6th Grade Science

for Utah SEEd Standards
2020-2021

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for Utah SEEd Standards

Utah State Board of Education OER
2020-2021

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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

Making Science

What does science look and feel like?

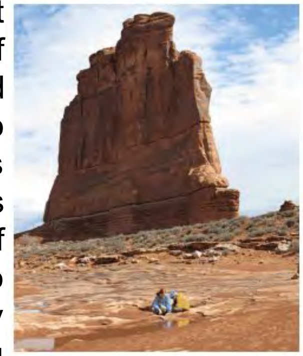
If you're reading this book, either as a student or a teacher, you're going to be digging into the "practice" of science. Probably, someone, somewhere, has made you think about this before, and so you've probably already had a chance to imagine the possibilities. Who do you picture doing science? What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

Often when we ask people to imagine this, they draw or describe people with lab coats, people with crazy hair, beakers and flasks of weird looking liquids that are bubbling and frothing. Maybe there's 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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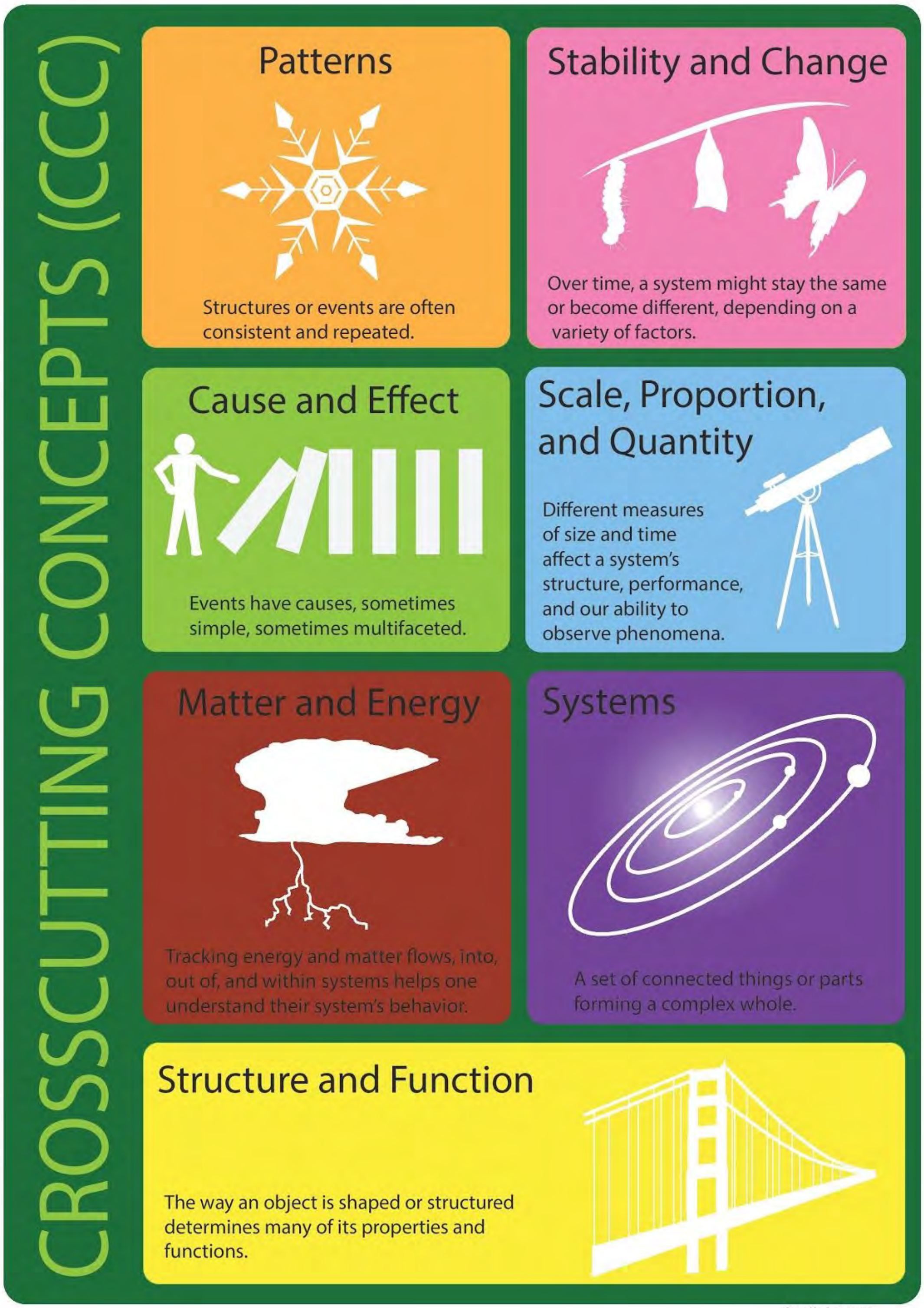
Cross Cutting Concepts

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 6th 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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CHAPTER 1

Strand 1: Structure and Motion within the Solar System

Chapter Outline

Phases are but part of the journey by Ee Shaw, https://flic.kr/p/aTAmx4, CC BY-NC-ND

The solar system consists of the Sun, planets, and other objects within the Sun's gravitational influence. Gravity is the force of attraction between masses. The Sun-Earth-Moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

1.1 Earth, Moon, and Sun System (6.1.1)

Public Domain

Explore this Phenomenon

You are walking out at night and, looking up into the sky, you see the scene above.

Record your observations in the box below and questions that you have based on your observations.

Observations	Questions

Draw a model that shows where the Sun, Earth, and Moon are located during a full moon.

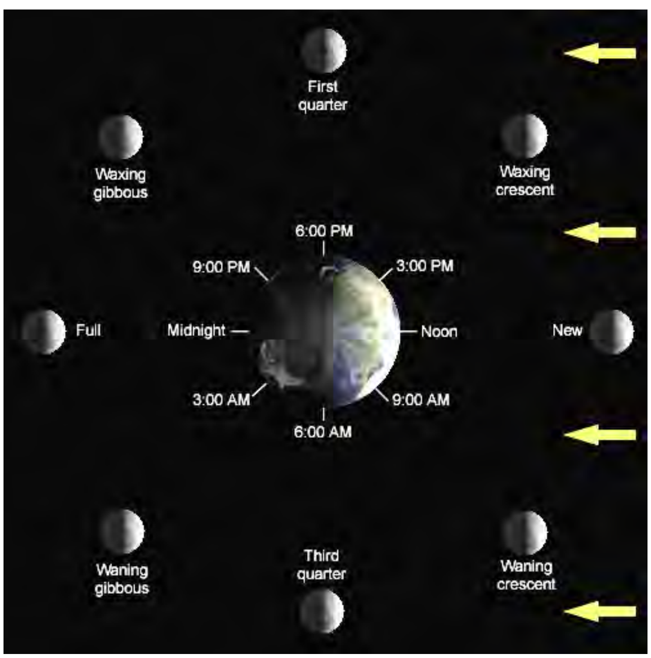
6.1.1 Phases of the Moon

Develop and use a model of the Sun-Earth-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. Examples of models could be physical, graphical, or conceptual. (ESS1.A, ESS1.B)

In this section, focus on visible patterns created by the positions of the Earth, Moon, and Sun throughout the month. The Earth-Moon-Sun System also creates observable patterns throughout the year. It is important to analyze this system in order to describe how it creates repeating, or cyclic, patterns.

Phases of the Moon

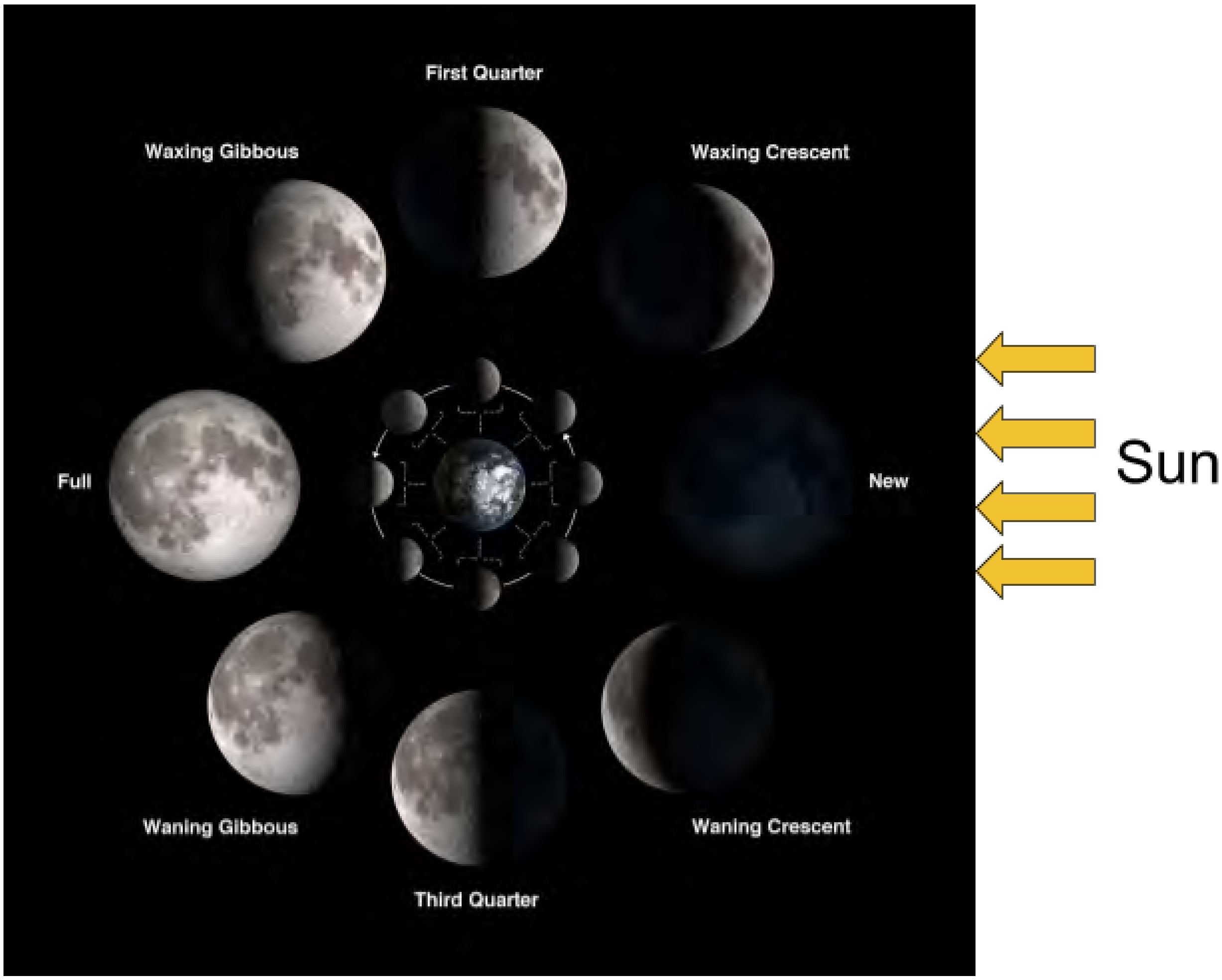
As the Moon orbits around Earth, different parts of it appear to be illuminated by the Sun. The Moon does not produce any light of its own. It only reflects light from the Sun. The Moon sometimes appears fully illuminated and sometimes appears completely dark. Although it changes in appearance, the Moon is always half illuminated by the Sun. From our perspective on Earth, we see all, a portion, or none of the illuminated part of the Moon. These predictable patterns in the appearance of the Moon are referred to as phases of the Moon.



- Visit this interactive for more information about the phases of the Moon: http://go.uen.org/aYG

The full Moon occurs when the Moon appears to be fully illuminated or lit up from our perspective on Earth. This happens when Earth is between the Moon and the Sun. As the Moon continues orbiting around Earth, the illuminated part that is visible from Earth decreases until the Moon appears to be completely dark. This phase is referred to as The New Moon. As the cycle continues, the illuminated part of the Moon will appear to increase until it is fully illuminated again as a Full Moon. This predictable pattern takes about 28 days.

- Watch this video to see the phases change: http://go.uen.org/aYI



https://moon.nasa.gov/resources/154/

We always see the same side of the Moon, because as the Moon revolves around the Earth, the Moon rotates so that the same side is always facing the Earth. This chart shows why this happens. The center ring shows the Moon as it revolves around the Earth, as seen from above the North Pole. This predictable pattern occurs about every 28 days.

Focus Questions

1. What causes the appearance of the Moon to change in a predictable pattern?

2. Where are the Sun, Earth, and Moon positioned for full and new moons to occur?

3. How does the Moon receive its light? Why can we see the Moon on Earth?

4. Why do we only get to see one side of the moon?

Putting It Together

Public Domain

A month later, you are hiking up the canyon and, looking up, you see the scene above again. Based on what you have learned, draw a revised model that shows the position of the Sun, Earth, and Moon.

Explore this Phenomenon

You go outside one night to see the full moon. As you look at the moon, portions of it gradually become dark, looking something like the series of images below over time.

Public Domain

Record your observations in the box below and questions that you have based on your observations.

Observations	Questions

Draw a model of the position of the Sun, Earth, and Moon during a lunar eclipse.

Lunar Eclipses

Sometimes a full moon moves through Earth's shadow. This is a lunar eclipse. During a total lunar eclipse, the Moon travels completely in Earth's shadow. During a partial lunar eclipse, only a portion of the Moon enters Earth's shadow. Since Earth's shadow is large, a lunar eclipse lasts for hours.

Partial lunar eclipses occur at least twice a year, but total lunar eclipses are less common. The Moon glows with a dull red coloring during a total lunar eclipse. The red coloring is due to light from the Sun being refracted through Earth's atmosphere.

In this diagram, you can see that the moon's orbit around Earth is at a tilt. This is why we don't get a lunar eclipse every month.
This diagram is not to scale: the moon is much farther away from Earth than shown here.
(Public Domain: https://spaceplace.nasa.gov/eclipses/en/*)*

Go to https://spaceplace.nasa.gov/search/lunar/ to explore more about eclipses.

Public Domain https://spaceplace.nasa.gov/eclipses/en/

Focus Questions

1. During the phases of the Moon, when would a lunar eclipse occur?

2. Why does a shadow pass over the Moon during a lunar eclipse?

3. Explain why we do not see a lunar eclipse every month.

Putting It Together

You go outside one night expecting to see a full moon. As you look at the moon, portions of it gradually become dark, looking something like the series of images below over time.

Public Domain

Review the model that you drew in the beginning of this section. Draw a revised model, based on what you have learned, that shows the positions of the Sun, Earth, and Moon during a lunar eclipse.

Explore this Phenomenon

A total solar eclipse as viewed from Earth. (public domain)

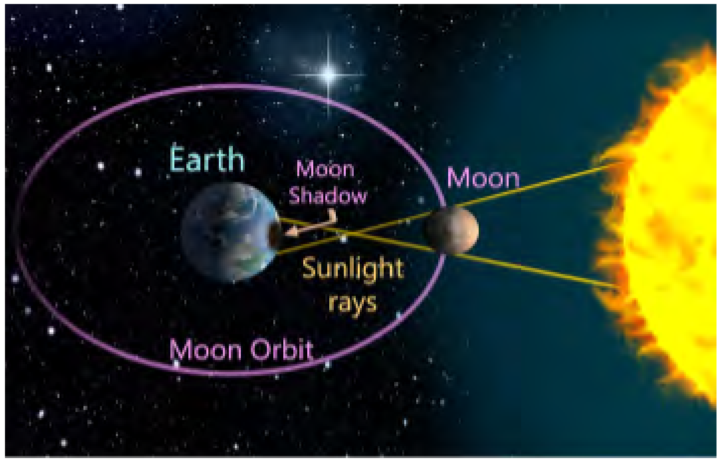
Record your observations in the box below and questions that you have based on your observations.

Observations	Questions

Draw a model of the position of the Sun, Earth, and Moon during a solar eclipse.

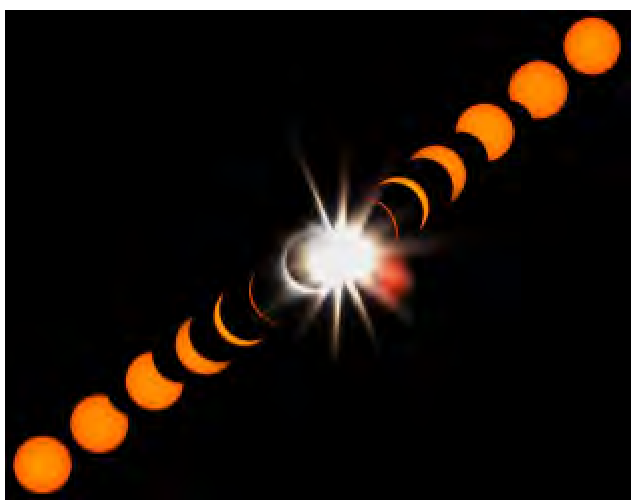
Solar Eclipses

A solar eclipse occurs when The New Moon passes directly between the Earth and the Sun. This casts a shadow on the Earth and blocks Earth's view of the Sun.



(pixabay, CC0)

A total solar eclipse occurs when the Moon's shadow completely blocks the Sun. When only a portion of the Sun is out of view, it is called a partial solar eclipse.



A solar eclipse shown as a series of photos.
(pixabay, CC0)

Solar eclipses are rare and usually only last a few minutes because the Moon casts a small shadow onto Earth. It is hazardous to your eyes to look directly at a solar eclipse without proper equipment.

- Visit this interactive to view models of solar and lunar eclipses: http://go.uen.org/b02

Focus Questions

1. What causes a solar eclipse?

2. How are solar eclipses different than lunar eclipses?

Putting It Together

A total solar eclipse as viewed from Earth. (public domain)

Review your initial model. Based on what you have learned, develop a revised model to show the positions of the Sun, Earth, and Moon during a solar eclipse.

Explore this Phenomenon

(pixabay - CC0)

The images above show the same tree at different times of the year. What do you think causes these differences?

Draw a model that shows the position of the Earth and Sun during each picture.

Seasons

- Visit this interactive to explore the causes of Earth's seasons: http://go.uen.org/aYL

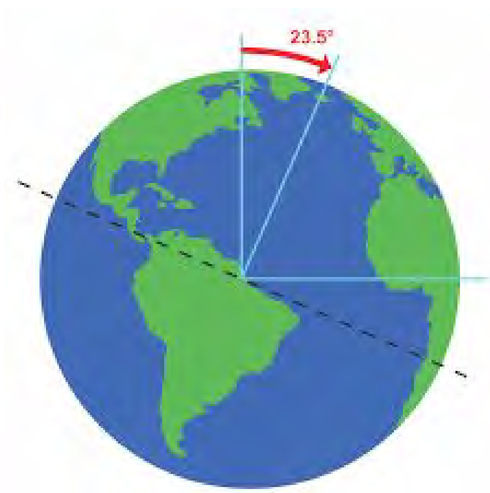
The days are getting warmer. Flowers begin to bloom. The sun appears higher in the sky, and daylight lasts longer. Spring seems like a fresh, new beginning. What causes these welcome changes?

Some people think that Earth is closer to the Sun in the summer and farther away from the Sun in the winter, but that's not true! Why can't that be true? Because when it's summer in one hemisphere, it's winter in the other.

The Earth revolves in an orbit, or the path a planet takes around an object. Initially believed to have a circular orbit, the Earth's orbit is actually slightly elliptical. As Earth moves throughout the year to new positions around the sun, the movement results in our four seasons: summer, autumn, winter, and spring.

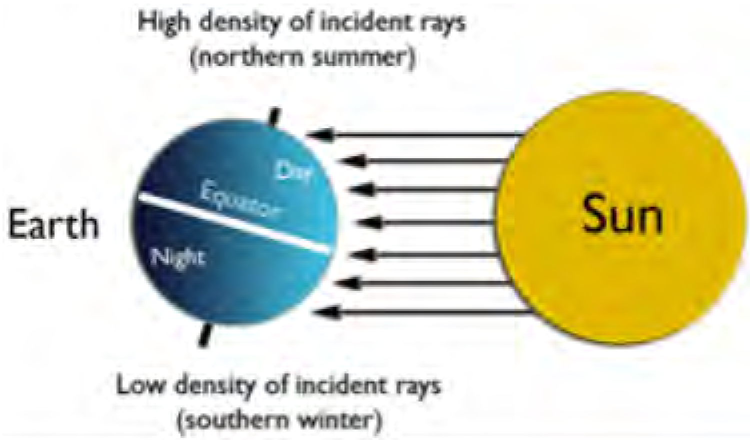
The distance from the sun doesn't have much effect on the heating and cooling of Earth. In fact, the Northern Hemisphere is closest to the Sun during winter. So, why do we, in the Northern Hemisphere, feel colder when we are closest to the Sun?

Earth's axis of rotation is tilted at a 23.5 degree angle. Because of this tilt, one of the hemispheres is angled toward the Sun. This causes that hemisphere to receive more direct energy from the Sun.



As Earth revolves around the Sun, the axis of rotation maintains its tilt. The axis always points in the same direction, which is toward the North Star (Polaris). The combination of the Earth's revolution around the Sun and Earth's 23.5 degree angle tilt are the reasons we have seasons.

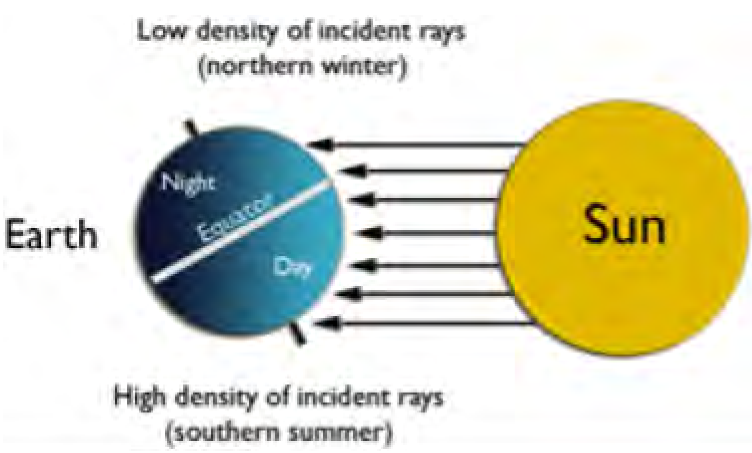
Northern Hemisphere Summer



Ck12.org, CC BY-SA

During summer in the Northern Hemisphere, the North Pole is tilted towards the Sun. The Sun's rays strike the Northern Hemisphere more directly. The region gets a lot of sunlight. At this time, the Northern Hemisphere experiences summer, while the Southern Hemisphere experiences winter.

Northern Hemisphere Winter



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During winter in the Northern Hemisphere, light from the Sun is spread out over a larger area. This indirect light is the same amount of light energy spread over a larger area on the Earth's surface. Therefore, the surface of the Earth does not get as warm. Additionally, with fewer daylight hours in winter, there is less time for the Sun to warm the Earth's surface.

During winter in the Northern Hemisphere, it is summer in the Southern Hemisphere. In contrast, when it is winter in the Southern Hemisphere it is summer in the Northern Hemisphere. The hemisphere that is experiencing summer, experiences more hours of daylight. The hemisphere that is experiencing winter has less hours of daylight. This is caused by the tilt of the Earth.

Summer occurs in the hemisphere that is tilted toward the Sun. This is when the Sun appears high in the sky and its energy strikes Earth more directly and for longer periods of time. The hemisphere that is tilted away from the Sun experiences winter and the Sun appears lower in the sky. The Earth receives less direct energy from the Sun for shorter periods of time.

Focus Questions

1. What seasons do you experience where you live?

2. What causes the seasons?

3. How does the Sun impact seasons?

4. What is the relationship between the Sun and the season you are experiencing?

Putting It Together

(pixabay - CC0)

The images above show the same park in all four seasons. What causes the seasons? Review your initial model. Draw a revised model that shows the position of the Earth and Sun during different seasons based on what you have learned.

1.2 Gravity and Inertia (6.1.2)

Explore this Phenomenon

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This picture shows children tossing a ball. Why does the ball return to Earth in a curved path rather than traveling in a straight line and then falling straight to the ground? To answer this question, develop a model to explain why objects fall following a curved path rather than in a straight line.

6.1.2 Gravity and Inertia

Develop and use a model to describe the role of gravity and inertia in orbital motions of objects in our solar system. (ESS1.B)

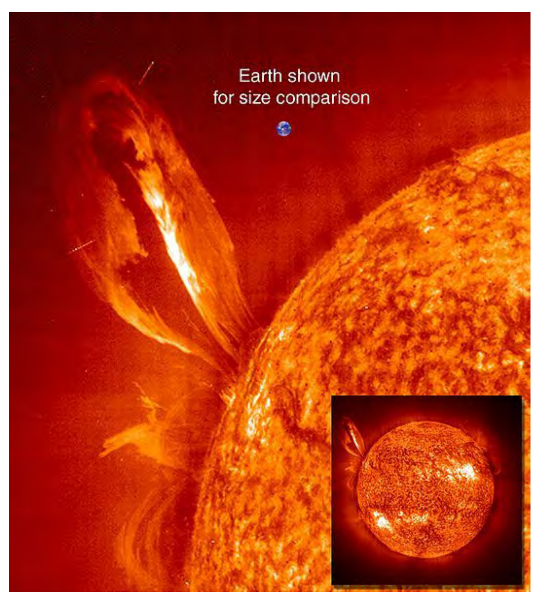
As you read, focus on systems, an organized group of related objects. In this section, it is important to examine how the objects in our solar system are affected by gravity and inertia.

The Role of Gravity and Inertia

Most of the objects that are part of our solar system are constantly orbiting the Sun, the star in our solar system. Mass is a measure of the amount of matter in an object. Everything that has mass also has gravity. Gravity is the attraction of one particle or body to another. You have gravity. Your pencil has gravity.

Larger masses have a stronger gravitational force, or the measurement of the pull of gravity, than smaller masses. The greater the mass of an object, the greater the gravitational pull it has on other objects.

The Sun is the most massive object in our solar system and so it exerts the greatest force of gravity on all the planets. Since the Sun is the largest mass in our solar system, its gravitational force holds Earth and other planets in orbit around it. This force of gravity makes all the planets move in an orbital motion around the Sun instead of moving in a straight line.



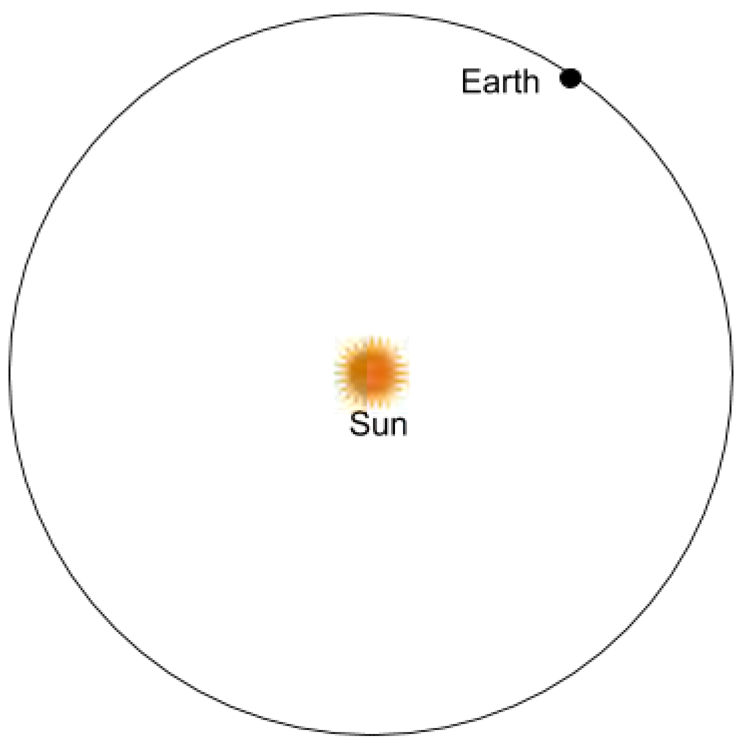
The distance between the Sun and each of its planets is very large. The greater the distance between objects, the smaller the force of attraction. The force of gravity is dependent upon the mass of objects and the distance between the two objects. Gravity keeps each planet orbiting the Sun because, despite the large distances, the star and its planets have very large masses. We wouldn't be here without gravity.

As you can see in this NASA picture, Earth is tiny compared with the massive sun. Gravity pulls Earth toward the Sun, but Earth never falls into the Sun. Instead, it constantly revolves around the Sun, making one complete revolution every 365.25 days, or one year.

The reason the Earth revolves around the Sun instead of falling into it is because of inertia. Inertia is the tendency of an object to resist a change in its motion. All objects have inertia and the inertia of an object depends on its mass. Objects with greater mass also have greater inertia. The Earth's inertia keeps it moving forward at the same time that it is pulled by the Sun's gravitational force. Working together, inertia and gravity cause Earth to orbit the Sun.

Orbital Motion

Earth and many other bodies—including asteroids, comets, and the other planets—move around the Sun in curved paths called orbits. Generally, the orbits are elliptical, or oval, in shape. You can see the shape of Earth's orbit in the next figure. Because of the Sun's strong gravity, Earth and the other bodies constantly fall toward the Sun, but their forward movement causes them to fall around the Sun instead of into it. As a result, they keep orbiting the Sun and never crash to its surface. The motion of Earth and the other bodies around the Sun is called orbital motion. Orbital motion occurs whenever an object is moving forward and at the same time is pulled by gravity toward another object.

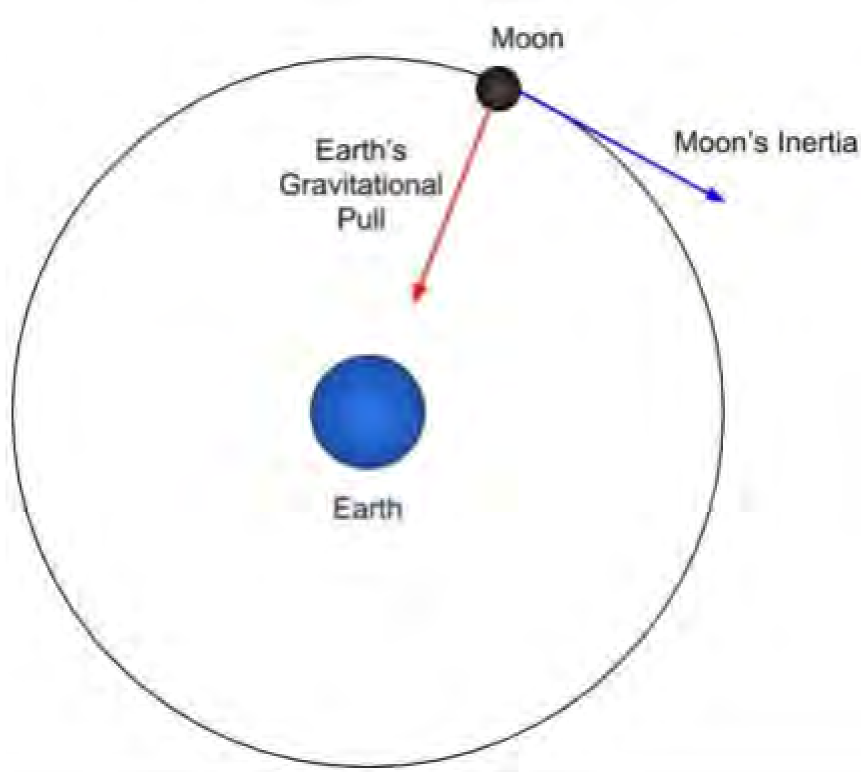


Earth does not orbit the sun in a perfect circle. It has an elliptical orbit, different from a circle by 1.67%. (*size and distance not to scale*)
M Huddleston, CC0

- Visit this interactive to model gravity and orbits: http://go.uen.org/aYO

Orbital Motion of the Moon

Just as Earth orbits the Sun, moons also orbit planets. The Moon is affected by Earth's gravity more than it is by the Sun's gravitational pull because the Moon is much closer to Earth. The Earth's gravity pulls the Moon toward Earth. At the same time, the Moon has forward movement, or inertia, that partly counters the force of Earth's gravity. This inertia causes the Moon to orbit Earth instead of falling toward the surface of the planet.



(T. Poulsen, CC0)

Focus Questions

1. Why is the Sun called the center of the solar system?

2. Why doesn't Earth crash into the Sun?

3. How does the Moon maintain its orbit around Earth?

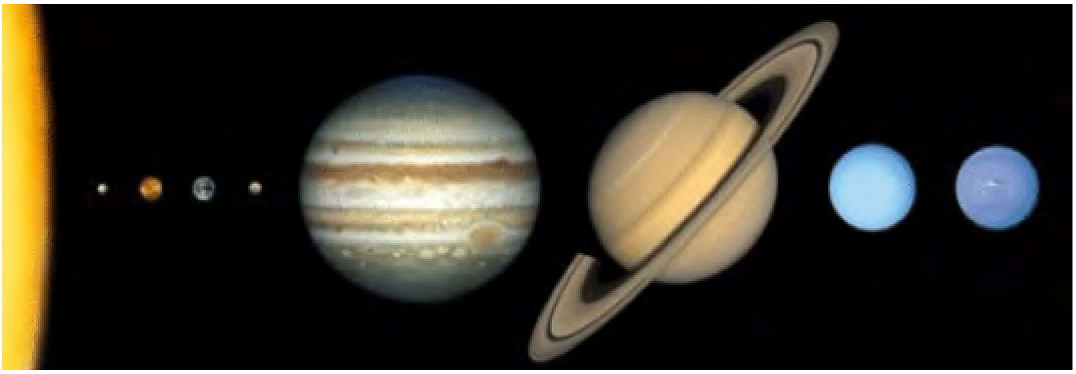
Putting It Together

Ck12.org, CC BY-SA

This picture shows children tossing a ball. Why does the ball return to Earth in a curved path rather than traveling in a straight line and then falling straight to the ground? Consider what you have learned in this section. Develop a model to explain why propelled objects fall following a curved path rather than in a straight line.

1.3 Scale of the Solar System (6.1.3)

Explore this Phenomenon



Public Domain

This image is one example of a model of our solar system.

1. What is useful about this model for understanding the solar system?

2. What are the limitations of this model?

3. Is this model an accurate scale depiction for size and distance? Why?

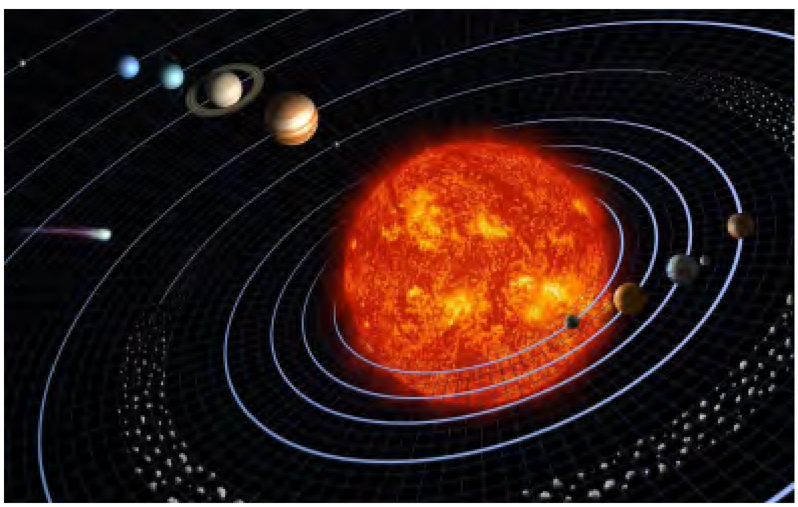
6.1.3 Objects in the Solar System

Use computational thinking to **analyze data** and determine the scale and properties of objects in the solar system. Examples of scale could include size and distance. Examples of properties could include layers, temperature, surface features, and orbital radius. Data sources could include Earth and space-based instruments such as telescopes and satellites. Types of data could include graphs, data tables, drawings, photographs, and models. (ESS1.A, ESS1.B)

In this section focus on scale. Objects in our solar system vary greatly in scale and properties. It is important to analyze what is relevant data related to scale and how the size of objects and distance between objects affects our solar system's structure and performance

Scale and Properties of Objects in the Solar System

The solar system is made up of eight planets and their moons, asteroids, comets, and many smaller objects that orbit the Sun. The Sun is the star at the center of our solar system. It sustains life on Earth because it is a source of heat, light, and energy.



(pixabay, CC0)

A planet is a celestial body that revolves around a star. It does not give off its own light. It is also larger than asteroids or comets. The planets of our solar system, in order from the Sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

At one time, Pluto was also considered a planet, but it's status was changed to a dwarf planet on August 24, 2006 by the International Astronomical Union (IAU) because while it does orbit the sun like other planets, it is much smaller.

Measuring Distances

Since stars and galaxies are so far away from each other, measuring distances in miles or kilometers is difficult because the numbers are so large. Let's begin with the Earth's distance from the Sun. Earth is about 93,000,000 miles or 150,000,000 kilometers from the Sun. This distance is called an Astronomical Unit and is the average distance between the Earth and the Sun.

Scientists and astronomers sometimes use a light-year, the distance light travels in one year, to measure these distances. A beam of light from the Sun takes 8.3 minutes or about 500 seconds to reach the Earth. Speed of light, the time it takes light to travel, is about 186,000 miles per second (300,000 kilometers per second). The speed of light is much faster than rockets can travel today.

Light-Year Calculation

- 60 seconds per minute (×) 60 minutes per hour= 3,600 seconds per hour.
- 3,600 seconds per hour (×) 24 hours per day= 86,400 seconds per day.
- 86,400 seconds per day (×) 365 days a year= 31,536,000 seconds per year.
- 31,536,000 seconds per year (×) 186,000 miles per second= 5,865,696,000,000 miles per year=1 light-year in miles.

Or

- 31,536,000 seconds per year (×) 300,000 kilometers per second= 9,469,800,000 kilometers per year=1 light-year in kilometers.

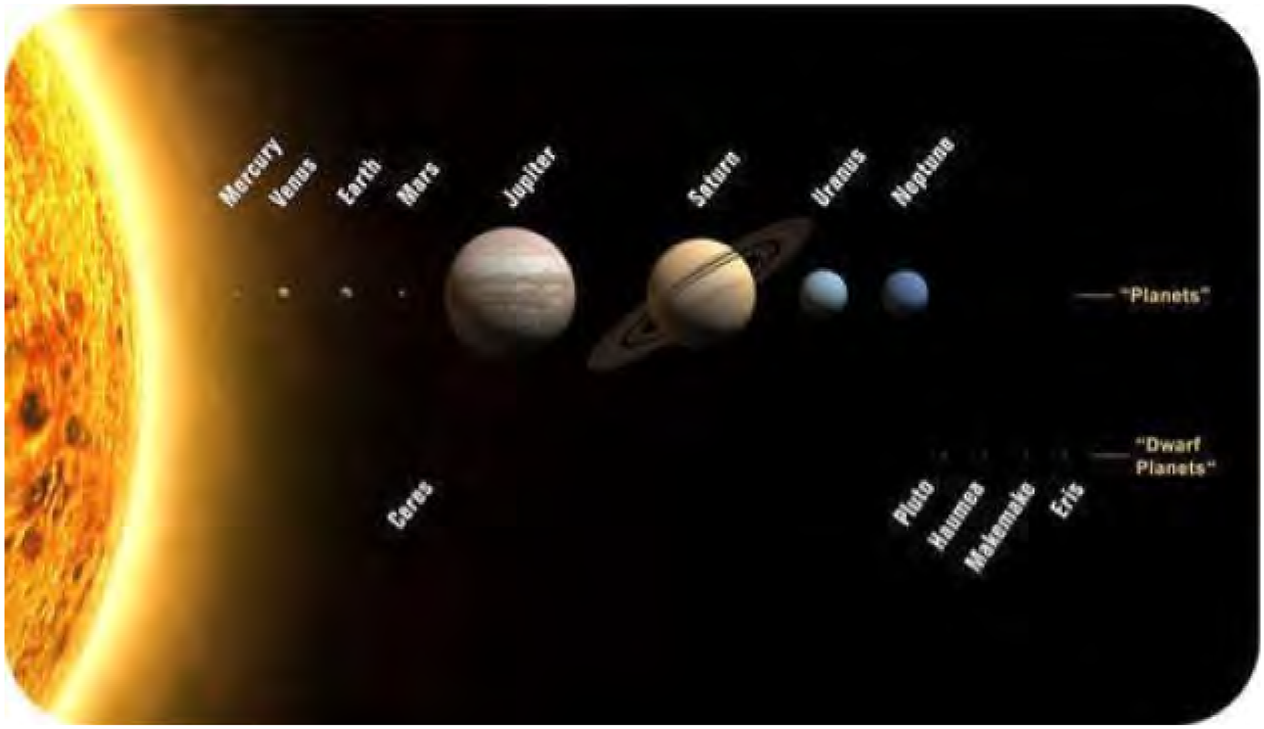
The table below shows the distances between the Sun and the planets using light years, miles, kilometers and astronomical units.

Distance of Planets from the Sun

Planet	Light-Years	Miles (mi)	Kilometers (km)	Astronomical Units (AU)
Mercury	0.000006 (3.2 light minutes)	36,000,000	58,000,000	0.39 AU
Venus	0.000011 (6 light minutes)	67,000,000	108,000,000	0.72
Earth	0.000016 (8.3 light minutes)	93,000,000	150,000,000	1.00
Mars	0.000024 (12.7 light minutes)	141,000,000	228,000,000	1.52
Jupiter	0.000082 (43.3 light minutes)	484,000,000	778,000,000	5.20
Saturn	0.000151 (79.5 light minutes)	888,000,000	1,429,000,000	9.54
Uranus	0.000304 (2.7 light hours)	1,786,000,000	2,875,000,000	19.22
Neptune	0.000476 (4.2 light hours)	2,799,000,000	4,504,000,000	30.06

Measuring Size

The Sun is an average size star. But, it is the largest object in the solar system. The Sun makes up 99.8 percent of the mass of the Solar System.



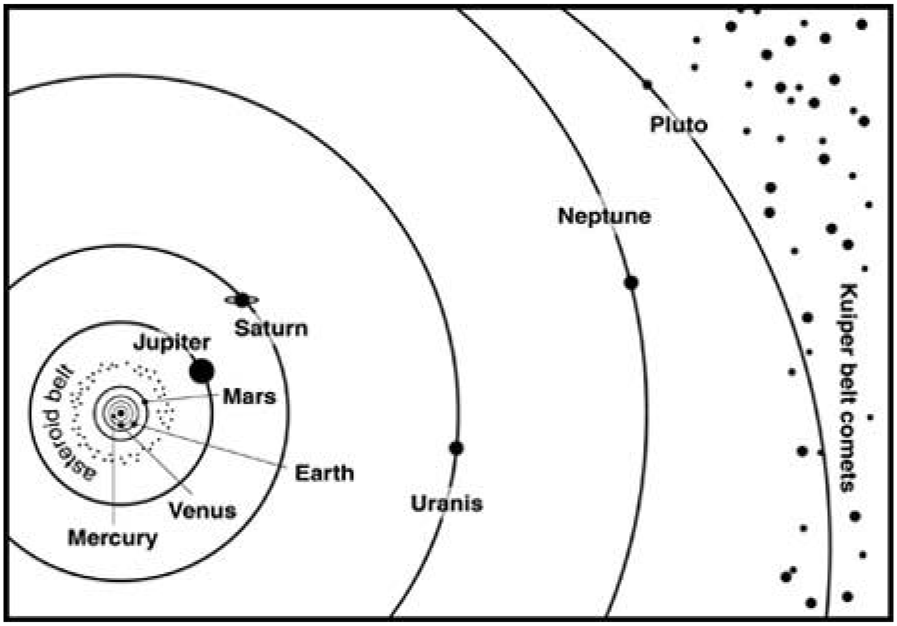
Relative sizes of the Sun, planets, and dwarf planets are to scale. The relative distances are not to scale.
(NASA, public domain)

The next table provides data to compare the sizes of the Sun and the planets. The table also shows how long it takes each planet to spin on its axis (the length of a day) and how long it takes each planet to complete an orbit (the length of a year); in particular, notice how slowly Venus rotates relative to Earth.

Mass, Diameter, Rotation, and Revolution of Planets and Sun as Compared to Earth

Object	Mass (Relative to Earth)	Diameter of Planet (Relative to Earth)	Length of Day (Earth Days)	Length of Years (Earth Years)
Sun	333,000 x Earth’s Mass	109.2 x Earth's diameter	---	---
Mercury	0.06	0.39	56.84 Earth days	0.24 Earth years
Venus	0.82	0.95	243.02	0.62
Earth	1.00	1.00	1.00	1.00
Mars	0.11	0.53	1.03	1.88
Jupiter	317.8	11.21	0.41	11.86
Saturn	95.2	9.41	0.43	29.46
Uranus	14.6	3.98	0.72	84.01
Neptune	17.2	3.81	0.67	164.8

The next figure shows the relative sizes of the orbits of the planets, asteroid belt, and Kuiper belt. In general, the farther away from the Sun, the greater the distance from one planet's orbit to the next. The orbits of the planets are not circular but slightly elliptical.

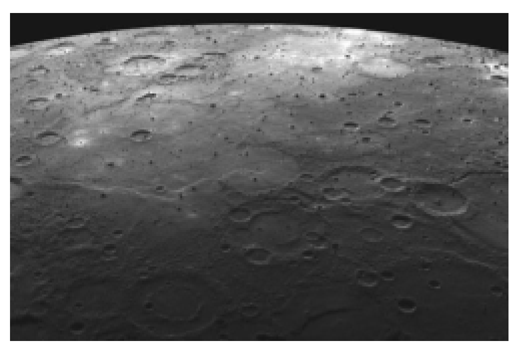


Planets

Planets are bodies that orbit a star. In our solar system there are eight planets. The following facts can be used to compare the planets:

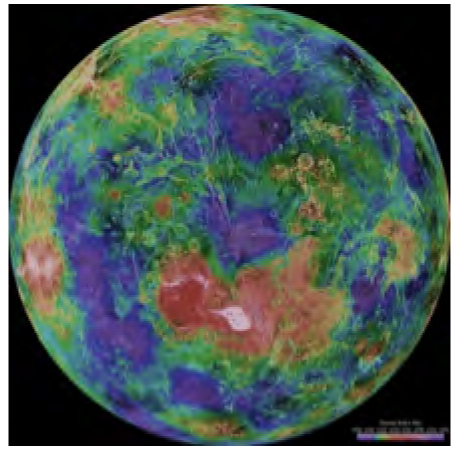
Mercury

- It is the nearest planet to the Sun.
- Earth's Moon and Mercury's surface look similar.
- It has a very thin atmosphere.
- It has no moons.
- It has the greatest range of temperature, 662˚F (day) to -274˚F (night) = 936˚.
- Rotation: 58.7 Earth days.
- Revolution: 88 Earth days.
- Distance from Sun: 0.39 AU's.



Public Domain

Venus



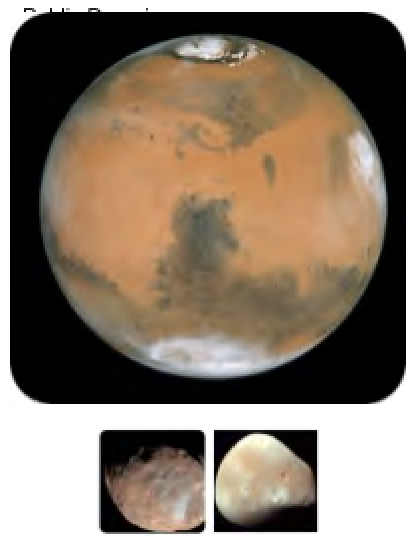
Public Domain

- It is the second planet from the Sun.
- It spins slowly backwards as it orbits the Sun.
- Its atmosphere is mostly made up of carbon dioxide.
- The atmosphere traps heat making Venus the hottest planet (860˚F).
- Its surface is one dominated largely by volcanic activity.
- There are very few craters on Venus.
- It has no moons.
- Rotation: 243 Earth days.
- Revolution: 224.7 Earth days.
- Distance from Sun: 0.72 AU's.

Earth

- It is the third planet from the Sun.
- It is covered by about 70% water and 30% land.
- It has 1 large moon.
- It has conditions necessary to support life.
- It has volcanoes, mountains, earthquakes and a few craters.
- Rotation: 24 hours.
- Revolution: 365.25 days.
- Distance from Sun: 1 AU.

Mars



Mars and its moons (Phobos and Deimos)
Public Domain

- It is the fourth planet from the sun.
- Iron oxides (rust) cause its surface to be reddish in color.
- It has polar ice caps made of frozen carbon dioxide and water ice.
- It has 2 small moons (Phobos and Deimos).
- It has a thin atmosphere that is less than 1% of Earth's.
- Huge dust storms sometimes cover the surface.
- Rotation: 24.6 hours.
- Revolution: 687 Earth days.
- Distance from Sun: 1.52 AU's.

Jupiter


Public Domain

- It is the fifth planet from the sun.
- Its atmosphere is made mostly of hydrogen, helium and methane.
- Its Great Red Spot is a storm, which has lasted for at least 400 years.
- It has a very small and faint ring system.
- It has 4 large and 63 small moons for a total of 67 moons.
- It is the largest planet in our solar system.
- Jupiter has very faint rings discovered by Pioneer 10.
- Ganymede is the largest moon in the Solar System. It is larger than Mercury.
- Four largest moons (Io, Europa, Callisto, and Ganymede) were discovered by Galileo in 1610
- Rotation: 9.9 hours.
- Revolution: 11.9 Earth years.
- Distance from Sun: 5.2 AU’s.

Saturn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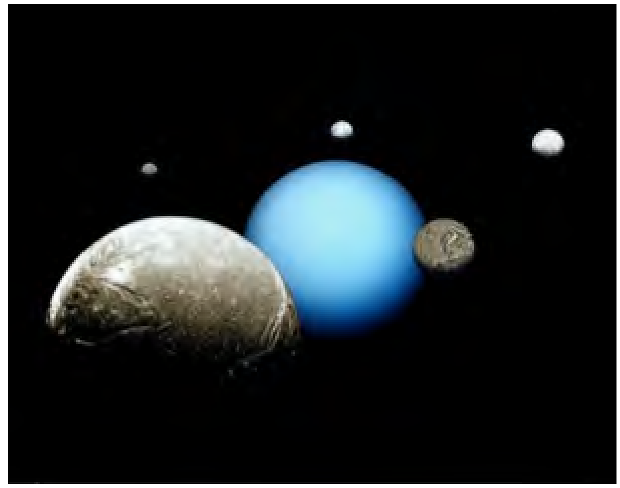
- It is the sixth planet from the Sun.
- It is the second largest planet.
- It has an atmosphere of hydrogen, helium, and methane.
- It has 82 moons, the most of any planet..
- The largest moon, Titan, is larger than Mercury.
- It is not very dense, so if it were set upon Earth’s oceans, it would float.
- It has a large ring system. Saturn and rings would fit between the Earth and the Moon.
- Rotation: 10.7 hours.
- Revolution: 29.4 Earth years.
- Distance from Sun: 9.58 AU’s.

Uranus

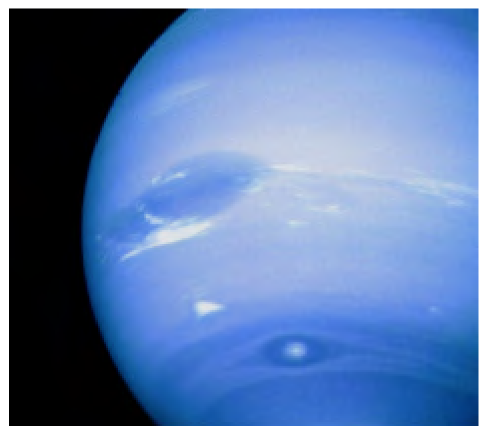
- It is the seventh planet from the Sun.
- It is the third largest planet in our solar system.
- It has a small faint ring system.
- Its axis points toward the Sun, so it rotates on its side.
- It has 27 moons.
- It has an atmosphere of hydrogen, helium, and methane.
- Methane causes Uranus to appear blue in color.
- Rotation: 17.2 hours.
- Revolution: 83.7 Earth years.
- Distance from Sun: 19.20 AU's.



Public Domain

Neptune

- It is the eighth planet from the Sun.
- It sometimes has a Great Dark Spot that is a huge storm system as large as Earth.
- It has the fastest winds in the solar system.
- Its atmosphere is made of hydrogen, helium, and methane.
- Methane causes Neptune to appear blue in color.
- It has 14 moons.
- Its moon, Triton, has an atmosphere.
- It has a small, faint ring system.
- Rotation: 16.1 hours.
- Revolution: 163.7 Earth years.
- Distance from Sun: 30.05 AU's.



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Comparing the Eight Planets

The sizes of the planets in this picture are shown to scale and allow us to compare sizes. The distances between the planets are not to scale.

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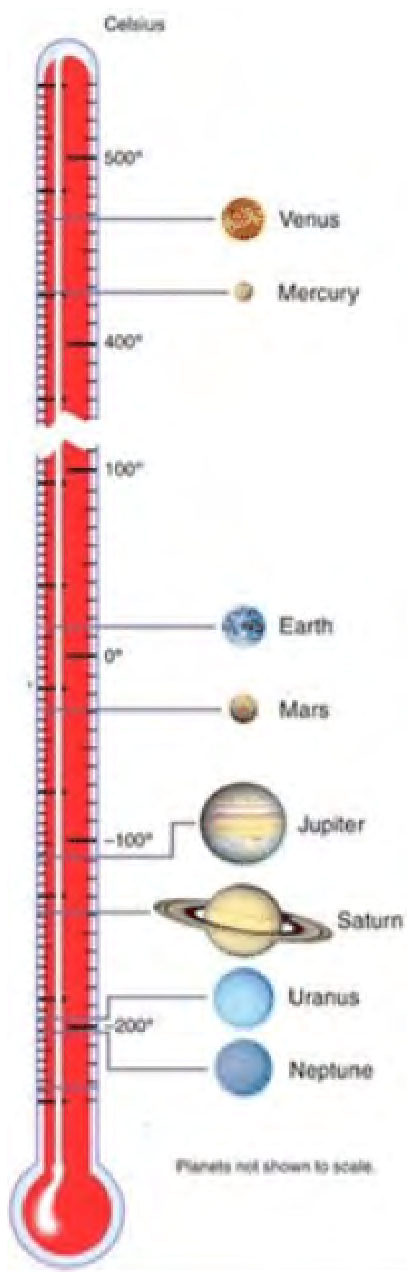

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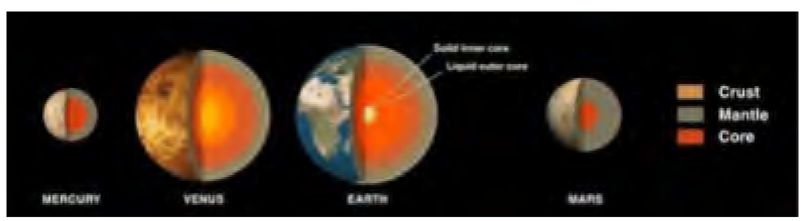
Here is an image showing the average temperatures of the planets. Mercury is the closest to the Sun, but Venus is actually hotter than Mercury.

The Inner Planets

Look at the picture of the solar system again. The four planets closest to the Sun, Mercury, Venus, Earth, and Mars, are called the inner planets. They all are made of rock; some of them have a thin layer of gas around them called an atmosphere.

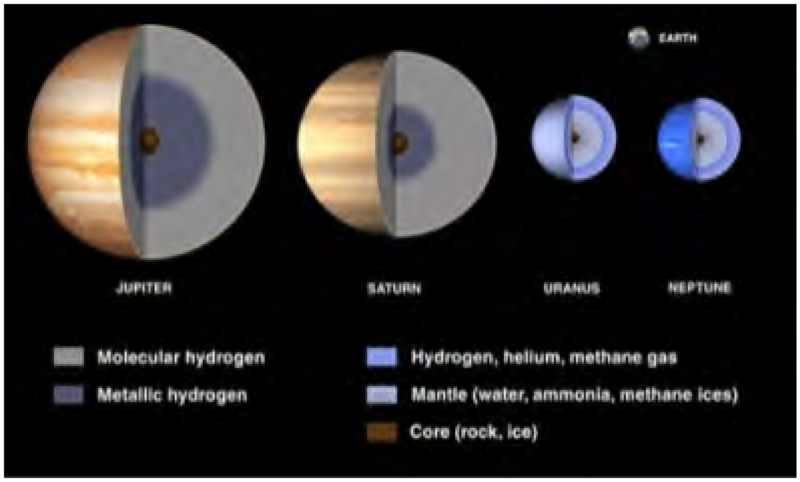
The next image shows us what the cores of each of the rocky planets may look like. The core is the inner part of the planet, and it is made up of different layers.



Inner Planets
(Public Domain)

The Outer Planets

The four outer planets are gas giants. These planets are very far from the Sun. They don't have a hard surface that a spacecraft can land on. Instead, they are giant balls of very cold gases. Astronomers think that these planets have hot, solid cores, deep beneath their atmospheres.



Outer Planets
(Public Domain)

Dwarf Planets

The dwarf planets of our solar system are exciting proof of how much we are learning about our solar system. With the discovery of many new objects in our solar system, astronomers refined the definition of a planet in 2006. Pluto did not fit the criteria for a planet, so it was placed in a new category of dwarf planets with other similar celestial bodies.

According to the International Astronomical Union (IAU), a dwarf planet must:

- Orbit a star
- Have enough mass to be nearly spherical
- Not have cleared the area around its orbit of smaller objects
- Not be a moon

Dwarf planets are like planets except they have not cleared their orbits of smaller objects, such as rocks and dust. They do not have enough gravity to pull the rocks and dust into the composition of the planet.

Pluto and its moon, Charon, are actually two objects.
(Public Domain)

There are many dwarf planets. Here are five that have been recognized by the IAU: Pluto, Ceres, Haumea, Makemake, and Eris.

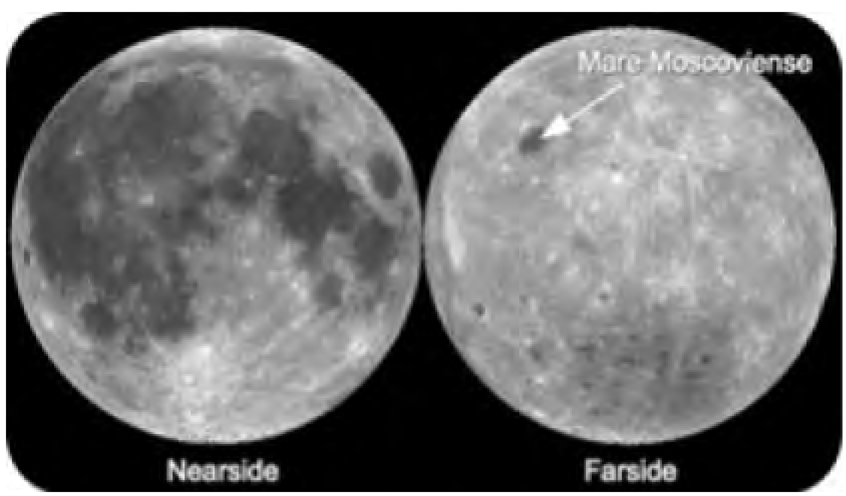
Dwarf Planet	Diameter	# of Moons	Location
Pluto	2,400 km	3	Kuiper Belt, sometimes passes inside Neptune's orbit
Ceres	950 km	0	Asteroid belt
Haumea	1,916x1,518*	2	Kuiper Belt
Makemake	Between 1,360 and 1,480**	0	Kuiper Belt
Eris	2,326 km	1	Kuiper Belt

**diameter of the dwarf planet along its longest axis.*
***estimate based on current data*

Astronomers know there may be other dwarf planets far out in the solar system. Look for Quaoar, Varuna, and Orcus to possibly be added to the list of dwarf planets in the future. We still have a lot to discover and explore!

Earth's Moon

A moon is a celestial body that orbits around a planet.



(Public Domain)

The surface of Earth's Moon is covered with craters that are made by space rocks that hit the Moon at high speeds. The rocks may be as small as grains of sand or as big as a house. They travel so fast that they explode when they hit the Moon, and they make a round hole. The Moon has a pale grey surface. You can also see dark grey marks on it.

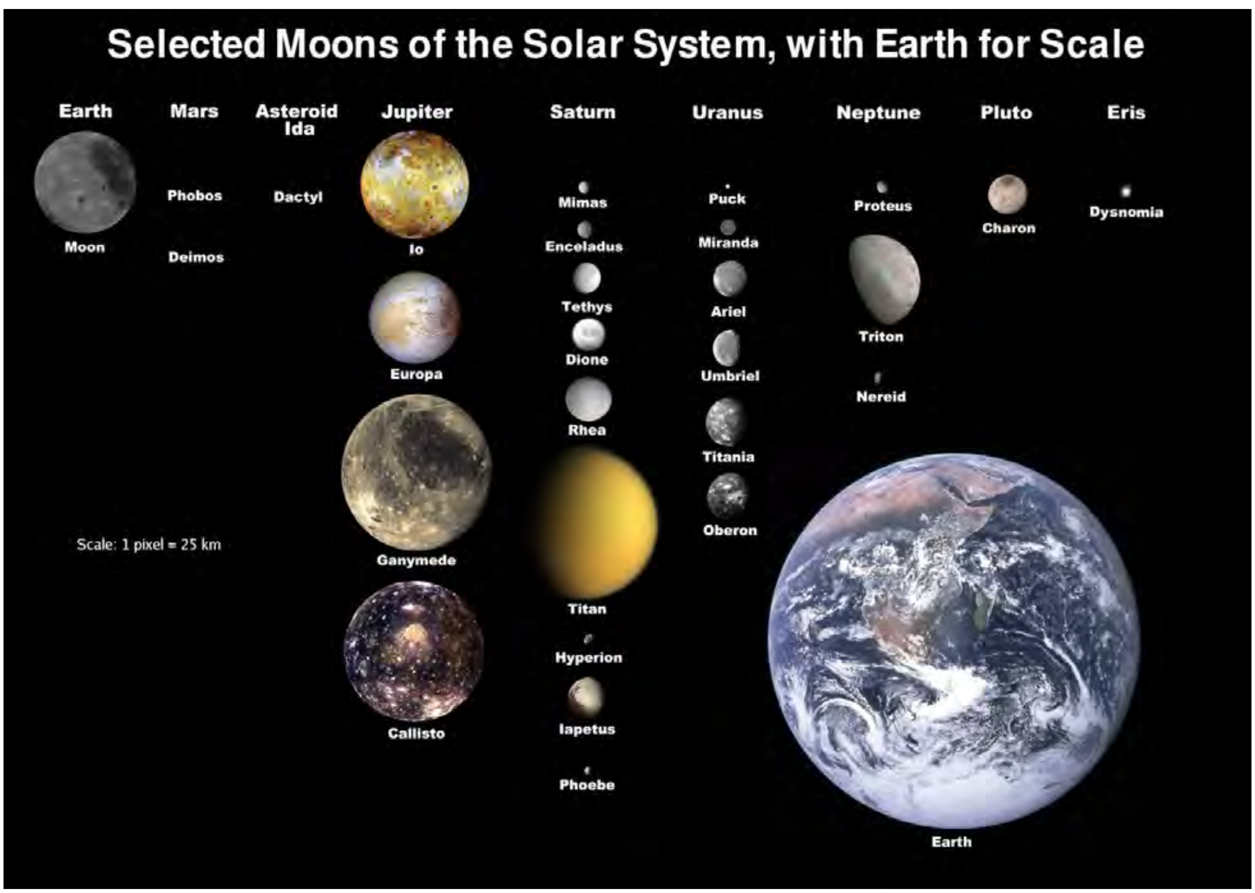
The first astronauts to walk on the Moon stepped into fine, powdery dust. They collected rock samples to bring back to Earth. The footprints from the astronauts who first walked on the Moon are still there! There is no wind on the Moon to blow them away. Those footprints will be on the moon in many thousands of years.

(Public Domain)

The light-colored areas are craters, highlands, and mountains. The darker areas are plains. Some of these plains were made when huge space rocks hit the Moon. They later filled with lava. Because the Moon has no air, no wind, and no water, there is no erosion. That is the reason why the craters on the Moon change very little after they are made.

Moons of Other Planets

Other planets have moons too. The next image shows some of the moons in our solar system. Not all of them are shown here. They are at the correct size scale so they can be compared to Earth and our Moon.



Public Domain, NASA

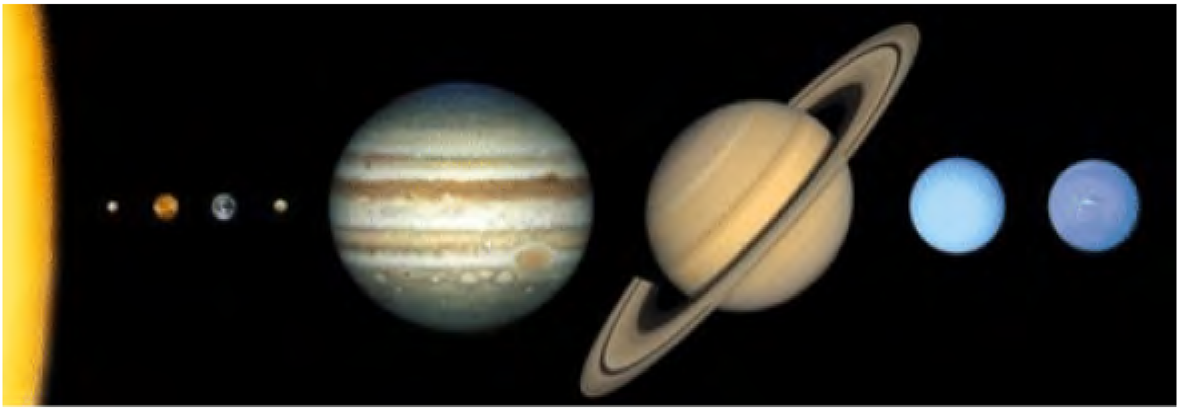
Focus Questions

1. What patterns can you identify among planets that have a larger diameter?

2. What characteristics of Pluto might have led to it being classified as a Dwarf Planet rather than a Planet?

3. What is an astronomical unit? Why is this unit used to measure distances in the solar system?

Putting It Together



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The image above is one example of a model of our solar system. Review what you wrote at the beginning of this section. Based on what you have learned rewrite your answers.

1. What is useful about this model for understanding the solar system?

2. What are the limitations of this model?

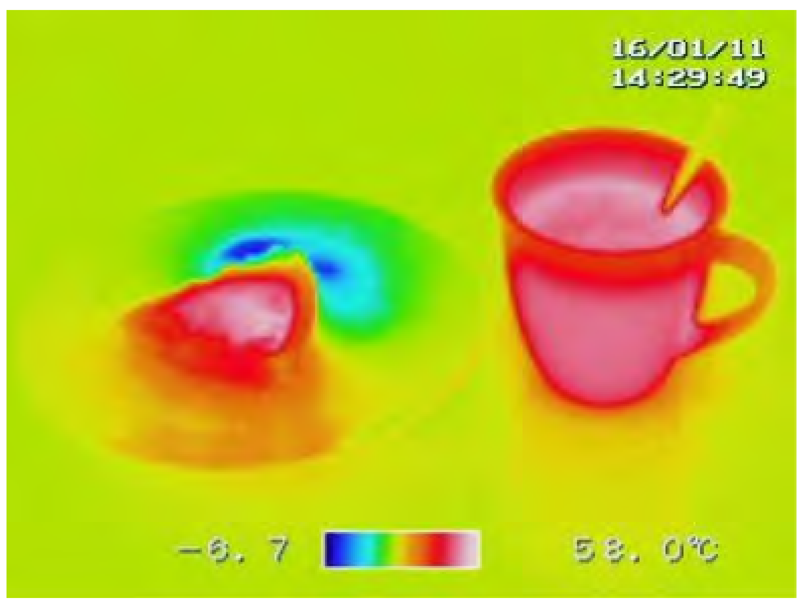
3. Is this model an accurate scale depiction for size and distance? Why? Provide evidence for your reasoning.

CHAPTER 2

Strand 2: Energy and Matter

Chapter Outline

Matter and energy are fundamental components of the universe. Matter is anything that has mass and takes up space. Transfer of energy creates change in matter. Changes between general states of matter can occur through the transfer of energy. Density describes how closely matter is packed together. Substances with a higher density have more matter in a given space than substances with a lower density. Changes in heat energy can alter the density of a material. Insulators resist the transfer of heat energy, while conductors easily transfer heat energy. These differences in energy flow can be used to design products to meet the needs of society.



Cup of coffee and slice of apple pie with ice cream on it through an infrared camera
wikimedia, Public Domain

2.1 Atoms and Molecules (6.2.1)

Explore this Phenomenon

Pixabay.com, CC0

Salt and sugar look and feel similar. However, they do not taste similar? Why?

Develop an initial model to explain how matter, such as sugar and salt, may look similar but taste very different.

6.2.1 Atoms and Molecules

Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H_2O), atmospheric oxygen (O_2), and carbon dioxide (CO_2). (PS1.A)

In this section focus on proportions and quantities. There are differences between atoms and molecules. It is important to develop models that show how different proportions and quantities of atoms form different molecules.

Atoms and Molecules

Everything you can see, touch, smell, feel, and taste is made of atoms. Atoms are the basic building-block of all matter (including you and me, and everyone else you'll ever meet), if we want to know about what something is made of, then you have to know a few things about these incredibly small particles.

Smallest Building Blocks

Everyday experiences should convince you that matter is found in many forms, yet all matter you have ever seen is made of atoms. Atoms are the smallest unit of matter. These atoms combine to form molecules, which can be made up of the same or different types of atoms. Molecules are formed when two or more atoms link up. For instance, a molecule of oxygen that we breathe is made of two atoms of oxygen (O_2). A molecule of water is made of two atoms of hydrogen (H_2) and one atom of oxygen (O). All water molecules have the same ratio: two hydrogen to one oxygen (H_2O). The next figure shows a water molecule that has two hydrogen atoms (shown in gray) bonded to one oxygen atom (shown in red).

Label the atoms in this model.

(ck12.org, CC BY-SA)

To help develop your model of atoms and molecules, think of interlocking building blocks. Each block is individual with its own color, shape, and size like an atom. You can combine these blocks together to form a simple structure like a molecule.

Two things are important to know about molecules:

- A molecule always has the same type of atoms in the same proportions. For example, carbon dioxide always has two atoms of oxygen for each atom of carbon, and water always has two atoms of hydrogen for each atom of oxygen.

- A pure substance always has the same composition throughout. For example, all the water in the ocean has the same type and proportion of atoms.

Properties of Molecules

The properties of a molecule are different from the properties of the atoms that form them. That's because atoms in a molecule combine and become an entirely different substance with its own unique properties. Do you put salt on your food? Table salt is the molecule sodium chloride. A molecule of table salt, contains an atom of sodium and an atom of chlorine. As shown in the figure below, sodium is a solid that reacts explosively with water, and chlorine is a poisonous gas. But together in table salt, sodium and chlorine form a harmless unreactive compound that you can safely eat.

(ck12.org, CC BY-SA)

Focus Questions

1. How would a model of an atom and molecule be different?

2. How would you model a carbon dioxide molecule that has one atom of carbon and two atoms of oxygen (CO_2)?

Putting It Together


Review your initial model. Based on what you have learned, draw a revised model to explain how matter, such as sugar and salt, may look similar but taste very different. Be sure to add labels or captions to your revised model.

2.2 States of Matter (6.2.2)

Explore this Phenomenon

(CC0)

Hold a chocolate chip in your hand for a few minutes. Record your observations and questions in the chart below.

Observations	Questions

Draw a model to explain what causes chocolate to melt and what happens when it melts.

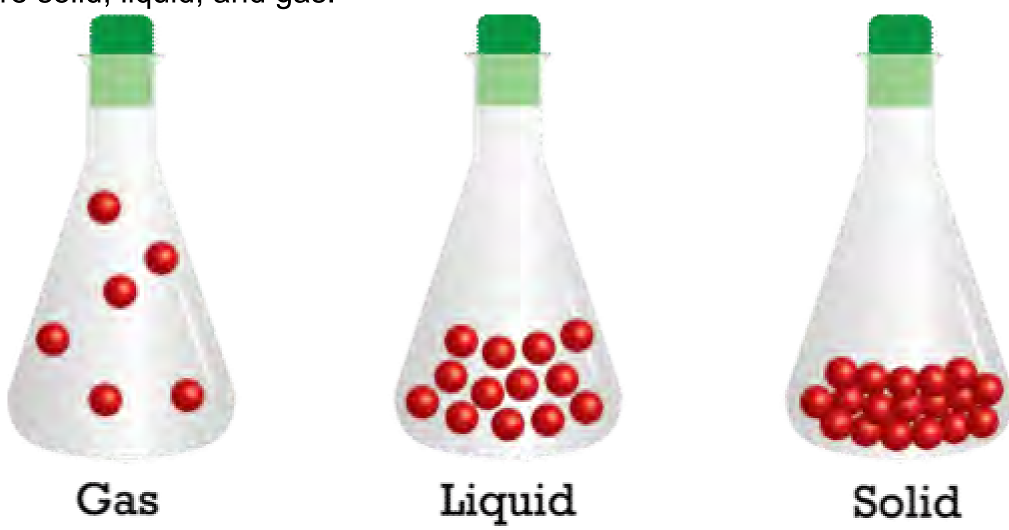
6.2.2 States of Matter

Develop a model to predict the <u>effect</u> of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating). (PS1.A, PS3.A)

In this section, focus on cause and effect. Events have causes. Look for relationships that explain why things are happening. Notice how adding and removing energy causes phase changes and how that affects density.

States of Matter

There are three major states in which any given type of matter can exist. The three states are solid, liquid, and gas.



(ck12.org, CC BY-SA)

Solids are defined by the following characteristics:

- Definite shape (will hold its shape)
- Definite volume
- Particles vibrate in place

Liquids have the following characteristics:

- No definite shape (takes the shape of its container)
- Has definite volume

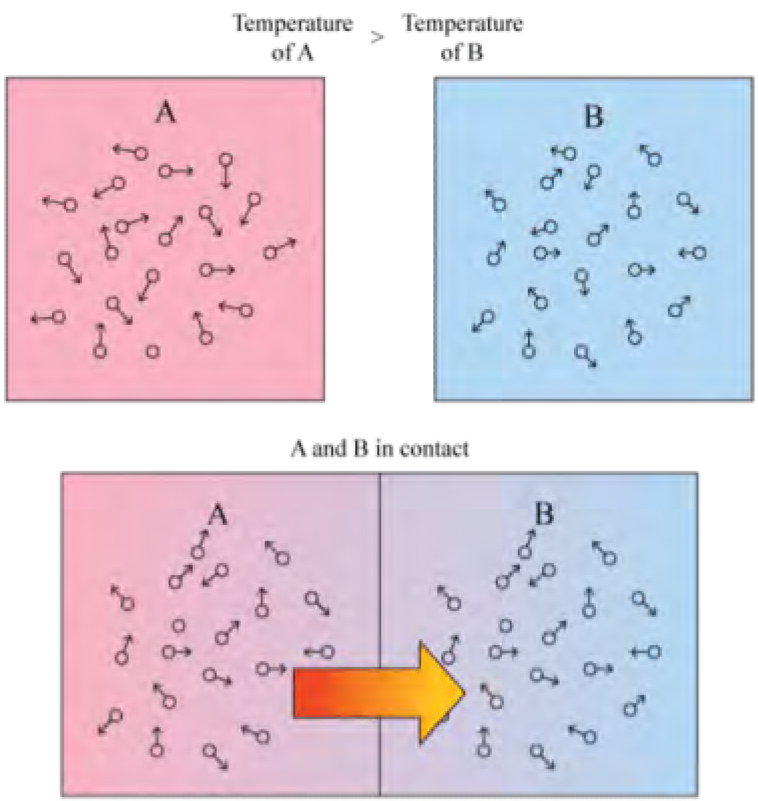
- Particles are free to move over each other, but are still attracted to each other

Gases have the following characteristics:
- No definite shape (takes the shape of its container)
- No definite volume
- Particles move in random motion with little or no attraction to each other

How tightly atoms and molecules are packed together is referred to as density. Solids are denser than liquids. Liquids are denser than gases.

What Is Heat?

Heat is the transfer of thermal energy between substances. Thermal energy is the energy causing the particles of matter to move. Temperature is the average measure of that energy. Thermal energy always moves from matter with greater thermal energy to matter with less thermal energy, so it moves from warmer to cooler substances. You can see this in the next figure.



(ck12.org, CC BY-SA)

Faster-moving particles of the warmer substance bump into and transfer some of their energy to slower-moving particles of the cooler substance. Thermal energy is transferred in this way until both substances have the same thermal energy and temperature. (equilibrium)

As thermal energy is transferred, materials expand and temperature increases. As temperatures decrease materials tend to contract. The density of a substance is temperature dependent and usually decreases as temperature increases. Density is an important physical property of matter. It reflects how closely packed the particles are along with the arrangement of the particles in matter. For instance, a golf ball and a table tennis ball are about the same size. However, the golf ball is much heavier than the table tennis ball. Now imagine a similar size ball made out of lead. That would be very heavy indeed! What are we comparing? By comparing the mass of an object relative to its size, we are studying a property called density. Matter with less density will rise and matter with greater density will sink.

How do you cool down a glass of room-temperature cola? You probably add ice cubes to it, as in the last picture. You might think that the ice cools down the cola, but in fact, it works the other way around. The warm cola heats up the ice. Thermal energy from the warm cola is transferred to the much colder ice, causing it to melt. The cola loses thermal energy in the process, so its temperature falls.

(*Tumbler of Cola with Ice* by Simon Cousins, CC-BY)

Changes in States of Matter

A change of state occurs whenever matter changes from one state to another, for example a solid changing to a liquid. This change is an effect of energy being transferred from one substance to another. Changes of state are physical changes, meaning they are reversible changes and do not change how molecules are combined. For example, when fog changes to water vapor, it is still water (H_2O) and can change back to liquid water again. Matter may change back and forth between these states.

As energy in a substance is transferred, it causes a change in its state. In the previous example, ice was added to a cola. The energy was transferred from the warmer cola to the cooler ice. This caused the ice to melt and change from a solid to a liquid.

Types of Phase Changes

Melting occurs when particles of a solid absorb enough energy to partly overcome the force of attraction holding them together. This allows them to move out of their fixed positions and slip over one another. The solid becomes a liquid.

The process in which water or any other liquid changes to a solid is called freezing. Freezing occurs when a liquid cools to a point at which its particles no longer have enough energy to overcome the force of attraction between them. Instead, the particles remain in fixed positions, crowded closely together.

When air cools, it can hold less water vapor, so some of the water vapor in the air changed to liquid water. The process in which water vapor—or another gas—changes to a liquid is called condensation. Another common example of condensation is pictured in the next figure.

This picture shows the contrail (condensation trail) left behind by a jet. Water vapor in its exhaust gases condense on dust particles in the air.
By Stiopa - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=25255800

Evaporation is the process in which a liquid changes to a gas. It occurs when individual liquid particles at the exposed surface of the liquid absorb just enough energy to overcome the force of attraction with other liquid particles. If the surface particles are moving in the right direction, they will pull away from the liquid and move into the air becoming a gas.

- Visit this interactive to explore States of Matter: http://go.uen.org/aZe

Focus Questions:

1. Draw a model that shows the motion of particles in a solid, liquid and a gas.

2. Why do chocolate chips melt in your hand?

3. Ice floats in water. What does this tell us about the density of ice?

Visit this video to learn more about the density of ice: http://go.uen.org/b1k

Putting It Together

(CC0)

Develop a model of the melting chocolate to explain the effect of heat energy on the states of matter and density.

2.3 Heat Energy and Particle Motion (6.2.3)

Explore this Phenomenon

(*Emerald Bay, Lake Tahoe, USA* by Michael https://commons.wikimedia.org/wiki/File:Emerald_Bay.jpg#/media/File:Emerald_Bay.jpg, CC-BY)

Pixabay.com, CC0

The first photo shows a large lake, and the second shows a small pond. The two different bodies of water are close in geographic location. Which body of water will freeze first? Explain your reasoning.

6.2.3 Heat Energy

Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation. (PS3.A)

In this section, focus on the relationship between heat transfer and the average particle motion in matter.

Heat Energy and Particle Motion

When heat flows into an object, its thermal energy increases and so does its temperature. The amount of temperature increase depends on three things: 1) how much heat was added, 2) the size of the object, and 3) the material of which the object is made.

Thermal energy and temperature are closely related. Both reflect the amount of moving particles of matter as energy. However, temperature is the average measure of that energy, whereas thermal energy is the total energy within a system. Does this mean that matter with a lower temperature has less thermal energy than matter with a higher temperature? Not necessarily. Another factor also affects thermal energy. The other factor is mass.

(ck12.org, CC-BYSA)

The soup is boiling hot and has a temperature of 100 °C (212 F), whereas the water in the tub is just comfortably warm, with a temperature of about 38 °C(100.4F). Although the water in the tub has a much lower temperature, it has greater thermal energy. This is because temperature is a measure of the average energy of the particles, rather than a measure of the total energy. The particles of soup have a greater average energy than the particles of water in the tub; the soup has a higher temperature. However, the mass of the water in the tub is much greater than the mass of the soup in the pot. This means that there are many more particles of water in the tub than particles in the soup. All these moving particles give the water in the tub greater total energy, even though their average energy is less. Therefore, the water in the tub has greater thermal energy than the soup.

Focus Questions

1. What factors influence how much the temperature of an object will increase or decrease?

2. Look at the pot of soup and the tub of water in the figure above. Which object has a greater amount of thermal energy? Explain your reasoning.

3. What is the difference between thermal energy and temperature? Describe an example.

Putting It Together

(*Emerald Bay, Lake Tahoe, USA* by Michael https://commons.wikimedia.org/wiki/File:Emerald_Bay.jpg#/media/File:Emerald_Bay.jpg, CC-BY)

Pixabay.com, CC0

Reread your initial explanation about which body of water will freeze first. Then consider what you have learned about thermal energy and construct an explanation that describes which body of water will freeze first and why.

2.4 Engineering Design (6.2.4)

Explore this Phenomenon

CC0

Have you ever noticed that when you walk on a tile floor it feels colder than when you walk on carpet?

Why does a tile floor feel colder than carpet?

6.2.4 Engineering Design

Design *an object, tool, or process* that minimizes or maximizes heat energy transfer. *Identify criteria and constraints, develop a prototype for iterative testing, analyze data from testing, and propose modifications for optimizing the* ***design solution****.* Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C)

Engineering uses scientific knowledge to solve human needs and wants. In this section focus on how the structure of different materials helps them function as conductors or insulators.

Engineering Design

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

Engineering design can be accomplished in many different ways. Some of the steps have to be repeated, and the steps may not always be done in the same sequence, but there are some basic steps to solving an engineering problem. First, an engineer defines the problem that needs to be solved, and researches what criteria (success outcomes) and constraints (limitations) they need to consider. Next, engineers brainstorm to come up with many possible ideas for solutions. Finally, engineers select the solution that best meets the criteria and constraints for the situation. They design, build, test, and revise their solution. This is called optimizing the solution.

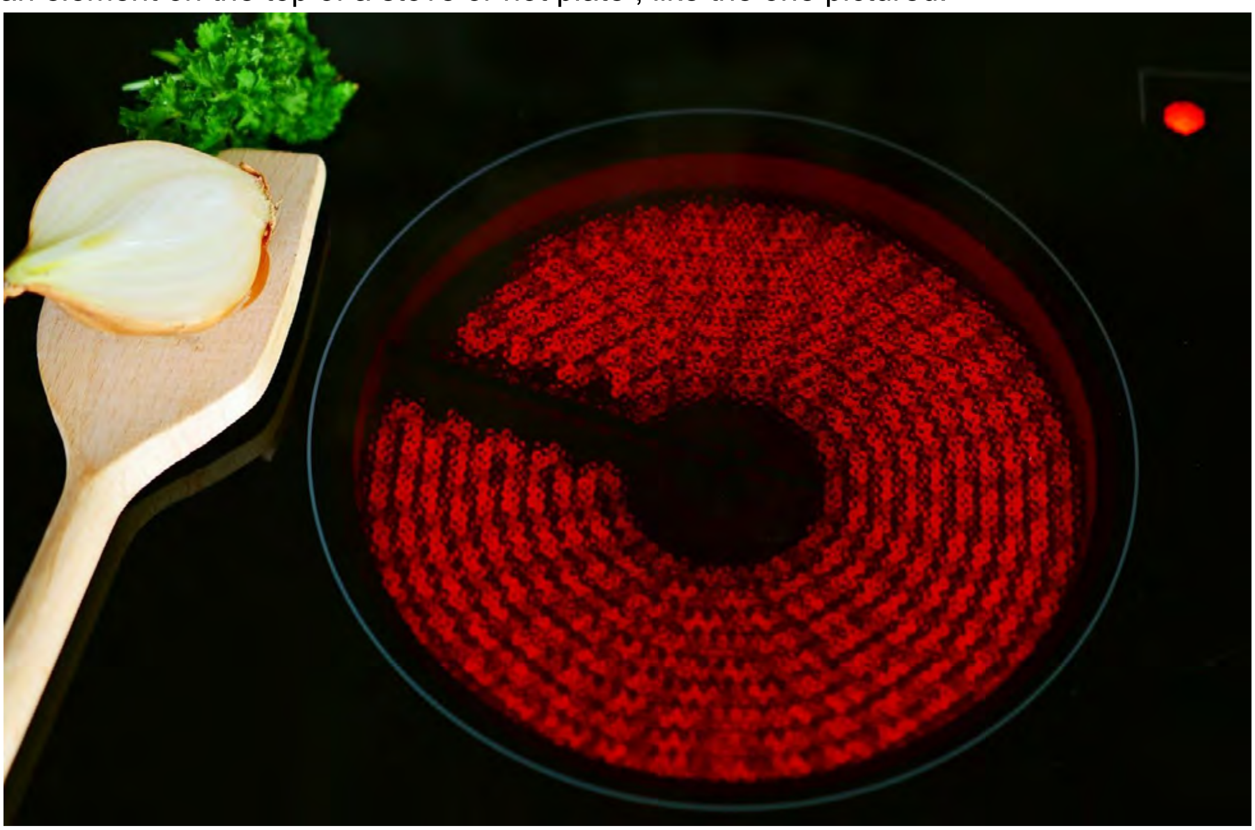
Consider the problem of developing a solar-powered car. Many questions would have to be researched in the design process. For example, what is the best shape for gathering the sun's rays? How will sunlight be converted to usable energy to run the car? Will a backup energy source be needed? After researching the answers, possible designs are developed. This generally takes imagination as well as sound reasoning. Then a model must be designed and tested. This allows any problems with the design to be worked out before a final design is selected and produced.

Heat Energy Transfer: Thermal Conductors

Conduction is the transfer of thermal energy between particles of matter that are touching. Thermal conduction occurs when particles of warmer matter bump into particles of cooler matter and transfer some of their thermal energy to the cooler particles. Conduction is usually faster in certain solids and liquids than in gases. Materials that are good conductors of thermal energy are called thermal conductors.

When hot water flows through the coils of the radiator, the metal quickly heats up by conduction and then radiates thermal energy into the surrounding air.

Besides the heating element inside a toaster, another example of a thermal conductor is an element on the top of a stove or hot plate , like the one pictured.



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 picture, are good thermal insulators because their feather filling traps a lot of air.

(ck12.org, CC-BY-SA)

Another example of a thermal insulator is pictured below. This picture shows fluffy pink insulation inside the attic of a home. Like the down filling in a snowsuit, the insulation traps a lot of air. The insulation helps to prevent the transfer of thermal energy into the house on hot days and out of the house on cold days. Other materials that are thermal insulators include plastic and wood. That's why pot handles and cooking utensils are often made of these materials. This helps to prevent the transfer of energy that can cause burns.

(ck12.org)

Focus Questions

1. What are some examples of thermal conductors? What makes these examples thermal conductors?

2. What are some examples of thermal insulators? What makes these examples thermal insulators?

3. What types of materials would be useful in maintaining the temperature in a home? Why?

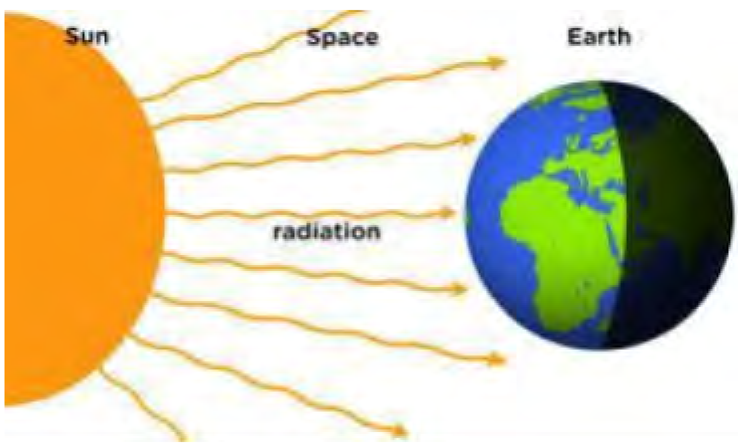
Putting It Together

Based on what you have learned, revise your initial explanation to describe why a tile floor feels colder than carpet when you stand on it.

CHAPTER 3

Strand 3: Earth's Weather Patterns and Climate

Chapter Outline



(Public Domain)

The Sun is the main source of Earth's heat. Heat is transferred through radiation. It affects our weather. It causes the water cycle. Earth's surface is heated unevenly. Uneven heating affects the density of atmosphere and ocean currents. This results in convection currents. Convection currents are formed in the oceans and atmosphere. This circulation influences regional and global climates.

3.1 Water Cycle (6.3.1)

Explore This Phenomenon

A small amount of liquid water on the surface of a table. **24 hours later the water is gone.**
Image by Robert Bigelow, Clark Planetarium

Pour a small amount of water onto a table in a warm room or on the sidewalk outside. If you continue to observe the water from time to time, you will find that eventually all the water you poured out will be gone. If you pour water onto the sidewalk when the Sun is shining, the water is gone very quickly. Why does the water disappear? Where does the water go?

6.3.1 Water Cycle

Develop a model to describe how the cycling of water through Earth's systems is driven by energy from the Sun, gravitational forces, and density. (ESS2.C)

In this section, focus on energy. Think about how the transfer of energy drives the motion and cycling of water throughout the water cycle.

The Water Cycle

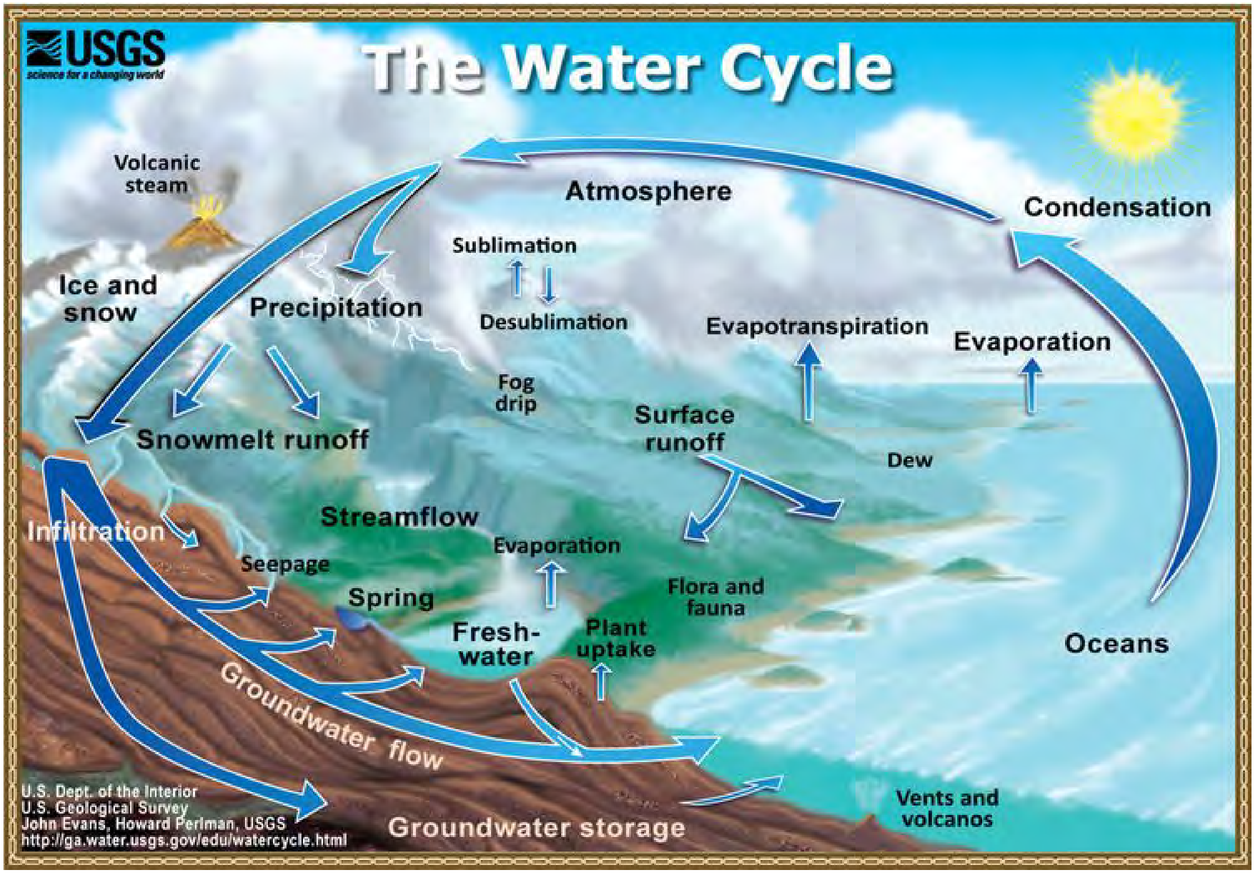
The water molecules found in your glass of water could have erupted from a volcano early in Earth's history. The molecules probably spent time in a glacier. They may have been far below the ground. They could have been in the belly of a dinosaur. Because of the properties of water, water molecules can cycle through almost anywhere on Earth. Where will those water molecules go next?

Water constantly moves between living organisms, such as plants. It moves between non-living things, such as clouds, rivers, and oceans. The water cycle does not have a starting or ending point. It is a nonstop recycling process. It involves oceans, lakes and other bodies of water. It also involves the land surfaces and the atmosphere. One possible pathway water could follow is:

- Water molecules on the ocean's surface get energy from the Sun. The molecules change from a liquid to gas. This process is called ***evaporation***. Evaporated water molecules mix with the air molecules above the ocean surface.
- The air with these gaseous water molecules is heated by the Sun. This heated air rises high in the atmosphere.
- Temperature decreases with altitude. High in the atmosphere the temperature is cold enough for water molecules in the air to lose energy and become denser. This causes them to change from a gas into many tiny droplets of liquid water, a process called ***condensation***. These tiny water droplets form a cloud. This cloud is pushed by winds which carry it over land.
- As the water droplets in the cloud increase in size, they become heavier and eventually fall back to Earth's surface. This is called ***precipitation***.
- When the liquid water molecules reach the surface, they can move into the ground or flow along the surface. If these water molecules flow along the surface into a stream or river, they can eventually move back into the ocean where this cycle can begin again.

Most precipitation that occurs over land is not absorbed by the soil. This water remains on the surface and is called runoff. Runoff collects in streams and rivers and eventually flows back into the ocean.

Water moves through living organisms. Plants soak up water through their roots. The water moves up the plant. It will evaporate from the leaves. This process is called ***transpiration***. Another name for transpiration is evapotranspiration. Transpiration, like evaporation, returns water back into the atmosphere.



Forces that Drive the Water Cycle

Solar Energy

The Sun provides the energy that drives the water cycle. For water to evaporate it requires energy. The Sun directly supplies energy needed for evaporation. Water can also evaporate when it absorbs energy from objects it touches. Most of the energy that on Earth's surface comes either directly or indirectly from the Sun.

Density and Gravity

When a parcel of air containing gaseous water molecules is heated by the Sun, it will expand. This decreases the density of this particular parcel of air, so that it weighs less.

It will then be pushed upward by colder, denser air that is pulled downward and underneath it by gravity.

Energy lost by water molecules in condensation is acquired by the surrounding air molecules, increasing their motion. This causes the air around the water droplets to expand, decreasing its density. This heated air within the cloud rises (this upward movement of air is called an updraft). These rising air molecules exert an upward force on the liquid water drops and ice crystals in the cloud and keep them aloft even though they are denser than the air.

As cloud droplets collide they merge to form larger drops. If the drops become large enough, the force from the rising air is no longer strong enough and the drops will fall to the ground as rain, snow or hail.

Some of the water falling on land will seep into the ground. This is a process called ***infiltration***. Water which doesn't seep into the ground moves across the surface from a higher to lower elevation. This is caused by gravity. It will eventually flow into streams and rivers and then into lakes or the ocean.

Earth's Water Reservoirs

Water can be found in many different locations on the Earth. It can be found in oceans, clouds, puddles or living things. Each of these locations is called a reservoir.

Oceans

Most of Earth's water is stored in the oceans. In fact, 97% of the Earth's water is in this reservoir. Water can remain in the ocean for hundreds or thousands of years. Or it can evaporate in days or hours.

Atmosphere

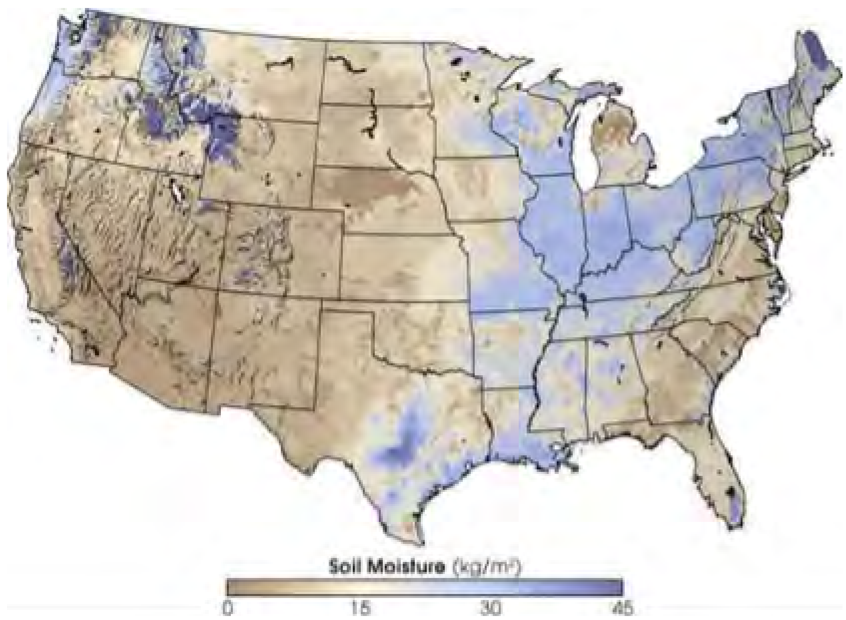
When water absorbs energy it will change from a liquid to a gas (water vapor). The Sun's energy can evaporate water from the ocean surface or from lakes, streams, or puddles on land. Water vapor remains in the atmosphere as a gas until it condenses to become tiny droplets of liquid. If it is cold enough, the water molecules can freeze and form ice crystals. The droplets (or ice crystals) make up clouds, which are blown about the globe by wind. As water droplets in the clouds collide and grow, they fall from the sky as precipitation. Precipitation can be rain, sleet, hail, or snow. Sometimes precipitation falls back into the ocean and sometimes it falls onto the land surface.

Streams and Lakes

When water falls from the sky as rain it may enter streams and rivers that flow downward to lakes and oceans. Water that falls as snow may sit on a mountain for several months. Snow may become ice in a glacier, where it will remain for hundreds or thousands of years. Snow and ice slowly melt over time to become liquid water, which provides a steady flow of fresh water to streams, rivers, and lakes. A water droplet falling as rain could also become part of a stream or a lake. At the surface, the water will eventually evaporate and reenter the atmosphere.

Soil

A significant amount of water seeps into the ground. Soil moisture is an important reservoir for water (next figure). Water trapped in soil is important for plants to grow.



The moisture content of soil in the United States varies greatly.
(ck12.org, CC BY-SA)

Groundwater

Water may seep through dirt and rock below the soil and then through pores infiltrating the ground. The water goes into Earth's groundwater system. Groundwater enters aquifers (which are porous layers of rock that can hold water) that may store fresh water for centuries. The water may come to the surface through springs. It may find its way back to the oceans. Water can remain in this reservoir for hundreds or even thousands of years.

Biosphere

Plants and animals depend on water to live. Plants and animals are another place where water is stored. Plants take up water from the soil and release large amounts of water vapor into the air through their leaves in transpiration. Water can move quickly through this reservoir.

Focus Questions

1. Explain how energy from the Sun affects the movement of water through the water cycle.

2. What is a water reservoir? List 3 examples of water reservoirs.

3. Describe how water can change states as it moves through the water cycle.

4. What roles do density and gravity play in the water cycle?

Putting It Together

A small amount of liquid water on the surface of a table. **24 hours later the water is gone.**
Image by Robert Bigelow, Clark Planetarium

Pour a small amount of water onto a table in a warm room or on the sidewalk outside. If you continue to observe the water from time to time, you will find that eventually all the water you poured out will be gone. If you pour water onto the sidewalk when the Sun is shining, the water is gone very quickly. Why does the water disappear? Where does the water go?

Develop a model that shows where the water in the photographs has been and where it is going based on what you have learned.

3.2 Pressure and Air Masses (6.3.2)

Explore This Phenomenon

Storm Front by Nicholas D.,
https://flic.kr/p/9VFSdS,

Visit this link for a video of a storm front moving into Salt Lake City:
http://go.uen.org/aZz

What are you observing? What are you wondering? What could be a possible explanation for this phenomenon?

6.3.2 Air Pressure

Investigate the interactions between air masses that <u>cause</u> changes in weather conditions. Collect and analyze weather data to provide evidence for how air masses flow from regions of high pressure to low pressure causing a change in weather. Examples of data collection could include field observations, laboratory experiments, weather maps, or diagrams. (ESS2.C, ESS2.D)

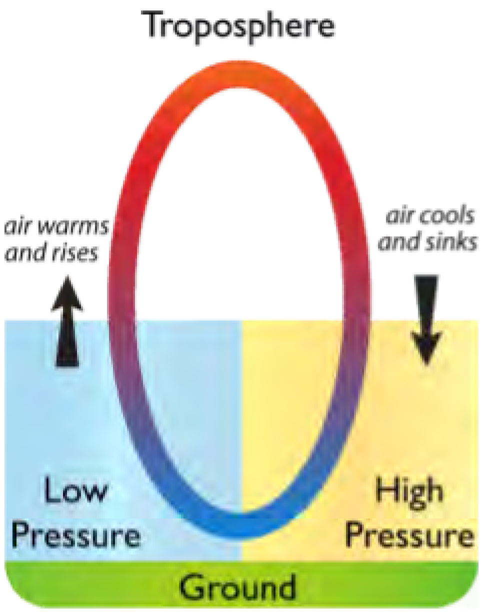
In this section, focus on cause and effect. Analyzing cause and effect relationships help us to predict natural phenomena, such as changes to the weather.

Air Pressure

Pressure in the atmosphere is created by the weight of the atmosphere pushing down on the surface. Air heated at the surface rises, creating a low pressure zone. Air from the surrounding area rushes into the space left by the rising air. As air cools it sinks back to the surface. When the air reaches the ground, it creates a high pressure zone. Air flowing from areas of high pressure to low pressure creates winds. The greater the pressure difference between the pressure zones, the stronger the wind blows.

Warm air can hold more moisture than cool air. When warm air rises and cools in a low pressure zone, it may not be able to hold all the water it contains as vapor. Some water vapor may condense to form clouds and precipitation. When cool air descends, it warms and can then hold more moisture.

Gases at sea level are also compressed by the weight of the atmosphere above them. The force of the air weighing down over a unit of area is known as its atmospheric pressure, or air pressure. Why are we not crushed? The molecules inside our bodies are pushing outward to compensate. Air pressure is felt from all directions, not just from above.



Warm air rises, creating a low pressure zone; cool air sinks, creating a high pressure zone
(ck12.org, CC BY-SA)

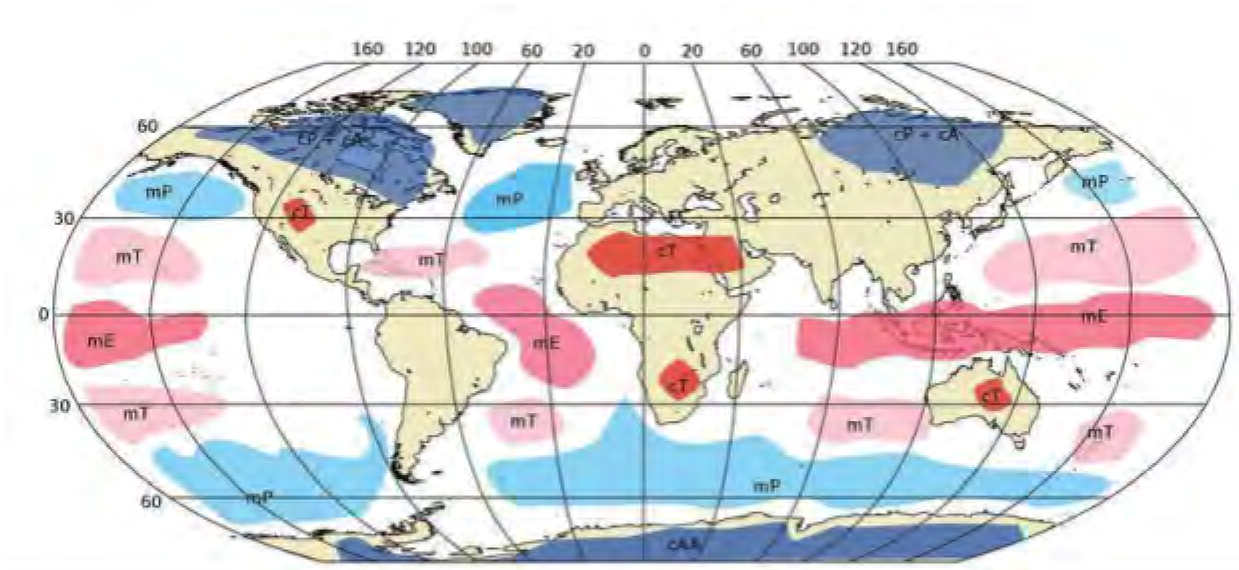

This bottle was closed at an altitude of 3,000 meters where air pressure is lower. When it was brought down to sea level, the higher air pressure caused the bottle to collapse.
(Ck12.org, CC BY-SA)

At higher altitudes the atmospheric pressure is lower and the air is less dense than at lower altitudes. That's what makes your ears pop when you change altitude. Gas molecules are found inside and outside your ears. When you change altitude quickly, like when an airplane is descending, your inner ear keeps the density of molecules at the original altitude. Eventually the air molecules inside your ear suddenly move through a small tube in your ear to equalize the pressure. This sudden rush of air is felt as a popping sensation.

Air Masses

An air mass is a body of air that has nearly the same temperature and humidity. When the air mass sits over a region for several days or longer, it picks up the distinct temperature and humidity characteristics of that region.

Air masses form over a large area. They can be 1,600 km (1,000 miles) across and several kilometers thick. Air masses form primarily in high pressure zones, most commonly in polar and tropical regions. Temperate zones are ordinarily too unstable for air masses to form. Instead, air masses move across temperate zones, so these areas are prone to having more varied weather.



This picture shows where different types of
air masses form. Some form over land and
some form over water. They are also
named for the area over which they form.
(Public Domain)

Air masses are slowly pushed along by high-level winds. When an air mass moves over a new region, it shares its temperature and humidity with that region. So the temperature and humidity of a particular location depends partly on the characteristics of the air mass that sits over it.

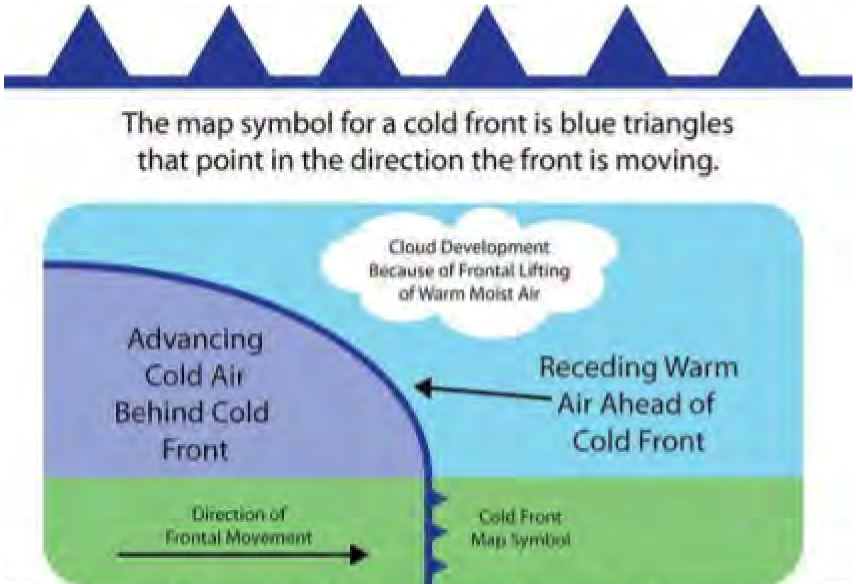
Fronts

Two air masses meet at a front. At a front, the two air masses have different characteristics and do not easily mix. One air mass is lifted above the other, creating a low pressure zone. If the lifted air is moist, there will be condensation and precipitation. Winds are common at a front. The greater the temperature difference between the two air masses, the stronger the winds will be. Fronts are the main cause of stormy weather.

There are four types of fronts, three moving and one stationary. With cold fronts and warm fronts, the air mass at the leading edge of the front gives the front its name. In other words, a cold front is right at the leading edge of moving cold air and a warm front marks the leading edge of moving warm air.

Cold Fronts

When a cold air mass takes the place of a warm air mass, there is a cold front (next figure).



The cold air mass slides beneath the warm air mass and pushes it up.
(ck12.org, CC BY-SA)

Imagine that you are standing in one spot as a cold front approaches. Along the cold front the cold air pushes up the warm air, causing the air pressure to decrease (Figure above). If the humidity is high enough clouds will develop. High in the atmosphere, winds blow ice crystals from the tops of these clouds. At the front, there will be a line of rain showers, snow showers, or thunderstorms with blustery winds. Behind the front is the cold air mass. This mass is drier, so precipitation stops. The weather may be cold and clear or only partly cloudy. Winds may continue to blow into the low pressure zone at the front.

A developing thunderstorm
(CC0)

The weather at a cold front varies with the season.

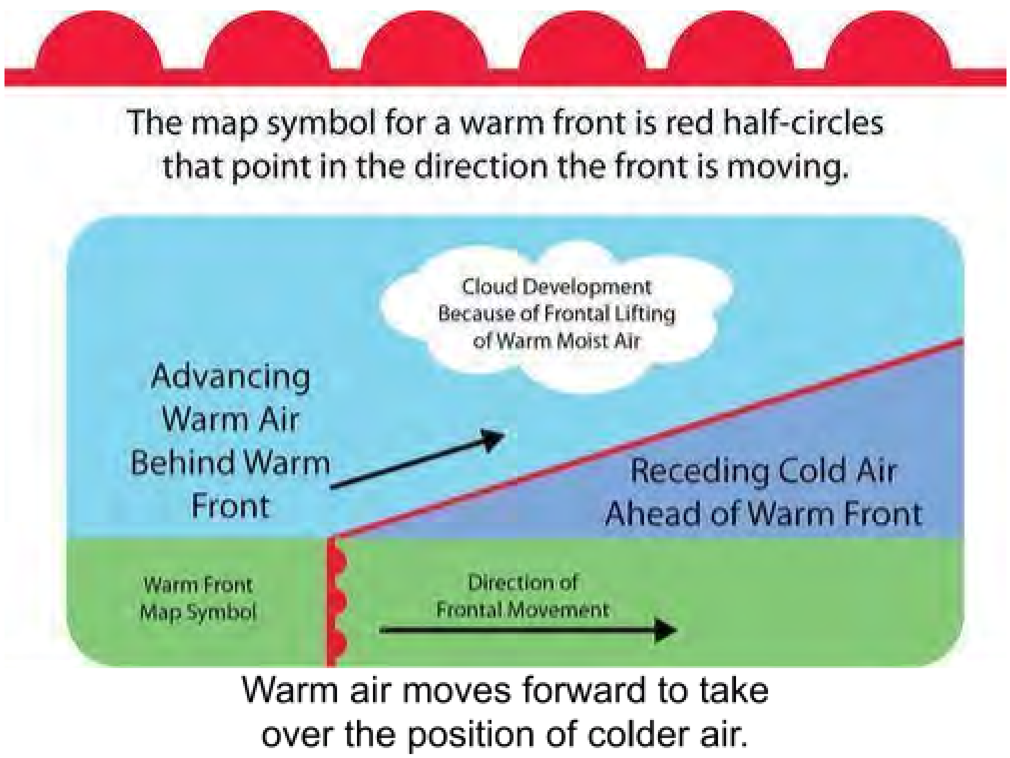
- Spring and summer: the air is unstable so thunderstorms or tornadoes may form.
- Spring: if the temperature variation is high, strong winds blow.
- Autumn: strong rains fall over a large area.
- Winter: the cold air mass is likely to have formed in the frigid arctic, so there are frigid temperatures and heavy snows.

Warm Fronts

At a warm front, a warm air mass slides over a cold air mass (next figure). When warm air moves over the colder air the atmosphere is relatively stable.

Imagine that you are on the ground in the wintertime under a cold winter air mass with a warm front approaching. The transition from cold air to warm air takes place over a long distance. The first signs of changing weather appear long before the front is actually over you. Initially, the air is cold: the cold air mass is above you and the warm air mass is above it. High clouds mark the transition from one air mass to the other.

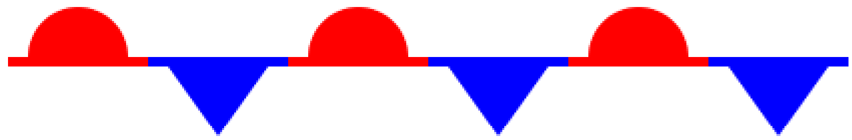
Over time, the clouds become thicker. As the front approaches clouds appear and the sky turns gray. Since it is winter precipitation falls as snow. Winds grow stronger as the low pressure approaches. As the front gets closer, the cold air mass is just above you but the warm air mass is not too far above that. The weather worsens. As the warm air mass approaches, temperatures rise and snow turns to sleet and freezing rain. Warm and cold air mix at the front, leading to the formation of clouds and fog.



(ck12.org, CC BY-SA

Stationary Fronts

At a stationary front the air masses do not move (next figure). A front may become stationary if an air mass is stopped by a barrier, such as a mountain range. A stationary front may bring days of rain, drizzle, and fog. Winds usually blow parallel to the front, but in opposite directions. After several days, the front will likely break apart.



The map symbol for a stationary front has red domes for the warm air mass and blue triangles for the cold air mass.

Occluded Fronts

An occluded front usually forms around a low pressure system (next figure). The occlusion starts when a cold front catches up to a warm front. The air masses, in order from front to back, are cold, warm, and then cold again.

The map symbol for an occluded front is mixed cold front triangles and warm front domes.

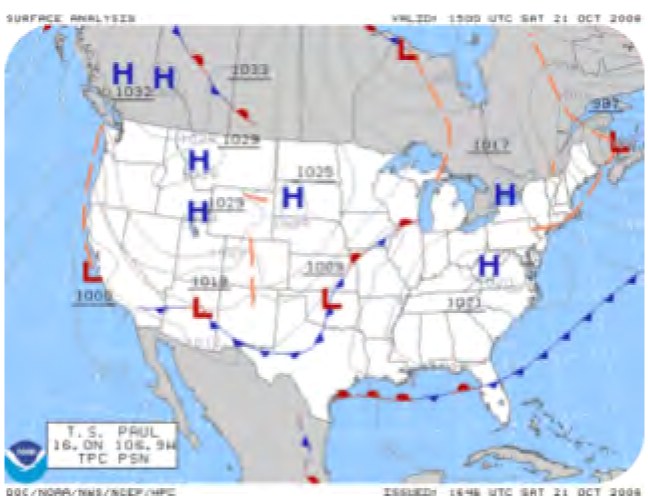
The weather at an occluded front is especially fierce right at the occlusion. Precipitation and shifting winds are typical. The Pacific Coast has frequent occluded fronts.

Focus Questions

1. Describe how the different types of air masses move.

2. What type of weather is associated with a warm front?

3. Look for patterns in the weather map from NOAA. What type of weather would you expect around low pressure areas? Why?



Public Domain

Putting It Together

Storm Front by Nicholas D.,
https://flic.kr/p/9VFSdS, CC BY-NC

Visit this link for a video of a storm front moving into Salt Lake City:
http://go.uen.org/aZz

What could be an explanation for this phenomenon? What is occurring? Why? What weather would you expect to observe? Why?

3.3 Climate (6.3.3)

Explore this Phenomenon

The same sun shines on the entire Earth.

This location is frigid and dry.
(Snowdrifts at Chimney Bank
By colin grice, via wikimedia commons, CC BY-SA)

This location is warm, moist, and mild.
(CC0)

Develop a model to explain why these two locations have different climates.

6.3.3 Climate

Develop and use a model to show how unequal heating of Earth's systems cause patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional patterns such as lake-effect and wintertime temperature inversions. (ESS2.C, ESS2.D)

As you read this section, focus on systems. Think about both the atmosphere and the ocean as systems as you learn about how heat energy is distributed around Earth by these two systems.

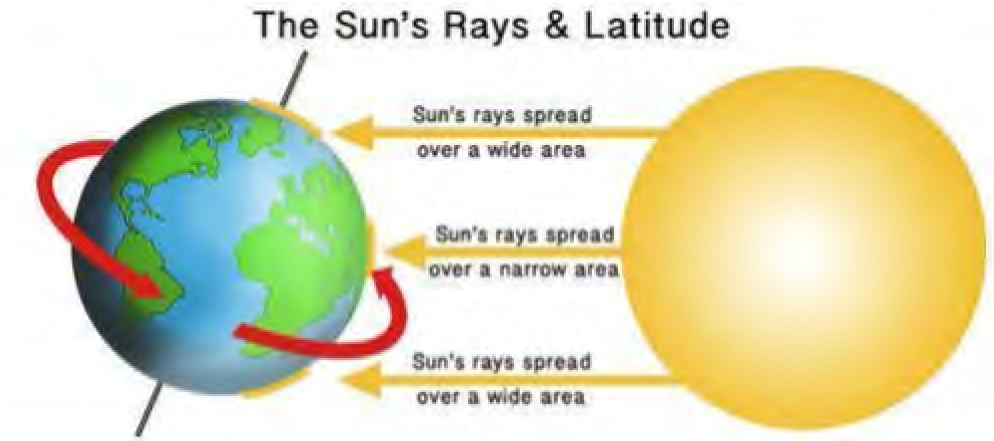
Overall Movement of Air and Water

The atmosphere and hydrosphere make a system that together moves incoming heat from the sun from the equator out across the planet. In this system, we are talking about all of the air above ground that make up the atmosphere. We are also talking about the water within the oceans of the planet. As the sun warms the air, it begins to rise and move. It forms a series of convection cells. When the movement of air is averaged out, you get three main air cells in the northern hemisphere. You also get three in the southern hemisphere. The overall motion is movement of air from the equator to the poles and back again. This air movement pushes on the ocean water. Through friction, it causes surface currents to form. These surface currents also move water that has absorbed energy at the equator. It moves to the poles, spreading out the total energy.

This is the global conveyor belt. The water freezes at the poles. It becomes salty and dense. The water sinks and slowly makes its way back to the equator. This transfer of energy, along with other geographical factors, cause areas with common weather to occur. The 30 year average of these areas is called climate. The following sections provide more information about atmospheric and oceanic circulation. This determines climate.

Energy and Latitude

Different parts of Earth's surface receive different amounts of sunlight (next figure). The Sun's rays strike Earth's surface most directly at the Equator. Near the poles, the Sun's rays strike the surface less directly. This spreads the rays over a wide area. The more focused the rays are, the more energy an area receives, and the warmer it is.



In the summer the lowest latitudes get the most energy from the Sun. The highest latitudes get the least.
(ck12.org, CC BY-SA)

The difference in solar energy received at different latitudes causes unequal heating of Earth's surface. Places that get more solar energy will be warmer. Places that get less solar energy will be cooler. Warm air rises and cool air sinks. This principle means that air moves around the planet. The Earth's atmosphere carries heat, therefore the heat moves around the globe in ways that affect weather patterns.

Circulation of the Atmosphere and the Ocean

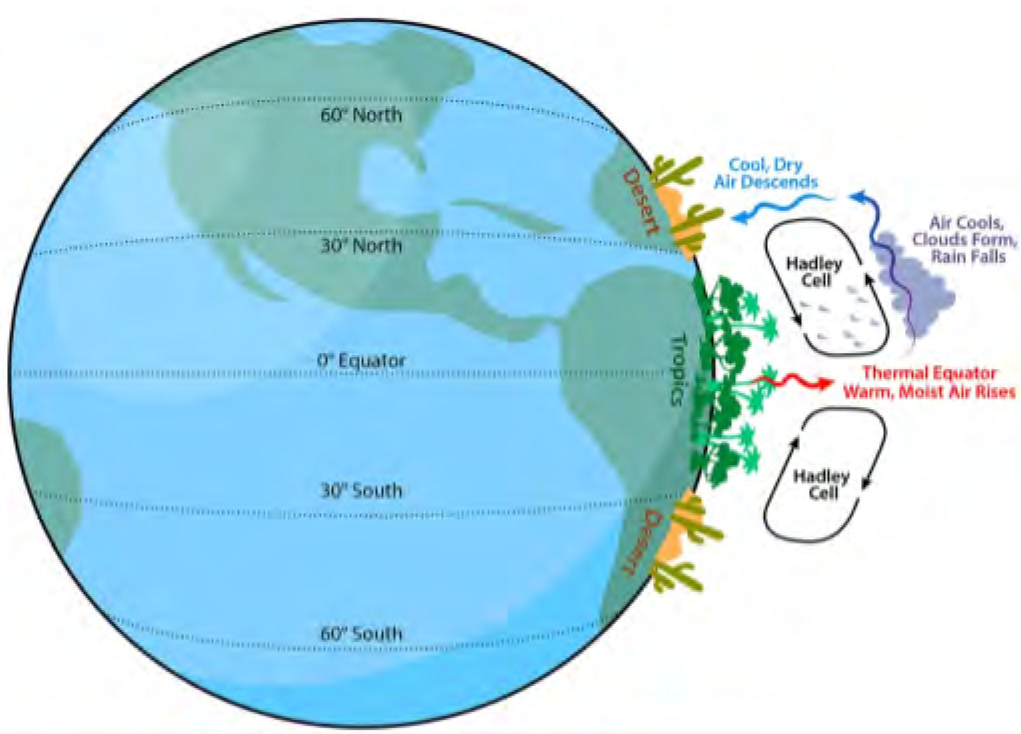


Diagram of atmospheric circulation showing the cause of Hadley Cells.
(CC BY-SA, https://askabiologist.asu.edu/explore/desert)

It may not look like it, but various processes work to moderate Earth's temperature across the globe. Atmospheric circulation brings warm air towards the poles and cold polar air towards the Equator. If the Earth’s atmosphere didn’t move the temperature differences would be much greater. In general, cold air masses tend to flow toward the Equator and warm air masses tend to flow toward the poles. This brings heat to cold areas and cools down areas that are warm. It is one of the many processes that act to balance out the planet’s temperatures.

- Visit this video to learn more about global atmospheric circulation: http://go.uen.org/b1j

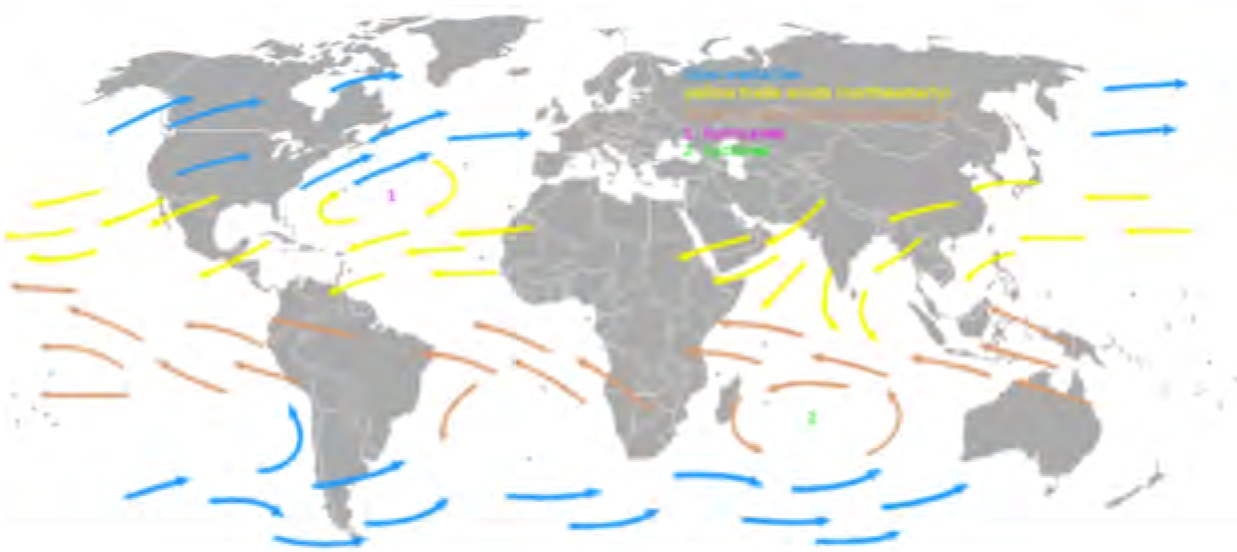
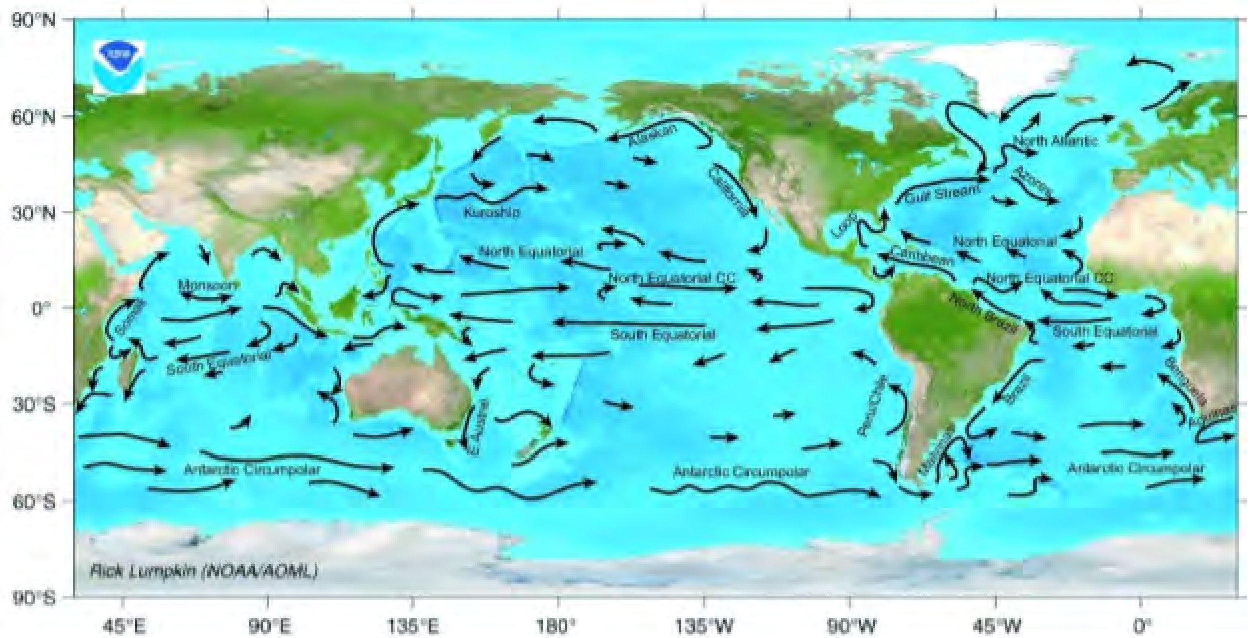


Diagram of global atmospheric circulation patterns.
(Public Domain)

Ocean water moves in predictable ways along the ocean surface. Surface currents can flow for thousands of kilometers. They can reach depths of hundreds of meters. Surface currents do not depend on the weather. They remain unchanged even in large storms because they depend on factors that do not change. They are created by global wind patterns and the rotation of the Earth. They are important because they distribute heat around the planet and are a major factor influencing climate around the globe.

Winds on Earth are either global or local. Global winds blow in the same direction all the time. They are connected to the unequal heating of Earth by the Sun and the rotation of the Earth. These predictable wind patterns allowed early sailing ships to travel around the globe. Ocean currents created by these wind patterns move ocean water around the planet. Normally warm water at the Equator will be pushed to the polar areas and colder water will be pushed to the equator.



Major ocean surface currents
(Public Domain)

Surface currents play a huge role in Earth's climate. The Equator and poles have very different climates. These regions would have very different climates if ocean currents did not transfer heat from the equatorial regions to higher latitudes.

An example of how ocean currents affect an area's climate is the Gulf Stream. The Gulf Stream is a river of warm water in the Atlantic Ocean. It is about 160 kilometers wide and about a kilometer deep. Water that enters the Gulf Stream is heated as it travels along the Equator. The warm water then flows up the east coast of North America and across the Atlantic Ocean to Europe. The energy the Gulf Stream transfers is more than 100 times the world's energy demand.

The Gulf Stream's warm waters raise temperatures in the North Sea. This raises the air temperatures over land between 3 to 6°C (5 to 11°F). London is about six degrees further south than Quebec. However, London's average January temperature is 3.8°C (38°F). Quebec's is only -12°C (10°F). Because air traveling over the warm water in the Gulf Stream picks up a lot of water, London gets a lot of rain. Quebec is much drier and receives its precipitation as snow. When water reaches high latitudes where the temperatures are cold enough to cause the density to increase, it sinks into the deep ocean basins as demonstrated in the next figure.

Public Domain

- The following video provides more information about what determines climate: http://go.uen.org/b1i

Focus Questions

1. What causes Earth's poles to be much cooler than the Equator?

2. How do surface currents form?

3. Describe the Earth systems that are responsible for moving heat energy from the Equator to the poles.

Putting It Together

The same sun shines on the entire Earth.

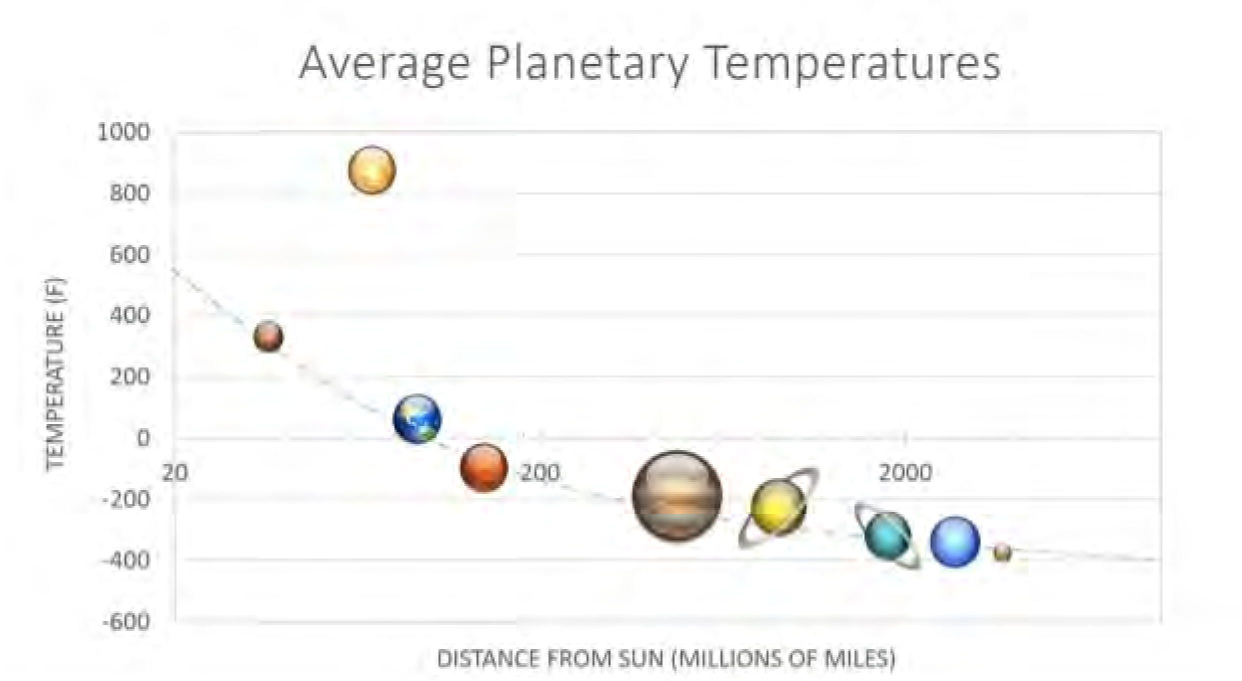
This location is frigid and dry.
(Snowdrifts at Chimney Bank
By colin grice, via wikimedia commons, CC BY-SA)

This location is warm, moist, and mild.
(CC0)

Look at the model you created at the beginning of this unit, revise your model based on your new understanding about the unequal heating of Earth's systems that cause patterns of atmospheric and oceanic circulation to explain why these two locations have different climates.

3.4 The Greenhouse Effect (6.3.4)

Explore this Phenomena



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Although Mercury is the planet closest to the sun, Venus is the hottest planet in our solar system. Construct an explanation for the high surface temperature on Venus.

6.3.4 Greenhouse Effect

Construct an explanation supported by evidence for the role of the natural greenhouse effect in Earth's energy balance, and how it enables life to exist on Earth. Examples could include comparisons between Earth and other planets such as Venus and Mars. (ESS2.D)

As you read this section, focus on how energy from the Sun interacts with Earth and the atmosphere. Think about how the natural greenhouse effect contributes to Earth's energy balance, and allows for life to exist on Earth.

What is the Greenhouse Effect?

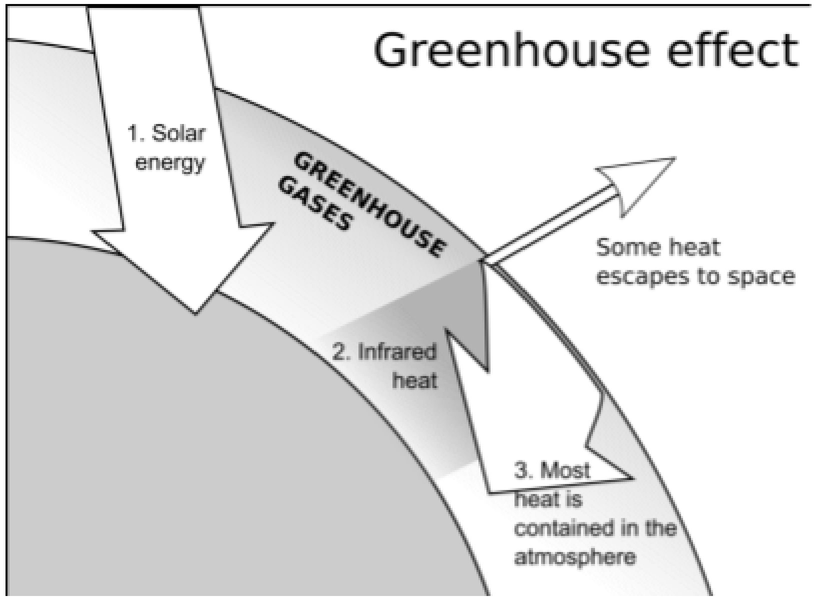
When sunlight heats the Earth's surface, some of the heat radiates into the atmosphere. Some of this heat is absorbed by gases in the atmosphere and emitted in all directions. This is the greenhouse effect. It keeps Earth warm. The greenhouse effect allows Earth to have temperatures that can support life.

Gases that absorb heat in the atmosphere are called greenhouse gases. They include carbon dioxide and water vapor. Greenhouse gases act as insulation for the planet. The warming of the atmosphere is because heat is absorbed and emitted by greenhouse gases. Greenhouse gases are the components of the atmosphere that moderate Earth's temperatures.

The greenhouse effect is a natural feature of Earth's atmosphere. Without the greenhouse effect, Earth's surface temperature would average -18°C (0°F). This is too cold to support life as we know it. With the greenhouse effect, Earth's surface temperature averages 15°C (59°F). It is this temperature range to which today's diversity of life has adapted.

The movement of energy due to the greenhouse effect is shown in the figure below. As much as 30% of the solar radiation which reaches the Earth's surface is reflected back into space. About 70% is absorbed as heat. This heat warms the land, waters, and atmosphere. If there were no atmosphere, most of the heat would radiate back out into space. Earth's atmosphere contains molecules of water (H_2O), carbon dioxide (CO_2), methane (CH_4), and ozone (O_3). They absorb some of the infrared radiation. Some of this radiation also warms the atmosphere. Some are radiated down to the Earth's surface or out into space. A balance between the heat which is absorbed and the heat which is radiated out into space results in a balance which maintains a constant average temperature for the Earth.

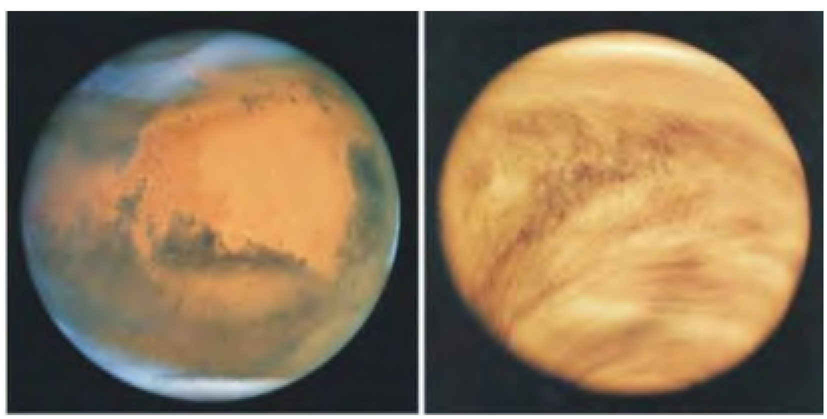
- For more information about the greenhouse effect, view: http://go.uen.org/b1g



Without greenhouse gases, most of the sun's energy (transformed to heat) would be radiated back out into space. Greenhouse gases in the atmosphere absorb and reflect back to the surface much of the heat which would otherwise be radiated. (CC0)

If we compare Earth's atmosphere to the atmospheres which surround Mars and Venus (next figure) we can understand why the composition of the Earth's atmosphere is important. Mars' atmosphere is very thin. It has less than 1% of the surface pressure of the Earth. The thin atmosphere cannot hold heat. The average surface temperature is -5°C (-67°F) even though that atmosphere is 95% CO_2 and contains a great deal of dust. Daily differences in temperature are extreme. Mars's atmosphere cannot hold heat.

Venus' atmosphere is much thicker than Earth's. The air pressure is 92 times the surface pressure of Earth. 96% of the atmosphere is CO_2. This strong greenhouse effect heats the surface temperature of Venus as high as 500°C, the hottest of any planet in our solar system. The thick atmosphere prevents heat from escaping at night. Daily temperature differences are small.



The thickness of a planet's atmosphere strongly influences its temperature through the greenhouse effect. Mars (left) has an extremely thin atmosphere, and an average temperature near -55°C. Venus (right) has a far more dense atmosphere than Earth, and surface temperatures reach 500°C.
(Public Domain)

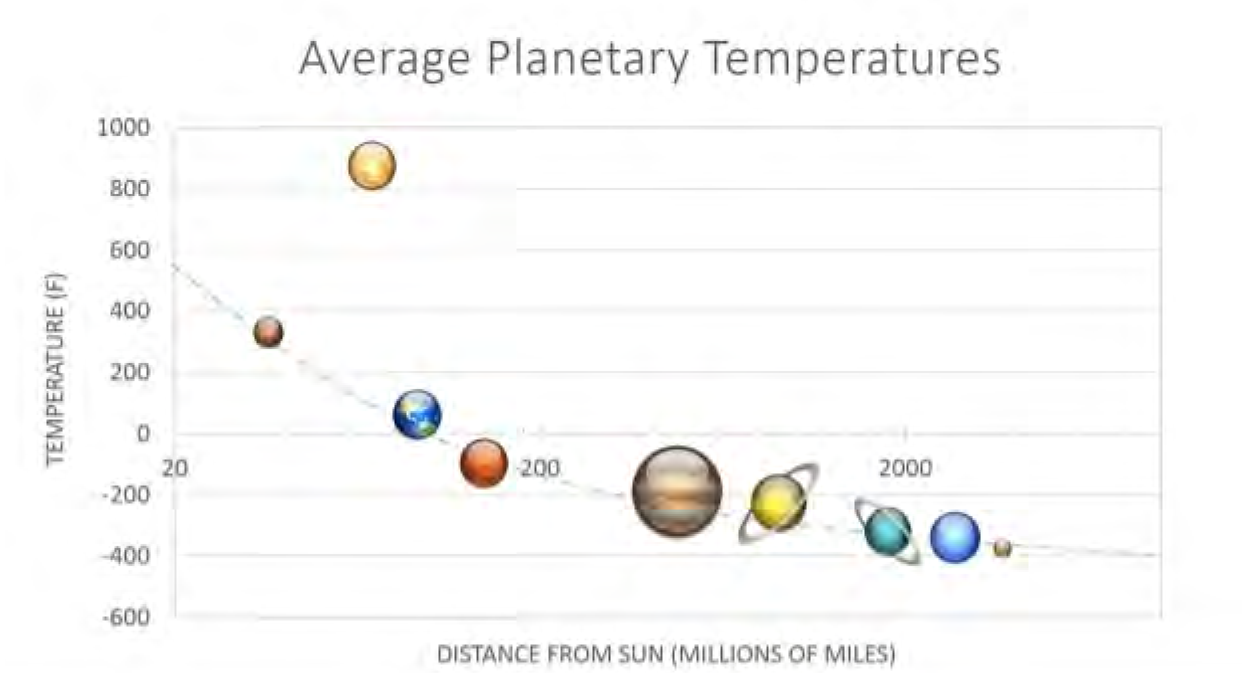
Focus Questions

1. Explain how the atmosphere enables life to exist on Earth.

2. Draw a Venn diagram comparing the atmosphere of Mars and Venus.

3. How would Earth's temperature be affected if the greenhouse gases in the atmosphere decreased? How would Earth's temperature be affected if the greenhouse gases in the atmosphere increased?

Putting It Together



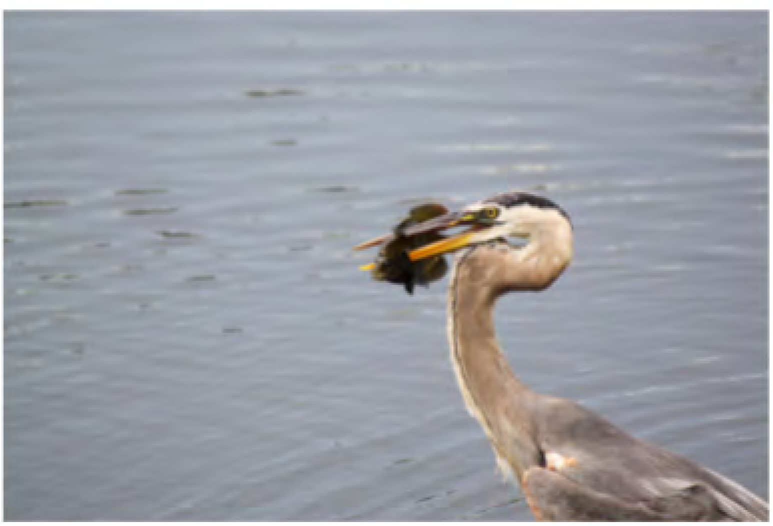
CC0

Although Mercury is the planet closest to the sun, Venus is the hottest planet in our solar system. Construct an explanation for the high surface temperature on Venus that includes the role of the natural greenhouse effect.

CHAPTER 4

Strand 4: Ecosystems

Chapter Outline



GreatBlueHeronTampaFL by Chad E., CC BY)00

Ecology is the study of ecosystems. That is, ecology is the study of how living organisms interact with each other and with the nonliving part of their environment. The living organisms, such as plants and animals, interact with each other and the environment around them. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem, resulting in system variations. Additionally, ecosystems benefit humans through processes and resources, such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

4.1 Ecosystems (6.4.1)

Explore this Phenomenon

CC0, https://pixabay.com/photos/swan-swimming-lake-river-nature-839546/

Record observations and questions you have about the interactions in the ecosystem.

Observations	Questions

Make a claim about what might happen to the ecosystem if a drought caused the river to stop flowing.

6.4.1 Ecosystems

Analyze data to provide evidence for the <u>effects</u> of resource availability on organisms and populations in an ecosystem. **Ask questions** to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments. (LS2.A)

Focus on cause and effect as you read this section. Think about how changes to the living and nonliving parts of an ecosystem might affect the organisms and populations in the ecosystem

What is an Ecosystem?

An ecosystem consists of all the nonliving factors and living organisms interacting in the same habitat. Living organisms are biotic factors. The biotic factors of an ecosystem include all the populations in a habitat. That includes all the species of plants, animals, and fungi, as well as all the microorganisms. Abiotic factors include sunlight, soil, water, temperature, and air impact the living organisms greatly contribute to the environment.

Utah has four different types of ecosystems. These include the desert, wetland, alpine, and forest ecosystems..Each system contains biotic and abiotic factors that characterize the area. Let's explore each of the ecosystems.

Utah's Desert Ecosystems

Utah is known for its deserts and beautiful rock formations. Most of the southern and western parts of the state are desert. The desert ecosystems do not receive a lot of precipitation. It tends to become hot in the day and gets cold at night. The lack of water results in sandy soil that does not have a lot of nutrients. The soil also does not hold a lot of water, so when it does rain the area will sometimes have flash floods. Plants and animals in the desert do not require a lot of water to survive. The plants in the desert respond to the environment by adapting to the dry conditions.

Public Domain, https://commons.wikimedia.org/w/index.php?curid=21213670

By Jim Harper - en-wikipedia, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=1054130

For example, the Prickly Pear Cactus (see picture above) stores water in its stems and roots. The roots are shallow so they can absorb more water when it rains. Prickly needles surround the outside of the cactus to protect it from being eaten. The Leopard Lizard is a common animal in the Utah deserts. It has adapted to the hot ground by growing long legs and toes to keep its body up! Another animal found in desert ecosystems is the Jack Rabbit (see picture above). This animal is known for its large ears and feet. They use their ears to keep them cool! Their hind legs are very long so they can run quickly and avoid predators.

How do the living organisms in the desert respond to the abiotic factors of their ecosystem?

Utah's Wetland Ecosystems

Above:https://pixabay.com/photos/utah-great-salt-lake-water-95570/ , CC0
Left:https://pixabay.com/photos/snowy-egret-egretta-garzetta-2196540/, CC0

Wetlands are areas located between water and land. The land is covered with water for most of the year, but the water can rise and fall. Utah has two types of wetlands. The Great Salt Lake area has a saltwater ecosystem. Utah Lake has a freshwater wetland ecosystem. The dirt is typically saturated with water. Wetlands also have a seasonal change in temperature and precipitation. Wetlands are beneficial because they provide water sources for plants and animals. The plants in the wetlands do not need long roots. Instead, they have leaves that spread across the water. Some common plants found in wetlands areas of Utah include cattails and duckweed. The Great Salt Lake area is so salty most animals cannot survive. However, tiny brine shrimp do well in the area. They are eaten by many of the birds, such as the Snowy Egret, who use the wetlands as a place to stop during migration.

How do the abiotic factors of the wetlands help the wildlife survive?

Utah's Alpine Ecosystems

The alpine ecosystem is defined as an area that is so high in elevation that regular trees and plants cannot grow. The ground is covered in snow and is frozen almost the entire year. Most of the precipitation comes from snow. Wind often blows and dries out the plants in alpine areas. Plants in alpine ecosystems are short. They commonly grow in clusters and have tough leaves so they don't blow away in the wind. Two examples of plants that grow in the alpine ecosystems are the Tufted Rockmat and the Wooly

Butterweed. The Muscoid Fly is a small animal that survives in the high altitudes by climbing into flowers at night that are shaped like solar reflectors and keep the flies warm!

Pixabay.com, CC0

Why do you think some plants in alpine ecosystems grow in clusters?

Utah’s Forest Ecosystems

An aspen forest in the summertime
https://pixabay.com/photos/aspen-forest-wildflower-colorado-2578702/, CC0

The forest ecosystem is defined as an area with temperatures that change throughout the year, but it receives enough precipitation to support plants and animals. The forests in Utah usually have four seasons. The soil is very rich because of the plants and animals. Trees, shrubs, flowers, and small plants are common in forest ecosystems. The trees are much larger in the forest than other areas. A common tree in Utah's forests include Quaking Aspen, which can grow up to 50 feet tall. Another common tree is the Cottonwood. They usually grow near water and produce flowers in the spring that look like puffs of cotton. Mule deer (see below), Boreal Chorus Frog (shown below), and the Red Fox, all call the forest home.

https://pixabay.com/photos/mule-deer-doe-female-wildlife-2069456/, CC0

By The original uploader was Tnarg 12345 at English Wikipedia. - Transferred from en.wikipedia to Commons., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2232718

Think about the difference between trees in the forest and the smaller shrubs found in the Alpine ecosystem. What are some of the abiotic factors that affect the tree growth?

Within an ecosystem, organisms will also vary depending on the availability of resources. If an ecosystem changes, it can cause changes to the population of organisms in that ecosystem. For example, if fertilizers from agricultural runoff enter a freshwater pond, it causes more algae to grow. Algae blocks sunlight from reaching the bottom of the pond. The growth of organisms, living on the bottom, which require sunlight is limited. Droughts, many years with significantly less precipitation, can also cause changes to an ecosystem. What might happen to a forest ecosystem if there was a major drought?

Focus Questions

1. Define an ecosystem.

2. A drought is one example of a change that can affect an ecosystem. What is another example of a change that might affect an ecosystem? Describe an interaction that would be affected by that change.

Putting It Together

The image below shows an ecosystem.

CC0, https://pixabay.com/photos/swan-swimming-lake-river-nature-839546/

1. Based on what you have learned, what are some examples of biotic and abiotic factors in this ecosystem?

2. What kind of ecosystem does this represent?

3. What would happen if the water stopped flowing in this area? Review your initial claim of what might happen if a drought caused the river to stop flowing. Based on what you have learned, revise your claim.

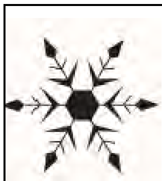
4.2 Interactions among Organisms (6.4.2)

Explore this Phenomenon

The images show relationships in an ecosystem. What patterns are you observing?

6.4.2 Interactions among Organisms

Construct an explanation that predicts <u>patterns</u> of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments such as competition, predation, and mutualism. (LS2.A)



Analyzing patterns allows us to identify similarities and differences within systems. As you read the following section, focus on the patterns of interactions between organisms. Pay attention to the types of interactions that occur between organisms in all ecosystems.

Interactions among Organisms

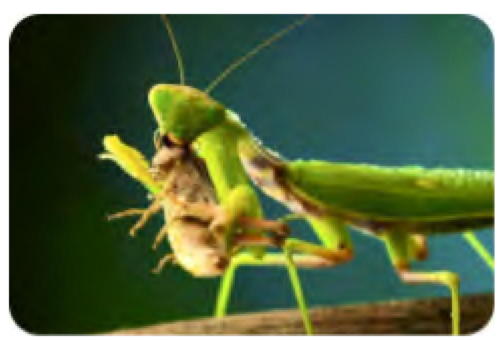
All ecosystems have the same general roles that organisms fill. It's just that the organisms that fill those roles are different. For example, every ecosystem must have some organisms that produce food in the form of chemical energy. These organisms are primarily algae in the oceans, plants on land, and bacteria at hydrothermal vents.

Organisms interact with each other in different ways; however, those interactions are the same across every ecosystem. For example, some species compete for the same resources. Other species interact in predator-prey relationships. Some interactions are beneficial to both species. These relationships are essential to maintaining the balance of organisms in an ecosystem.

Competition

Competition occurs between species that try to use the same resources. When there is competition, one species may move or adapt so that it uses different resources or obtains the resources in a different way. It may live at the tops of trees and eat leaves that are somewhat higher on bushes, for example. If one species cannot find a way to compete, it will die out.

Predator-Prey



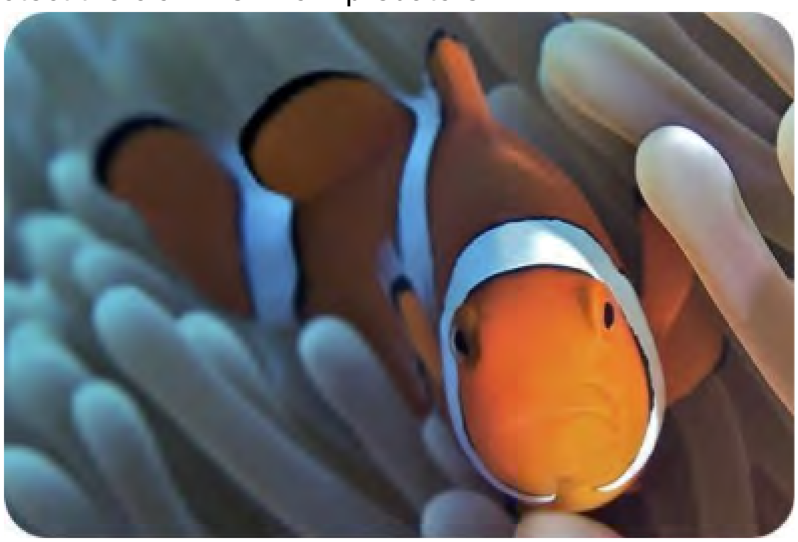
The predator-prey relationship is when a predator organism feeds on another living organism or organisms, known as prey. In some predator-prey relationships the predator hunts, kills, and eats its prey. When you think of an animal hunting for its food, large animals such as lions may come to mind. However, many tiny animals also hunt for their food. For example, the praying mantis eats grasshoppers. To eat the grasshopper, the praying mantis first has to catch the grasshopper, which is a form of hunting.

Mutualism

Some relationships between species are beneficial to the interacting species. Mutualism describes a relationship between two different species in which both species are helped.

An example of mutualism is between deer and the bacteria that live in their intestines. The bacteria get a place to live. Meanwhile, the bacteria help the deer digest food. Both species benefit, so this is a mutualistic relationship.

The clownfish and the sea anemones also have a mutualistic relationship. The clownfish protects the anemone from anemone-eating fish, and the stinging tentacles of the anemone protect the clownfish from predators.



Ck12.org, CC BY-SA

Focus Questions

1. Both wolves and mountain lions prey on mule deer. What type of interaction does this describe?

2. Patterns of interactions between organisms exist across many ecosystems. Describe a predator-prey interaction that occurs in a marine ecosystem and a predator-prey interaction that occurs in a desert ecosystem.

Putting It Together

Construct an explanation for the pattern of interactions shown in each image. In a desert and a marine environment, what might be an example of this type of interaction?

4.3 Matter and Energy in Ecosystems (6.4.3)

Explore this Phenomenon

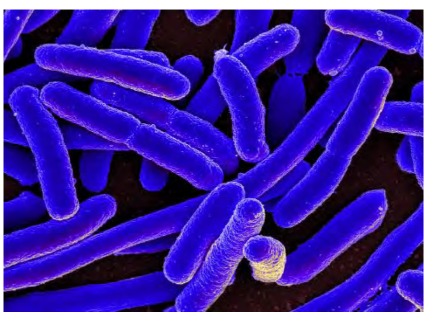
The next images show organisms that live in or around the Great Salt Lake.

Brine shrimp

Green algae

Brine flies

Bacteria



California Gull

Eared grebe

All organisms need energy to survive. Develop a model to show the cycling of energy in this ecosystem.

6.4.3 Matter and Energy

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts. (LS2.B)

Energy and matter play an important role in many of Earth's systems, including ecosystems. As you read this section, focus on how energy flows from producers to consumers and the role that decomposers play in helping to recycle matter in an ecosystem.

Matter and Energy in Ecosystems

Energy must constantly flow through an ecosystem for the system to remain stable. What exactly does this mean? Essentially, it means that organisms must eat other organisms. Food chains (figure below) show the eating patterns in an ecosystem. Food energy flows from one organism to another. Arrows are used to show the feeding relationship between the animals. The arrow points from the organism being eaten to the organism that eats it. For example, an arrow from a plant to a grasshopper shows that the grasshopper eats the leaves. Energy and nutrients are moving from the plant to the grasshopper. Next, a bird might prey on the grasshopper, a snake may eat the bird, and then an owl might eat the snake. The food chain would be:

Ck12.org, CC BY-SA

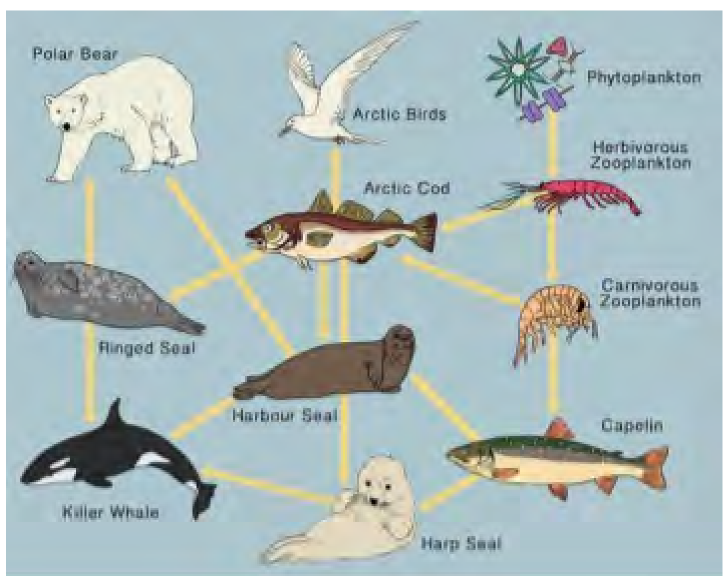
In a wetland ecosystem, one possible food chain might look like this: cattail → grasshopper → frog → hawk. The producers are always at the beginning of the food chain, bringing energy into the ecosystem. Through photosynthesis, the producers not only create their own food, but also create the food for the other organisms in the ecosystem. Next come the consumers. They eat other organisms in order to obtain energy. In the wetland example, cattails are the producers. They are eaten by grasshoppers, which are then eaten by frogs. Finally, hawks eat frogs. The grasshoppers, frogs, and hawks are all consumers in this food chain.

Polyporus squamosus Molter by Dan Molter, https://en.wikipedia.org/wiki/File:Polyporus_squamosus_Molter.jpg, CC BY-SA

Producers and consumers are not the only roles organisms have in an ecosystem, decomposers also play a very important role in maintaining ecosystem stability. Decomposers are organisms that obtain nutrients and energy by breaking down dead organisms and animal waste. Decomposers release nutrients back into the environment. These nutrients are recycled back into the ecosystem so that the producers can use them. They are passed to other organisms when the producers are eaten or consumed. Examples of decomposers are mushrooms on a decaying log, bacteria in the soil, and earthworms.

Imagine what would happen if there were no decomposers. Waste and the remains of dead organisms would pile up and the nutrients within the waste and dead organisms would not be released back into the ecosystem. Producers would not have enough nutrients.

Each organism can eat and be eaten by many different types of organisms, so simple food chains are rare in nature. We can combine food chains together to create a more accurate flow of energy within an ecosystem. A food web (next figure) shows the feeding relationships between many organisms in an ecosystem. For example, the arctic cod is eaten by the harbor seal, harp seal, ringed seal, and arctic birds. Even though a food web shows many more arrows, it still shows the cycling of matter and the flow of energy.



Food web in the Arctic Ocean, ck12.org, CC BY-SA.

Focus Questions

1. Which is a more accurate model to show the flow of energy in an ecosystem, a food chain or food web? Explain your reasoning.

2. How do decomposers play a role in the cycling of matter in an ecosystem?

3. Refer to the food web of the Arctic Ocean. Suppose a pesticide in the water killed all the Zooplankton. Describe two effects this would have on the ecosystem.

Putting It Together

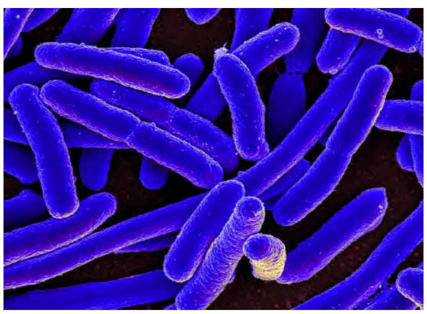
The next images show organisms that live in or around the Great Salt Lake.

Brine shrimp

Green algae

Brine flies

Bacteria



California Gull

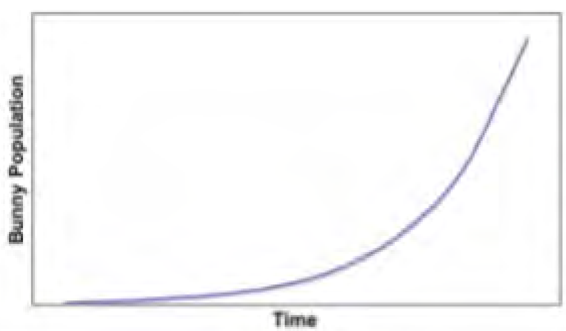
Eared grebe

Revise your initial model to show the cycling of matter and flow of energy among the organisms that live in and around the Great Salt Lake.

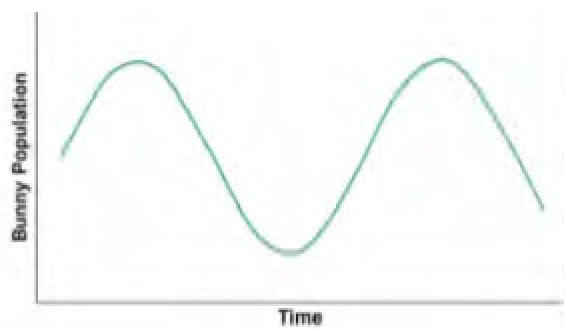
4.4 Stability of Populations in Ecosystems (6.4.4)

Explore this Phenomenon

Public Domain



Bunny population without predators



Bunny population with predators (CC0)

These graphs depict the population of bunnies over time in an ecosystem.Explain how these two graphs are different and explain why.

Using evidence from the graphs, construct an argument for the difference in population stability in the two scenarios.

6.4.4 Stability of Populations

Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts. (LS2.C)

Focusing on the relationship between stability and change in an ecosystem helps us to better understand interactions within an ecosystem. As you read, think about how small changes to one part of an ecosystem can cause a large change to another part of an ecosystem.

Stability of Populations in Ecosystems

In the early 1800s, when people began to settle in the West, the government paid people to seek out wolves and kill them. By the 1920s, there were no more wolf packs in Yellowstone National Park. Elk populations in the park increased, and the population of aspen trees began to decline. In 1995, the National Park Service reintroduced 31 grey wolves into Yellowstone National Park. Over the years, the wolf population has continued to grow.

Public Domain

Current research by wildlife biologists is helping us to learn the important role wolves play in maintaining biodiversity in their ecosystem. After the reintroduction of the wolves, new aspen trees began to grow because fewer elk were grazing on the young seedlings. Biologists have also discovered that in areas where elk are more vulnerable to wolf attacks, the growth of aspen groves have been increasing dramatically. These are just a few reasons that the reintroduction of the wolves has increased the biodiversity of the whole park. The example of the wolves in Yellowstone National Park is an example of how changes in populations of one organism affect the populations of other organisms.

The stability of populations in an ecosystem is affected by many factors. For a population to be healthy, factors such as food, nutrients, water and space, must be available. Low food supply or a lack of space are limiting factors in an ecosystem. When there are limiting factors in an ecosystem, populations of a species can decline.

This decline could be caused by less offspring being born, increase in death rates, or individuals emigrating to other areas.

Limiting Factors

If there are 12 hamburgers at a lunch table and 24 people sit down at a lunch table, will everyone be able to eat? At first, maybe you will split hamburgers in half, but if more and more people keep coming to sit at the lunch table, you will not be able to feed everyone. The amount of hamburgers limit the number of people at the lunch table.

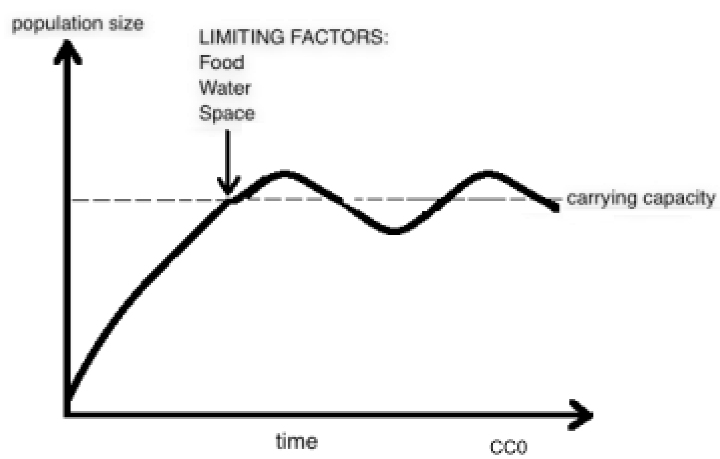
Similarly, the amount of food limits the number of organisms in an ecosystem.

If organisms cannot get food, they will die or find a new place to live. It is possible for any resource to be a limiting factor, however, a resource such as food can have dramatic consequences on a population.

Other limiting factors include light, water, nutrients or minerals, oxygen, the ability of an ecosystem to recycle nutrients and/or waste, disease and/or parasites, temperature, space, and predation.

Weather can also be a limiting factor. Whereas most plants like rain, an individual cactus-like *Agave Americana* plant actually likes to grow when it is dry. Rainfall limits reproduction of this plant which, in turn, limits growth rate. Can you think of some other factors like this?

Human activities can also limit the growth of populations. Such activities include the use of pesticides and herbicides as well as habitat destruction.



When the population size is small, there is usually plenty of food and other resources for each individual. Organisms can easily reproduce, so the birth rate is high. As the population increases, the food supply, or the supply of another necessary resource, may decrease. When necessary resources, such as food, decrease, some individuals will die. Overall, the population cannot reproduce at the same rate, so the birth rates drop. This will cause the population growth rate to decrease.

When the population decreases to a certain level where every individual can get enough food and other resources, and the birth and death rates become stable, the population has leveled off at its carrying capacity.

Focus Questions

1. Explain why aspen tree populations declined when wolf packs were eliminated in Yellowstone Park.

2. What are three examples of limiting factors?

3. Give one example to a limiting factor not mentioned above?

4. When organisms face limiting factors, what effect will this have on their population?

Putting It Together

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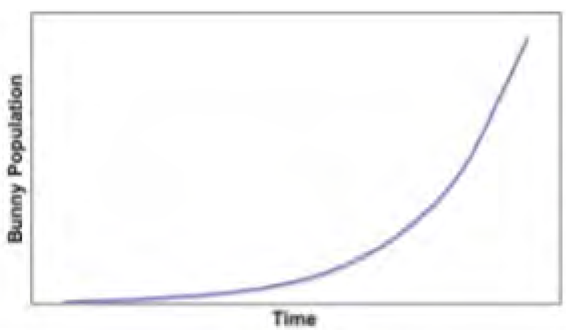
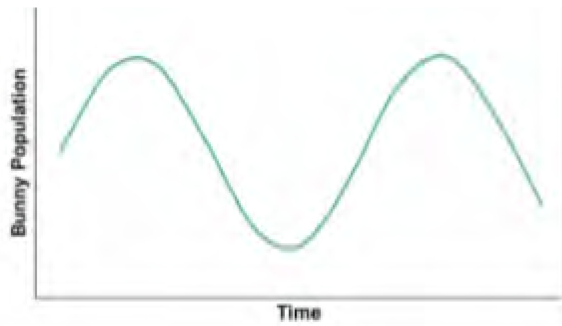


Bunny population without predators



Bunny population with predators
(CC0)

These graphs show the population of bunnies over time in an ecosystem. After learning about stability and change in ecosystems, construct an argument using evidence from the two graphs for the changes in bunny population in the two scenarios.

4.5 Stability and Change (6.4.5)

Explore this Phenomenon

NASA, Public Domain

In 1959, a railroad causeway was built in the middle of the Great Salt Lake and it cut the lake into two different lakes. The south arm of the lake gets fresh water from Bear, Weber and Jordan rivers, and it stays green. However, the north arm turned to pink because of high salinity. The change in the salinity caused the brine shrimp population to decrease in the lake. Utah is one the top shrimp providers to the world and shrimp provides a food resource to the migrating birds. Design a solution to provide a stable ecosystem in the Great Salt Lake.

See a video of this story at:
https://www.sltrib.com/news/environment/2018/09/12/why-is-great-salt-lake/

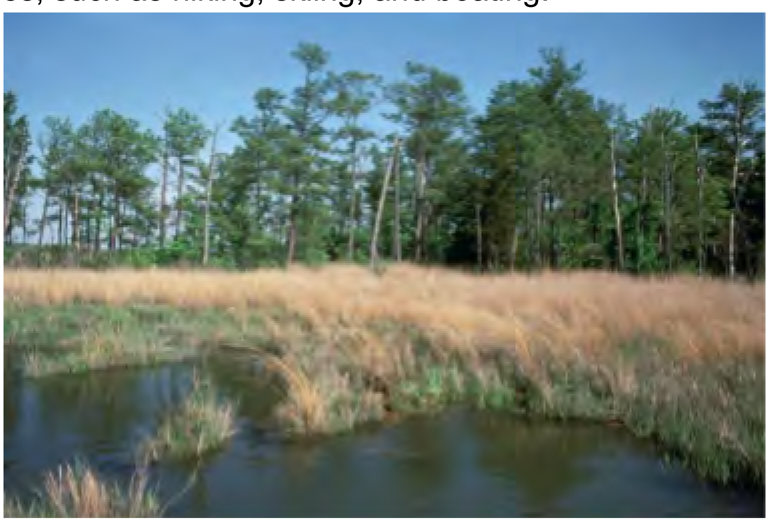
6.4.5 Stability and Change

Evaluate competing design solutions for preserving ecosystem resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize **obtaining, evaluating and communicating** information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion. (LS2.C, LS4.D, ETS1.A, ETS1.B, ETS1.C)

In this chapter you have learned how changes to the living and nonliving parts of an ecosystem affect the ecosystem. As you read this section, think about how human activities can also change ecosystems and why maintaining ecosystem stability is important for preserving the services that ecosystems provide to humans.

Preserving Ecosystem Services

The positive benefits that ecosystems provide to people are called ecosystem services. Some examples of ecosystem services are providing people with clean drinking water, timber, and plants that may be used for medicine and other materials. Ecosystems services are important because they help us to regulate flooding, soil erosion, forest fires, and water pollution. They also provide us with places we can go for outdoor recreation activities, such as hiking, skiing, and boating.



Public Domain

Wetlands play a key biological role by removing pollutants from water. For example, they can trap and use fertilizer that has washed off a farmer's field, and therefore they prevent that fertilizer from contaminating another body of water. Since wetlands

naturally purify water, preserving wetlands also helps to maintain clean supplies of water.
Healthy forests provide us with both goods and services. Trees are a source of timber, and a habitat for many animals. The decomposition that takes place on forest floors, adds nutrients to the soil and increases soil quality. Forests also help prevent flooding by containing water in the soil and slowly releasing water over time.

Deserts provide ecosystem services through recreation and tourism. They provide people with places to hike, camp, and enjoy the outdoors. People from all over the world visit deserts. This provides economic benefits through tourism.

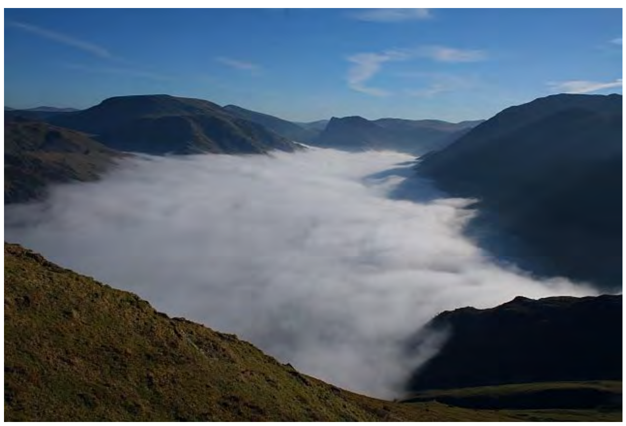
Many ecosystems in Utah are impacted by human activity. Scientists and engineers are continually studying ecosystems to understand how we can preserve ecosystem services while still meeting the needs of Utah's populations.

Quagga mussels are an invasive species that can be found in some of Utah's lakes. An invasive species is a species that is not native to an ecosystem and causes harm to that ecosystem. Quagga mussels form colonies on underwater surfaces, they eat plankton, depleting the food available for native fish. To help prevent the spread of quagga mussels, boaters are required to clean, drain, and dry their boats. Boat stops along the highway are one way that the Utah Division of Wildlife Services is trying to prevent the spread of this invasive species.

- To find more information about invasive species in Utah, go to: http://go.uen.org/aZJ

In June 2010, a fracture in an oil pipeline caused about 30,000 gallons of oil to spill into Red Butte Creek in Salt Lake City, Utah. The oil spill harmed aquatic wildlife, including fish, birds, and insects. Cleanup efforts included using absorbent booms and creating dams to help contain most of the oil. Ducks covered with oil were cleaned at Hogle Zoo. Scientists are still studying the effects of the oil on the Red Butte Creek ecosystem.

With the growth of urban areas, air quality becomes a concern. The wintertime inversions in Utah can greatly reduce the air quality where we live. During an inversion, air becomes trapped in the valleys. Home energy use, cars, and manufacturing all contribute to polluting the trapped air. Because this is harmful to all living things, including humans, several groups in Utah are working on ways to improve air quality. The Department of Transportation has invested in public transportation and high occupancy vehicle (HOV) lanes. The Division of Air Quality uses colors to inform the public about the quality of the air. This allows people to make informed decisions regarding energy and transportation use.



Air Quality Index - Particulate Matter	
301–500	Hazardous
201–300	Very Unhealthy
151–200	Unhealthy
101–150	Unhealthy for Sensitive Groups
51–100	Moderate
0–50	Good

Focus Questions

1. Describe an ecosystem service that affects you.

2. What are some ecosystem services provided by the ocean?

3. What can you do to help preserve ecosystems in Utah?

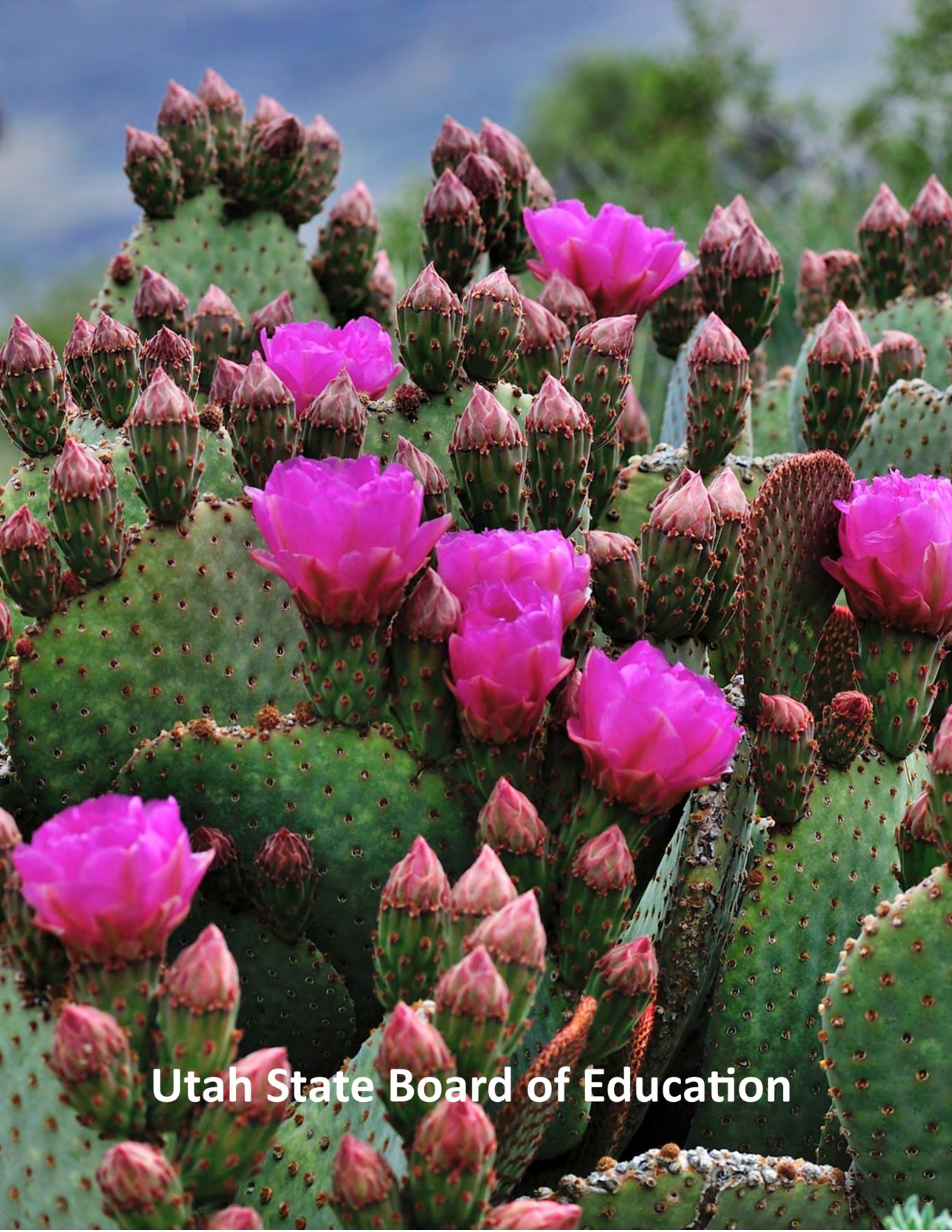
Putting It Together

NASA, Public Domain

150621-bridge-causeway-salt-lake.jpg by r. nial bradshaw, https://flic.kr/p/zJ3zUK, CC-BY

In 1959, a railroad causeway was built in the middle of the Great Salt Lake and it cut the lake into two different lakes. The south arm of the lake gets fresh water from Bear, Weber and Jordan rivers, and it stays green. However, the north arm turned to pink because of high salinity. The change in the salinity caused the brine shrimp population to decrease in the lake. Utah is one the top shrimp providers to the world and shrimp provides a food resource to the migrating birds. In December 2017, a breach was built to provide water flow between north and south arm.

Based on the evidence, evaluate and rewrite the solution.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