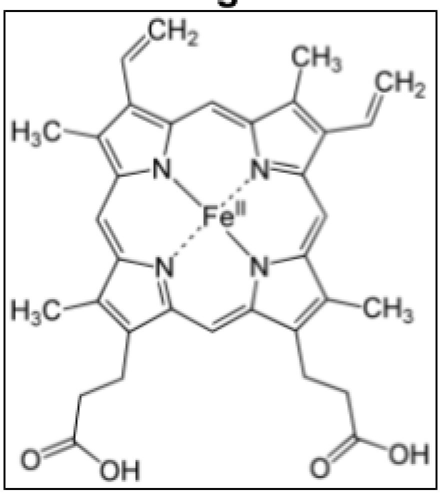
Why Food is Important

Living organisms need energy to live and they need matter to grow, eating provides for both needs.
Energy: If you look at food labels, they will always show calories. Calories are a way to measure energy, they show us the energy that can be released as a result of cellular respiration.

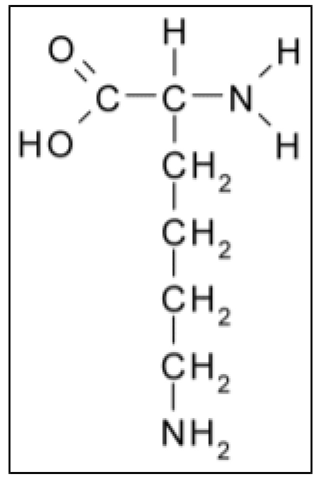
Eating a bunch of sugar may give you a lot of quick energy like a sugar rush, but you will also have a crash after if you don't eat other food. Your body will release the energy from that glucose quickly since it is ready to be used in cellular respiration when you eat it. We need to eat other foods like proteins and carbohydrates (carbs) that digestion and other biological processes can turn into molecules the body needs. The larger carbohydrate molecules take more time to break down into glucose, allowing energy to be provided over a longer time. This is why a balanced diet and meals throughout the day provide a constant supply of energy.

Matter: Our body needs other nutrients to help parts of our body grow and function properly so a diet of just sugar would not work, for example, we need iron to build hemoglobin so our blood can deliver the necessary oxygen for cellular respiration. We need proteins to get the amino acids necessary for building muscles.

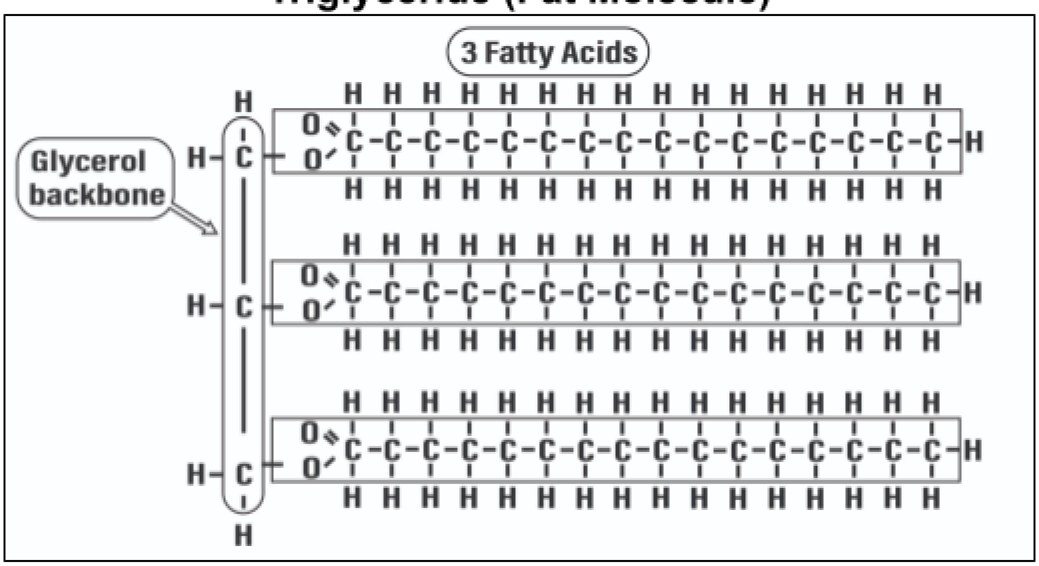
Hemoglobin



Lysine (Amino Acid)



Triglyceride (Fat Molecule)



(Top Left) by Yikrazuul, public domain; (Top Right) by User:Borb; https://commons.wikimedia.org/wiki/File:L-Lysine.png; CC BY; (Bottom) by authors; CC0

The Carbohydrates, fats, and proteins in our food all have a base of carbon, hydrogen, and oxygen atoms. During the digestion of food (carbohydrates, fats, proteins) these larger molecules are broken down to form new molecules that support growth and/or release energy. The phrase “you are what you eat” is quite true in that the atoms in the food you eat rearrange to become the molecules that your body is made of. Proteins from your food are broken into smaller molecules called amino acids and then are used to build your muscles, create enzymes, produce hormones, antibodies, release energy and to support many other body functions.

Image by dbreen; pixabay.com; CC0

Putting It Together

Image by gianyasa; pixabay.com; CC0

When you don't eat, especially before exercising, you notice that you don't feel well. Often you feel weak, shaky and light headed. When you eat well, you don't notice those problems.

Focus Questions:

1. Where do you think the energy comes from to be able to do those things?
2. What do you think would happen if you were not able to get access to the energy?
3. What two types of matter do you need to have access to energy?
4. Why might a coach tell an athlete to eat a lot of protein while training and a high carb (carbohydrate) meal the night before a competition?

Final Task:

Think about your most recent meal. Develop a model that shows how the matter and energy from your food is transformed by cellular respiration.

3.3 The Carbon Cycle and Ecosystems (8.3.3)

Phenomenon #1

Image by Impermanent; pixabay.com; CC0

Apples on the ground start wrinkling, attracting flies. Their size shrinks, and brown spots start to form.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

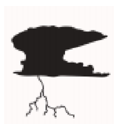
1. What do you think is happening to the matter in the fruit?

2. Where is the carbon going that was in the fruit?

3. What are two things you need to know to be able to answer the above questions more accurately?

8.3.3 Carbon Cycle & Ecosystems

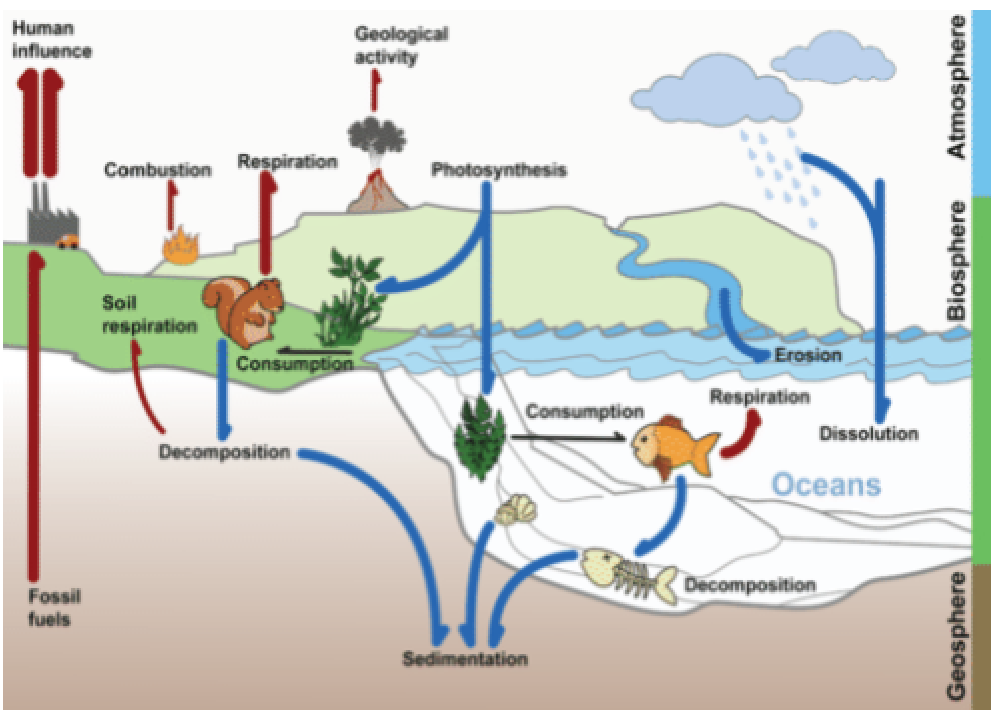
Ask questions to **obtain, evaluate, and communicate information** about how changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of an ecosystem. Emphasize describing the cycling of matter and flow of energy through the carbon cycle. (LS2.B, LS2.C)




In this section, focus on how small changes in one part of a system might cause large changes in the cycling of matter, flow of energy, and stability of an ecosystem.

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 cannot be made, the atoms already exist and must be recycled from other living organisms. Carbon is stored in things like sedimentary rocks, the atmosphere, and other parts of the ecosystem. Exactly how does carbon get recycled and move through the ecosystem?



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

Look at the diagram for how carbon can cycle through organisms through the processes of cellular respiration, photosynthesis and decomposition. What other processes do you see that don't relate to the living parts of the ecosystem? Carbon can transfer between the atmosphere and water like the ocean. Carbon from once living things can be deposited and become part of rocks or form fossil fuels. The soil is another important stop for carbon in the cycle as it is the home for many of our decomposers. If you look at the diagram, carbon doesn't just cycle in and out of living things, it cycles between both living and nonliving parts of the ecosystem.

Carbon In and Out

Carbon dioxide cycles through various parts of the ecosystem through different processes, some of them are listed below.

- Living organisms release carbon dioxide (CO_2) during cellular respiration. Carbon dioxide is breathed out into the atmosphere or water, depending on where the organism lives.
- Photosynthesis removes carbon dioxide (CO_2) from the atmosphere or water and uses it to make chemicals like glucose ($C_6H_{12}O_6$).
- Carbon dioxide (CO_2) is given off through respiration when the carbon containing tissues of dead organisms and other organic (once living) materials decompose.
- Burning organic (once living) material, such as fossil fuels or firewood, releases carbon dioxide (CO_2) into the atmosphere.
- When limestone forms from the bodies of sea creatures carbon atoms may be stored in sedimentary rock for millions of years.
- Carbon dioxide is released when limestone is heated during the human production of cement.
- When volcanoes erupt, they release carbon dioxide (CO_2) that was stored in the mantle.
- Ocean water releases dissolved carbon dioxide (CO_2) into the atmosphere when water temperatures rise.
- Carbon dioxide (CO_2) is removed from the atmosphere when ocean water cools and dissolves more carbon dioxide from the atmosphere.
- Flowing water can slowly dissolve carbon in sedimentary rock. This carbon often ends up in the ocean.

Carbon often will cycle quickly through the living parts of an ecosystem through the processes of photosynthesis, respiration, & decomposition as producers (mostly plants and algae) do photosynthesis and are consumed by things like animals. As organisms live and then die the carbon in their matter is cycled by decomposers. Carbon can sometimes move quickly between the soil, atmosphere and bodies of water as a result of these processes. Different carbon stores (rocks, ocean and the atmosphere) can hold different quantities of carbon for different amounts of time. Sometimes carbon can be stuck for thousands of years or more in one location. This is often the case when carbon makes it into sedimentary rocks and fossil fuel deposits. There are not many paths out of these carbon stores.

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. The use and burning of fossil fuels has released great quantities of carbon dioxide into the atmosphere that had been stored away in the earth for millions of years. Cutting forests and clearing land have also increased carbon dioxide into the atmosphere. These activities reduce the number of plants that remove carbon dioxide from the air through photosynthesis. In addition, clearing of forests often involves burning what remains, this releases carbon dioxide into the atmosphere that was previously stored in plants.

Putting It Together

Image by Impermanent; pixabay.com; CC0

Apples on the ground start wrinkling, attracting flies, their size shrinks, and brown spots start to form.

Focus Questions:

1. What are the living & nonliving parts of the ecosystem that carbon can flow through?

2. What do you think is happening to the carbon in the fruit?

3. What are 2 likely locations carbon was before it was in the fruit?

4. What are the 2 most likely locations for carbon once it leaves the fruit?

Final Task:

Select a location in the carbon cycle and explain what is something that could happen that would affect the stability of the carbon cycling in or out of that location.

3.3 The Carbon Cycle and Ecosystems (8.3.3)

Phenomenon #2

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. The lack of wolves had an effect on the Yellowstone National Park ecosystem.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What effect could the removal of the predators have on the prey like deer?

2. What effect could the removal of the predators have on the vegetation (plants) in the yellowstone ecosystem?

3. What evidence would you collect to verify your predictions?

Energy Flow

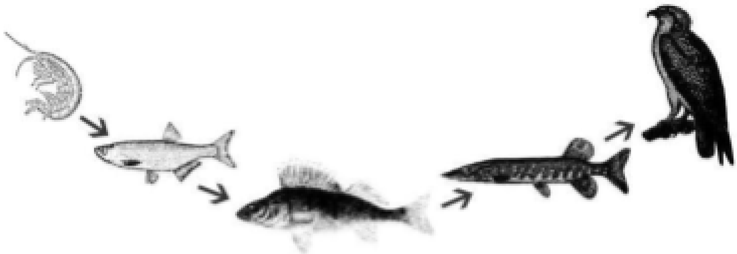
What is the source of energy for almost all ecosystems?

Ck12.org, CC BY-SA

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.



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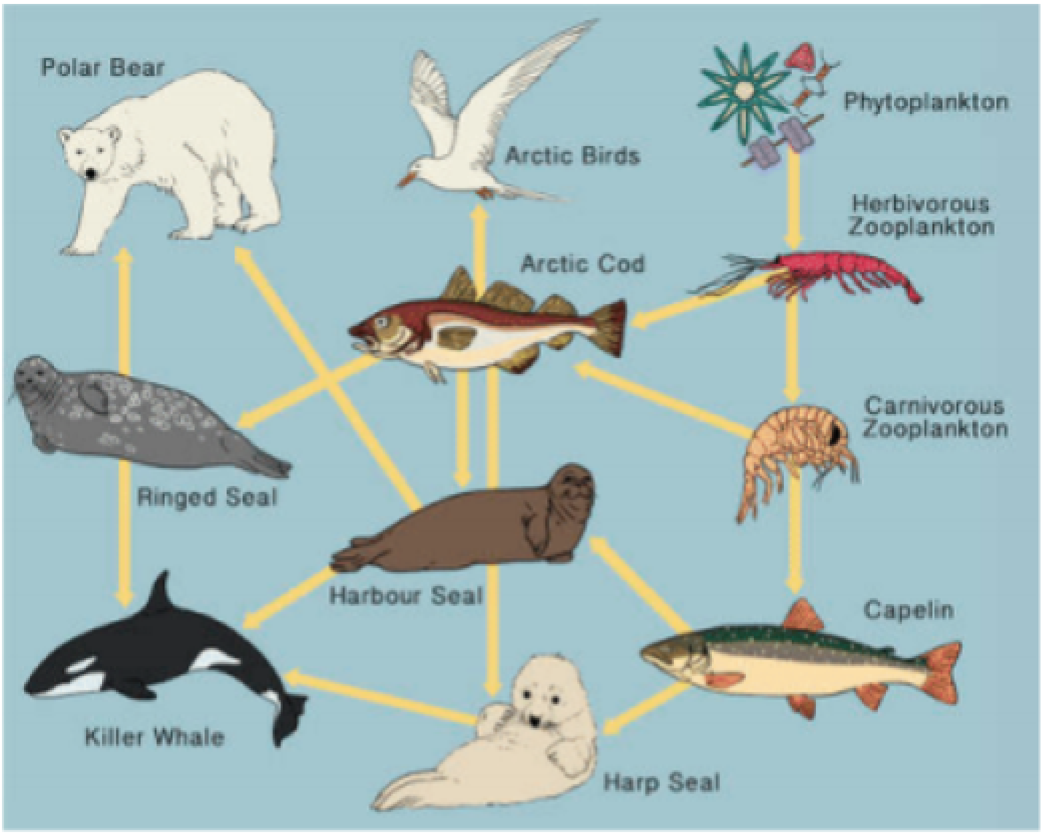
Food Web

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 of food. That means that humans are the top predators.



This image shows a food web of the Arctic Ocean.

Questions:

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 nonliving things, such as rocks and oceans, and then back into the atmosphere. The big idea is that matter is reused over and over again; matter cycles through ecosystems.

Energy on the other hand flows as it is converted from one form to another, but it is not cycled. The energy that comes from the sun does NOT return to the sun. Instead energy moves from one form to another. In ecosystems energy flows from the sun through plants and stored as chemical energy in the glucose. As the energy stored in the plants is transferred through each step of the food chain, the energy flows from one organism to the next. Some energy is used by the organism for normal functions, some is even transferred to the environment in the form of heat. At any point something dies in the food chain, the energy can be transferred to the decomposers or even stored for millions of years in fossil fuels.

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 the 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 is 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. In addition to providing matter for life processes, the nonliving parts of an ecosystem like water, soil, air are often homes for organisms big and small. Disruptions to these areas can also affect the stability of matter and energy transferring.

Image by Thomas Cizauskas; https://flic.kr/p/2i382Aw; CC BY-NC-ND

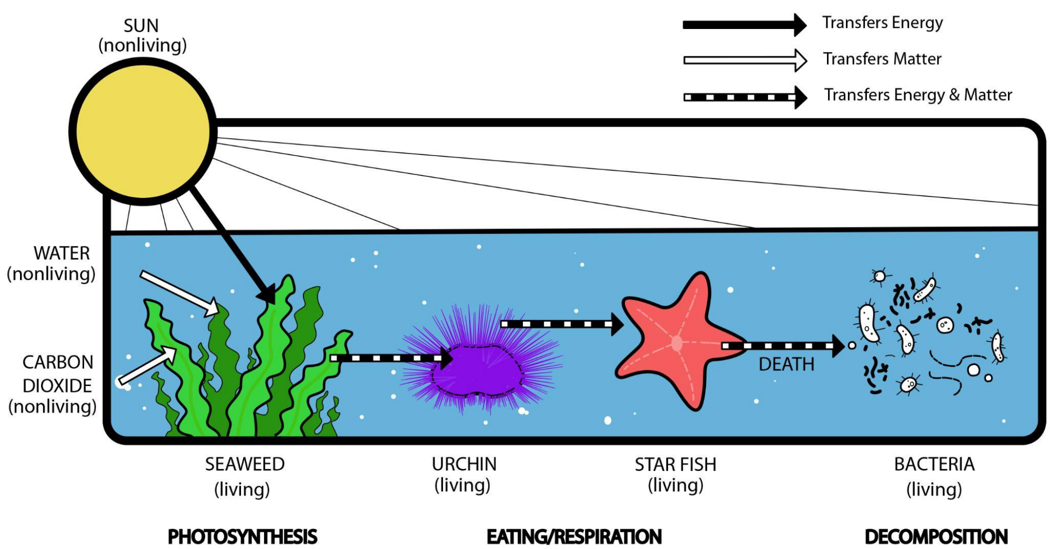
For example, in Yellowstone over the 70 years when the wolves were removed, the deer population increased dramatically and parts of the ecosystem started to have very few plants due to the over-eating of the vegetation from the large deer herds. The lack of plants led to increased erosion, which affected the flow of the rivers. These changes forced many species like beavers to leave Yellowstone in order to survive. The lack of beavers building dams resulted in the loss of habitats for many other species, which then also had to find new homes. This left a major gap in the ability of matter to cycle and energy to flow in the ecosystem, and the ecosystem became very unstable.

To try and fix the problem humans arranged the reintroduction of wolves to control the deer population. With the introduction of predators the deer started moving away from the meadows and more into forested areas. This allowed the plants in the meadows to grow back, which allowed beavers to return which created habitats for songbirds, ducks, muskrats, otters, and fish. The return of these food sources also supported the return of grizzly bears, which also feed on vegetation like berries. Wolves also helped control the coyote population which allowed an increase of rabbits and mice, which resulted in more hawks, weasels, foxes, badgers. Ravens and eagles returned to feed on what the wolves left behind. These many changes that have been seen since the return in 1995, resulted in the awareness of the important role wolves had in the stability of matter and energy in the ecosystem.

Image by author, CC0

Every part of an ecosystem has a role. Food webs help us understand the interconnection between the living parts of the ecosystem and make predictions of the possible effect of changes. However, disruptions anywhere can be critical. When they do happen, nature always tries to find ways to continue life to adjust and find a new balance of energy flow and matter cycling. No matter the cause, human or natural, sometimes new balances can be found, sometimes they can't.

Below is a simple example of matter and energy moving through a sequence of the tide pool ecosystem.



- How could disruptions like pollution making the water cloudy or rising temperatures in the ocean affect the stability of this ecosystem?

- Which of the parts of the ecosystem shown would have the greatest impact on the stability of the ecosystem if removed? Explain.

Putting It Together

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. As a result deer populations became overpopulated and affected the ecosystem dramatically.

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

Focus Questions:

1. Starting with the sun giving energy to plants, how did the absence of the wolves in Yellowstone interrupt the flow of energy among living things?
2. How did the absence of the wolves in Yellowstone interrupt the cycling of matter among both the living and nonliving parts of the ecosystem?
3. How did this interruption in the flow of energy affect the stability of the ecosystem over all? Discuss at least 3 changes that affected the stability.

Final Task:

- After learning more about the Yellowstone ecosystem, what is another possible disruption that could affect the stability and balance of cycling matter and the flow of energy? Explain.

- What additional information would help you know if you are right?

CHAPTER 4

Strand 4: Natural Resources

Chapter Outline

Image by shibang; pixabay.com; CC0

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 predict and forecast future disasters and work to mitigate or reduce the damages.

4.1 Natural Resources Geology (8.4.1)

Phenomenon

Coal Seams by Tim Whitlow, https://flic.kr/p/7yBouU CC BY-NC

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

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What would have caused the coal to form layers the way it has?

2. What do you know about how coal is formed?

3. Can you find layers like this everywhere in the world?

8.4.1 Natural Resources 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. (ESS3.A)

Focus on how Earth's geological processes, now and in the past, are the cause that affects the uneven distribution of resources around the globe.

Natural Resources

Natural resources are substances constructed by nature, like oil, copper, water, air, and salt. Many natural resources help to support life on Earth. In ecosystems, organisms use natural resources from their habitat for things like food and shelter. Humans are one species in a large web which includes all life on earth as well as the available resources. Humans are different from all other life because 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.

Questions

- How many natural resources can you name that are available in the United States?
- 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 Utah have abundant coal deposits while another state like California has little to none?

These answers all have to do with how coal is formed. Over millions of years, plant material growing in swamps die and are buried before they can be decomposed, they are then compacted, and altered through geological processes and the result is the fossil fuel coal. It is not possible to find all natural resources equally in every location throughout the earth because the same geological events just didn't happen in some locations. Utah has coal because there were swamps here millions of years ago. California doesn't because there were no swamps there. The distribution of many natural resources depends on the geological past 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.

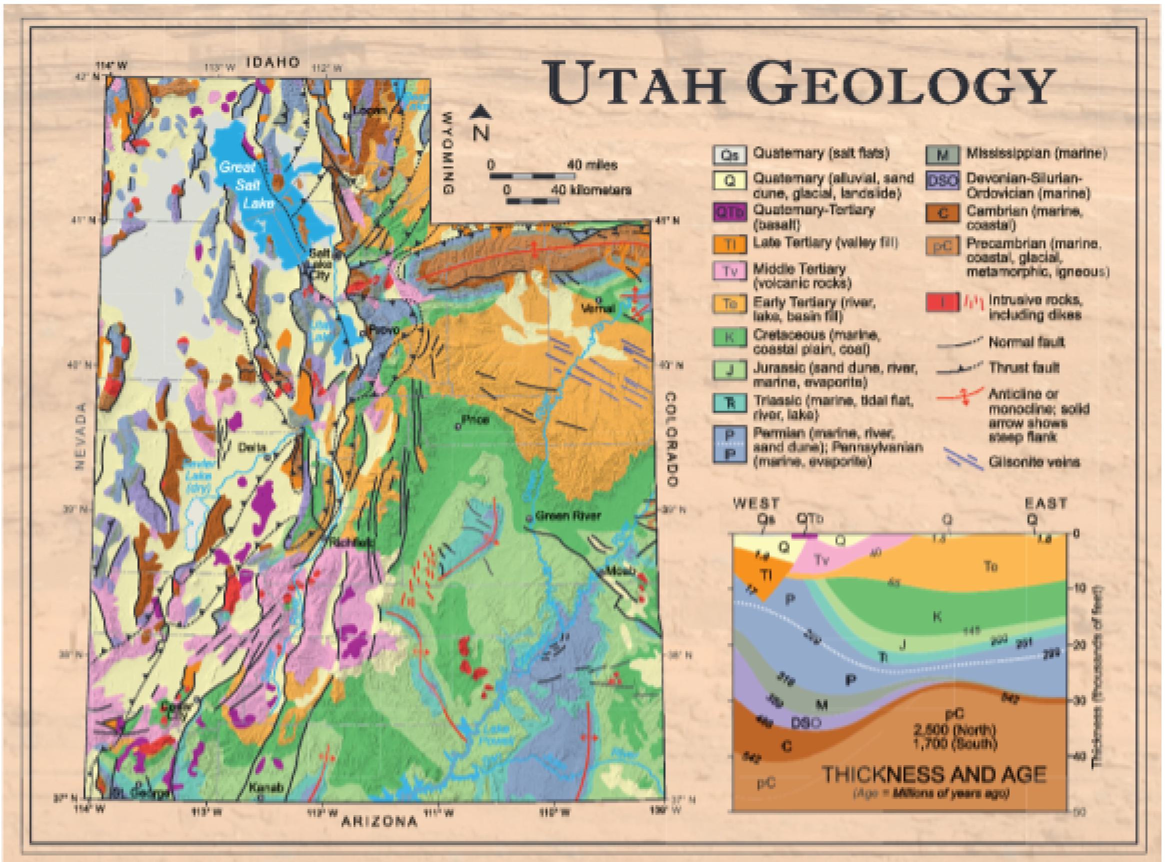
Mineral and fossil fuel resources fall into four main groups.

- 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 is not a geological resource but it is also dependent on the geology of an area. Water will only collect in and flow through certain porous 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 rock.
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	Porous rock where aquifers can form. Aquifers involve rocks with spaces in between the particles where water can fill in the empty space



**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:

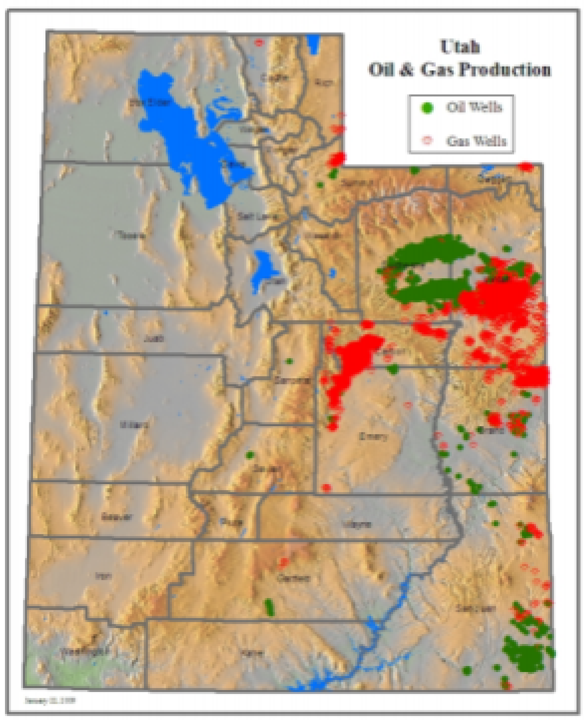
- Volcanic rocks (red, purple and pink areas)
- Sedimentary rocks deposited in lakes and oceans (gray, orange and blue rocks)
- Metamorphic rocks (dark brown)
- Loose sediment that has filled valley floors (light tan)
- Earthquake faults (solid or dotted black lines)

Using the information from the resource chart, what kind of resources would you possibly expect to find on the west side of utah? What would you expect to find in the east?

Utah is a state with a very diverse geologic history. We have mountains and valleys, flat tablelands, faults and earthquakes, dormant volcanoes, sedimentary rocks that were deposited in lakes and oceans, and metamorphosed rock. For this reason, Utah has a wide variety of mineral and fossil fuel resources.

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

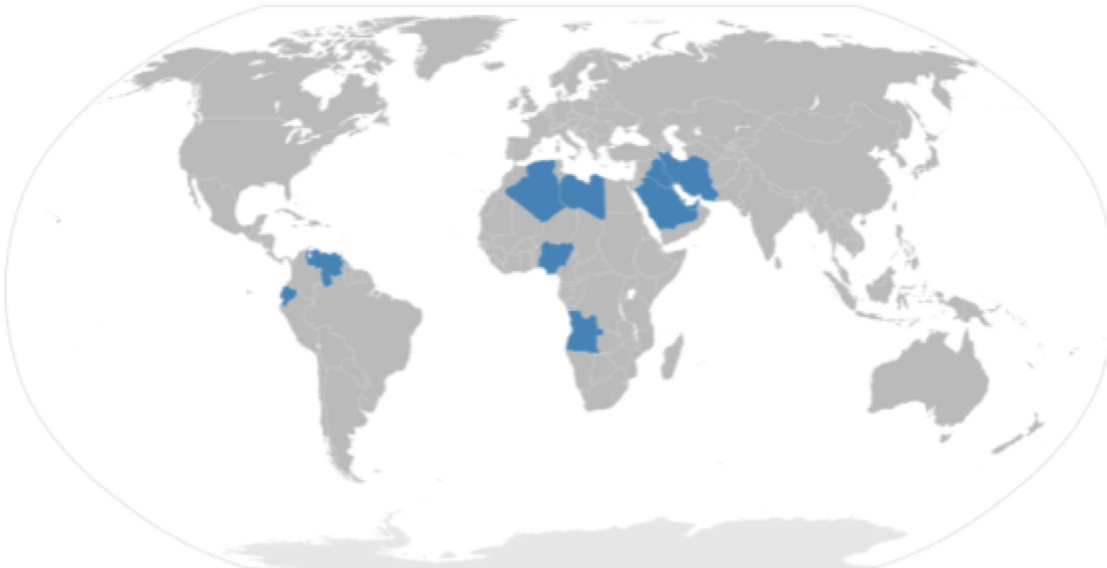
Utah has been a major producer of copper and other metals that are associated with volcanic rocks. On the geological map you will notice that most of the igneous volcanic rock is mostly found in the western half of the state. Whereas coal and oil are found in areas that were once swampy or at the bottom of water. Sedimentary rock is the type of rock that usually forms as water deposits sediments over time. If you look at the geological map you will notice that there are a lot of sedimentary rocks found in the eastern half of the state which is where we find coal and oil.



*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.

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 variety in the geological past, which provides more variety of resources. Small countries often struggle to provide all the resources their people need and have to maintain good relations with their neighbors so that they can trade for resources they lack. The high demand worldwide for oil is an advantage to the countries below.



Public Domain

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

Putting It Together

Coal Seams by Tim Whitlow, https://flic.kr/p/7yBouU CC BY-NC

Focus Questions:

Using the photo above, answer the following:

1. What caused the coal to form in flat bands?

2. What must have happened in the past in order to find coal here?

3. Why can't you find coal everywhere on earth?

Final Task:

Construct an explanation based on evidence to show how the uneven distribution of coal is caused by the geological history of the area?

4.2 Renewable and Nonrenewable Resources (8.4.2)

Phenomenon

CC0

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

Logging is the practice of cutting down trees for the use of the natural resource of wood. There are a variety of ways that this can be done but in some cases large areas of forest are cleared of all the trees in the area. Often after this is done the areas will have issues with landslides and erosion and often animals who are unable to find homes will move to other areas.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What do you think are some other effects of cutting down trees in the forest?

2. What effects could be mitigated (lessened) if logging were done a different way?

3. Why do you think that organisms are unable to live in the area after the trees are gone?

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. (ESS3.A, ESS3.C)

Focus on how the consumption of natural resources causes a variety of effects on Earth's systems.

Natural Resources

A natural resource is something supplied by nature and used to improve living conditions. When you think of natural resources, you may think of minerals and fossil fuels and you would be right. However, ecosystems are also natural resources that people often don't think of. All natural resources are generally classified in one of two categories, either renewable or nonrenewable.

Renewable resources have an unlimited supply and nonrenewable resources have a limited supply. Will this planet eventually run out of oil? Although scientists disagree on when supplies will run out, scientists do agree that they will run out. Fossil fuels are classified as a nonrenewable resource because they take millions of years to form and we are using them at a faster rate than they can naturally be made. Wind and sunlight are considered renewable resources because you can't ever run out of them.

Renewable Resources

Renewable resources are unlimited or can be replenished by natural processes about as quickly as humans use them. Sunlight and wind are renewable resources because there is a constant supply from nature. They are not destroyed when they are used and can be recycled.

So what about water? In a dry state like Utah, water is always a concern. It is however considered a renewable resource because it is always being replenished through the water cycle. It is only because of our location, we have a limited supply each year we have to be careful with how much we use.

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 natural resources like trees are not unlimited, but nature can regrow them. However, we have to be careful to make sure we don’t take more than what nature can replace. 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

- 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

- 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 CC BY-SA

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

Nonrenewable Resources

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Nonrenewable resources are natural resources that exist in limited amounts and are unable to be naturally replaced within the lifespan of a person and so can be used up. Materials like metals and minerals are non-renewable because their deposits take such a long time through geological processes to be deposited. Other examples include fossil fuels such as oil, 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. Scientists estimate at current rates of use, petroleum will be used up in about 50 years and coal in less than 300 years. Nuclear power is also considered to be a nonrenewable resource because it uses up uranium. There is a set amount on earth which will sooner or later run out.

Ck12.org, CC BY-SA

Coal is another nonrenewable resource.

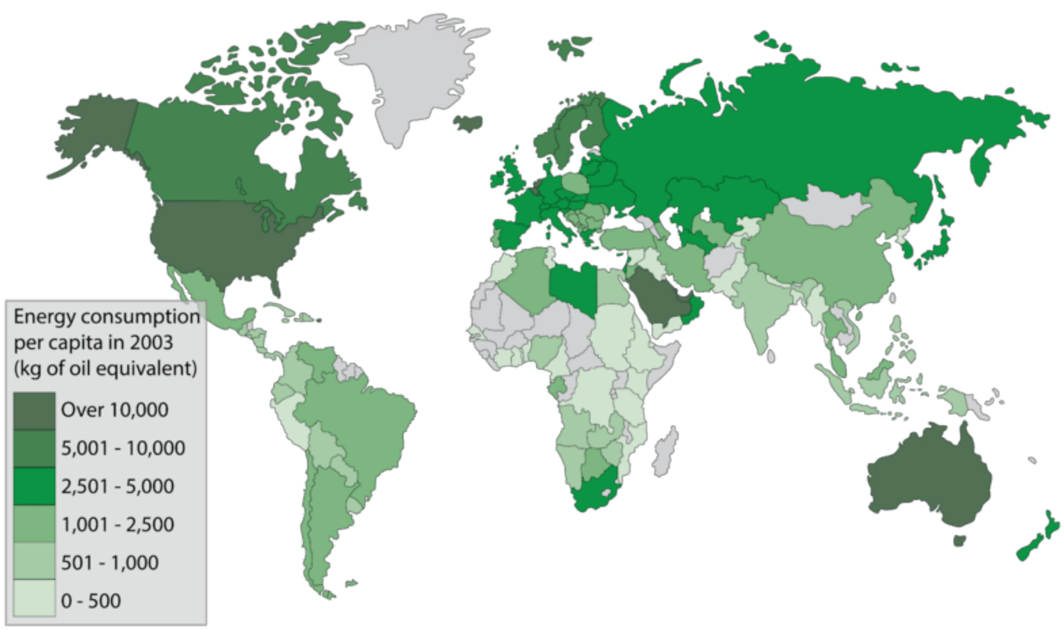
https://climate.nasa.gov/quizzes/quiz-energy/, Public Domain

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

Society's Use of Resources

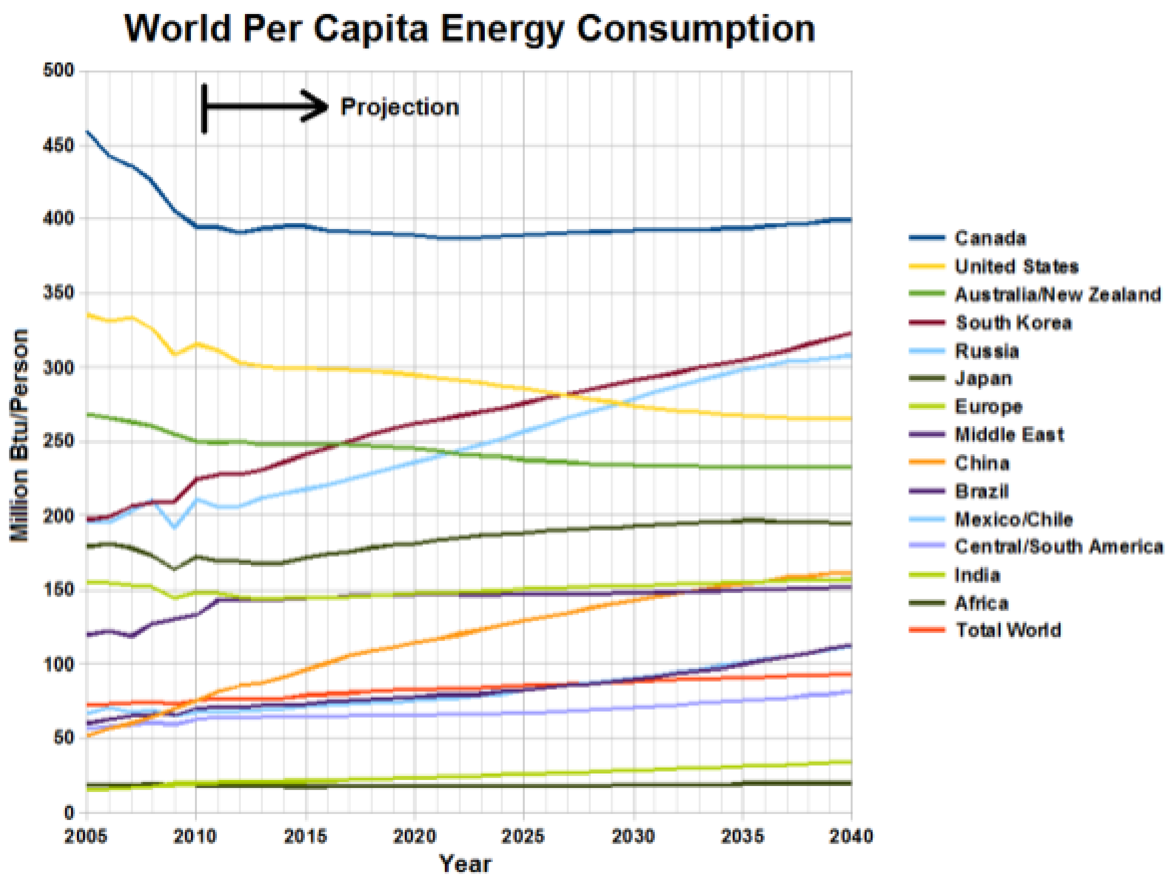
Many times when we discuss resources, power is a main concern. As a society we have become very dependent on power for transportation, hospitals, heating and cooling our homes, light, entertainment, and preserving our food. Population growth, especially in developing countries, should make people think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

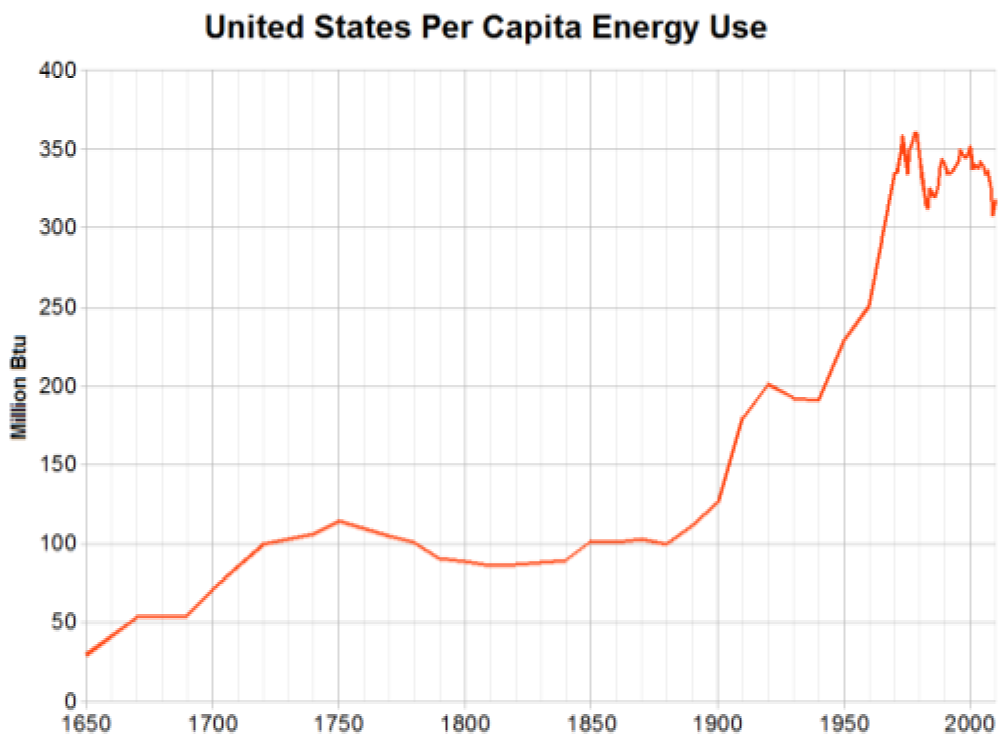
Which countries are using the most energy?



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

Who is projected to be using the most energy per person in 2040?

Who is projected to be using the least by 2040?



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

What has happened to the United States per capita energy use over the period shown in the graph?

Putting It Together

Deforestation in Nigeria by Foreign and Commonwealth Office, https://flic.kr/p/6m6Hja, CC BY-ND

Focus Questions:

1. How are earth’s systems affected by deforestation and logging?

2. What is causing some of those effects?

3. Why do we need to cut down the trees?

Final task:

Construct an argument from the evidence presented to you in this chapter about the effects on Earth’s systems caused by the human consumption of Earth's resources.

4.3 Problems Caused by Natural Resource Usage (8.4.3)

Authentic Situation

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

Oil spills happen sometimes when transporting oil in a ship and the ship has a leak. It can also happen in oil rigs at sea if the pipes bringing the oil up from the sea floor malfunctions. No matter how the oil spill occurs it is deadly to the wildlife in the area. The petroleum on this bird has made it so it cannot fly and will die without human help.

Observations & Wonderings

What is the Problem in this situation?

What are the possible criteria (positive outcomes) to this situation?

What are the constraints (limitations) with this situation?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. Why do humans use petroleum?

2. What are the effects of human use of petroleum on the environment?

3. What are possible solutions to this problem?

8.4.3 Solutions for Problems Caused by Natural Resource Usage

Design a solution to monitor or mitigate the potential <u>effects</u> 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. (ESS3.A, ESS3.C, ETS1.A, ETS1.B, ETS1.C)

In this section, focus on what effect does human use cause to the natural environment.

Engineering Design

This is an engineering standard. Refer to page 10 to read about engineering design. Which type of engineering task is utilized in this SEEd Standard?

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 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/8D6MEM 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.

Large oil spills, like the Exxon Valdez in Alaska in 1989, get a lot of attention. 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.

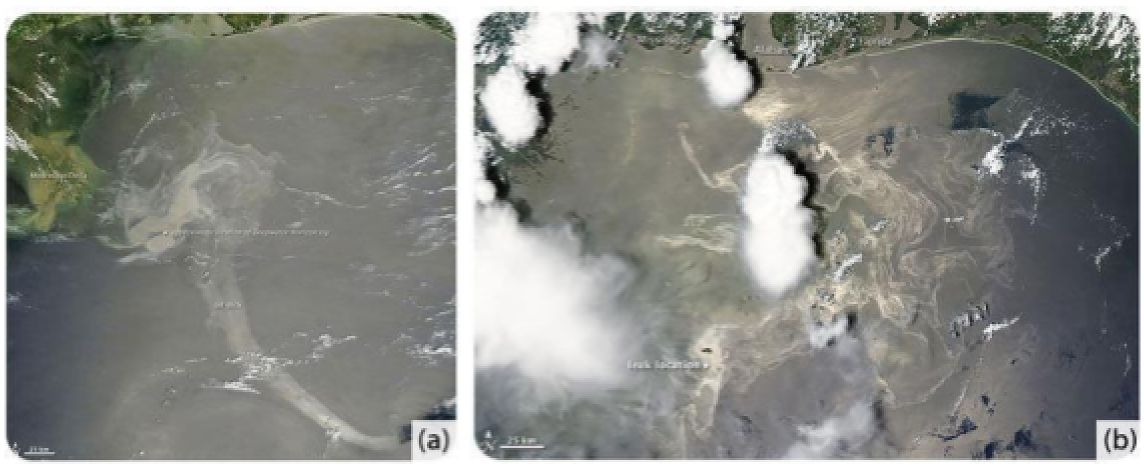
By Coastguard

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.

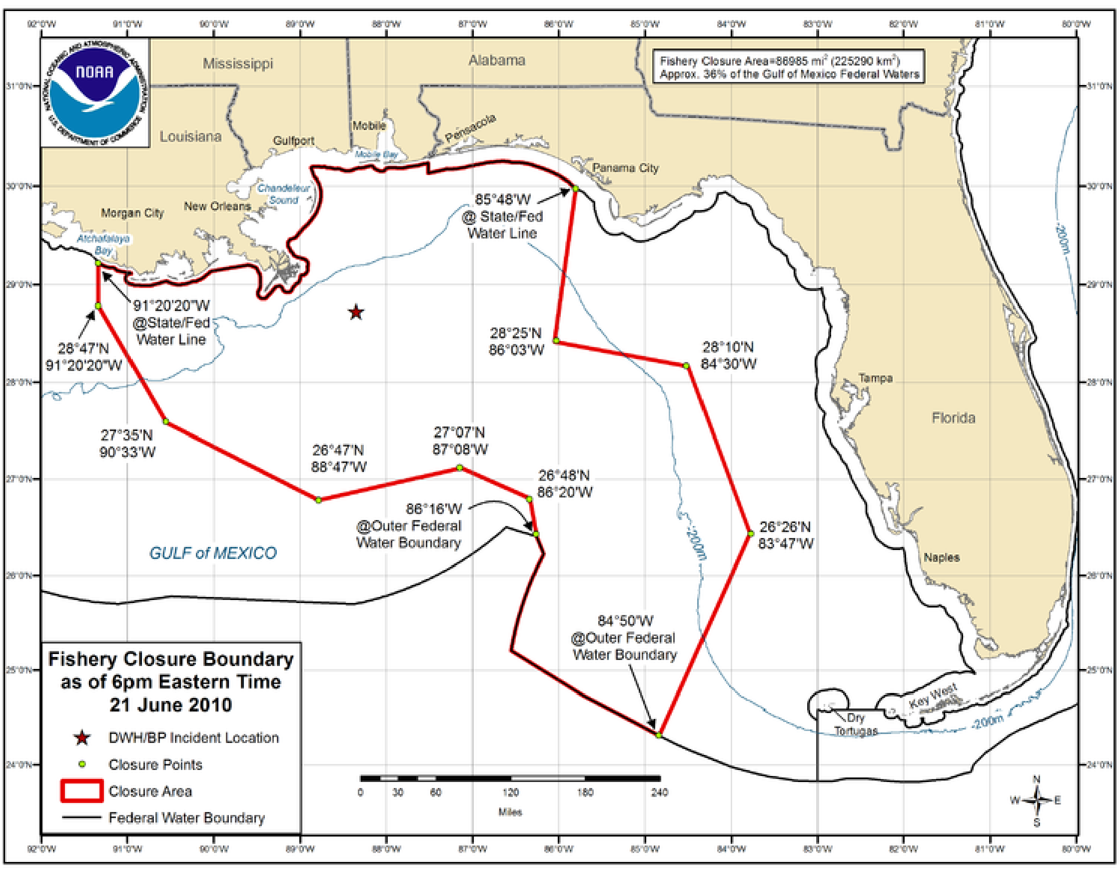
Of the above suggested ways of dealing with the oil in the water. Remember that the criteria is that the oil needs to be removed from the water and the constraints are that it needs to happen as quickly as possible and hopefully cost as little money as possible. Based on these criteria and constraints evaluate the different options to determine which you think is the best option.

Plugging the Well

Eventually 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.



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.

Monitoring for future accidents

There are ways to monitor 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

Focus Questions:

1. Explain the problems for the wildlife when an oil spill occurs.

2. What are ideas of possible solutions to deal with this issue?

3. What criteria (positive outcomes) and constraints (limitations) would make a solution good?

Final Task:

Design a solution to monitor or mitigate the potential effects of the use of oil on the environment. Evaluate your idea by giving evidence as to why it meets the criteria and constraints of the problem.

4.4 Global Climate Change (8.4.4)

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 of 65 to 90 degrees F with high humidity, abundant rainfall, nitrogen-rich soil, and barrier from wind.

Unfortunately the range they live in is changing. Places where cocoa beans used to grow easily are now places where they struggle to survive because the temperatures have increased beyond the 90 degrees F they prefer. Farms that used to focus on harvesting cocoa beans are having to find alternative crops in order to make enough money to survive.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What would cause a cocoa bean to no longer be able to survive?

2. How has the instability and change of the climate affected the cocoa beans?

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. (ESS3.D)

In this section, focus on what effect temperature changes have on regional climates, whether they are slow changes over time or sudden events causing larger changes.

What is Climate

Climate is the average weather patterns in an area over a long period of time. A description of climate includes information on average temperature in different seasons, rainfall, and sunshine.

Many things can affect a region's climate. Latitude describes a location's distance from the equator. Locations closer to the equator get more sunlight and are warmer than areas closer to the poles and farther from the equator. Elevation is how far from sea level an area is. Utah on average has a higher elevation because it is in the mountains. Cedar City Utah has a much higher elevation than St George and so on average Cedar city has much cooler temperatures and has 26% more rainy days than St. George which is only about 50 miles away. Atmosphere is another major effect on climate. The atmosphere has the ability to trap energy from the sun warming up the planet. Other things like how close an area is to water, the topography, ocean currents, vegetation, prevailing winds, the changes in solar radiation, and volcanic activity.

Which of these factors do humans have the ability to influence?

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. A few degrees of temperature change will also affect the humidity level required by the cocoa tree. Lower humidity and higher temperatures in the area will increase the evaporation of water from the leaves. This causes the cocoa tree to not produce cocoa beans and survive.

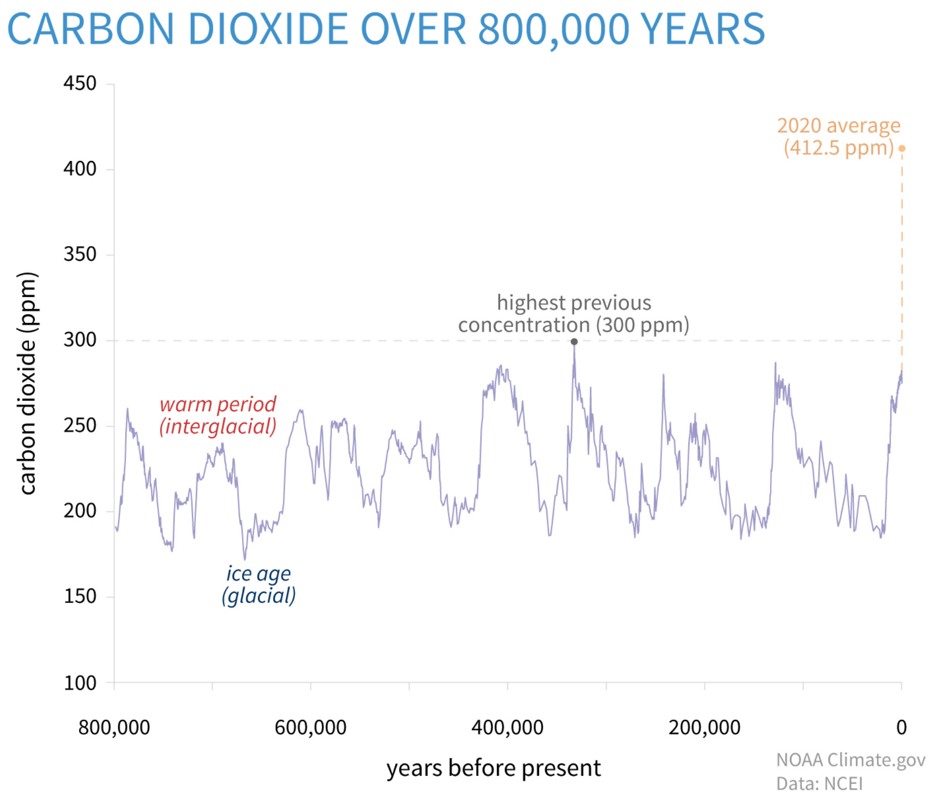
Temperature changes can also affect rainfall in certain regions. When rainfall is normal or high, the farm lands will be productive. When rainfall is low, no crops grow. Drought makes land unsuitable for farming. Changes in rainfall patterns will increase as temperatures warm.

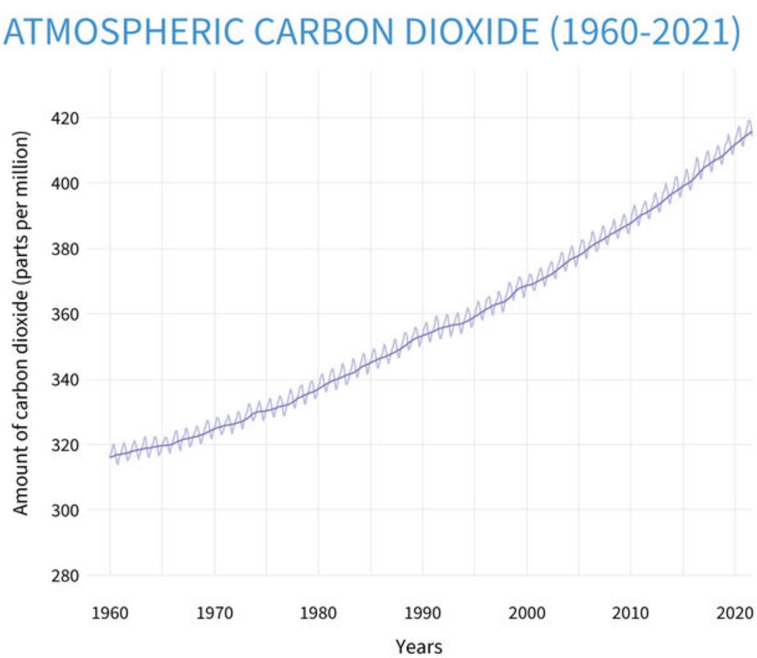
Causes of Global Climate Change

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 are some other factors at work.

Scientists confirm that recent global climate increase is due mainly to human actions. The actions involve releasing greenhouse gases into the atmosphere. Greenhouse gases aren’t all bad. They keep the atmosphere warm which is a good thing. However as the phrase goes, you can have too much of a good thing. The graphs below show the carbon dioxide levels over the last 800,000 years.

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





NOAA Climate.gov image, based on data from NOAA Global Monitoring Lab; https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide; Public Domain

What do the graphs show about carbon dioxide levels before human activity compared to after? What is it that humans are doing that is causing such an increase? Carbon dioxide is a greenhouse gas that is released into the atmosphere when fossil fuels are burned. The more carbon dioxide in the atmosphere, the more effectively the atmosphere traps heat. So the more greenhouse gases we get in the atmosphere the more heat our atmosphere traps and the result is increased global temperatures.

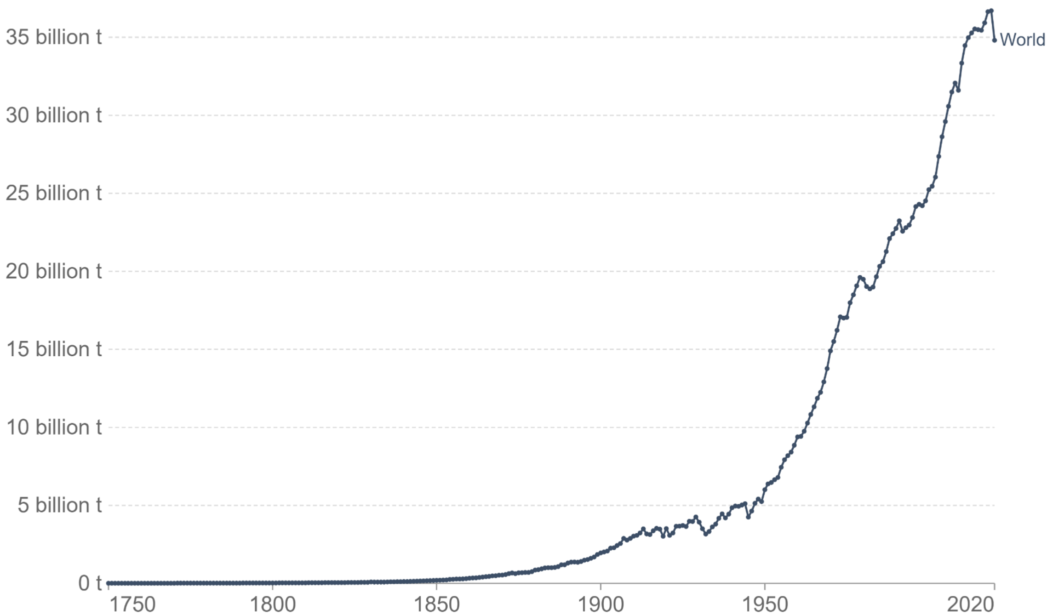
Other human activities also release greenhouse gases into the atmosphere. For example, growing rice and raising livestock both release methane, another greenhouse gas, into the atmosphere. We are also reducing the amount of land with vegetation for homes and other human use. This affects the amount of carbon dioxide that is being removed through photosynthesis. The increase in carbon dioxide being added and reduction of carbon dioxide being removed has a great impact on the balance of earth's systems regulating climate.

Data from the late 20th century shows that nature has produced about 780 gigatons of carbon dioxide yearly that is released into the atmosphere, natural processes have also removed about 780 gigatons of carbon dioxide yearly through natural cycles like the carbon cycle. Natural events have sometimes affected that balance with what we see in cycles of climate change throughout history that have had major impacts on ecosystems and caused mass extinction. The graph below shows extra carbon dioxide produced by human activity since 1750. This added carbon dioxide nature is not able to remove and it has an effect on the planet’s climate.

Who are the main producers of carbon dioxide emissions from burning fossil fuels?

Annual CO2 emissions

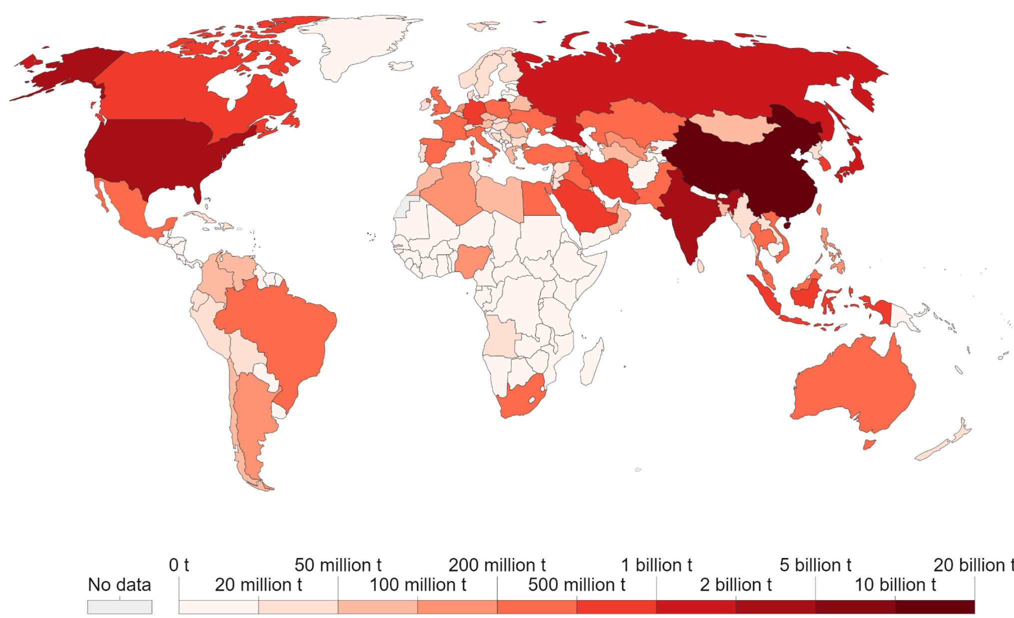
Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.



Source: Global Carbon Project

Annual CO2 emissions, 2020

Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.



Source: Global Carbon Project

Effects of Climate Change

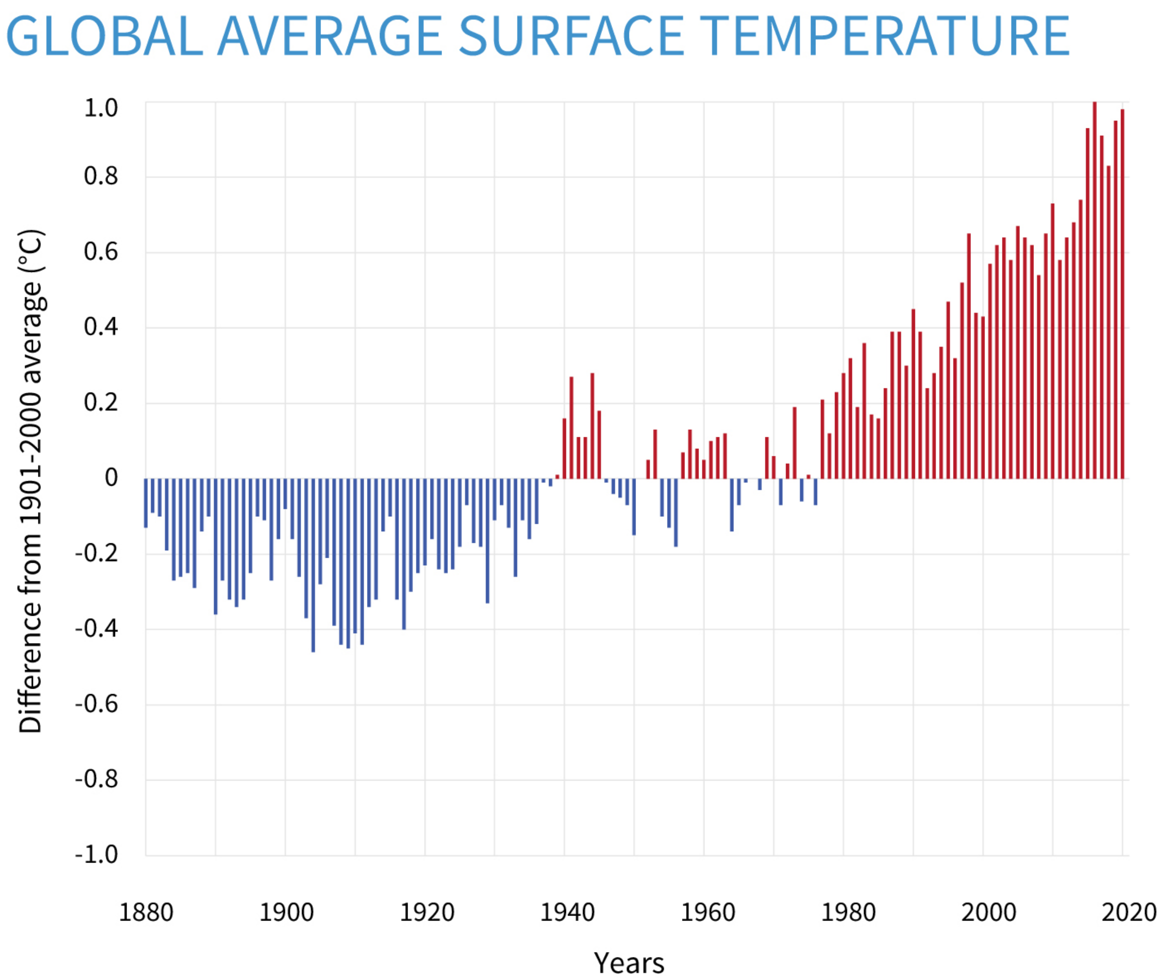
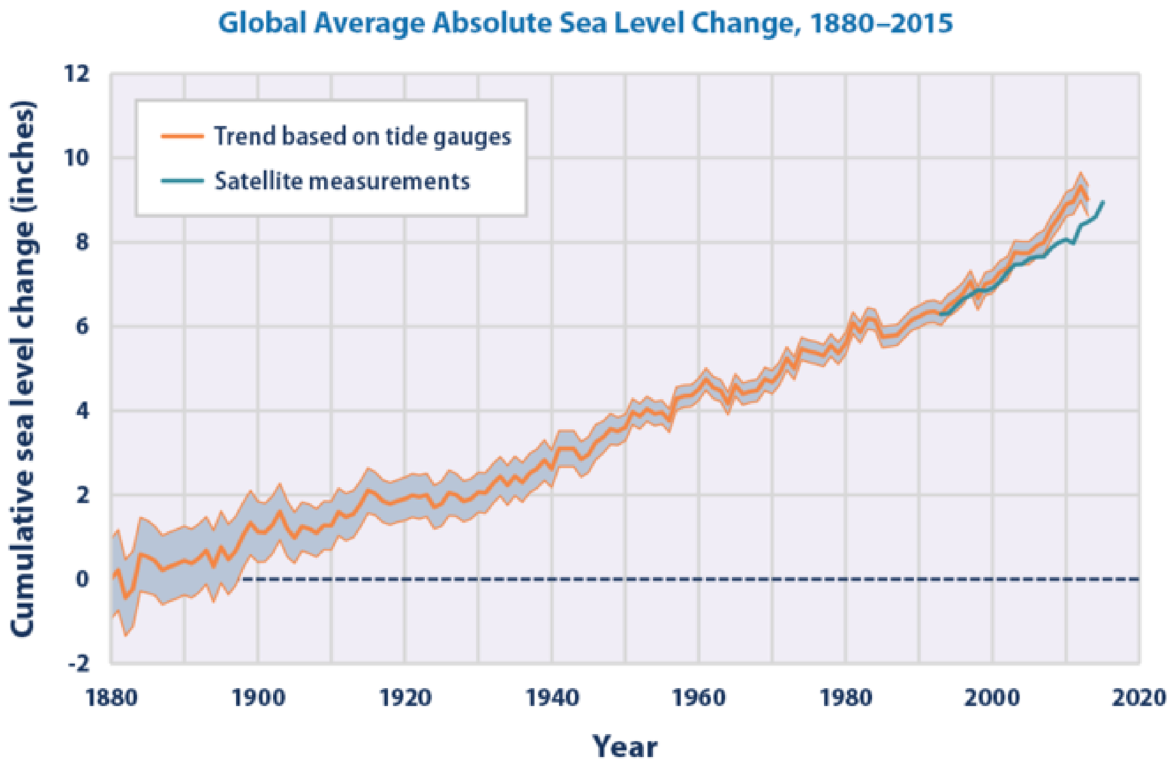


Image by National Oceanic and Atmospheric Administration; https://www.climate.gov/media/12885; public domain

The evidence that the earth is warming is present. On average the overall temperature change as of 2020 was 1 degree higher than the normal. However this means that in some areas the temperature was drastically higher and in some areas there may be colder temperatures. However one of the things we have noticed is for some organisms 1 degree is all it takes to affect their ability to survive.

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).



Data sources:

- CSIRO (Commonwealth Scientific and Industrial Research Organisation). 2015 update to data originally published in: Church, J.A., and N.J. White. 2011. Sea-level rise from the late 19th to the early 21st century. Surv. Geophys. 32:585–602. www.cmar.csiro.au/sealevel/sl_data_cmar.html.
- NOAA (National Oceanic and Atmospheric Administration). 2016. Laboratory for Satellite Altimetry: Sea level rise. Accessed June 2016. http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/LSA_SLR_timeseries_global.php.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

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 where the usual amount of ice was for 1979–2000. Notice how much smaller the ice coverage was in 2011 compared to the normal 1979-2000 average.

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

Nasa Public Domain

Anytime something occurs that can influence climate, the balance of matter cycles and the stability of ecosystems in that region are affected. These changes can cause drastic effects to organisms survival as the climate in the area changes.

Putting It Together

Pixabay.com, CC0

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

Focus questions

1. What factors affect the climate in the area where cacao beans grow?

2. Which factors that affect the climate in the area are changing?

3. What is changing about the climate where they grow?

4. Which factors do humans have control over when it comes to the climate of the area.

Final Task

Write an argument based on evidence from the chapter that climate change is affecting the cacao plants and how some of those factors are human caused while others are natural.

4.5 Natural Hazards (8.4.5)

Phenomenon

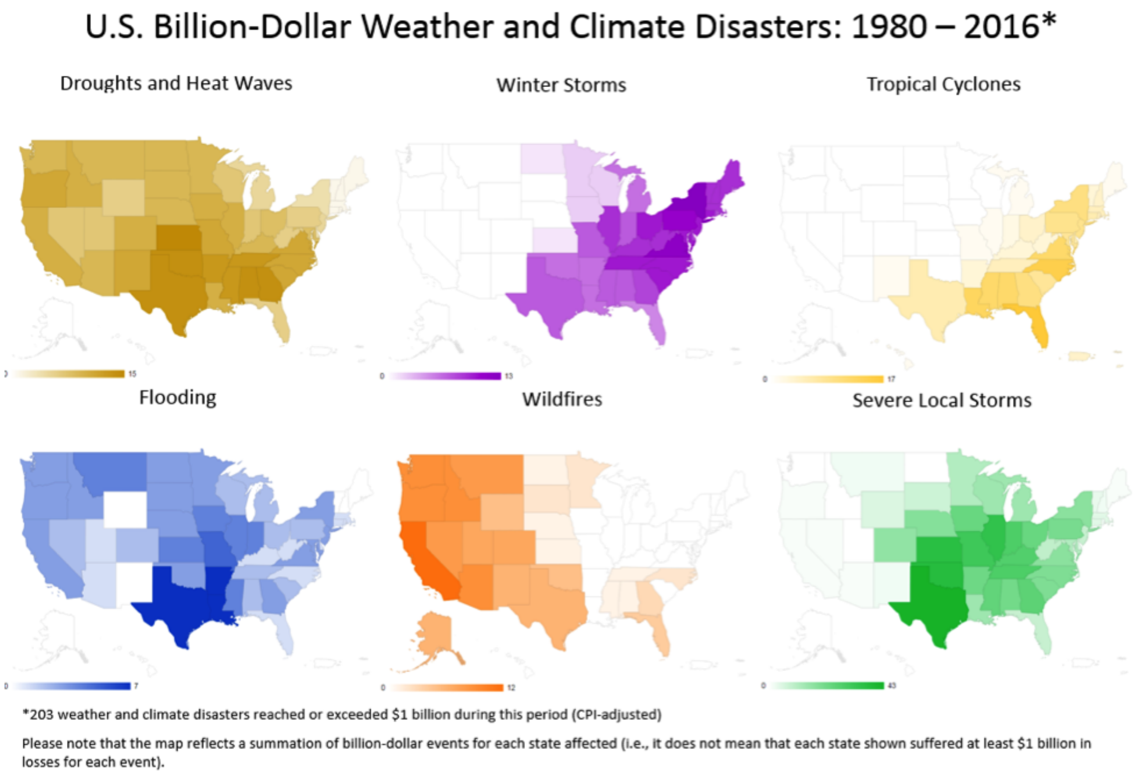


Image by NOAA; https://www.climate.gov/news-features/blogs/beyond-data/2016-historic-year-billion-dollar-weather-and-climate-disasters-us; Pubic Domain

Above are maps of the United States showing types of natural hazards that have caused different areas in the U.S Billions of dollars in damage.

Observations & Wonderings

What are you observing about this phenomenon?

What are you wondering about this phenomenon?

Focus Questions: Give your best response prior to learning about this topic. Your initial answers may change as you explore this unit.

1. What patterns do you notice in the occurrences of these disasters?

2. Are there any areas that are more affected by natural hazards than others?

3. What are some ways that we could use this information to reduce the amount of damage caused by these natural hazards?

8.4.5 Natural Hazards

Analyze and interpret patterns of the occurrence of natural hazards to forecast future catastrophic events, and investigate how data is 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. (ESS3.B)

In this section, focus on patterns. Graphs, charts, and images can be used to identify patterns in data that affect our ability to prepare and respond to natural hazards.

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 of wind, rain, ice and even lightning which causes damage to structures, our way of life, and even loss of lives.

A natural hazard is an event that occurs in nature that has the potential to cause harm to humans or their property. There is no way for us to ultimately stop natural hazards from occurring. There are basically two types of natural hazards, geological and atmospheric. Geological hazards are events like earthquakes, volcanoes, landslides, rock falls, or sinkholes that result from geologic (land based) changes. Atmospheric hazards include tornadoes, hurricanes, flooding, avalanches, blizzards, or windstorms that are results of the weather.

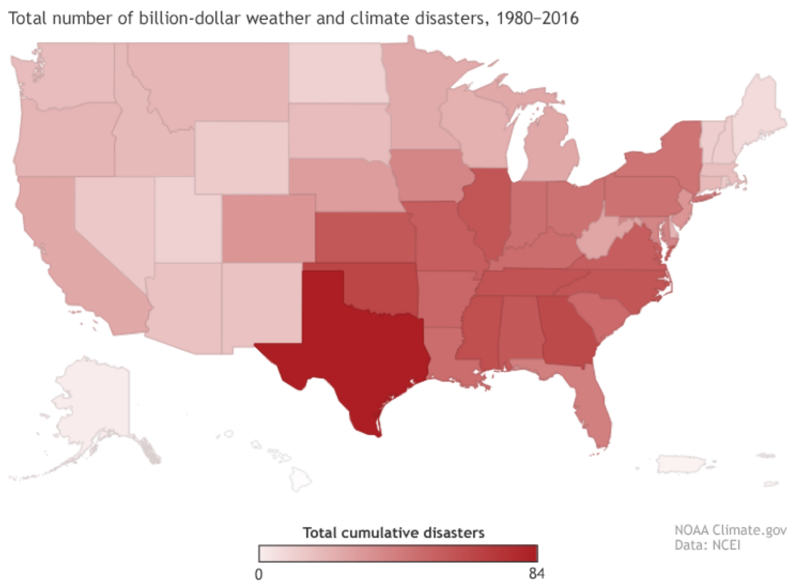


Image by NOAA; https://www.climate.gov/media/7928; Public Domain

Some areas of the planet are more prone to natural hazards because of their location. Above is a map showing the total number of billion dollar weather related disasters that occured from 1980-2016.

Analyzing data:

Circle the state that is the most likely to experience an extreme atmospheric natural hazard?

Where does Utah fall in the likelihood of a major atmospheric natural disaster based on events represented in this map??

Predicting Natural Hazards

When trying to predict natural hazards there are two things to consider. Can we predict where it will occur and can we predict when it will occur. Sometimes we can give general and less specific predictions of when and where a natural hazard will occur. For example with earthquakes we can give a general idea that they happen along fault lines and by tracking data we can see how often large earthquakes usually occur. For example Utah is about 100 years overdue for a large earthquake. But these types of general predictions are not as helpful when it comes to the actual hazard occurring. There are over 200 active fault lines in Utah that the earthquake could happen along and telling people that "there is a 50% chance of a large earthquake happening in the next 50 years somewhere in Utah" doesn't really help when it comes to evacuations before the event.

In contrast, some natural hazards we are able to put out very specific warnings about when and where something might occur. An example of this is that for tornadoes they are able to monitor the weather and identify when a tornado is likely to occur in the next few hours and in a much smaller area or region than an entire state. They can put out warnings letting people know to head to a storm shelter or to stay out of an area.

Predicting When

Sometimes we can predict when natural hazards will happen. Volcanic eruptions are often preceded by many small earthquakes around the volcano. Watching for these patterns, we can more likely predict the timing of the eruption. By collecting data on when tornadoes happen we know that they most often occur between the months of May and July in the United States. Hurricanes we have also collected data on and know that they normally occur between June and November with most occurring in August through October. Mudslides and flooding usually occur when there has been a lot of rain. This means that during extremely wet times they often monitor for these events more closely than they would during a dry period of time. Tsunamis, which are large waves caused by earthquakes under the ocean, can be predicted if the area is monitored for seismic activity. They can often notify areas on the shores by the earthquake and give enough time for evacuation to higher ground.

Image by NSGS; https://www.usgs.gov/media/images/lava-flow-inundation-puna-district; public domain

Some natural hazards are not predictable when they will occur. Earthquakes are caused by a break in the crust of the earth and a shift in the rocks and there is as of yet no way to know when the break is going to happen. If we collect data on when earthquakes have happened previously we can generally give an idea of when we think another large earthquake will occur but this is usually in terms of "sometime in the next 50 years" range. In order for a prediction to be helpful it needs to be more accurate than decades. Sink holes which are when the ground collapses into underground openings are also not something that we can predict accurately when they will occur.

Predicting Where

Sometimes we can predict where natural hazards will occur fairly accurately. By mapping tornadoes and hurricanes we have realized that there are patterns in where they occur. There are things that are usually present in order for them to occur. Tornadoes happen when a mass of cold air collides with a mass of warm air on flat ground, which is why we have an area called "tornado alley" . Hurricanes form over warm oceans in the wet tropics and then move northward with the prevailing winds, the Gulf a Mexico creates the perfect conditions for this in the fall. Landslides and rock falls happen on steep, unstable slopes, usually when there is a lot of water present after a large rainfall.

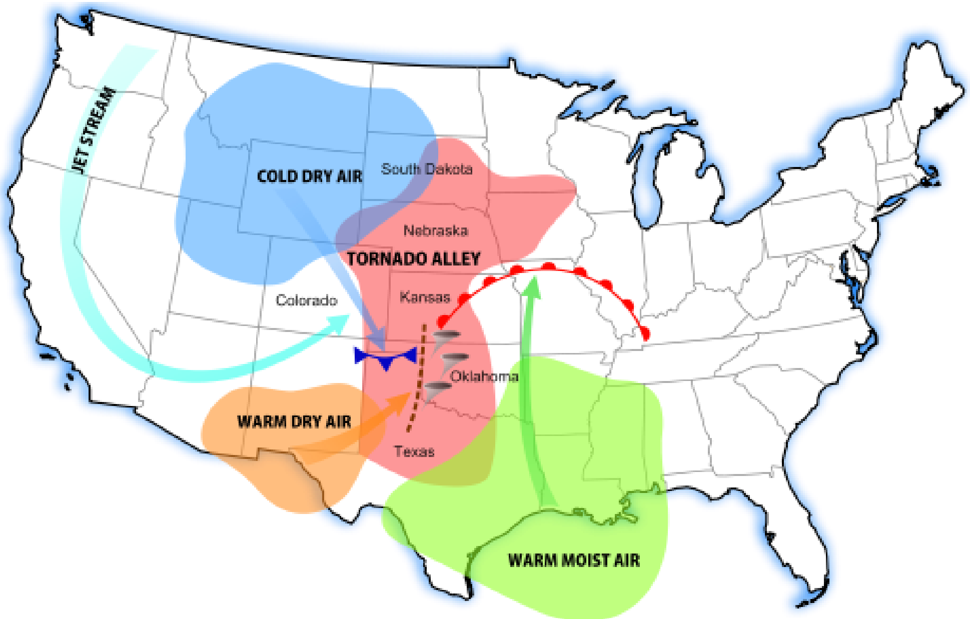


Image by Dan Craggs; https://commons.wikimedia.org/wiki/File:Tornado_Alley_Diagram.svg; CC BY-SA

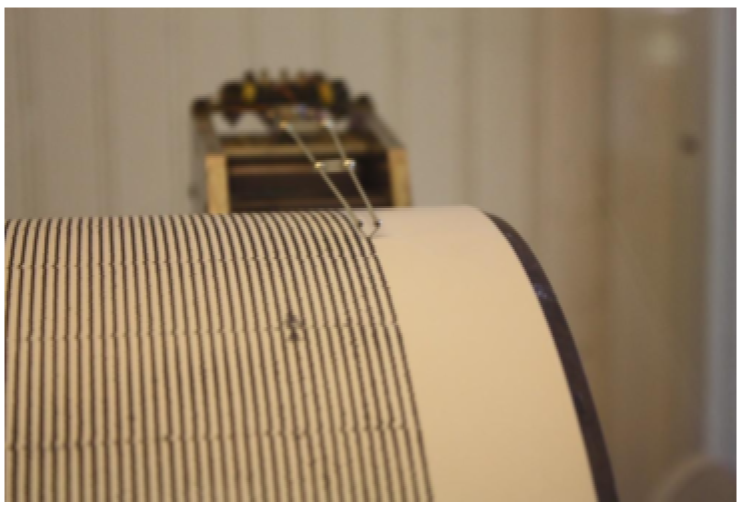
Oops by Brett L., https://flic.kr/p/iC1yU, CC BY-SA

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

With earthquakes we can predict general areas where they will occur mapping out active fault lines. But just as we cannot pinpoint exactly when they will occur we cannot predict exactly where the earthquake will happen either. For example we know that earthquakes are a problem for Utah even though we haven't had a large earthquake in a long time. 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.

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.

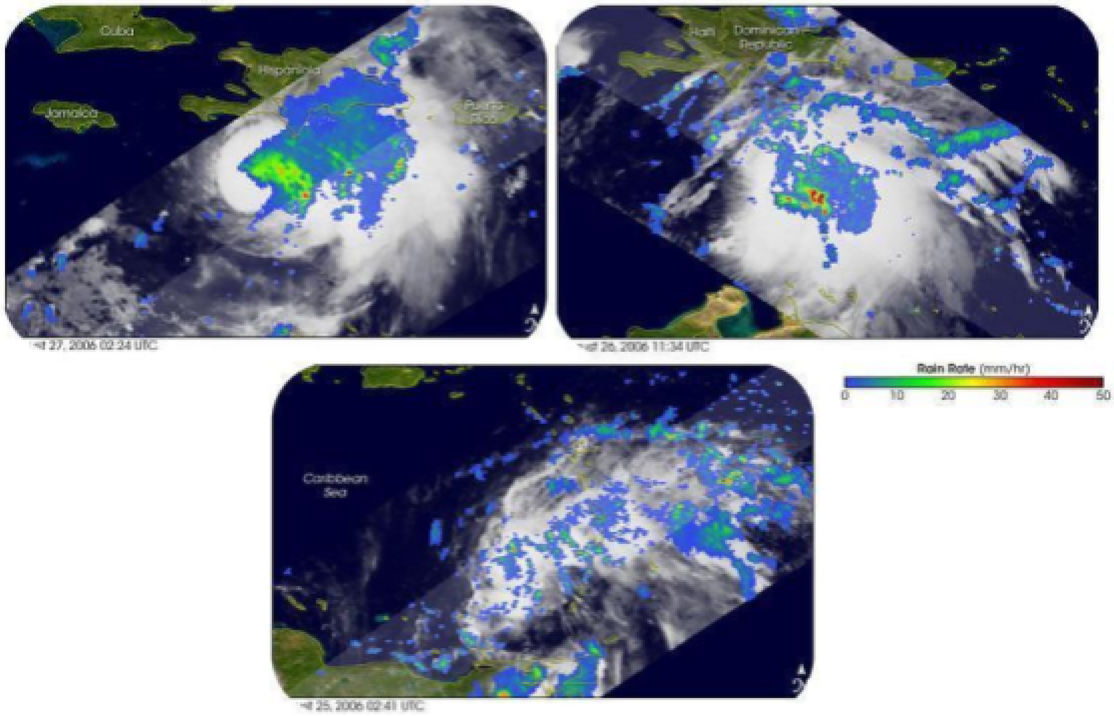


A seismometer is used to measure earthquake activity. These devices help us measure and record the strength of an earthquake while it is happening. They cannot predict an earthquake but by collecting information on earthquakes over time scientists can learn where earthquakes are more likely to happen.

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

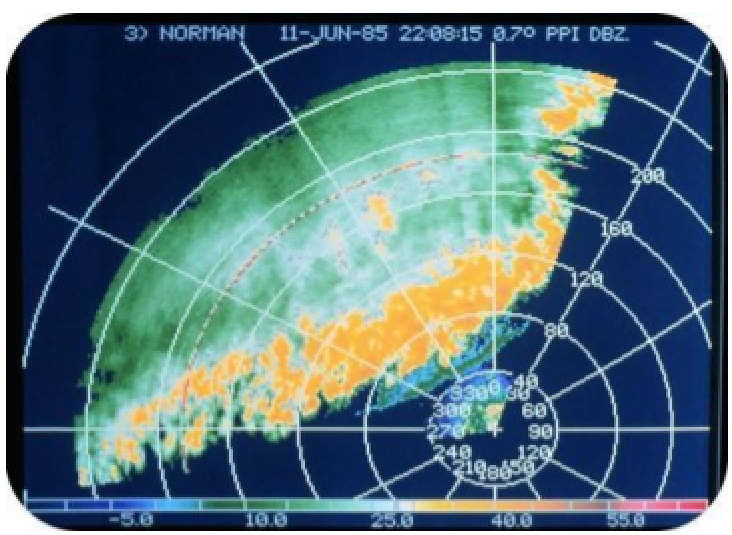
- Skyscrapers and other large structures built on soft ground must be anchored to bedrock, even if it lies hundreds of meters below the ground surface. They are also built to sway with an earthquake wave.
- The correct building materials must be used. Houses should bend and sway. Wood and steel are better 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.



Ck12.org, CC BY-SA

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.



Ck12.org, CC BY-SA

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

Public Domain

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.

Looking at the Data

The way that scientists can make predictions and make decisions on how to protect communities is by looking at the data. Protections against natural hazards are expensive. The tsunami warning system around the globe has cost billions of dollars but it has also saved money and lives. Evacuations are expensive and if they are unnecessary it is good to know. Hawaii received a warning of a needed evacuation for a tsunami coming from the indian ocean where an earthquake occurred, however their own warning system indicated that it was not necessary. They estimated that the unnecessary evacuation would have cost them over 200 million dollars.

Using data to figure out the right locations for the right warning systems is very important and allows communities to focus on the natural hazards that are likely to have the most effect.

Analyzing Data

Use the data and information that has been provided in the above chapter to answer the questions about the following natural hazards.

Analyzing Data on Sinkholes

Image by Eric Heather Haddox; https://flic.kr/p/CujdU; CC BY

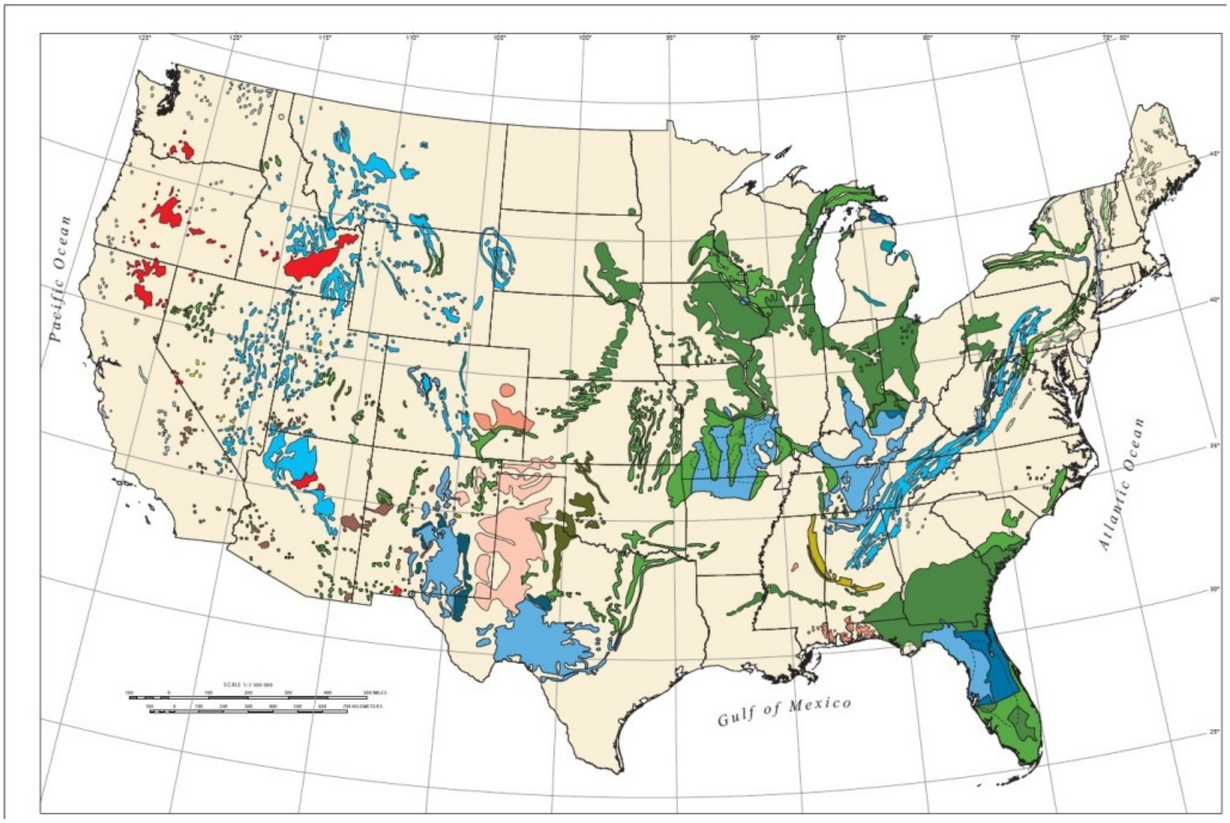


Image by NSGS; https://pubs.usgs.gov/of/2004/1352/data/USA_karst.pdf; public domain

The above map shows locations where sinkholes have occurred in The United States. Blues indicate larger sinkholes, greens indicate medium size sinkholes and pinks reds and yellows indicate smaller sinkholes.

Questions

Circle two states on the map above that should be the most concerned about sinkholes.		
Can we specifically predict when a sinkhole is going to occur?	Can you predict specifically or generally where they will occur?	Is there anything that can be done to protect property and human life?

What level of risk would you say Utah has of this natural hazard? High, Medium, or low risk?

Analyzing Data on Tornadoes

Public Domain

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

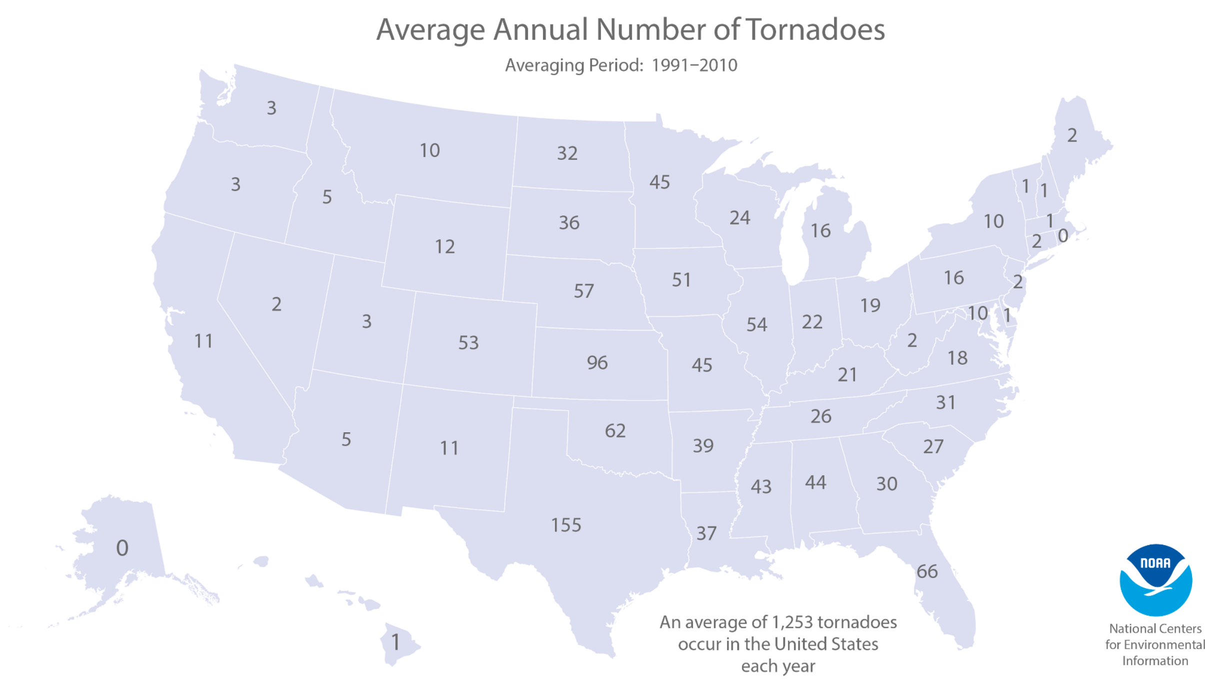


Image by NOAA; https://drupal-www.climate.woc.noaa.gov/maps-data/dataset/average-annual-and-monthly-numbers-tornadoes-state-maps; public domain

The map above indicates the average yearly number of tornadoes in each state in the United States.

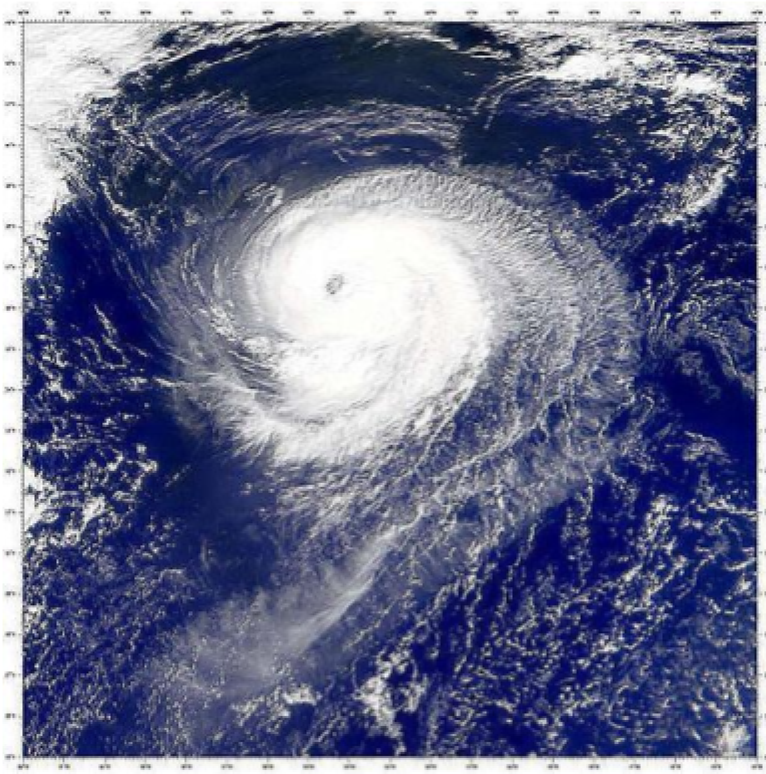
Questions

Circle two states on the map above that should be the most concerned about tornadoes.		
Can we specifically predict when a tornado is going to occur?	Can you predict specifically or generally where they will occur?	Is there anything that can be done to protect property and human life?

What level of risk would you say Utah has of this natural hazard? High, Medium, or low risk?

Analyzing Data on Hurricanes

Image by 12019; pixabay.com; CC0



Public Domain

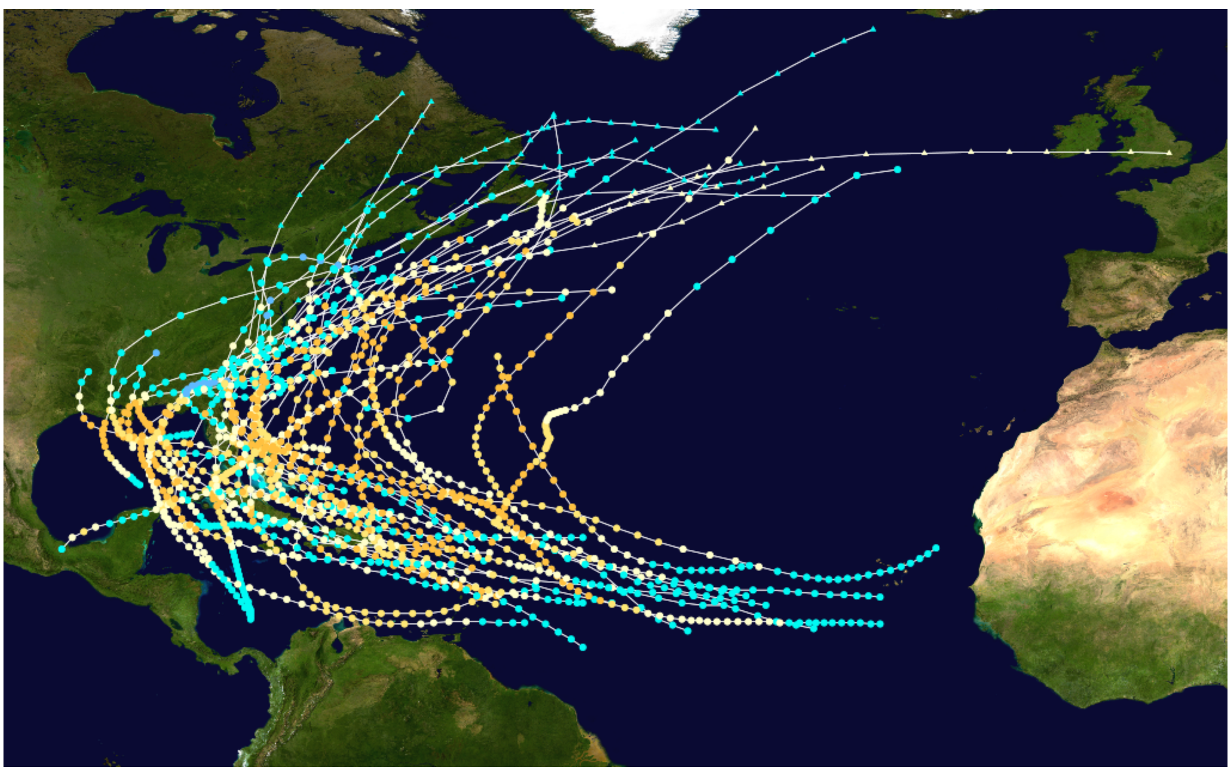


Image from https://commons.wikimedia.org/wiki/File:Category_3_Atlantic_hurricane_tracks.png; public domain

The map above indicates the pathways that category 3 hurricanes took over a period of years.

Questions

Describe what area of the United States needs to be most concerned about hurricanes?		
Can we specifically predict when a hurricane is going to occur?	Can you predict specifically or generally where they will occur?	Is there anything that can be done to protect property and human life?

What level of risk would you say Utah has of this natural hazard? High, Medium, or low risk?

Analyzing data about Earthquakes

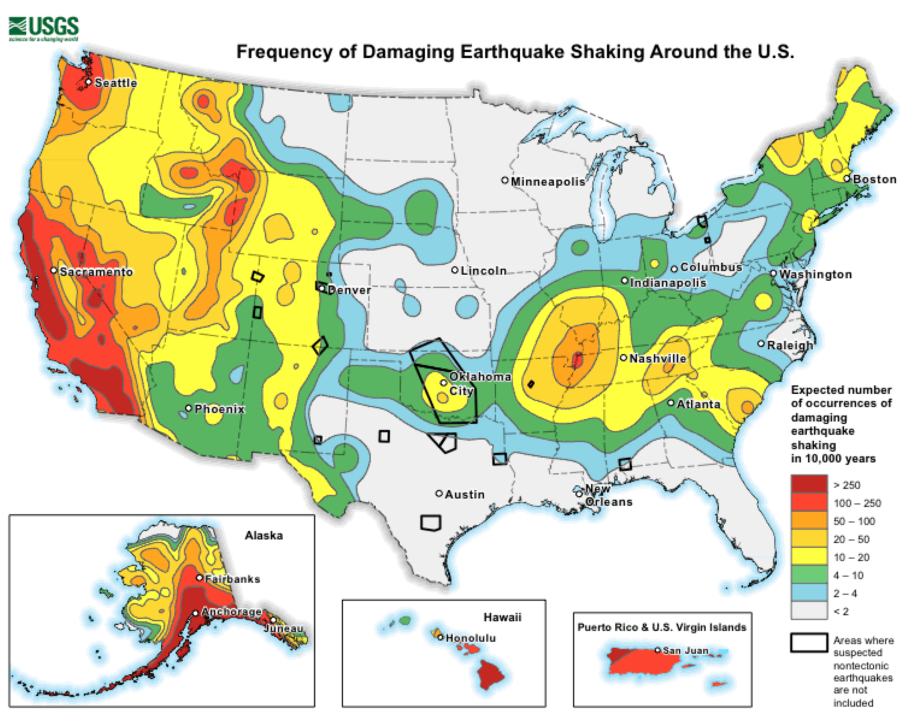


Image from NSGS; https://www.usgs.gov/media/images/frequency-damaging-earthquake-shaking-around-us; public domain

The map previously shows the frequency of damaging earthquakes in the United States.

Questions

Circle the two states that are most at risk for being hit by a large earthquake		
Can we specifically predict when an earthquake is going to occur?	Can you predict specifically or generally where they will occur?	Is there anything that can be done to protect property and human life?

What level of risk would you say Utah has of this natural hazard? High, Medium, or low risk?

Putting It Together

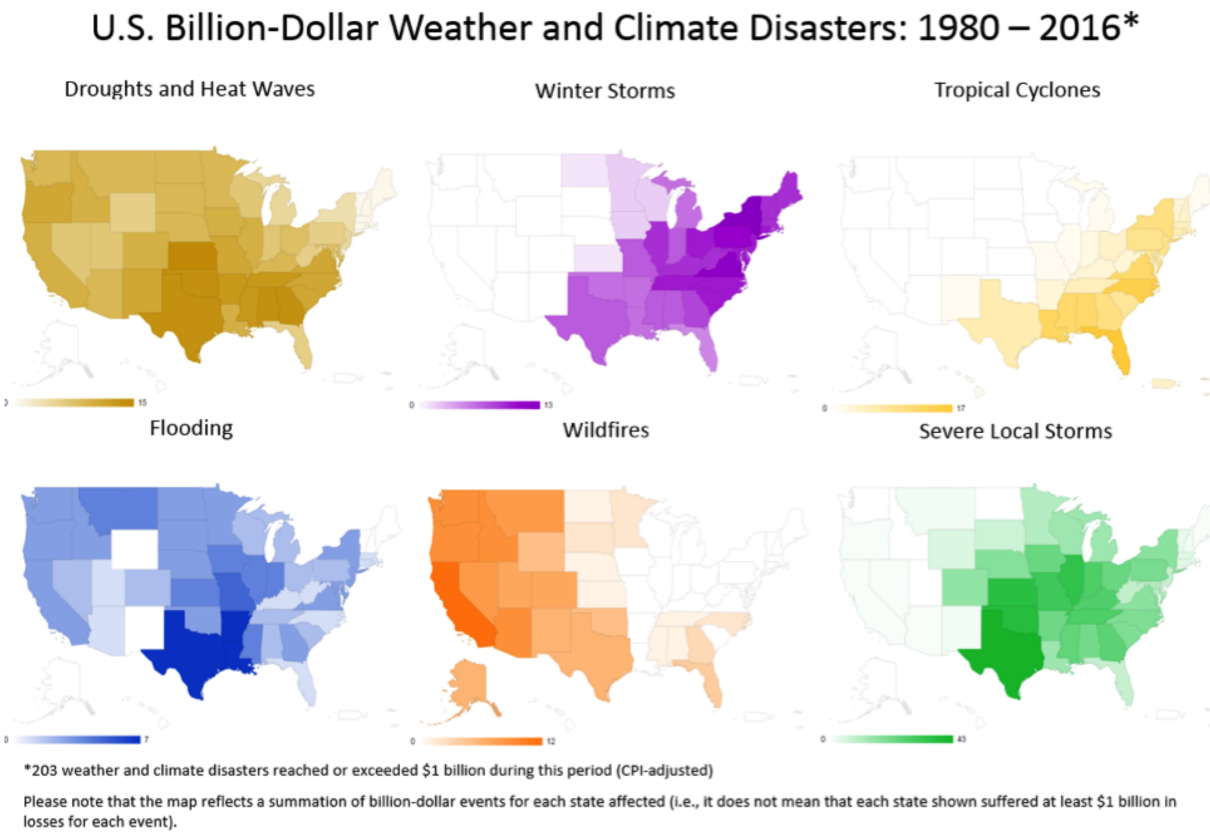


Image from NGSG; public domain

Focus Questions

1. Using what you know about natural hazards, analyze the data in the maps above. How could these states use this information moving forward?

2. Are the natural hazards represented in this data set predictable or unpredictable hazards?

3. If you wanted to reduce the amount of money spent in the U.S. on weather and climate related disasters, what would you suggest the U.S. government focus their efforts on?

Final Task

Looking at the data set of maps, identify the hazards that affect Utah, make a claim as to which hazard should be of most concern to Utah.

- Use the evidence from the maps to support your claim.
- Give a suggestion of something that would possibly help Utah mitigate (lessen) the damage caused by this hazard.