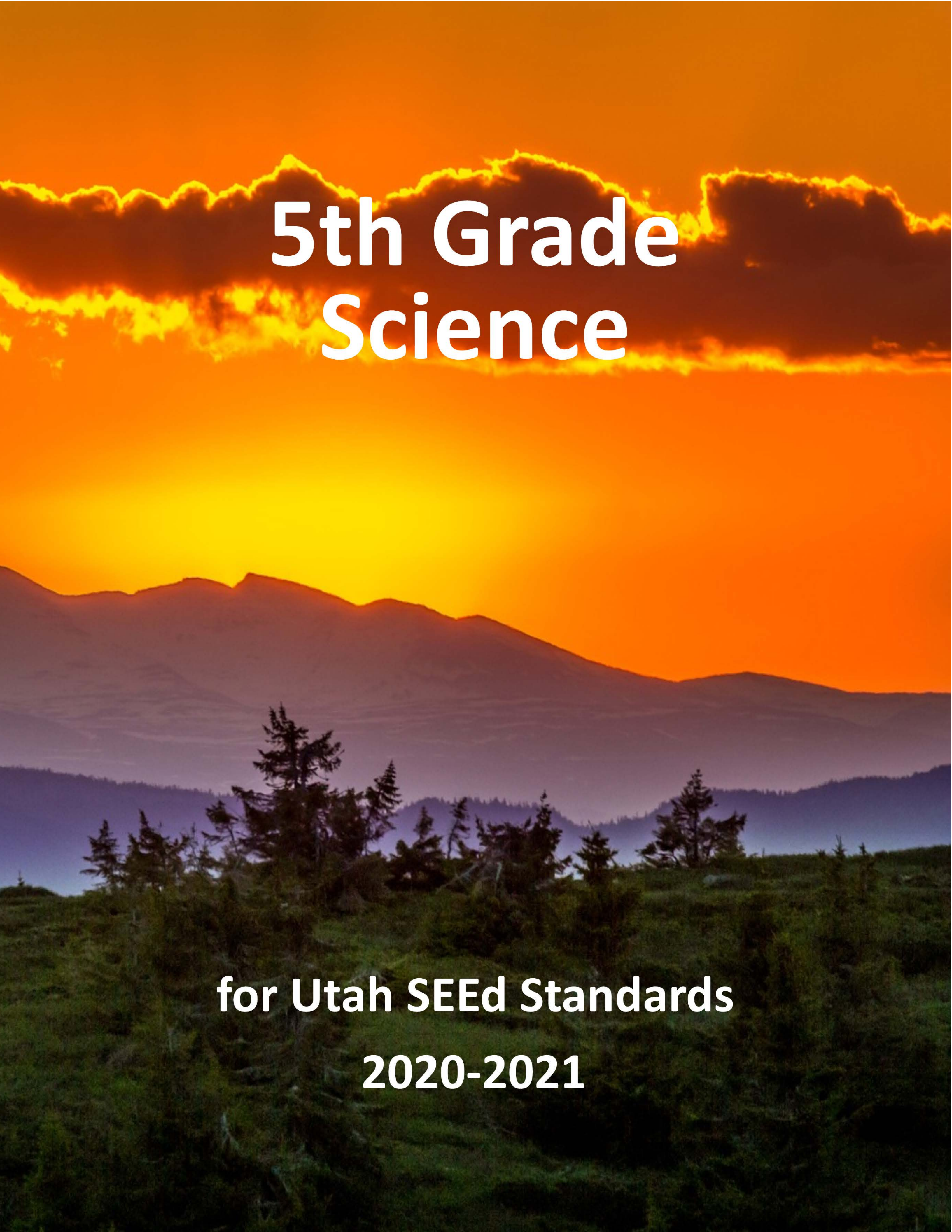

5th Grade Science

for Utah SEEd Standards

2020-2021

5th Grade

for Utah SEEd Standards

Utah State Board of Education OER
2020-2021

AUTHOR

USBE OER

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Students as Scientists

What does science look and feel like?

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

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

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

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

Scientists — and this includes all of us who do, use, apply, or think about science — don't fit a certain stereotype. What really sets us apart as humans is not just that we know and do things, but that we wonder and make sense of our world. We do this in many ways, through painting, religion, music, culture, poetry, and, most especially, science. Science isn't just a method or a collection of things we know. It's a uniquely human practice of wondering about and creating explanations for the natural world around us. This ranges from the most fundamental building blocks of all matter to the widest expanse of space that contains it all. If you've ever wondered "When did time start?", or "What is the smallest thing?", or even just "What is color?", or so many other endless questions then you're already thinking with a scientific mind. Of course you are; you're human, after all.

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

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

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

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

Adam Johnston
Weber State University

Science and Engineering Practices

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

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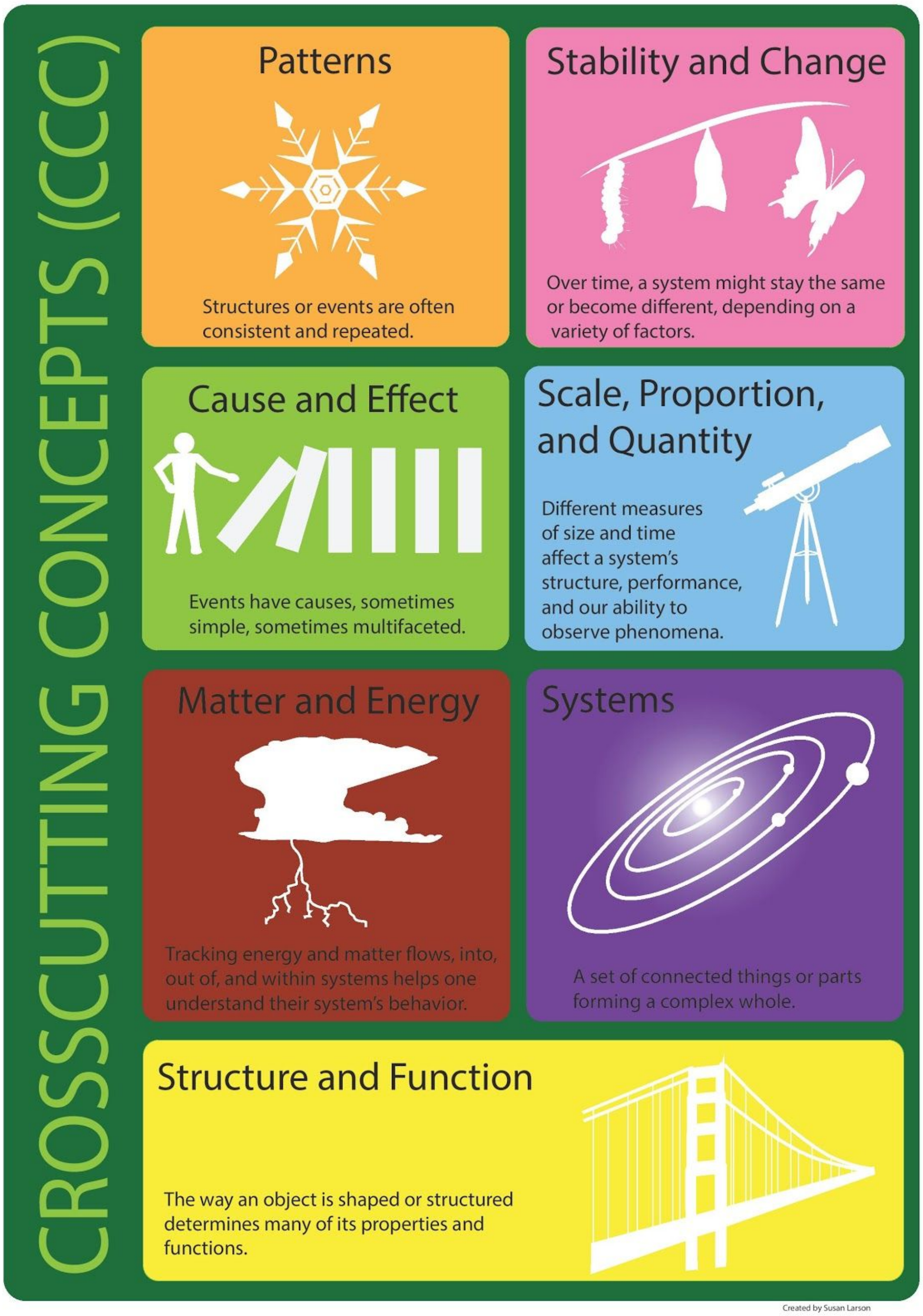
Cross Cutting Concepts

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



A Note to Teachers

This Open Educational Resource (OER) textbook has been written specifically for students as a reputable source for them to obtain information aligned to the 5th Grade Science Standards. The hope is that as teachers use this resource with their students, they keep a record of their suggestions on how to improve the book. Every year, the book will be revised using teacher feedback and with new objectives to improve the book.

If there is feedback you would like to provide to support future writing teams please use the following online survey: http://go.uen.org/bFi

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Strand 1: Characteristics and Interactions of Earth's Systems

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Image by Julius Silver, pixabay.com, CC0

Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). Within these systems, the location of Earth's land and water can be described. Also, these systems interact in multiple ways. Weathering and erosion are examples of interactions between Earth's systems. Some interactions cause landslides, earthquakes, and volcanic eruptions that impact humans and other organisms. Humans cannot eliminate natural hazards; solutions can be designed to reduce their impact.

1.1 Patterns in Earth’s Features (5.1.1)

Explore this Phenomenon

Tectonic plates and ring of fire by Astroskiandhike, https://commons.wikimedia.org/wiki/File:Tectonic_plates_and_ring_of_fire.png, CC-BY-SA

In the Pacific Ocean, you find the Ring of Fire. The Hawaiian Islands can be found in the Pacific Ocean. Recently, in Hawaii, there have been many new volcanic events. What patterns do you see that would explain the activity?

5.1.1 Patterns in Earth's Features

Analyze and interpret data to describe <u>patterns</u> of Earth's features. Emphasize most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans while major mountain chains may be found inside continents or near their edges. Examples of data could include maps showing locations of mountains on continents and the ocean floor or the locations of volcanoes and earthquakes. (ESS2.B)

In this chapter, you will be looking at different patterns we see on the Earth. Use these patterns to explain the data that you are collecting to explain the science phenomenon.

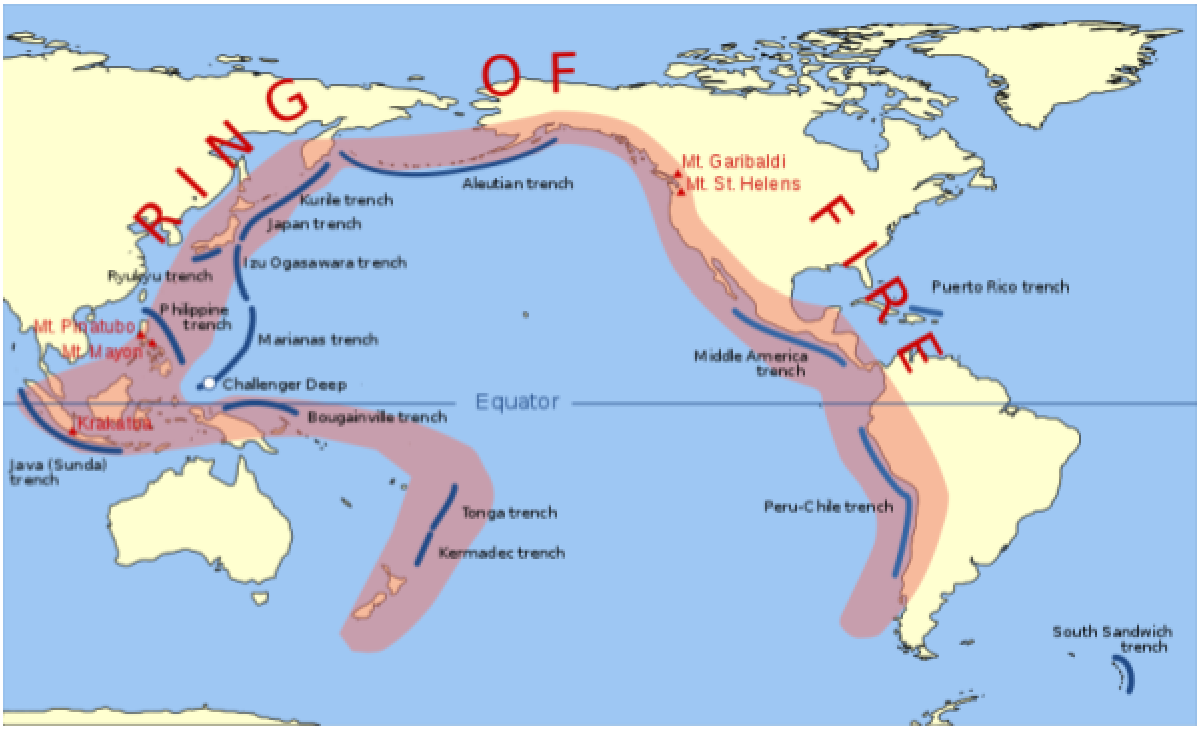
Volcanoes, Earthquakes, and Ocean Floor

Volcanoes

Volcanoes are openings in the Earth's crust that allow hot, melted rock (magma), ash, and gases to erupt outward. Volcanoes change the Earth's surface in a short period of time. More than half of Earth's surface is made up of volcanic rock. Volcanoes are evidence that we live on an active, changing planet. Do you know how a volcano forms? Most form along cracks in the earth's crust and reach far below the surface where temperatures are hot enough to melt rock. You would want to watch a volcanic eruption from a great distance, since many are violent and spit out huge quantities of lava, gas, rocks, and ash. Other eruptions pour out rivers of lava but cause little damage. Volcanoes can erupt underwater, forming huge ranges of volcanic mountains on the ocean floor. Although volcanoes can injure people and damage property, they are useful because their eruptions enrich the soil.

Pacific Ring of Fire

Most earthquakes and volcanic eruptions take place in the red band around the Pacific Ocean. Plate tectonics' processes can explain why. The Pacific Ocean basin is shrinking as the Atlantic Ocean basin grows.



Pacific Ring of Fire by Gringer, https://en.wikipedia.org/wiki/File:Pacific_Ring_of_Fire.svg, public domain

Why It Matters

- 81% of major earthquakes and 90% of total earthquakes take place around the Pacific Ring of fire.
- There were 17 earthquakes M 6.0 and greater in the month preceding November 4, 2013: 16 around the Pacific basin (94%) and 1 in the Mediterranean (6%).
- Lining the Pacific basin are 75% of the active volcanoes, 450 volcanoes in all.
- The Cascade Volcanoes make up part of the Pacific Ring of Fire. They span a distance of over 700 miles and include major cities along the western coast of North America. Two of these volcanoes erupted in the 20th century. Mount Lassen experienced a series of eruptions from 1915-1917 and Mount St. Helens's explosion in 1980 killed 57 people.

Cascade Volcanic Arc by NASA, public domain

Show What You Know

With the links below, learn more about the Pacific Ring of Fire. Then answer the following questions.

-Earthquake list: past 30 days

http://www.volcanodiscovery.com/earthquakes/major.html

-Interactive map of the world or local earthquake in real-time data:

https://earthquake.usgs.gov/earthquakes/map/

Look for a pattern where earthquakes are occurring in relation to one another.

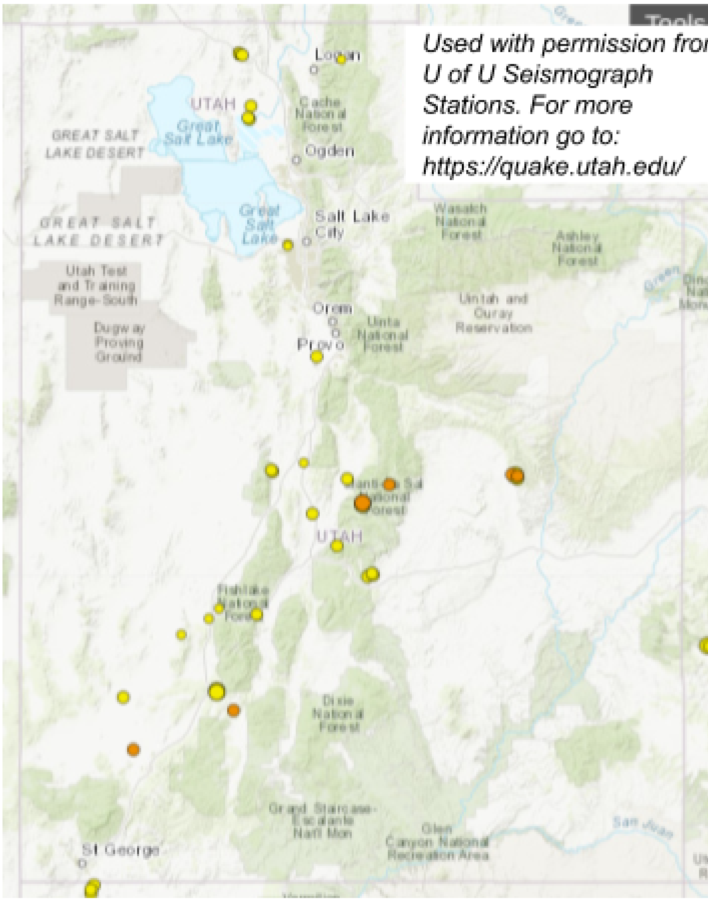
-CBS News, Earthquakes on the Pacific Ring of Fire:
http://www.youtube.com/watch?v=jpqUu0PLkmM

Use the earthquake list to determine the number of earthquakes M6.0 or greater in the past 30 days at the time you read this. What is the percentage that takes place around the Pacific? Is it close to 81%? How might that number get closer to 81%?

Earthquakes

Earthquakes are waves of energy that pass through Earth caused by a sudden shift of tectonic plates along fault lines. Earthquakes can cause sudden changes that alter the Earth's landscape dramatically. You know you are in an earthquake if the ground starts to shake. Tremendous forces under Earth's surface build up pressure, which is released in waves along a fault. Portions of Earth's crust moves creating waves. Some of the waves are surface waves. Other waves, called body waves, travel through the Earth's interior. In an earthquake, body waves are responsible for the sharp jolts. Surface waves are responsible for the rolling motions that cause most of the damage.

Earthquakes can create landforms on the Earth's surface. Mountains can form during an earthquake as the valley rocks slide down and the mountain rocks move up. During an earthquake, a fault may slip deep underground and leave no evidence on the surface that an earthquake has occurred. Earthquakes in the ocean may cause a tsunami, a large ocean wave.



Used with permission from U of U Seismograph Stations. For more information go to: https://quake.utah.edu/

Scientists use technology to measure and record the strength and locations of earthquakes. They measure earthquakes in various ways, including from 1-10 on the Richter scale. An earthquake measuring a 6 or higher is a very significant earthquake that can make changes to the features of the Earth's surface.

Earthquake Zones

- More than 900,000 earthquakes are recorded each year, but only a portion of them is felt. Major earthquakes are very rare.
- Most earthquakes take place along plate boundaries.
- The Pacific Ocean and its plate boundaries are responsible for 80% of the earthquakes, and the Mediterranean-Asiatic Belt region is responsible for 15% of the earthquakes. The other 5% is scattered.

Study Tip

The intensity and characteristic of a certain earthquake can be attributed to its location near a fault.

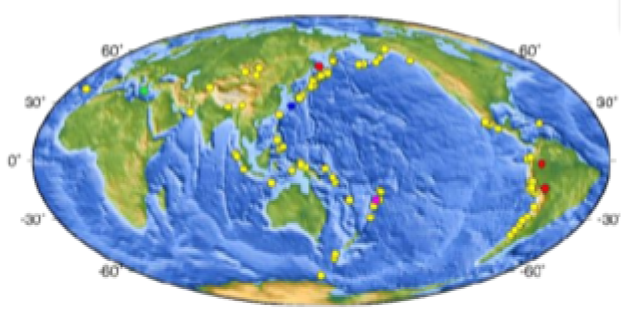


Image from earthquake.usgs.gov, public domain

Uplift

Image of the Grand Canyon
Image by Skeeze, pixabay.com, CC0

Uplift is the upward movement of Earth's crust. It occurs when part of Earth's surface rises above the surrounding land by great forces of heat and pressure deep within the Earth. Uplift formed the Colorado Plateau, creating nearly all the spectacular variety of Canyon County in Southern Utah. Imagine you are in a raft floating down the Colorado River through the Grand Canyon. One of the first things you will notice is the steep canyon walls on both sides of the river. You may ask, why are the walls so steep? Why do you see different layers of rock exposed?

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

Grand Staircase -picture of uplift
sm0676holeinrckrd by penny meyer, https://flic.kr/p/gNkef7, CC-BY-NC

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

Watch a short video about mountain building: http://go.uen.org/b0h

Ocean Floor

In the oceans, plates move apart at mid-ocean ridges creating openings for lava to rise upward, erupt, and cool. As more lava erupts and pushes the original seafloor outward, the seafloor spreads and forms new oceanic crust. The rising magma causes the ridge to be buoyant. This is why there is a mountain range running through the oceans. The plates pulling apart cause earthquakes.

Most mid-ocean ridges are located deep below the sea. The island of Iceland sits right on the Mid-Atlantic ridge.

The rift valley in Iceland is part of the Mid-Atlantic Ridge.

Mid Atlantic Ridge by Mangwanani, public domain

Plates can also move away from each other within a continent. This is called continental rifting. Magma rises beneath the continent. When this happens, the crust thins, breaks, and then splits apart. This is how the Atlantic Ocean formed when Pangaea broke up.

Putting It Together

Tectonic plates and ring of fire by Astroskiandhike,

In the Pacific Ocean, you find the Ring of Fire. The Hawaiian Islands can be found in the Pacific Ocean. Recently, in Hawaii, there have been many new volcanic events. What patterns do you see that would explain the activity? Use the data and the information you have gathered as you read to explain what is happening.

1.2 Earth's Water (5.1.2)

Explore this Phenomenon

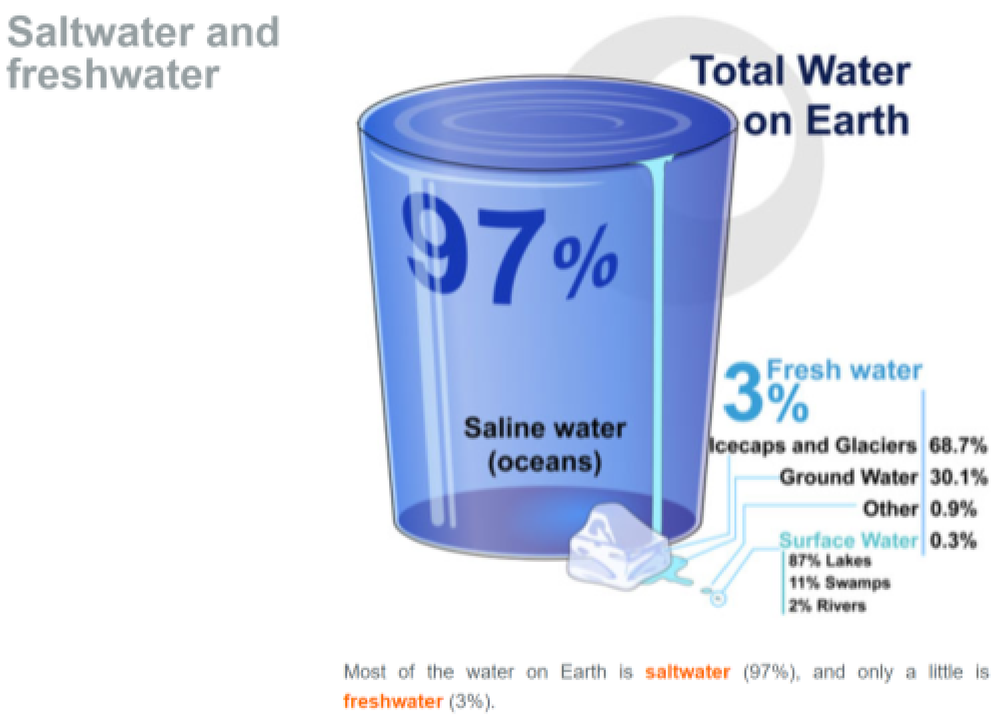


Image by Mariana Ruiz Villarreal (LadyofHats) for the CK-12 Foundation, CC BY-NC 3.0

The image above shows how water is distributed on the Earth. What things do you notice about the data above? What do you find surprising about this data?

5.1.2 Earth's Water

Use mathematics and computational thinking to compare the quantity of saltwater and freshwater in various reservoirs to provide evidence for the distribution of water on Earth. Emphasize reservoirs such as oceans, lakes, rivers, glaciers, groundwater, and polar ice caps. Examples of using mathematics and computational thinking could include measuring, estimating, graphing, or finding percentages of quantities. (ESS2.C)

In this section, focus on comparing the quantity of saltwater with freshwater found on the Earth. This can be done by using tables, graphs, comparing data, and sharing the data.

This section is adapted from information at: https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_object

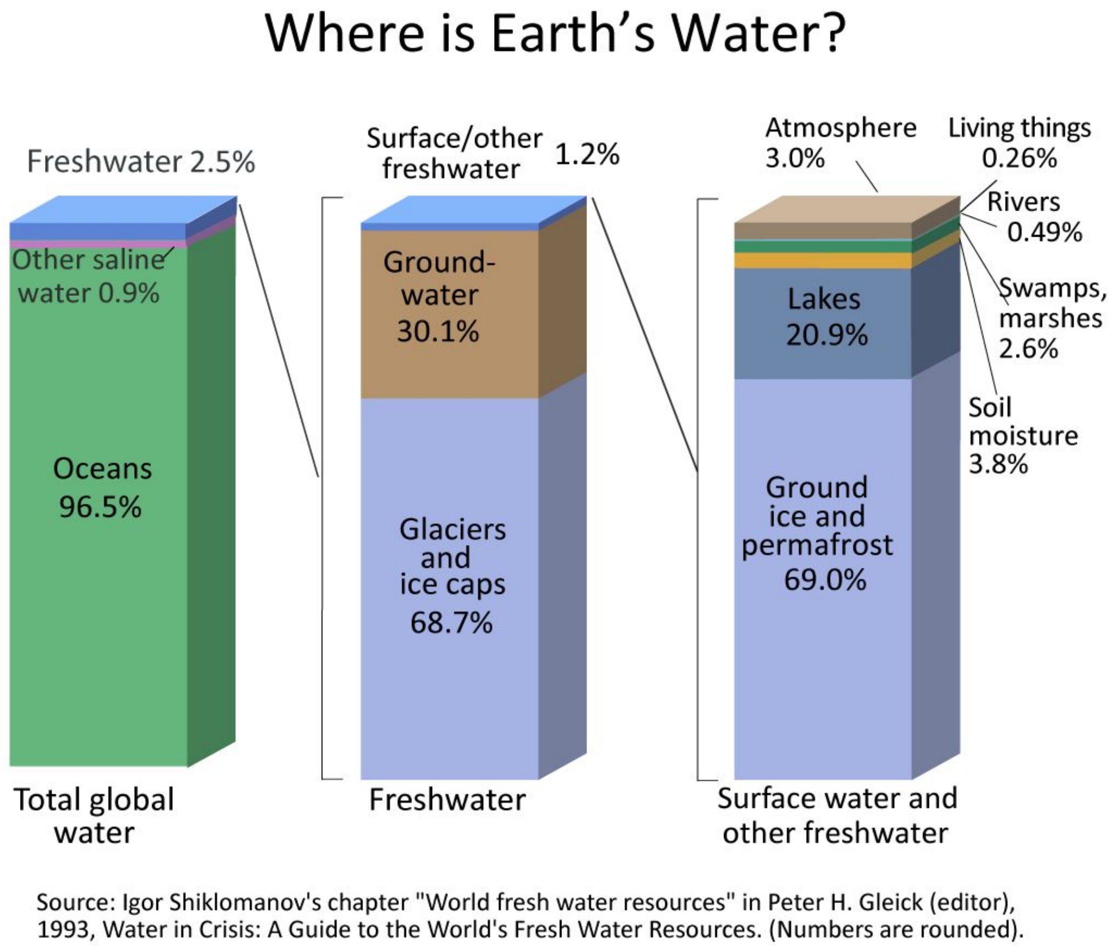
Where is Earth's Water?

"*Water, Water, Everywhere....*"

You've heard the phrase, and for water, it really is true. Earth's water is (almost) everywhere: above the Earth in the air and clouds, on the surface of the Earth in rivers, oceans, ice, plants, in living organisms, and inside the Earth in the top few miles off the ground.

For an estimated explanation of where Earth's water exists, look at this bar chart. You may know that the water cycle describes the movement of Earth's water, so realize that the chart and table below represent the presence of Earth's water at a single point in time. If you check back in a million years, no doubt these numbers will be different!

Here is a chart showing where water on, in, and above the Earth exists. The left column shows almost all of Earth's water is salty and is found in the oceans. Of the small amount that is freshwater, only a tiny portion is available to sustain human, plant, and animal life.



Notice how of the world's total water supply of about 332.5 million cubic miles of water, over 96 percent is salty. Of the total freshwater, over 68 percent is locked up in ice and glaciers, while another 30 percent of freshwater is in the ground. Fresh surface-water sources, such as rivers and lakes, only contain about 22,300 cubic miles (93,100 cubic kilometers), which is about 1/150th of one percent of total water. Rivers and lakes are the sources of most of the water people use every day. (Credit: USGS, Public domain

In the first column, notice that 2.5% of Earth's water is freshwater - the amount needed for life to survive.

- The middle column shows the breakdown of freshwater. Almost all of it is locked up in ice and in the ground. Only a little more than 1.2% of all freshwater is surface water, which provides most of life's needs.
- The right column shows the breakdown of surface freshwater. Most of the surface freshwater is locked up in ice, and another 20.9% is found in lakes. Rivers make up 0.49% of surface freshwater. Although rivers account for only a small amount of freshwater, rivers are the source of most usable water.

Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	% of freshwater	% of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps & Glaciers	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	2,526,000	10,530,000	30.1	0 .76
Salty	3,088,000	12,870,000	--	0.93
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Salty	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

One estimate of global water distribution

(Percentages are rounded, so will not add to 100)

Source: Igor Shiklomanov's chapter "World freshwater resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

How much water is there on, in, and above the Earth?

All Earth's water, liquid freshwater, and water in lakes and rivers. The Earth is a watery place. But just how much water exists on, in, and above our planet? About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. Water also exists in the air as water vapor, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers, and even in you and your dog.

Water is never stationary. Thanks to the water cycle, our planet's water supply is constantly moving from one place to another and from one state to another. Things would get stagnant without the water cycle!

The vast majority of water on the Earth's surface, over 96 percent is saltwater in oceans. Freshwater resources, such as precipitation, move into streams, rivers, lakes, and groundwater, and provide people with the water they need every day to live. Water sitting on the surface of the Earth is easy to visualize, and your view of the water cycle might be that rainfall fills up the rivers and lakes, but the unseen water below our feet is critically important to life. How do you account for the flow in rivers after weeks without rain? The answer is that there is more to our water supply than just surface water. There is also plenty of water beneath our feet.

Image by skeeze, pixabay.com, CC0

Lake Powell

Even though you may only notice water on the Earth's surface, more freshwater is stored in the ground than there is in liquid form on the surface. In fact, some of the water you see flowing in rivers comes from the seepage of groundwater into river beds. Water from precipitation continually seeps into the ground to fill aquifers, while at the same time water in the ground continually fills rivers through seepage.

Humans make use of both kinds of water. In the United States in 2010, we used about 275 billion gallons (1,041 billion liters) of surface water per day and about 79.3 billion gallons (300.2 billion liters) of groundwater per day. Although surface water is used more often to supply drinking water and to irrigate crops, groundwater is vital because it fills rivers and lakes and provides water for people in places where visible water is scarce, such as in desert towns of the western United States. Without groundwater, people would be sand-surfing in Palm Springs, California, instead of playing golf.

Putting It Together

Saltwater and freshwater

Most of the water on Earth is **saltwater** (97%), and only a little is **freshwater** (3%).

Revise your first claim to what you notice about water that is found on Earth. What type of data can you use to explain the phenomenon?

1.3 Weathering and Erosion (5.1.3)

Explore this Phenomenon

Image adapted from fence-post-great-salt-lake.jpg by r. nial bradshaw, https://flic.kr/p/9jfVr7, CC-BY

Along the Great Salt Lake fence posts look shattered at the tops. What can you infer that is happening to the posts? What type of questions do you have? What steps can you take to find out the reason for this?

5.1.3 Weathering and Erosion

Ask questions to plan and carry out investigations that provide evidence for the effects of weathering and the rate of erosion on the geosphere. Emphasize weathering and erosion by water, ice, wind, gravity, or vegetation. Examples could include observing the effects of cycles of freezing and thawing of water on rock or changing the slope in the downhill movement of water. (ESS2.A, ESS2.E)

In this section, the cause and effect of weathering and erosion will be explored and how weathering and erosion change the geosphere.

Weathering and Erosion

What is Weathering?

Weathering—the breaking down of earth's materials into smaller pieces—is a process that takes a very long time. Weathering breaks large boulders into rocks, rocks into pebbles, and pebbles into soil or sand. These pieces of rock are called sediments. Boulders are sediments and so is gravel. Silt and clay are also sediments, but much smaller in size compared to boulders or gravel. Weathering causes rocks on the Earth's surface to change form.

You cannot watch for millions of years as mountains are built, or as those same mountains gradually wear away, but you can see evidence a change has occurred.

Powerful forces of weathering include wind, water, temperature, living organisms, and chemicals.

- Wind: Particles carried by wind smooth and polish rocks.

Image from pixabay.com, CC0

● Water: Water can include precipitation, rivers, and oceans.

Image by Sven Lachmann (seaq68), pixabay.com, CC0

● Temperature: Changes in temperature through a freeze-thaw cycle will affect matter.

Thawing the Minnehaha Falls by MJI Photos, https://flic.kr/p/9qXMdc, CC-BY-NC-NC

● Living Organisms: Animals, as well as plants, may cause weathering.

Image by Massimiliano Pappalardo, pixabay.com, CC0

Animations of different types of weathering processes can be found here: http://go.uen.org/b4N

Physical Weathering
Physical weathering breaks rocks into smaller pieces. Rocks change physically without changing their composition. Smaller pieces of rock have the exact same minerals as the original rock. The main agents of physical weathering are water movement, freezing, plant growth, and wind.

- **Water Movement**

As precipitation strikes against the rock, some minerals break down easier than others. This causes rocks to break into smaller pieces. This breakdown of sediments can also be caused by other water sources such as streams, lakes, and rivers.

- **Freezing**

Weathering by freezing (sometimes referred to as ice wedging) is common where the temperature goes above and below freezing. Weathering by freezing happens when water seeps into cracks in rocks and then freezes. As the water freezes: turns from a liquid to a solid, it expands pushing the rock apart. This creates a larger crack, allowing more water to gather creating an even larger crack. This is how ice wedging works. When liquid water changes into solid ice, it increases in volume. You can see this when you fill an ice cube tray with water and put it in the freezer. The ice cubes expand to a higher level in the tray than what the water level originally was. You can find large piles of broken rock at the base of a slope. These rocks were broken up by freezing water.

- **Plants and Animals in Weathering**

Sometimes biological elements cause mechanical weathering. This can happen slowly. A plant's roots may grow into a crack in a rock. As the roots grow larger, they wedge open the crack.

Burrowing animals can also cause weathering. By digging for food or creating a hole to live in, the animal may break apart rock.

Today, human beings do a lot of mechanical weathering wherever we dig or blast into the rock. This is common when we build homes, roads, tunnels, or quarry stone for construction or other uses.

- **Wind**

Strong winds also cause weathering by blowing sand against rock surfaces.

Finally, the ice in moving glaciers can cause weathering. Pieces of rock embedded in the ice at the bottom of a glacier scrape against the rock below as the glacier slowly moves downhill.

Chemical Weathering

Water

Water (H_2O) is an amazing molecule. Other minerals change by adding water to their structure. Water reacts with the minerals in the rocks to create new substances.

Carbon Dioxide

Carbon dioxide (CO_2) combines with water when it rains. This creates a weak acid, called carbonic acid. This happens so often that carbonic acid is commonly found in nature. Carbonic acid slowly dissolves rock. It eats away at sculptures and monuments.

While this is normal, more acids are created when we add pollutants to the air. Any time we burn fossil fuels, it adds nitrous oxide into the air. When we burn coal rich in sulfur, it adds sulfur dioxide into the air. As nitrous oxide and sulfur dioxide react with water, they form nitric acid and sulfuric acid. These are the two main components of acid rain. Acid rain speeds up chemical weathering.

Oxygen

Oxygen (O_2) reacts with elements at the earth's surface in a process called oxidation. You are probably familiar with the rust that forms when iron reacts with oxygen. Many minerals are rich in iron. Red rocks are full of iron oxides. As iron changes into iron oxide, iron oxides make the red color in soil commonly found in Southern Utah.

Several years ago the copper dome on the Utah State Capitol building was replaced. When it was first changed, it was a bright copper color. Now it is dull green. Why? The copper color changed through chemical weathering. This is an example of a chemical change.

Image by kukiso, pixabay.com, CC0

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

Physical weathering increases the rate of chemical weathering. As rock breaks into smaller pieces, the surface area of the pieces increases. With more surface exposed, there are more places for chemical weathering to occur.

Erosion
Erosion—the movement of earth materials from one place to another—also contributes to Earth's changing landscape.

Water is the most powerful erosional force on earth. Rain carries soil away as it washes over the land, leaving behind gullies, valleys, and canyons. The paths of some rivers have changed as water erodes the banks.

Rivers and streams have formed many natural wonders including arches curved rock formations), which are formed by a combination of erosional forces. Ice, rain, and wind continue to weather the arches found in Utah's Arches National Park. One well-known arch is Delicate Arch.

Image by Free-Photos, pixabay.com, CC0

Someday, erosion will cause the arches to collapse, but until that time, we can enjoy their spectacular beauty.

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

Canyon Lands by Sathish J, https://flic.kr/p/oXrbmt, CC-BY-NC-ND

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

Image by Piero Di Maria (pdimaria), pixabay.com, CC0

Wind erosion moves soil in the air from place to place on Earth's surface. This is especially true in arid climates like Utah's climate. When there is soil in the air, gravity pulls the soil out of the air and deposits it somewhere else. When the wind blows away smaller, finer particles, this leaves behind a desert “pavement” with rocky, pebbled surfaces. Particles moved by the wind hit other landforms, weathering their surfaces by abrasion.

Glaciers—slow-moving, large masses of snow, ice, rocks, and dirt--form in cold regions on Earth. Here snowfall does not melt and oftentimes causes erosion. The weight of the snow builds up over time and is compacted by its own weight. After thousands of years, it turns to ice and becomes very heavy.

Image by Adrian Lang, pixabay.com, CC0

Gravity can pull the glacier slowly down a mountain slope. As it inches along, the glacier erodes the surface beneath. Valleys form as boulders and rock carried in the ice scrape the rock beneath the glacier. Glaciers also polish and scratch the land beneath them as they travel across its surface. You can see these features when glaciers melt and you walk across smooth rock surfaces at the bottoms of canyons.

Glaciers erode and deposit landforms that tell us stories about Earth’s history. They show the direction a glacier flowed and how far it traveled. Glaciers create fantastic and unique features in mountain areas. Rivers may form canyons with steep walls, but those canyons have a V-shape, like the lower section of Big Cottonwood Canyon on the east side
of the Salt Lake Valley.

Glacier Simulation https://phet.colorado.edu/en/simulation/glaciers
Phet Interactive Simulation

Putting It Together

Image adapted from fence-post-great-salt-lake.jpg by r. nial bradshaw, https://flic.kr/p/9jfVr7, CC-BY

Along the Great Salt Lake fence posts look shattered at the tops. What can you infer that is happening to the posts? What type of questions do you have? What steps can you take to find out the reason for this?

1.4 Interactions between Systems (5.1.4)

Explore this Phenomenon

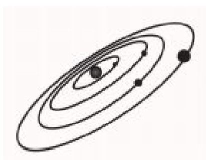
THE LIFECYCLE OF A HOODOO

Image by *Brian Roanhorse/NPS,* https://www.nps.gov/brca/learn/nature/hoodoos.htm

Over millions of years, hoodoos have formed at Bryce Canyon National Park. As forces in the geosphere and hydrosphere interact, how did the landforms change? How were the hoodoos formed?

4.1.5 Interactions between Systems

Develop a model to describe interactions between Earth's systems including the geosphere, biosphere, hydrosphere, and/or atmosphere. Emphasize interactions between only two systems at a time. Examples could include the influence of a rainstorm in a desert, waves on a shoreline, or mountains on clouds. (ESS2.A)



In this section, how Earth systems interact and are causes for change will be discussed.

Does this look familiar?

Gases, water, rock, and living organisms are all found at Earth's surface. These materials are also found above or below the surface. They interact with each other and in doing so alter each other. For example, the hydrosphere may cause some of the lithosphere to wash away.

Earth is made of layers. Since Earth is round, the layers all have the ending "-sphere" (Figure below).

Some of the different parts of the Earth are the:

- Atmosphere: The thin layer of air, mostly nitrogen and oxygen, that surrounds the Earth.
- Hydrosphere: All the water on Earth.
- Lithosphere: The solid rock part of Earth, including mountains, valleys, continents, and all of the rock beneath the oceans.
- Biosphere: The place on Earth where life exists.

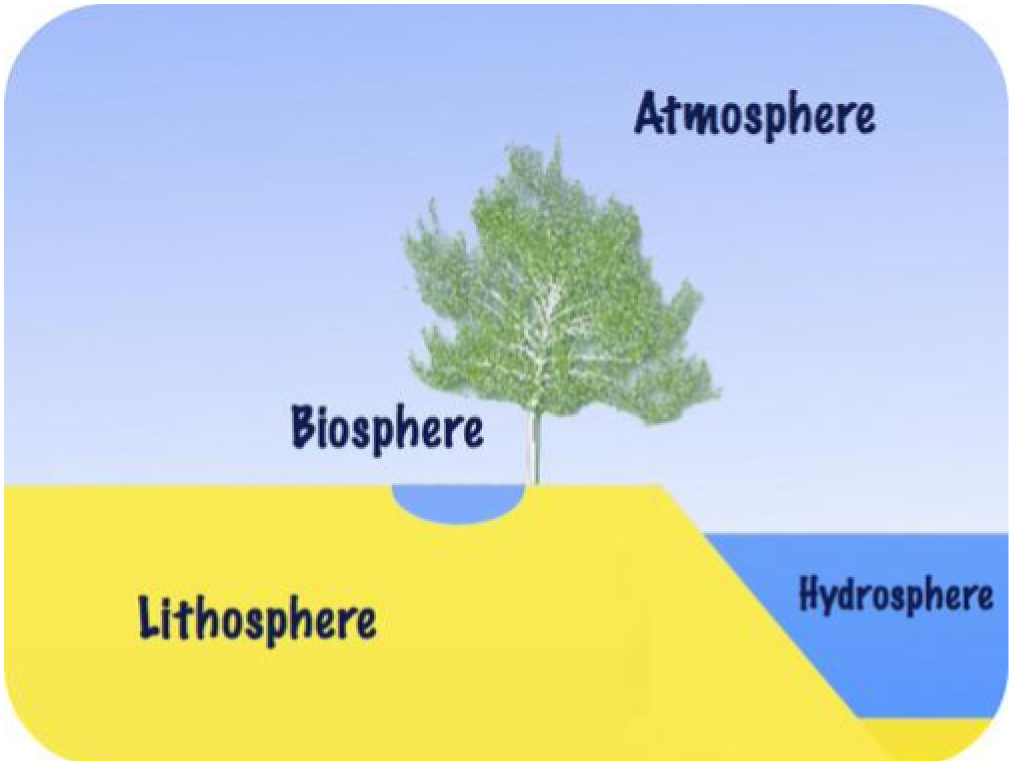


Image by CK-12 Foundation, CC-BY-NC 3.0

Earth has four layers: atmosphere, hydrosphere, biosphere, and lithosphere.

If you live near the mountains, you may have noticed storm clouds settling near the peaks. This was an interaction between which two of Earth's systems?

You may have been in a desert when it rained and noticed tiny rivulets flowing through the sand to the bottom of a hill. This was an interaction between which two of Earth's systems?

Because Earth's layers interact, Earth's surface is constantly changing.

You can see interactions between Earth's systems in Bryce Canyon.

Bryce Canyon by Andy Gippetti, https://flic.kr/p/UJFBZE, CC-BY-NC

- Hoodoos are spires of soft rock capped with an erosion-resistant rock found in arid regions.
- Bryce Canyon National Park is composed of different types of sedimentary rocks.
- Bryce Canyon's rocks formed at sea level in an ancient inland sea that covered most of Utah.
- Uplift moved the rock layers to a higher elevation.
- The elevation in which Bryce Canyon is located receives both above freezing temperatures and below-freezing temperatures over 200 nights out of the year. That is more than half of the days of the year in which Bryce Canyon reaches above/below freezing temperatures on the same night!
- The rocks at Bryce Canyon contain abundant calcium carbonate ($CaCO_3$), a mineral that dissolves when it comes into contact with even slightly acidic water.

Putting It Together

THE LIFECYCLE OF A HOODOO

Image by *Brian Roanhorse/NPS,* https://www.nps.gov/brca/learn/nature/hoodoos.htm

As you have read about different interactions of Earth's systems, describe how the landforms at Bryce Canyon have changed over time and how the hoodoos were created.

1.5 Impact on Humans (5.1.5)

Engineering Design Problem

Image from pixabay.com, CC0

Landslides cause $1 billion to $2 billion in damage in the United States each year. Mass wasting is responsible for the traumatic and sudden loss of life and homes in many areas of the world.

Read the following information identify different naturally occurring problems, why they occur, and their impact on humans.

From the natural problems, select one and tell what causes it to occur.

Consider different ways to solve the problem.

From the possible solutions, select the one that you think will be the most effective, cost the least, and be pleasing to look at.

Draw a picture of your design and explain why this solution is a better choice than the other solutions.

5.1.5 Impact on Humans

Design solutions to reduce the effects of naturally occurring events that impact humans. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data from testing solutions, and propose modifications for optimizing a solution. Emphasize that humans cannot eliminate natural hazards, but they can take steps to reduce their impacts. Examples of events could include landslides, earthquakes, tsunamis, blizzards, or volcanic eruptions. (ESS3.B, ETS1.A, ETS1.B, ETS1.C)

In this section, solutions will be designed to reduce the effects of naturally occurring events that impact humans.

Disasters

Landslides are the most dramatic, sudden, and dangerous examples of Earth materials moved by gravity. Landslides are sudden falls of rock.

Ferguson-slide by Eeekster, https://commons.wikimedia.org/wiki/File:Ferguson-slide.jpg, CC-BY

When large amounts of rock suddenly break loose from a cliff or mountainside, they move quickly and with tremendous force (Figure below). Air trapped under the falling rocks acts as a cushion that keeps the rock from slowing down. Landslides can move as fast as 200 to 300 km/hour.

This landslide in California in 2008 blocked Highway 140.

Landslides are exceptionally destructive. Homes may be destroyed as hillsides collapse. Landslides can even bury entire villages. Landslides may create lakes when the rocky material dams a stream. If a landslide flows into a lake or bay, they can trigger a tsunami.

Landslides often occur on steep slopes in dry or semi-arid climates. The California coastline, with its steep cliffs and years of drought punctuated by seasons of abundant rainfall, is prone to landslides.

Mudflows

A-frame buried in mudflow. Mount St. Helens National Volcanic Monument
by Robert Ashworth, https://flic.kr/p/3ykEne, CC-BY

Added water creates natural hazards produced by gravity (Figure below). On hillsides with soils rich in clay, little rain, and not much vegetation to hold the soil in place, a time of high precipitation will create a mudflow. Mudflows follow river channels, washing out bridges, trees, and homes that are in their path.

Contributing Factors

There are several factors that increase the chance that a landslide will occur. Some of these we can prevent and some we cannot.

Water

A little bit of water helps to hold grains of sand or soil together. For example, you can build a larger sandcastle with slightly wet sand than with dry sand. However, too much water causes the sand to flow quickly away. Rapid snowmelt or rainfall adds extra water to the soil, which increases the weight of the slope and makes sediment grains lose contact with each other, allowing flow.

Rock Type

Layers of weak rock, such as clay, also allow more landslides. Wet clay is very slippery, which provides an easy surface for materials to slide over.

Undercutting

If people dig into the base of a slope to create a road or a homesite, the slope may become unstable and move downhill. This is particularly dangerous when the underlying rock layers slope towards the area.

When construction workers cut into slopes for homes or roads, they must stabilize the slope to help prevent a landslide (Figure below). Tree roots or even grasses can bind the soil together. It is also a good idea to provide drainage so that the slope does not become saturated with water.

Retaining walls in Finland Utsjoki by Timo Saarenketo, https://flic.kr/p/edQe41, CC-BY

A rock wall stabilizes a slope that has been cut away to make a road.

Ground Shaking

An earthquake, volcanic eruption, or even just a truck going by can shake unstable ground loose and cause a slide. Skiers and hikers may disturb the snow they travel over and set off an avalanche.

Fire

As a fire burns through an area it removes the vegetation and leaves a layer of ash and burnt debris which prevents the soil from absorbing water. Rain then can trigger a landslide

Putting It Together

Image from pixabay.com, CC0

After reading about what natural disasters, select one and tell what causes it to occur. Consider different ways to solve the problem.

From the possible solutions, select the one that you think will be the most effective (criteria), cost the least (constraint), impact the most people (constraint), and be pleasing to look at (criteria).

Draw a picture of your design and explain why this solution is a better choice than the other solutions by telling which criteria and constraints you selected and why they are important.

CHAPTER 2

Strand 2: Properties and Changes of Matter

Chapter Outline

Image by Bokskapet, pixabay.com, CC0

All substances are composed of matter. Matter is made of particles that are too small to be seen but still exist and can be detected by other means. Substances have specific properties by which they can be identified. When two or more different substances are combined a new substance with different properties may be formed. Whether a change results in a new substance or not, the total amount of matter is always conserved.

2.1 Too Small to See (5.2.1)

Explore this Phenomenon



Images from pixabay.com, CC0

You make lemonade on a hot summer day by mixing lemon juice, sugar, and water together. When you look in the pitcher you see a liquid, but no particles of sugar and lemon.

1. Are all of the particles still in the pitcher?
2. Is the lemonade a new substance?

5.2.1 Too Small to See

Develop and use a model to describe that matter is made of particles on a scale that is too small to be seen. Emphasize making observations of changes supported by a particle model of matter. Examples could include adding air to expand a balloon, compressing air in a syringe, adding food coloring to water, or dissolving salt in water and evaporating the water. The use of the terms atoms and molecules will be taught in Grades 6 through 8. (PS1.A)

In this section, focus on the scale of particles too small to be seen. Evidence should be collected and/or observed in changes of the particle model of matter.

Matter

Matter is any substance that has mass. Everything you can see and touch is made of matter, including you! Some matter is so small you cannot see it with your eyes, like air and other gases, but you can observe how it interacts with other matter around it.

Image by Ri Butov, pixabay.com, CC0

Mass is the measurement of the amount of matter an object has. Everything that has mass, no matter how small, is considered matter. When you blow air into a balloon, you cannot see the air with your eyes, but you notice the balloon expands as you blow into it. This is evidence that air is matter because particles are filling the balloon and making it larger. When you mix salt and water together, the particles of salt dissolve in the water. When you look at the saltwater, you no longer see the particles of salt because their particles are too small to see. If you evaporate the water, the salt crystals will remain and you will observe them again.

Matter can exist as a solid, liquid, or gas. Matter cannot be created or destroyed, but it can undergo changes that you can observe.

States of Matter

SOLID

A solid is anything that holds its shape. Tables and chairs are solid objects. The floor under the tables and chairs is solid. The glass windows in the background are also solids.

Inn on the Park dining chairs by Katherine Esposito, https://flic.kr/p/amFB2D, CC-BY-NC

Image by anokarina, https://flic.kr/p/UWVEZk, CC-BY-SA

LIQUID

A liquid is anything that can fill the shape of its container. As you can see in this image the water curves with the sides of the glass. Water, milk, and blood are all examples of liquids.

GAS

Gas is matter that takes the volume and shape of a container. Gas is all around us; it is the air we breathe, the steam coming off of a boiling pot, and smoke from a fire. Oxygen is a gas that humans need to breathe and live. Trees use carbon dioxide, another common gas. Gases are necessary for many living things to survive.

Visit the following simulation to explore more about the states of matter: http://go.uen.org/b4C
http://go.uen.org/b4D

Putting It Together

Images from pixabay.com, CC0

How do you know the particles of lemon, sugar, and water are still in the lemonade?

Is the lemonade the same substance as its original ingredients?

2.2 Identifying Substances (5.2.2)

Explore this Phenomenon

Images from pixabay.com, CC0

Look at the two garden shovels pictured here. Both shovels were left outside for several weeks. One tool became rusty. The other tool did not. Why did this happen?

5.2.2 Identifying Substances

Ask questions to plan and carry out investigations to identify substances based on <u>patterns</u> of their properties. Emphasize using properties to identify substances. Examples of properties could include color, hardness, conductivity, solubility, or a response to magnetic forces. Examples of substances could include powders, metals, minerals, or liquids. (PS1.A)

In this section, focus on patterns of properties of matter.

Properties of Matter

When you encounter an unknown substance, you can use its properties to help you identify the substance. Let’s imagine you evaporated water from two different mixtures but don’t remember what mixture was in which dish. The crystals have the same white color, so you cannot use the property of color to differentiate them. You then decide to examine the crystals under a microscope to see if their shapes are the same. They are different! You compare the cube-like shapes of one and the elongated shapes of the other to determine one substance is salt and one is sugar. In this case, the property of shape helped you determine the identity of the substances.

Broken glass by Jef Poskanzer, https://commons.wikimedia.org/wiki/File:Broken_glass.jpg, CC-BY

When a large piece of glass breaks, its appearance changes. Instead of one solid sheet of glass, it has holes and cracks. It is still the same color and hardness, but it has changed in other ways.

Some properties of matter always be the same whether you have a small amount or a large amount of it. Some of those properties are listed next.

Properties	Example
color	Aluminum metal is gray-colored.
taste	Lemon juice tastes sour.
magnetism	Iron is attracted to magnets.
boiling point	The boiling point of water is 100°C.
density	The density of water is 1 g/mL.
solubility	Salt dissolves in water.
hardness	Diamond is the hardest substance known.

Some properties of matter will vary depending on the amount or size of a substance. Some examples of properties that will vary include:

- mass
- weight
- volume
- length

Putting It Together

Images from pixabay.com, CC0

What properties of the shovels are the same? Which properties are different? Use what you know about the properties of matter to explain why one shovel rusted and the other one did not.

2.3 Combining Substances (5.2.3)

Explore this Phenomenon

Image by Paul Barlow, pixabay.com, CC0

After the young man in the picture bent plastic tubes in half, the tubes began to glow. What happened? Use evidence to support your answer.

5.2.3 Combining Substances

Plan and carry out investigations to determine the effect of combining two or more substances. Emphasize whether a new substance is or is not created by the formation of a new substance with different properties. Examples could include combining vinegar and baking soda or rusting an iron nail in water. (PS1.B)

This section focuses on the cause and effect of combining two or more substances. Is a new substance created? What properties are noticed?

Combining Substances

Matter can exist as a solid, liquid, or gas and can change in different ways. In some changes, the substances are essentially the same and retain their properties. For example, if you cut a carrot and a stalk of celery into three pieces each and mix them together, you will still have the substances of carrot and celery. The celery is still green and the carrots are still orange. The carrots still taste like carrots and celery still tastes like celery. The three pieces of carrot and three pieces of celery will weigh the same as the original carrot and celery stalk. If you dissolve a half cup of dirt in a cup of water, your resulting substance will be a cup and a half of the mixture which will retain the original properties of dirt and water.

Melting is an example of a special type of change, a change of state. The shape of an ice cube changes as it melts and becomes a liquid. However, the matter does not change. It still has the same taste and your body will be able to use it in the same way. It is still water so it is a change of state. Other changes of state include evaporation (liquid to gas), freezing (liquid to solid), and condensation (gas to liquid).

When two or more substances are combined, sometimes they produce a new substance with different properties. Burning a piece of paper, combining baking soda and vinegar, lighting fireworks, and baking a cake are all examples of creating a new substance after combining two or more substances. When you begin with the ingredients for the cake, you have flour, sugar, eggs, liquid, and flavoring which all have unique properties. Through physical observation, you will notice the eggs look like eggs, sugar looks like sugar and the liquid-like liquid. The directions for the cake specify that you should bake it for a certain period of time at a specific temperature. You notice the cake is done when it is a particular color, is tall and fluffy, and separates slightly from the edge of the pan. The properties of the finished cake are different than the original ingredients.

You find a jar of old pennies at your grandfather's house and decide to clean them. You pour 1/4 cup of white vinegar and 1 tsp. of salt into a clear, shallow nonmetallic bowl and stir the mixture to dissolve the salt. You put 20 dull pennies into the bowl and let them sit in the solution for five minutes. You remove them from the liquid and rinse them in water. They are shiny again. What properties of the pennies changed? Stayed the same? What properties in the vinegar and salt interacted with the pennies?

Image by makingmilly, pixabay.com, CC0

Putting It Together

Image by Paul Barlow, pixabay.com, CC0

The stick contained a liquid and a small capsule also filled with liquid. What happened when the liquids combined? What properties in the two liquids in the glow stick changed? What properties remained the same?

Watch the videos below to observe how to separate matter based on its physical properties:

https://youtu.be/jWdu_RVy5_A

https://youtu.be/UsouAIL-YZU

2.4 Conservation of Matter (5.2.4)

Explore this Phenomenon

Ice in a drink glass by Steve Johnson, https://flic.kr/p/83sd2y, CC-BY

Image by Borist Trost, pixabay.com, CC0

Your teacher has a glass of water with ice in the classroom and asks you to weigh it. She then has you wait until the ice has melted and you weigh the cup again. You discover that the weight has not changed even though the ice is gone. How can you explain this?

5.2.4 Conservation of Matter

Use mathematics and computational thinking to provide evidence that regardless of the type of change that occurs when heating, cooling or combining substances, the total weight of matter is conserved. Examples could include melting an ice cube, dissolving salt in water, and combining baking soda and vinegar in a closed bag. (PS1.A, PS1.B)

In this section, matter and energy will be discussed and explored. The idea that matter is conserved is the most important idea to understand.

Conservation of Mass

The law of conservation of matter means that no matter what, the matter cannot be created or destroyed.

This law applies to ALL changes.

Image from pixabay.com, CC0

Imagine that you made a paper airplane. After making it, you decided to measure the mass of the paper airplane using a balance. Now imagine that you crumpled the paper airplane into a ball and measured the mass again. Would the mass be different? Why or why not?

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 that you started with? Was it destroyed by the flames? It may seem that way. What do you think happened? The truth is that the same amount of matter still exists. The wood combined with oxygen in the air and changed not only to ashes, but also to carbon dioxide, water vapor, and other gases. The gases floated into the air, leaving behind just the ashes. Although matter was changed, it was not created or destroyed. Because the same amount of matter still exists, we can say that matter is conserved. You may wonder how it can be conserved if something is now missing.

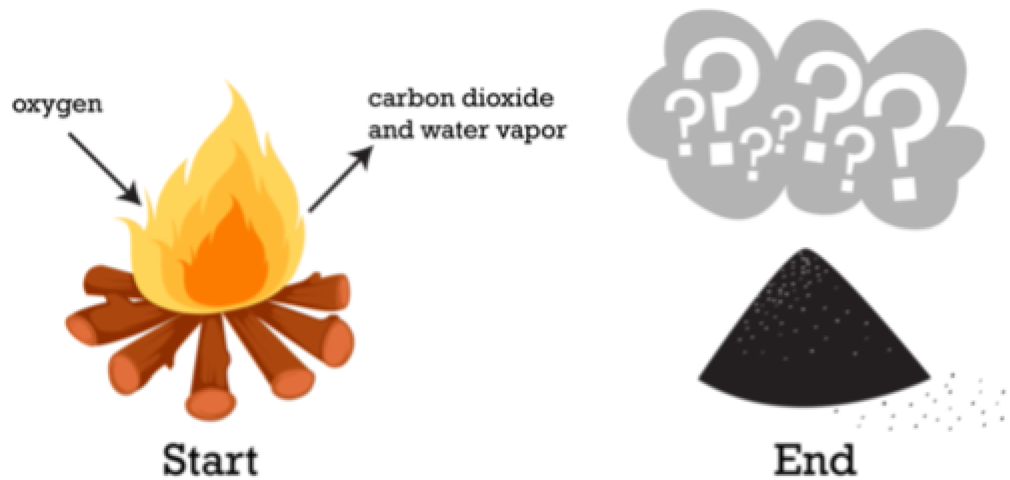


Image by Christopher Auyeung, Douglas Heriot, CK-12 Foundation, CC-BY-NC-SA 3.0

This burning campfire example illustrates a very important law in science: the law of conservation of mass. This law states that matter cannot be created or destroyed. Even when matter goes through a change, the total mass of matter always remains the same. If you were to weigh the oxygen and wood you started with, it would weigh the same as the ash and all the gases that were made when it was burned.

If you wanted to find the mass of a quantity of liquid water. Then you could freeze the water and find the mass of the ice. The mass before and after freezing would be the same, showing that mass is conserved when matter changes state.

Some videos that explain this phenomenon:

https://youtu.be/g2V7s3sR8T4

https://youtu.be/ibnIWn0omLQ

A Lego set released in 2013, "Gold Getaway", based on the Lego Castle theme, https://en.wikipedia.org/wiki/Lego#/media/File:Lego_Castle_70401-Gold_Getaway.jpg, CC-BY-SA 4.0

When creating a model with your favorite building materials, you put the pieces together. Your sister says the materials weigh less when you take them apart than they do when they are put together. Use mathematics and computational thinking to provide evidence your sister is incorrect.

Putting It Together

Ice in a drink glass by Steve Johnson, https://flic.kr/p/83sd2y, CC-BY

Image by Borist Trost, pixabay.com, CC0

Explain what happened to the ice. Where are the particles of the ice? How do the amounts of ice and water compare? Evaluate your first answer? How can you now explain why the weight of the water has not changed?

CHAPTER 3

Strand 3: Cycling of Matter in Ecosystems

Chapter Outline

Image by Bruno Glätsch, pixabay.com, CC0

Matter cycles within ecosystems and can be traced from organism to organism. Plants use energy from the Sun to change air and water into matter needed for growth. Animals and decomposers consume matter for their life functions, continuing the cycling of matter. Human behavior can affect the cycling of matter. Scientists and engineers design solutions to conserve Earth's environments and resources.

3.1 Building Plants (5.3.1)

Explore this Phenomenon

Asparagus by Pat Kight, https://flic.kr/p/4KBV5w, CC-BY-NC-ND

At the store, there were different types of asparagus on display. The green stalks are grown above the ground. The white stalks are grown underground. They are both the same type of plant. Create an explanation to explain the color difference in the asparagus.

5.3.1 Building Plants

Construct an explanation that plants use air, water, and energy from sunlight to produce plant matter needed for growth. Emphasize photosynthesis at a conceptual level and that plant matter comes mostly from air and water, not from the soil. Photosynthesis at the cellular level will be taught in Grades 6 through 8. (LS1.C)

In this section, energy and matter will be explored. Where the matter in plants comes from, is key to understanding.

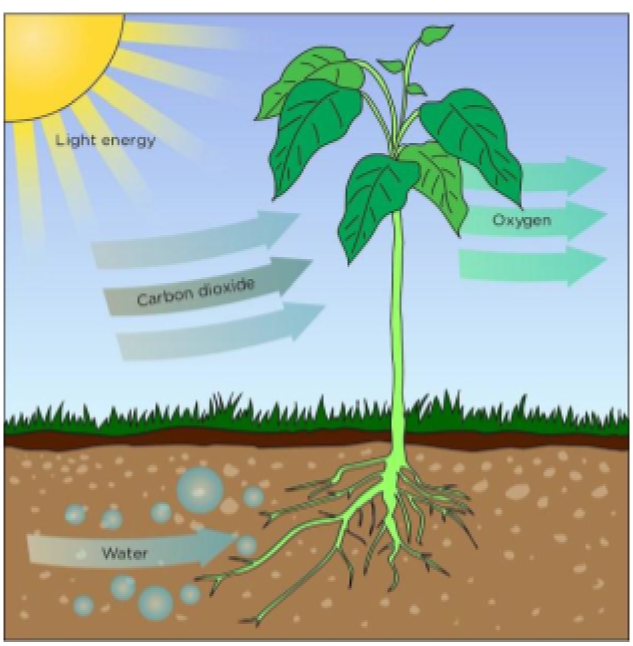
Plants and Food

Green plants are just like factories! They make food for themselves and every animal on earth using sunlight energy, water, and carbon dioxide. They also recycle the air and make oxygen for us to breathe.

The process of photosynthesis

The photosynthesis song

http://www.youtube.com/watch?v=C1_uez5WX1o&feature=youtu.be



Photosynthesis is the process that plants use to change the energy from sunlight into energy for food. Plants change light energy from the sun into food energy. Photosynthesis happens in all green parts of a plant. Leaves are usually the greenest parts. So plants do this mostly in their leaves.

There are some important requirements for photosynthesis to happen:

Chlorophyll: Chlorophyll is a green substance that plants use to capture light energy from the sun. This is what makes plants green. Chlorophyll is very important. Without chlorophyll, plants cannot use sunlight energy to make food. Also, oxygen levels in the air will go down. If that happens, plants and animals will suffocate.

Sunlight: Sunlight has energy. Plants use this energy to make sugars from water and carbon dioxide.

Water: The roots of a plant absorb water and nutrients from the soil. They move minerals from the roots upwards. They move sugars from the leaves downwards. Photosynthesis can only happen in water. Water is also important because it provides support to the plant to keep it upright. Like you, plants have skeletons. But unlike you, many plants have water skeletons!

Air (Carbon dioxide): The plant absorbs or takes in carbon dioxide from the air through little holes. These holes are found all over the plant, mostly under the leaves.

How does photosynthesis occur?

Plants use chlorophyll, sunlight, water, and carbon dioxide to make food. Here is a simple illustration to show how this process occurs:

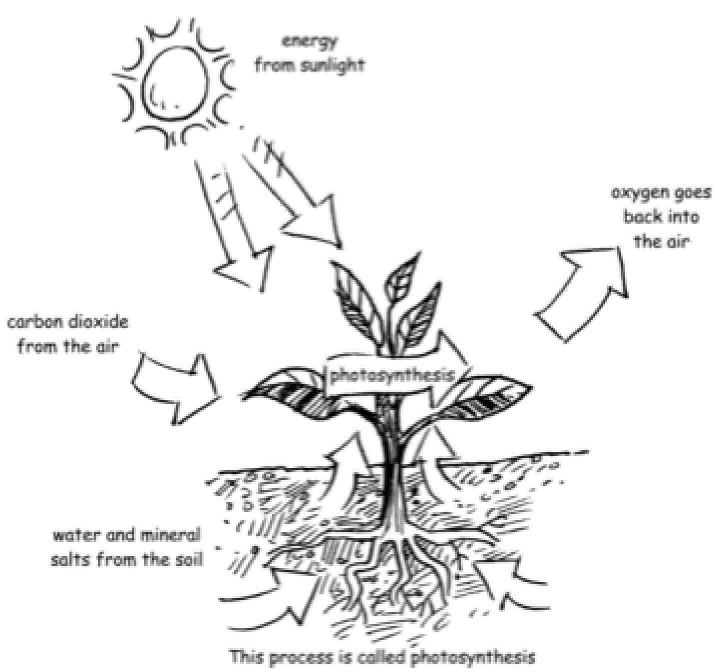


Image from Thunderbolt Kids, http://www.thunderboltkids.co.za/Grade6/01-life-and-living/chapter1.html, CC-BY-ND

A diagram illustrating the process of photosynthesis

- Chlorophyll captures sunlight energy.
- This energy splits the water into hydrogen and oxygen.
- The oxygen is released into the air.
- The hydrogen is used with carbon dioxide to make glucose (sugars).
- The sugars are moved from the leaves to other parts of the plants where they are stored.

Putting It Together

Asparagus by Pat Kight, https://flic.kr/p/4KBV5w, CC-BY-NC-ND

After learning about how plants create energy through photosynthesis, revise your explanation to explain the color difference in the asparagus.

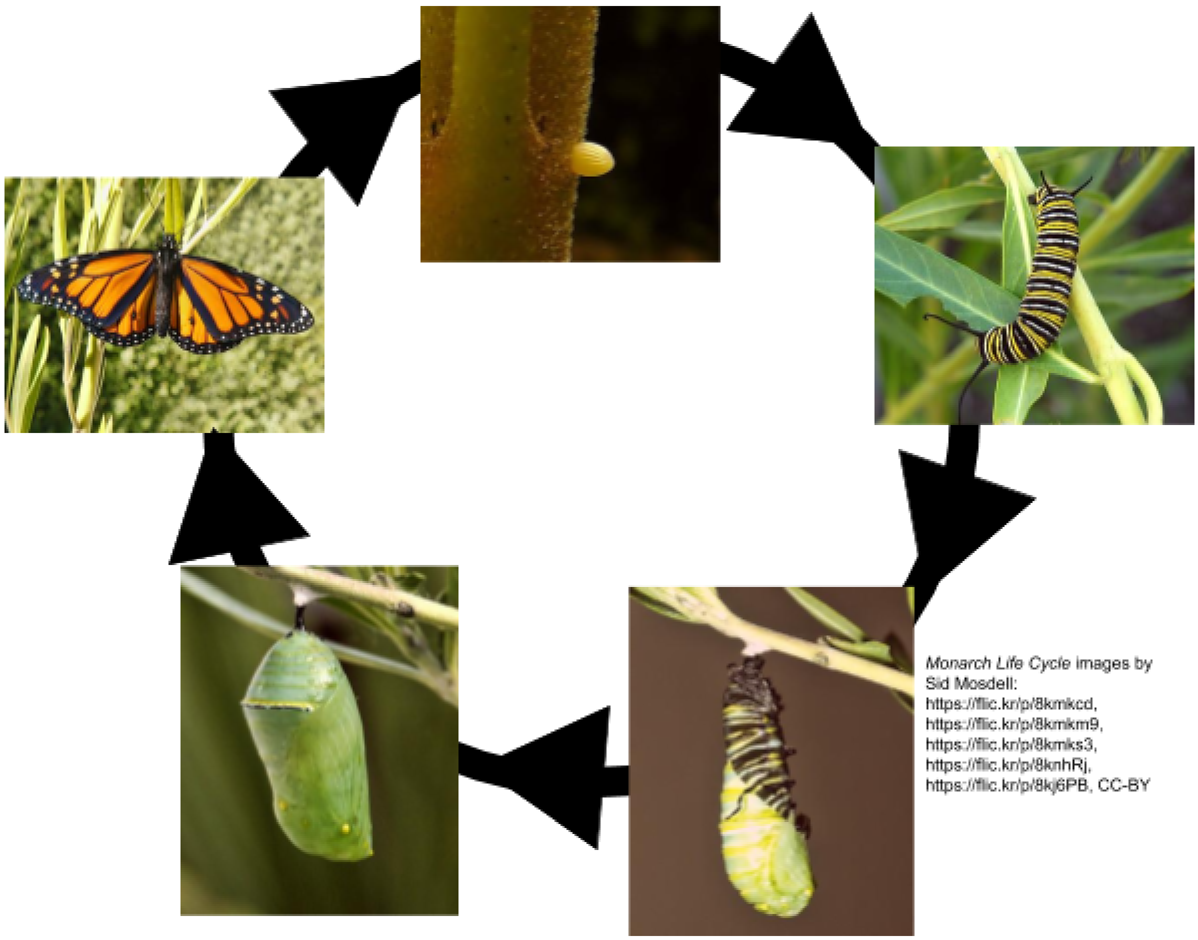
Photosynthesis video

http://www.youtube.com/watch?v=mpPwmvtDjWw

A game on growing plants
http://puzzling.caret.cam.ac.uk/pregame.php?game=16&phpsessid=65f1b591e2a1548e0f52d556373966ce

3.2 Consuming Food (5.3.2)

Explore this Phenomenon



Monarch Life Cycle images by Sid Mosdell: https://flic.kr/p/8kmkcd, https://flic.kr/p/8kmkm9, https://flic.kr/p/8kmks3, https://flic.kr/p/8knhRj, https://flic.kr/p/8kj6PB, CC-BY

Watch the rapid life cycle of a butterfly

[Life Cycle of a butterfly](https://youtu.be/kHby5DmmOUY)

https://youtu.be/kHby5DmmOUY

Butterflies obtain the energy needed for rapid growth from the food sources they consume. Where does this energy source originate?

5.3.2 Consuming Food

Obtain, evaluate, and communicate information that animals obtain energy and matter from the food they eat for body repair, growth, and motion and to maintain body warmth. Emphasize that the energy used by animals was once energy from the Sun. Cellular respiration will be taught in Grades 6 through 8. (PS3.D, LS1.C)

In this section, matter and energy will be explored. Energy and matter from food sources will be discussed. Energy used by animals was once energy produced from the sun.

How Energy Flows Through Ecosystems

All living things use energy constantly to survive. For example, it takes energy to move and grow. In fact, it takes energy just to stay alive. Energy can't be created or destroyed. It can only change form or be transferred. Energy changes form as it moves through ecosystems.

The Flow of Energy

Most ecosystems get their energy from the Sun. Plants convert sunlight into food through photosynthesis. Plants can store energy in many different places including:

- leaves (cabbage, spinach, lettuce)
- fruit (apples, bananas, peaches)
- stem (celery, sugar cane)
- seeds (wheat or sunflower seed)
- flowers (lavender, broccoli and cauliflower)
- roots (carrots or potatoes)

When an organism eats a plant they receive some of the energy stored in the plant. Organisms can also pass energy on to other organisms when they are eaten. In this way, energy flows from one living thing to another.

Living organisms release heat energy (thermal energy) into the atmosphere. Have you ever been in a room with a lot of people and it gets very hot? That is because of all the energy they are giving off. As a body uses the matter it consumes it produces the energy that makes your body warm.

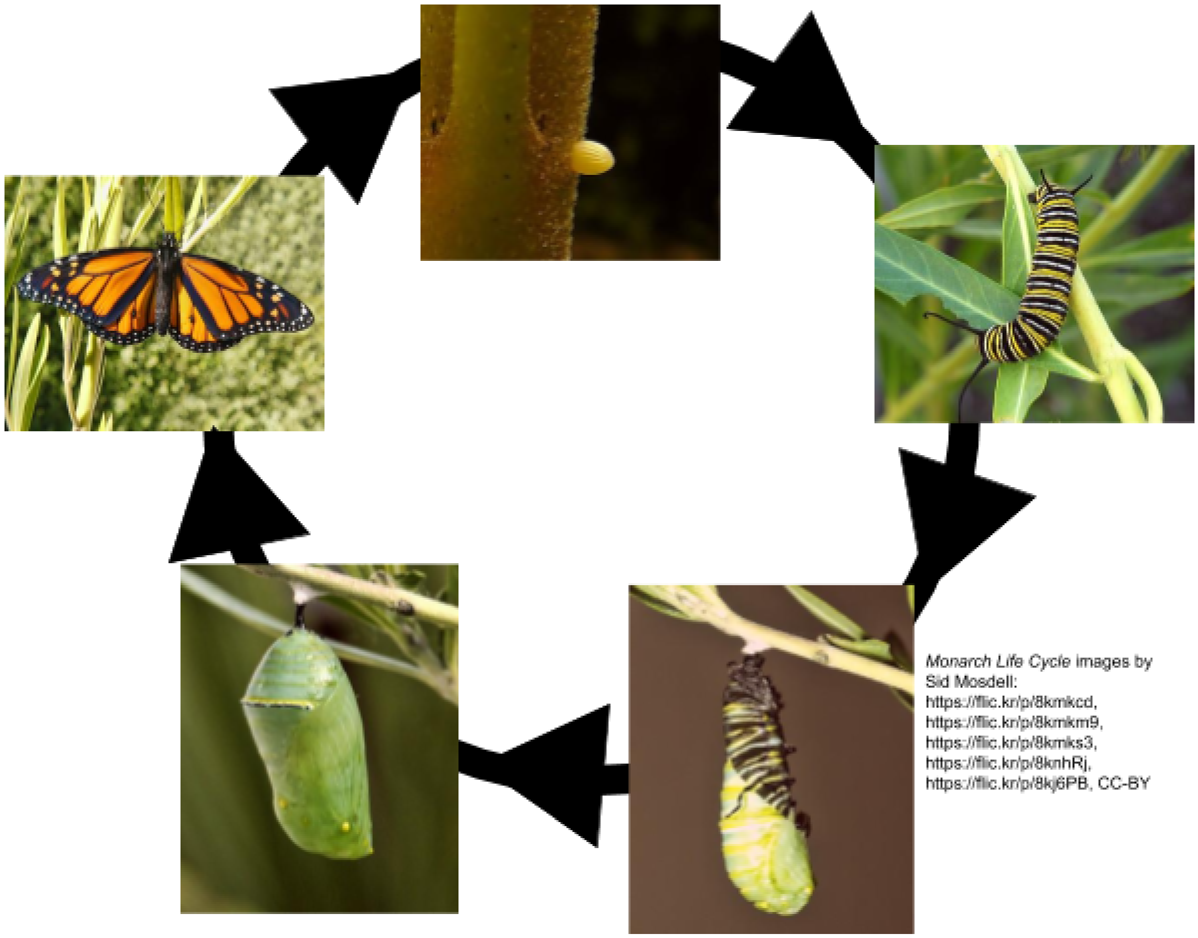
How Matter Moves Through Ecosystems

Living things need non-living matter as well as energy. What do you think the matter is used for? One thing is to build bodies. They also need it to carry out the processes of life. Unlike energy, matter is recycled in ecosystems. Decomposers release nutrients when they break down dead organisms.

- The nutrients are taken up by plants through their roots.
- The nutrients pass to primary consumers when they eat the plants.
- The nutrients pass to higher-level consumers when they eat lower-level consumers.
- When living things die, the cycle repeats.

Worms by Dan Brekke, https://flic.kr/p/hYNHN7, CC-BY-NC

Putting It Together



Monarch Life Cycle images by Sid Mosdell: https://flic.kr/p/8kmkcd, https://flic.kr/p/8kmkm9, https://flic.kr/p/8kmks3, https://flic.kr/p/8knhRj, https://flic.kr/p/8kj6PB, CC-BY

Butterflies obtain the energy needed for rapid growth from the food sources they consume. Explain the flow of energy from the sun to a butterfly. How does the butterfly use the energy gained for the rapid growth needed in its lifecycle? Use information learned in this chapter to explain your reasoning.

3.3 Movement of Matter (5.3.3)

Explore this Phenomenon

Owl with rat by Fish and Wildlife Research Institute, https://flic.kr/p/AiT4DJ, CC-BY-NC-ND

All animals need energy to survive. Each one gets its energy from different places. Create a model to show where the grass, mouse, and owl each get their energy.

5.3.3 Movement of Matter

Develop and use a model to describe the movement of matter among plants, animals, decomposers, and the environment. Emphasize that matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Examples could include simple food chains from ecosystems such as deserts or oceans or diagrams of decomposers returning matter to the environment. Complex interactions in a food web will be taught in Grades 6 through 8. (LS2.A, LS2.B)

In this section, the movement of matter will be identified. Matter cycles between air, soil, plants, animals, and microbes.

Energy Transfer

Animals can't use sunlight, water, and carbon dioxide to make food as plants do. Animals need to eat plants or other animals for energy to carry out their life processes. Living things that get their energy by eating either plants or animals are called consumers.

The organisms that produce food for those consumers are extremely important in every ecosystem. Organisms that produce their own food are called producers. They produce food through photosynthesis.

Organisms that use the food energy that was created by producers are called consumers. There are many types of consumers. Some consumers eat just producers. Others eat both producers and other organisms, and some just eat other organisms.

There are special animals called decomposers. They eat dead animals and other organic materials like fallen trees. They break the matter into tiny pieces that can go back into the soil as nutrients and minerals. These pieces must be small enough for plants to absorb.

There is a feeding relationship between producers, consumers, and decomposers. We call this relationship a food chain. Plants are the producers and animals are the consumers. When the animal dies decomposers like worms return the matter back into the soil.

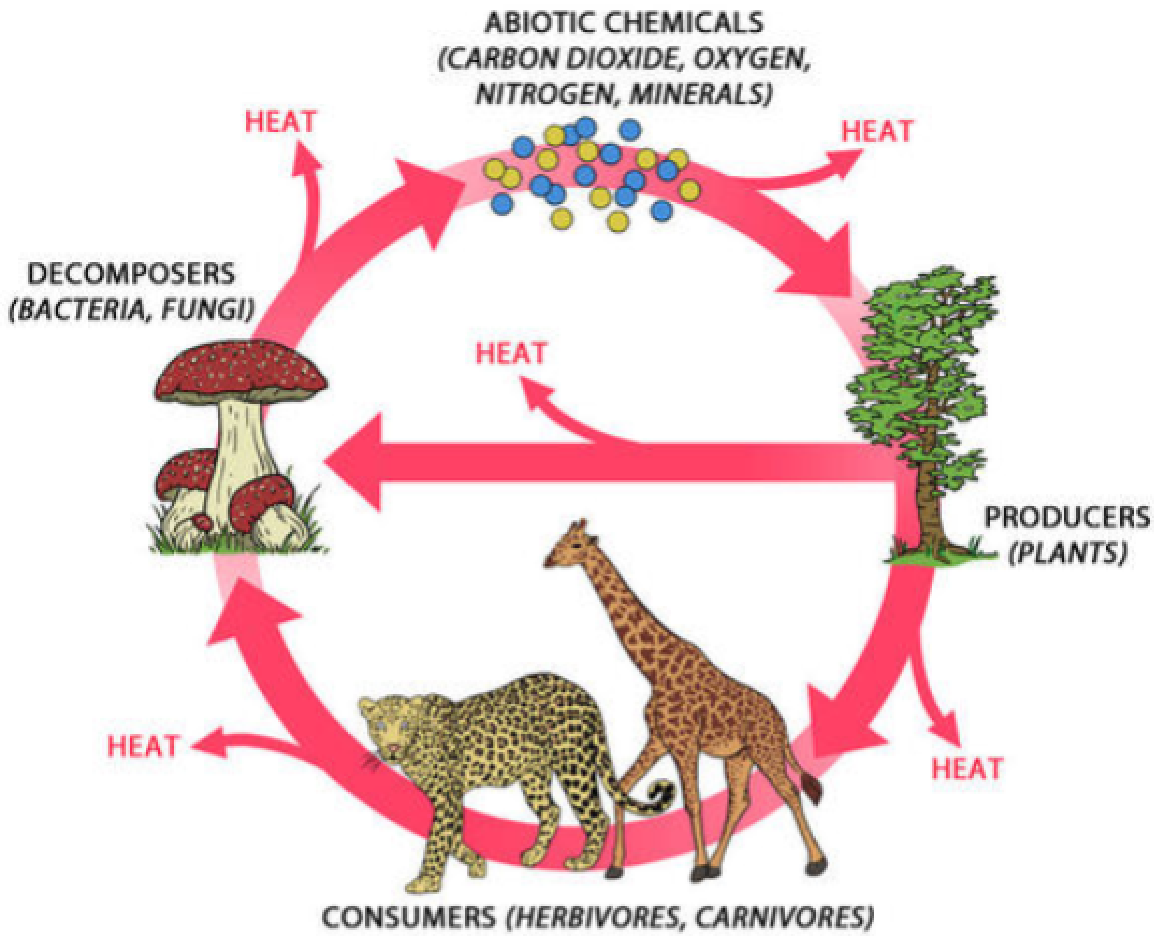


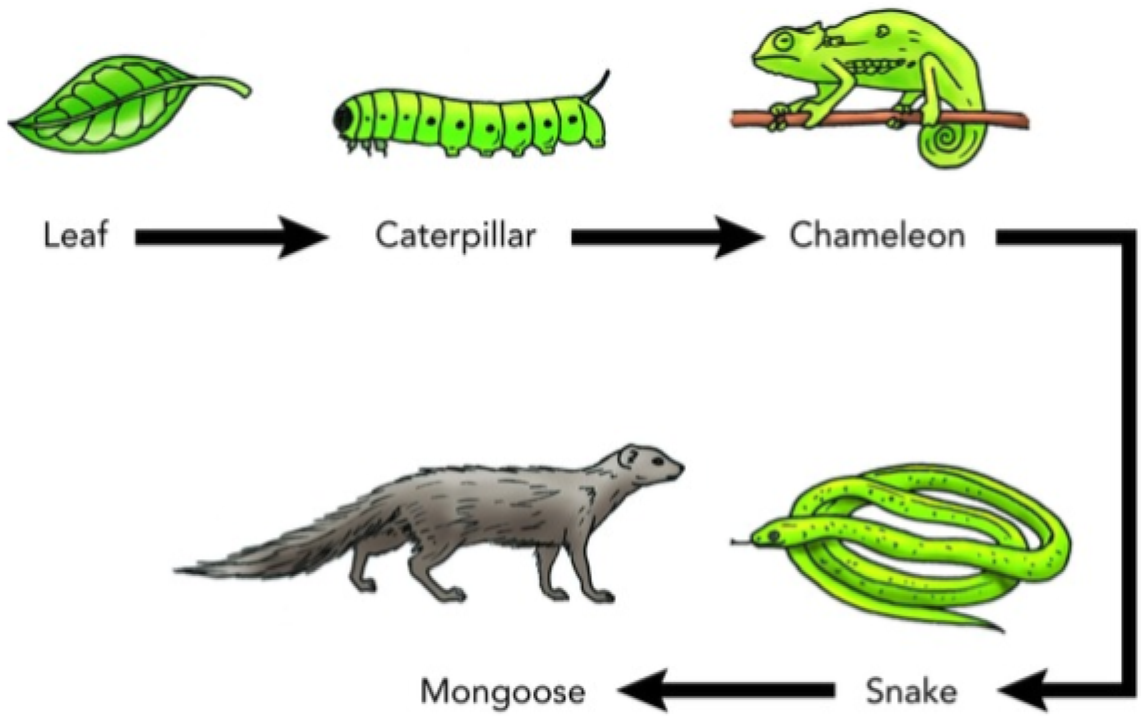
Image by Laura Guerin, CK-12 Foundation, CC BY-NC 3.0

Who eats whom?

Describing the flow of energy within an ecosystem essentially answers this question. To survive, one must eat. Why? To get energy. Food chains describe the transfer of energy within an ecosystem, from one organism to another. In other words, they show who eats whom. A food chain can describe how energy is passed from one organism to the next.

When drawing a food chain an arrow (→) is used between organisms to show that one eats the other and that energy is transferred from one organism to the next.

A simple food chain is: grass → cow → human → worms.



leaf to mongoose food chain by Siyavula Education, https://flic.kr/p/mFTVmg, CC-BY

Food Chains

A food chain represents a single pathway by which energy and matter flow through an ecosystem. An example is shown in the Figure above. Food chains are generally simpler than what really happens in nature. Their interactions are far more complex.

At each level of a food chain, a lot of energy is lost. Only about 10 percent of the energy passes to the next level. Where does that energy go? Some energy is given off as heat. Some energy goes into animal wastes. Energy also goes into growing things that another consumer can't eat, like fur. It's because so much energy is lost that most food chains have just a few levels. There’s not enough energy left for higher levels.

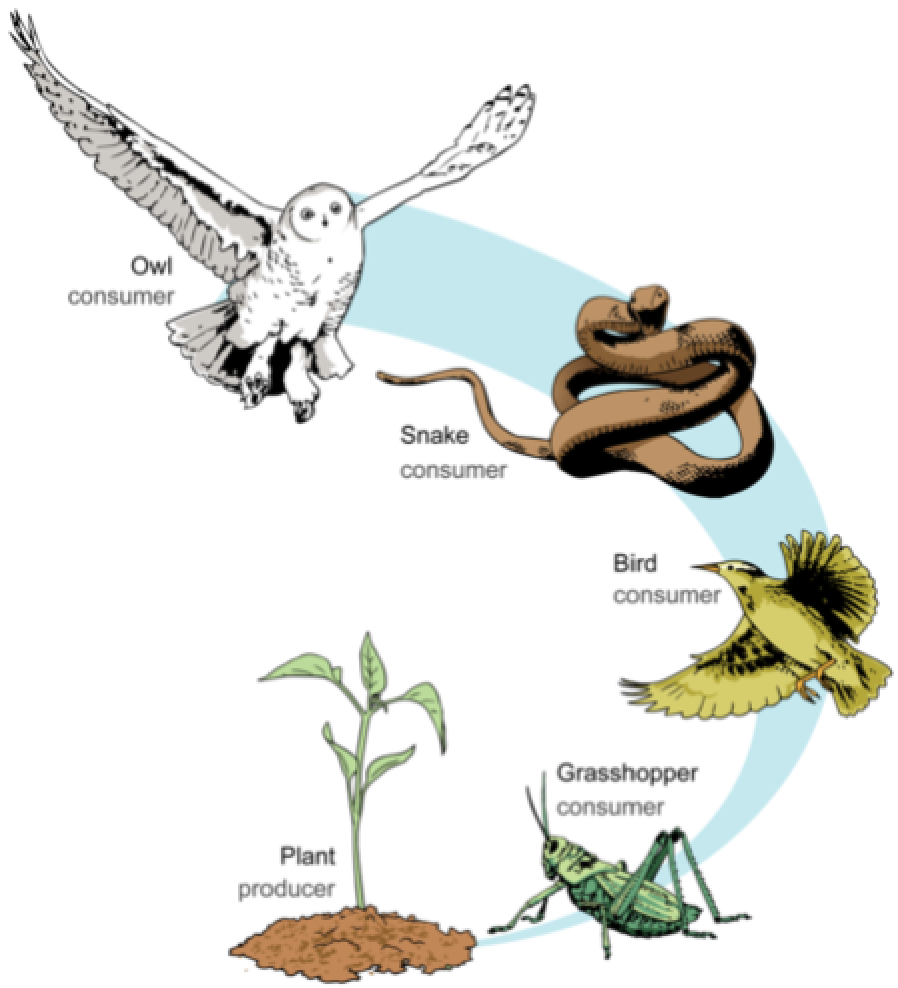


Image by Mariana Ruiz Villarreal (LadyofHats) for CK-12 Foundation, CC-BY-NC 3.0

This food chain includes producers and consumers. How could you add decomposers to the food chain?

A musical summary of food chains can be heard at: http://www.youtube.com/watch?v=TE6wqG4nb3M

Putting It Together

Owl with rat by Fish and Wildlife Research Institute, https://flic.kr/p/AiT4DJ, CC-BY-NC-ND

Develop and use a model to describe the movement of matter among plants, animals, decomposers, and the environment.

What if one part of the model is disrupted? What would be the result?

3.4 Conserving Resources (5.3.4)

Engineering Design Problem

Image from pxhere.com. CC0

Nonnative lake trout have been illegally introduced into Yellowstone Lake. Because of this, native cutthroat populations are in decline. If lake trout were to deplete the cutthroat population, the number of species dependent on the cutthroat for food could also decline. The dilemma: How do you protect the native Yellowstone cutthroat trout and other species dependent on the native trout?

You will evaluate design solutions proposed by the management of the park to help conserve native species

5.3.4 Conserve Resources

Evaluate design solutions whose primary function is to conserve Earth's environments and resources. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Emphasize how humans can balance everyday needs (agriculture, industry, and energy) while conserving Earth's environments and resources. (ESS3.A, ESS3.C, ETS1.A, ETS1.B, ETS1.C)

In this section, solutions will be designed which primary function is to conserve Earth's environments and resources.

Invasive Species

Invasive species are well known for the changes they cause in ecosystems. They may not have natural predators. In most habitats, there is a balance. This balance controls the size of groups of animals. Invasive species have an unfair advantage over their rivals. They are able to out-compete the native species for resources. At times, invasive species are very successful. In some areas, they have taken over the habitat. In this case, the native species goes extinct.

Recently, cargo ships have transported new species to the Great Lake. These include the zebra mussel, spiny water flea, and ruffe (a freshwater fish)

A video that addresses invasive species: Invasive Species from AMNH
http://www.youtube.com/watch?v=ENhldZeyF6o

These new species are better at hunting for food. They have caused some of the native species to go extinct.

Invasive species can disrupt food chains. They can carry disease. They may also prey on native species directly. More importantly, they out-compete native species for limited resources, like food. All of these effects can lead to extinction of the native species.

Read the following information to help you learn more about this problem so you can identify an effective possible solution.

Lake Trout in Yellowstone Lake

Nonnative lake trout have been illegally introduced into Yellowstone Lake. Their presence in the lake poses a serious threat to the native cutthroat trout population because young lake trout compete with cutthroats for food and adult lake trout prey on cutthroats. If lake trout were to deplete the cutthroat population, the number of species dependent on the cutthroat for food (such as bears, eagles, and otters) could decline. This could destroy the excellent cutthroat trout fishing in the lake that people have enjoyed for over a century.

The dilemma is: How do you protect the native Yellowstone cutthroat trout and other species dependent on the native trout?

Design solutions proposed by Yellowstone National Park management-

1. Eliminate the lake trout entirely by destroying all fish life, and then reintroduce the cutthroat. This would cost between $32 and $181 million.

- https://www.jhnewsandguide.com/the_hole_scroll/yellowstone-to-put-toxin-in-gibbon-river-to-remove-exotic/article_2573e2d0-fcca-5ffc-9328-28c4a4844304.html

2. Gillnet some, not all, the lake trout to reduce costs.

fishes by peacecorpschadsey, https://flic.kr/p/5zJQRk, CC-BY-SA

3. Leave the lake trout alone and see what happens.

4. Recruit thousands of anglers to catch lake trout.

This text is adapted from *Dueling Mandates* by the National Park Service. To read about more issues, go to: https://www.nps.gov/common/uploads/teachers/lessonplans/DuelingMandates-Instructions-and-Dilemma-Cards.pdf

Almost half of the streams and lakes in Yellowstone National Park did not support trout populations prior to the coming of European Americans. Stocking programs initiated by the U.S. Fish Commission in the late 1800s and early 1900s established populations of rainbow, brown, brook, and lake trout, as well as Yellowstone cutthroat trout, in most of the fishless waters.

In some cases, nonnative fishes were introduced into waters where native cutthroat trout flourished. As a consequence, native cutthroat trout were often replaced by the introduced nonnatives, and hybridization between cutthroat trout and rainbow trout was common.

The goal of these introductions was to provide angling opportunities for visitors to the Yellowstone area. In this vein, these stockings were very successful. There was little concern for whether these interactions with native trout were harmful; the main goal was to provide fish for anglers. As nonnative trout expanded in Yellowstone National Park, the range of the native cutthroat trout contracted.

Despite these introductions, Yellowstone cutthroat trout flourished in many parts of their native range within the Park, and until the 1990s, Yellowstone Lake supported the largest genetically pure population of Yellowstone cutthroat trout on earth.

Lake trout (*Salvelinus namaycush*) are native to Canada, Alaska, the Great Lakes, New England, and parts of Montana. The species was first documented in Yellowstone Lake in 1994. Evidence from chemical patterns in lake trout ear bones sampled in the late 1990s indicate that they were introduced illegally from nearby Lewis Lake sometime in the 1980s. Despite major efforts to remove them by gillnetting, the lake trout have had a significant ecological impact on the native Yellowstone cutthroat trout, an important food for other native animals. Lake trout differ from cutthroat trout as potential prey because they can grow larger, occupy deeper areas of the lake, and spawn in the lake instead of in shallow tributaries.

- 1890s: The park stocked fish; lake trout were introduced to Lewis and Shoshone lakes.
- Lake trout were illegally introduced into Yellowstone Lake in the 1980s and 1990s.
- 1980s–1990s: Lake trout illegally introduced into Yellowstone Lake
- 1994: First verified lake trout caught in Yellowstone Lake.

- A mature lake trout can eat ~41 cutthroat trout per year.
- The cutthroat trout population in Yellowstone Lake is ~10% or less of historic highs.
- Many wildlife species, including the grizzly bear, otter, and bald eagle, depend on cutthroat trout for a portion of their diet.
- Most predators can't catch lake trout because the trout live in deep water, spawn in the lake, and are large.

Current Status

- Gillnetting has removed more than 3.14 million lake trout since 1994.
- Anglers catch approximately 20,000 lake trout each year.
- Population models estimate a 70% decline in age 6+ lake trout since 2012.
- Lake trout recruitment remains strong. However, 2018 results indicate that is beginning to decrease as well.

Outlook

With continued aggressive control efforts, fisheries managers expect to reduce lake trout numbers and lessen impacts to cutthroat trout. Recent monitoring indicates Yellowstone cutthroat trout in Yellowstone Lake are starting to rebound and the lake trout population is in decline.

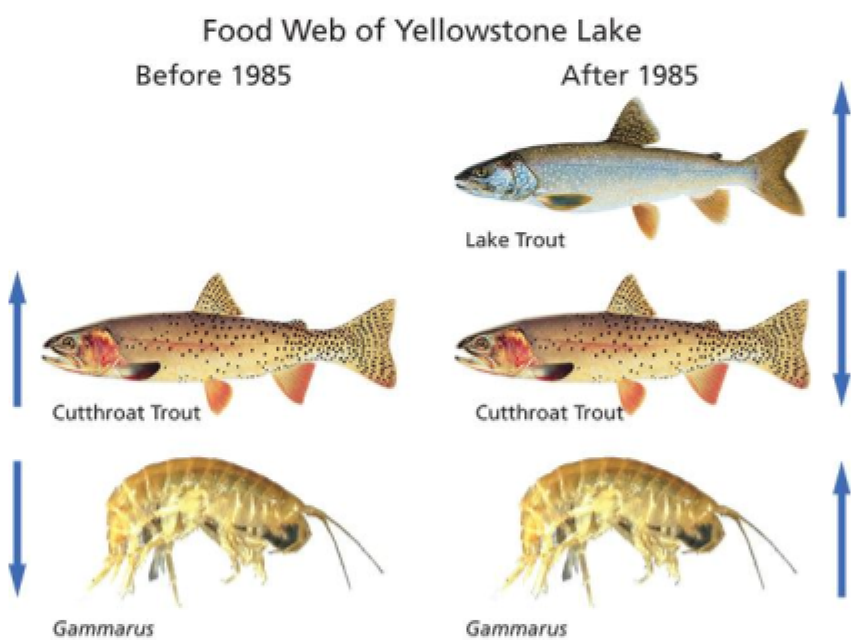


Image from nps.gov, public domain

Putting It Together

Image from pxhere.com. CC0

To help you find the best solution for the invasive species problem that is affecting the Yellowstone cutthroat,

a. First, write a sentence that clearly describes the problem.

b. Next, write end goals that will help you know you have successfully solved the problem. These are your criteria for success.

c. Now, write the limitations or constraints you have to solving the problems such as cost, time, and materials.

d. Compare each possible solution to your list of criteria and constraints.

e. Which solution best meets the items in those lists?

f. How does this design solution balance everyday needs (agriculture, industry, and energy) while conserving Earth's environments and resources?

Are there any advantages to keeping an invasive species in the new environment?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