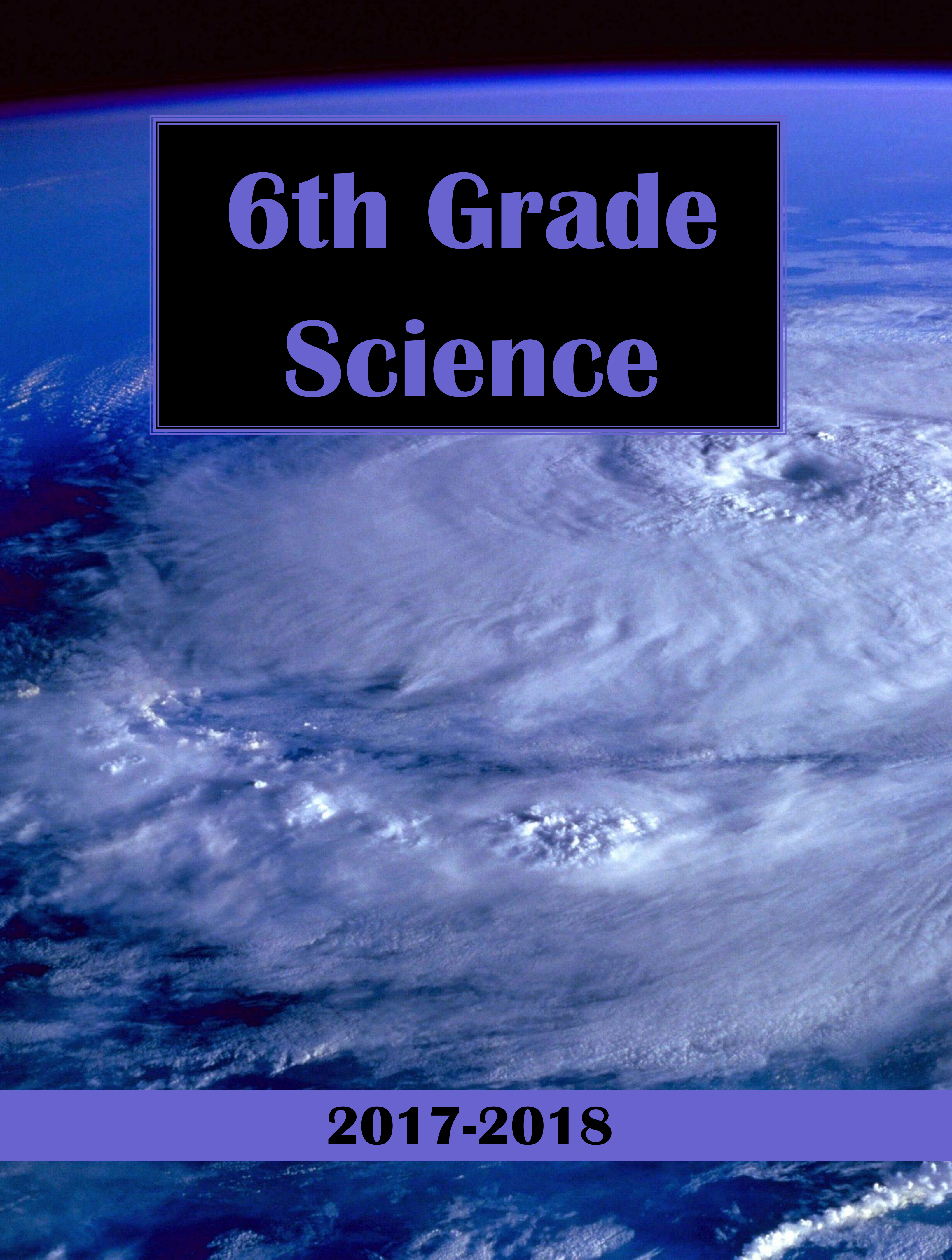
6th Grade Science



2017-2018

6th Grade Science

for Utah SEEd Standards

Utah State Board of Education OER

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next generation textbooks

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Utah State Board of Education OER

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CHAPTER 1

Using this Book

Chapter Outline

1.1 Credits and Copyright

 We express our gratitude to the CK-12 Foundation for their pioneering work on secondary science textbooks, without which the current book would not be possible.

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

1.2 Students as Scientists

Making Science

What does science look and feel like?

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

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

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

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

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

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

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

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

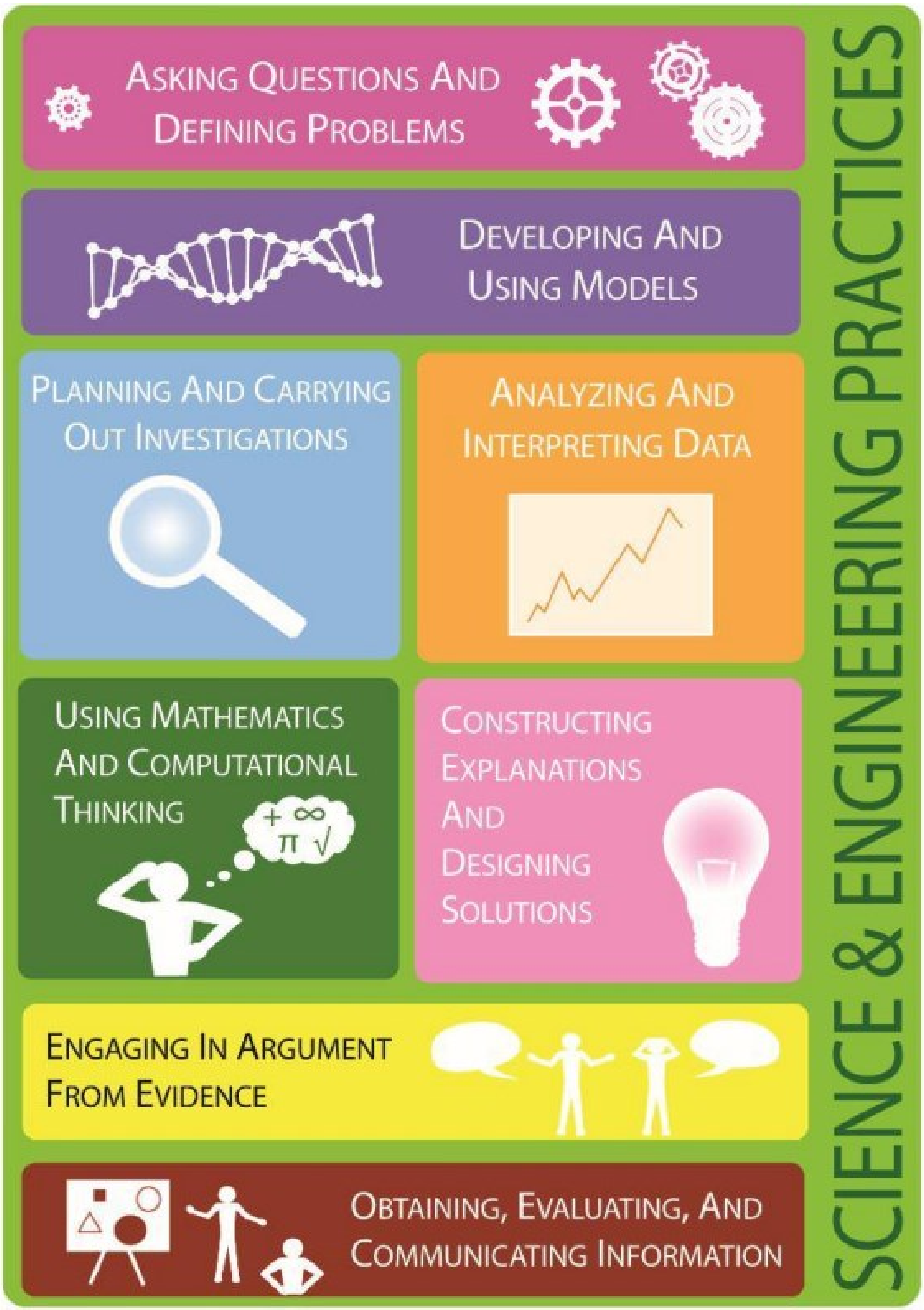
Just as there is science to be found in a puddle or a pit or a simple rock formation, there's science in a soap bubble, in a worm, in the spin of a dancer and in the structure of a bridge. But this thing we call "science" is only there if you're paying attention, asking questions, and imagining possibilities.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

Adam Johnston

Weber State University

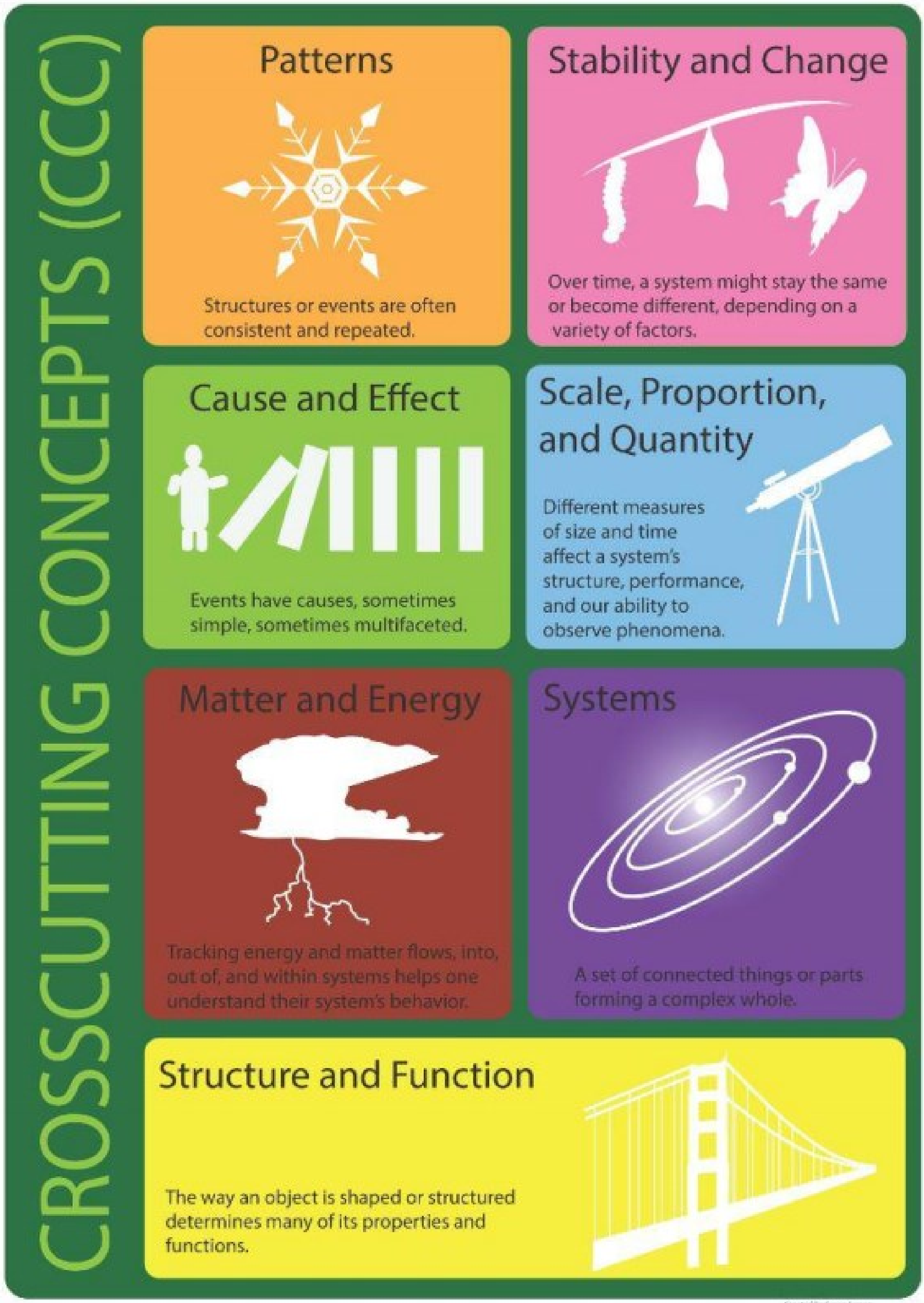
Science and Engineering Practices

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



Crosscutting Concepts

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



1.3 A Note to Teachers

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

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

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

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

CHAPTER 2

Strand 1: Structure and Motion within the Solar System

Chapter Outline

The solar system consists of the Sun, planets, and other objects within 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.

2.1 Earth, Moon, and Sun System (6.1.1)

Explore this Phenomenon

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

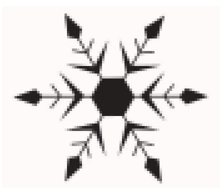
What do you notice?

Observations	Questions

Draw a model that shows the position of the Sun, Earth, and Moon 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.

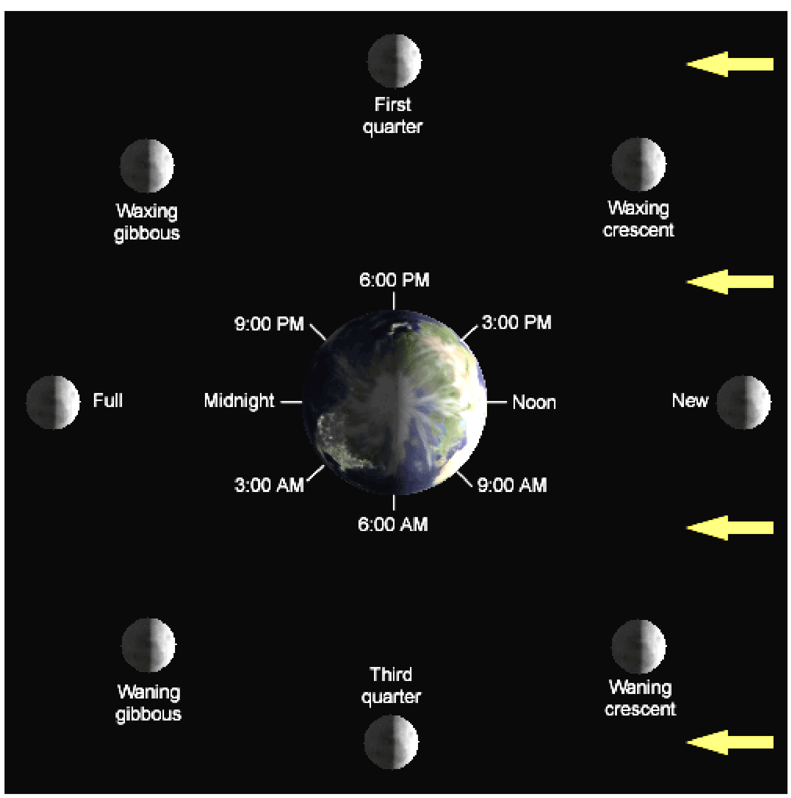


In this section focus on observable patterns created by the positions of the Earth, Moon, and Sun throughout the month. The Earth-Moon-Sun System also creates observable patterns throughout the year. It is important to analyze this system in order to describe how it creates repeating, or cyclic, patterns,

Phases of the Moon

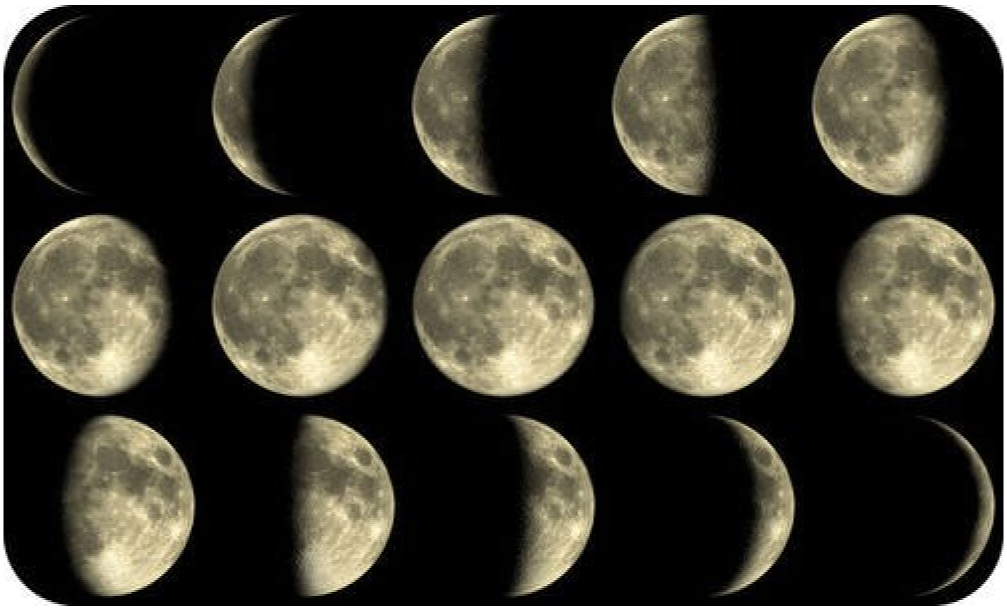
As the moon orbits around Earth, different parts of it appear to be illuminated by the Sun. The Moon does not produce any light of its own. It only reflects light from the Sun. The Moon sometimes *appears* fully illuminated and sometimes *appears* completely dark. Although it changes in appearance, the 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://bit.ly/2dPQlKZ



A full moon occurs when the Moon appears to be fully illuminated 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 a new moon. As the cycle continues, the illuminated part of the Moon will appear to increase until it is fully illuminated again. This predictable pattern takes about 28 days.

- Watch this video to see the phases change: http://go.nasa.gov/2dZEFVb



The illumination of the Moon increases to a full moon and decreases to a new moon. This predictable pattern occurs about every 28 days.

Focus Questions

1. What causes the appearance of the Moon to change in a predictable?
2. Where are the Sun, Earth, Moon positioned for full and new moons to occur?
3. How does the Moon receive its light?

Putting It Together

A month later, you are hiking up the canyon and, looking up the canyon, 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 during a full moon.

Explore this Phenomenon

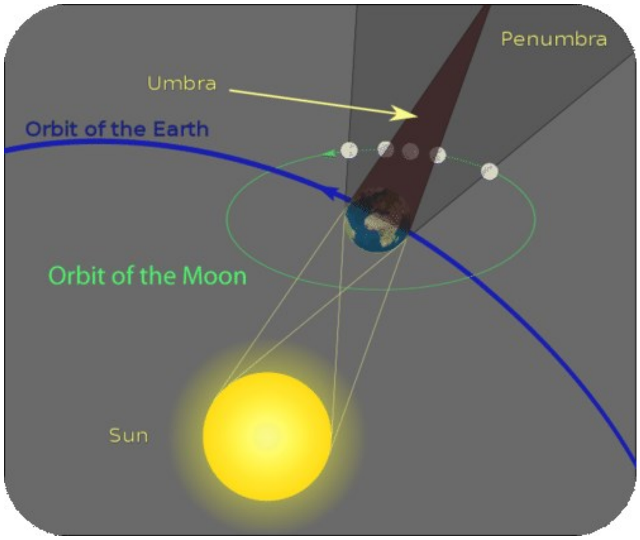
You go outside one night and expect to see a full moon, but part of the full moon is dark.

What do you notice?

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.

A lunar eclipse is shown in a series of pictures.

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 and expect to see a full moon, but part of the full moon is dark.

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

The image shows a solar eclipse as viewed from Earth.

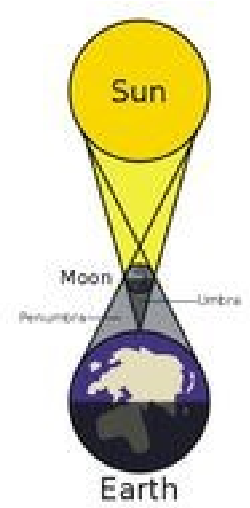
What do you notice?

Observations	Questions

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

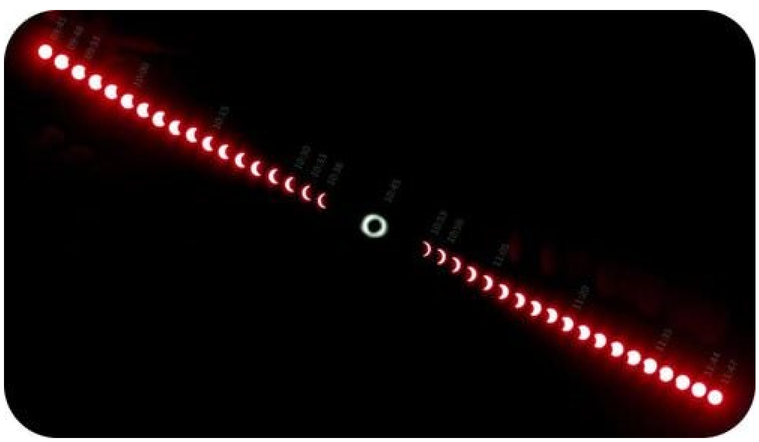
Solar Eclipses

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.



A solar eclipse, not to scale.

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.

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

Focus Questions

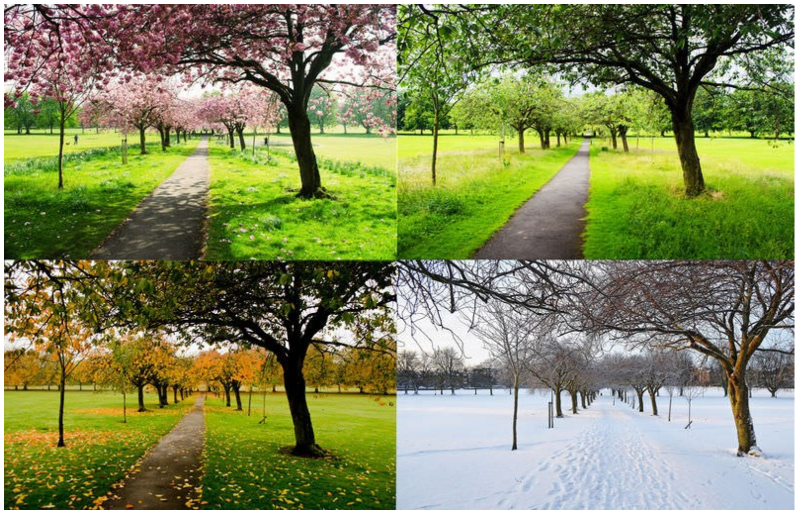
1. What causes a solar eclipse?
2. How are solar eclipses different than lunar eclipses?

Putting It Together

A photo of a total solar eclipse.

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



The images above show the same park in all four seasons. What causes the seasons? Draw a model that shows the position of the Earth and Sun during different seasons.

Seasons

Visit this interactive to explore the causes of Earth's seasons.

- http://tinyurl.com/j9nqnnw

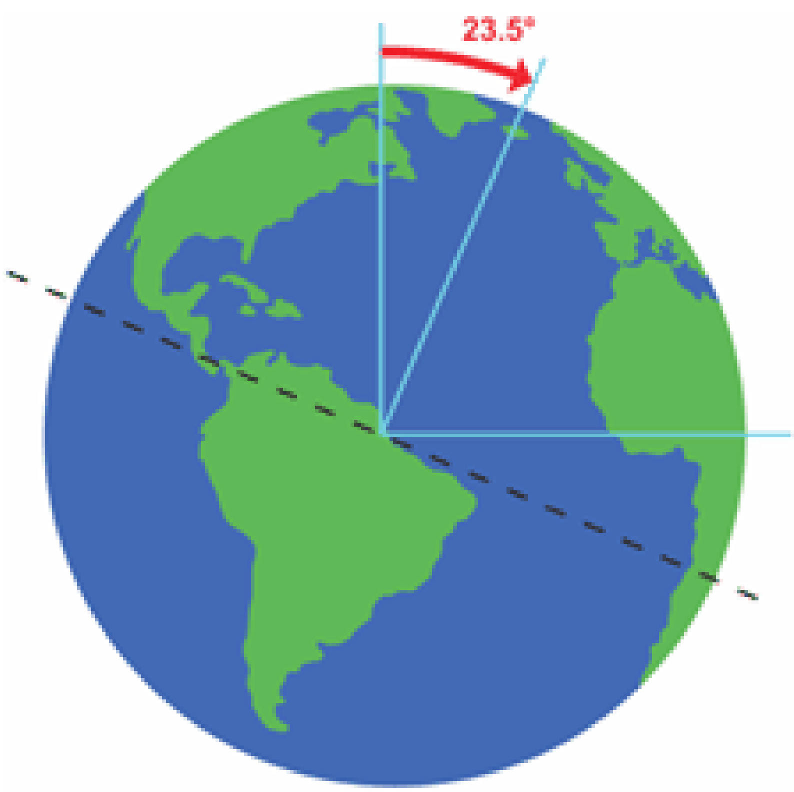
The days are getting warmer. Flowers begin to bloom. The sun appears higher in the sky, and daylight lasts longer. Spring seems like a fresh, new beginning. What causes these welcome changes?

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 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.

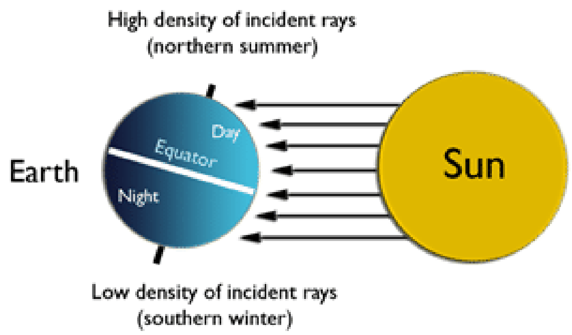
The distance from the sun doesn't have much effect on the heating and cooling of Earth. In fact, the Northern Hemisphere is closest to the Sun during winter. So, why do we, in the Northern Hemisphere, feel coldest when we are closest to the Sun?

Earth's axis of rotation, or imaginary poles on which Earth spins, 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.



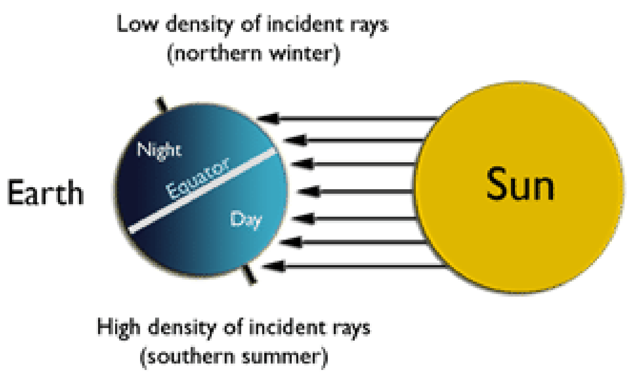
As Earth revolves around the Sun, the axis of rotation maintains its tilt. The axis always points in the same direction, which is toward the North Star (Polaris). The combination of the Earth's revolution around the Sun and Earth's 23.5 degree angle tilt are the reasons we have seasons.

Northern Hemisphere Summer



During summer in the Northern Hemisphere, the North Pole is tilted toward 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



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.

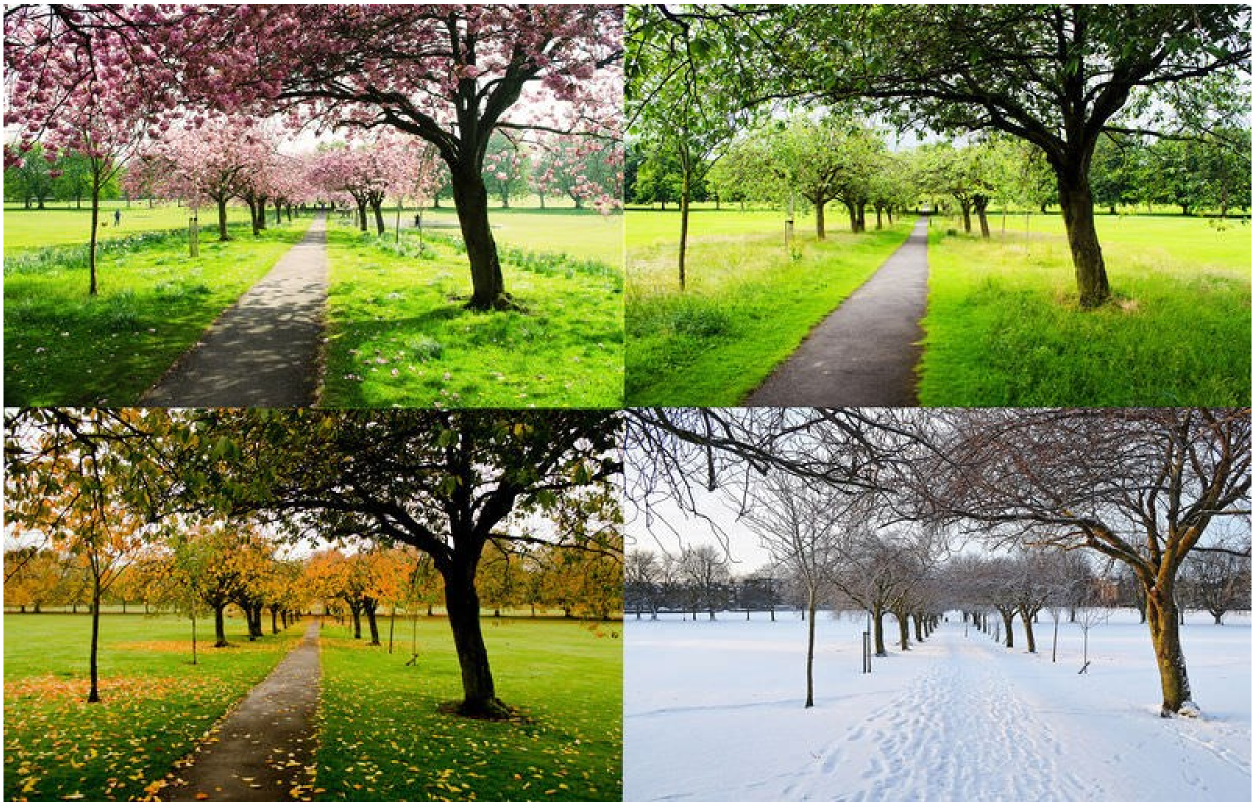
During winter in the Northern Hemisphere, it is summer in the Southern Hemisphere. In contrast, when it is winter in the Southern Hemisphere it is summer in the Northern Hemisphere. The hemisphere that is experiencing summer, experiences more hours of daylight. The hemisphere that is experiencing winter 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 the seasons?

Putting It Together



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.

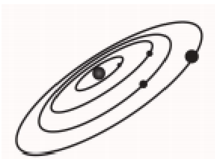
2.2 Gravity and Inertia (6.1.2)

Explore this Phenomenon

The picture above shows the Earth in orbit around the Sun.
Develop a model to explain why objects in the solar system stay in orbit around the Sun.

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.



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.

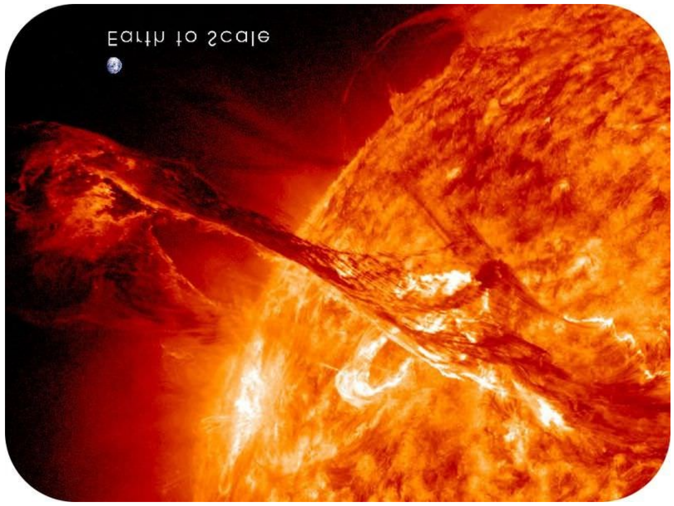
The Role of Gravity and Inertia

Most of the objects that are part of our solar system are constantly orbiting the Sun, the star of 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.

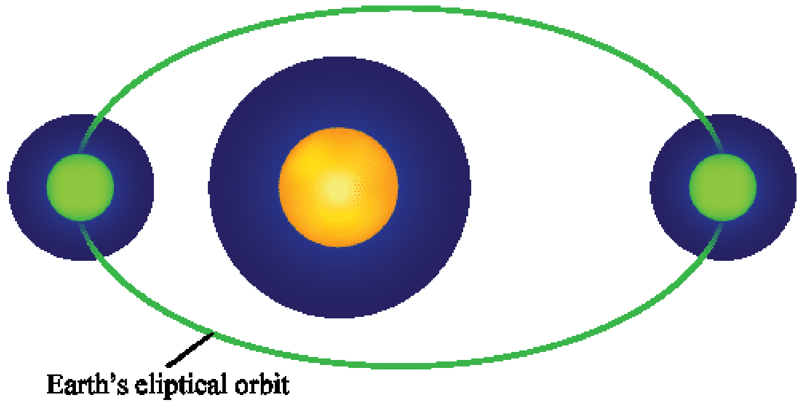


As you can see in this NASA photo, Earth is tiny compared with the massive sun. The Sun's gravity is relatively strong because the force of gravity between two objects is directly proportional to their masses. Gravity pulls Earth toward the Sun, but Earth never falls into the Sun. Instead, it constantly 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

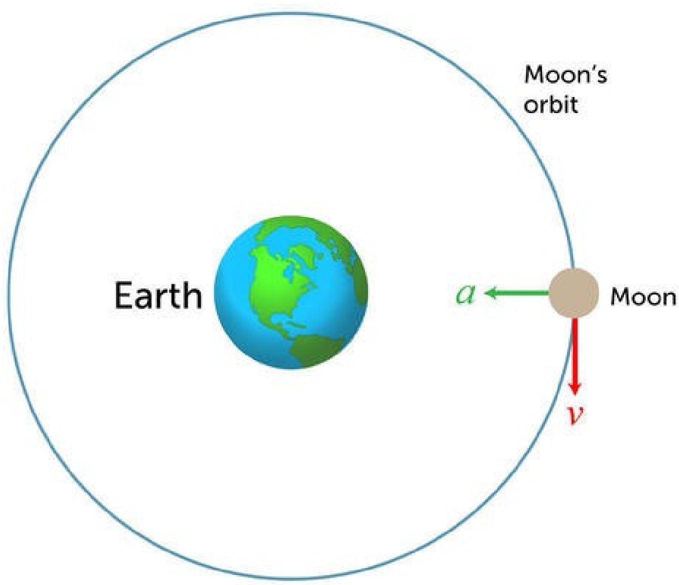
Earth and many other bodies—including asteroids, comets, and the other planets—move around the Sun in curved paths called orbits. Generally, the orbits are elliptical, or oval, in shape. You can see the shape of Earth's orbit in the figure below. Because of the Sun's strong gravity, Earth and the other bodies constantly fall toward the Sun, but they stay far enough away from the Sun because their forward movement causes them 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.



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.

The figure below shows the forces involved in the Moon's orbital motion around Earth. In the diagram, *(v)* represents the forward movement, or velocity, of the Moon, and *(a)* represents the gravity between Earth and the Moon. The line encircling Earth shows the Moon's actual orbit, which results from the combination of v and a.



Focus Questions

1. Why is the Sun called the center of the solar system?
2. Why doesn't Earth crash into the Sun?
3. Why does the Moon maintain its orbit around Earth?

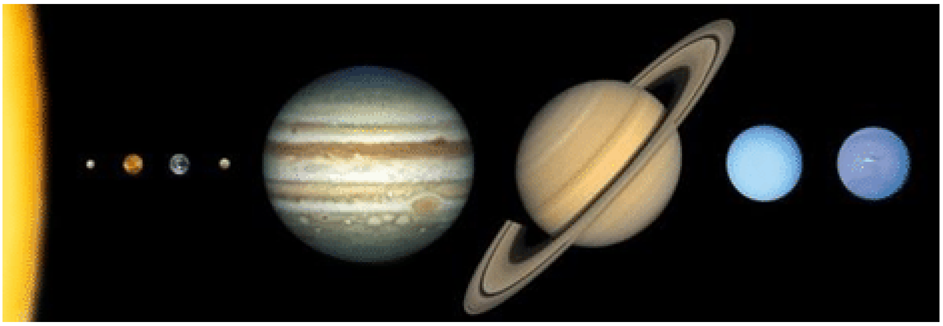
Putting It Together

The picture above shows the Earth in orbit around the Sun.

Consider what you have learned in this section. Develop a revised model to explain why objects in the solar system stay in orbit around the Sun.

2.3 Scale of the Solar System (6.1.3)

Explore this Phenomenon



The image above is one example of a model of our solar system.

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

What are the limitations of this model?

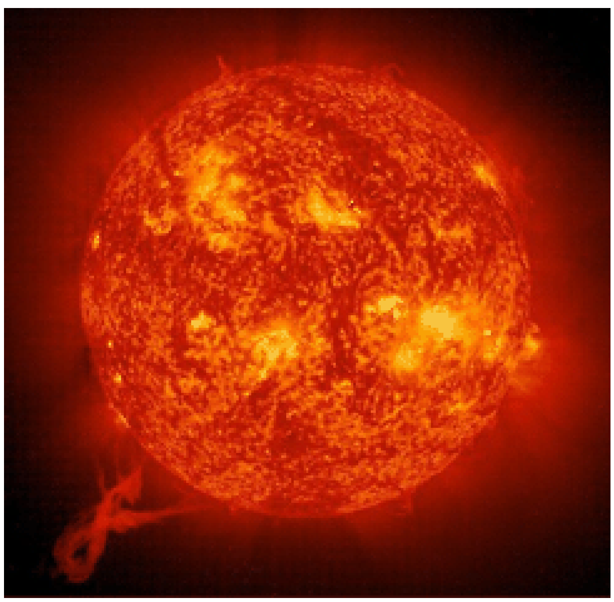
6.1.3 Objects in the Solar System

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.

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 and is a source of heat, light, and energy.



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 its status was changed to a dwarf planet on August 24, 2006 by the International Astronomical Union (IAU).

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. Scientists and astronomers sometimes use a light-year, the distance light travels in one year, to measure these distances.

Let’s begin with the Earth’s distance from the Sun to see how this works. Earth is about 93,000,000 miles (150,000,000 kilometers) away from the Sun. 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.

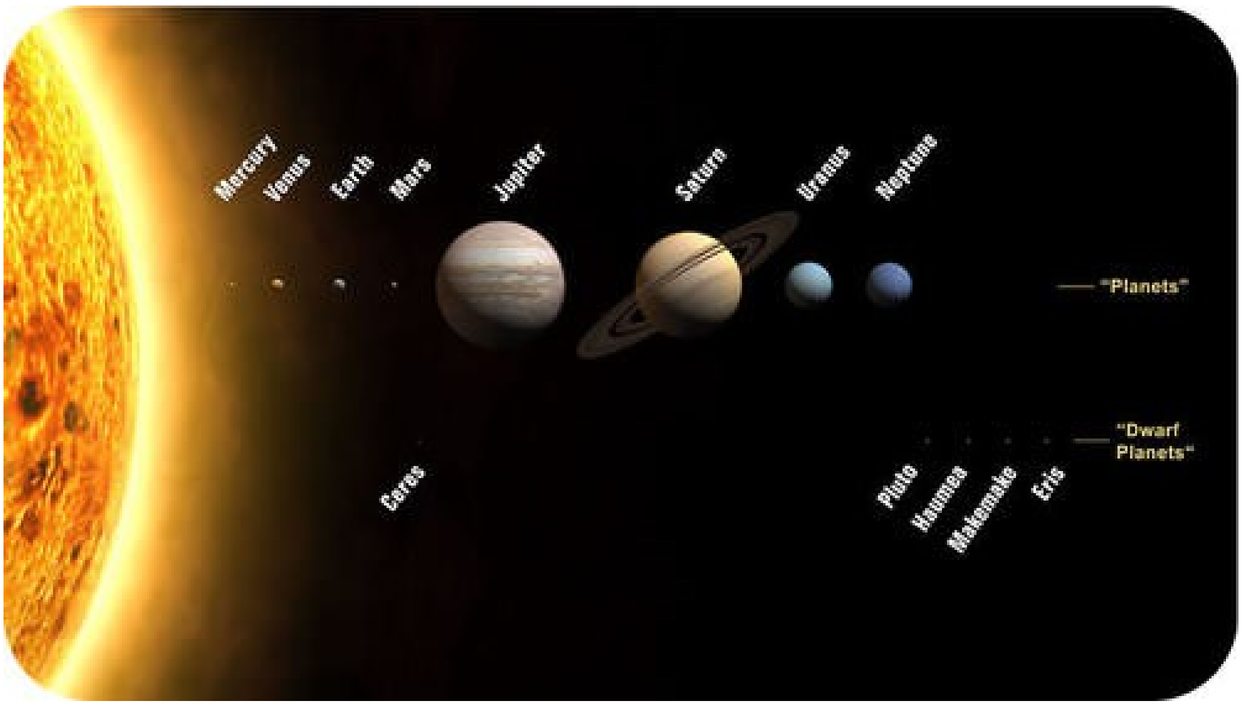
The table below shows the distances between the Sun and the planets using light years, miles, kilometers and astronomical units. An astronomical unit (AU) is a comparison measurement. One astronomical unit is equal to the distance between the Sun and the Earth.

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 star. But, it is the largest object in the solar system. The Sun is more than 500 times the mass of everything else in the solar system combined!



Relative sizes of the Sun, planets, and dwarf planets and their positions relative to each other are to scale. The relative distances are not to scale.

The table below 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

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 figure below 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.

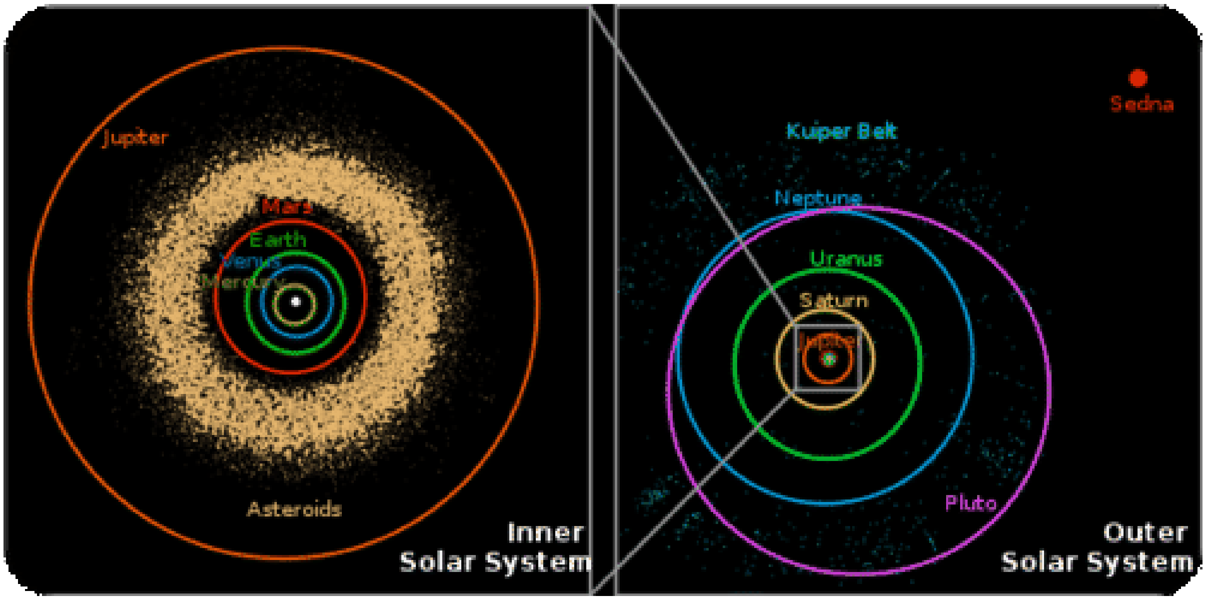


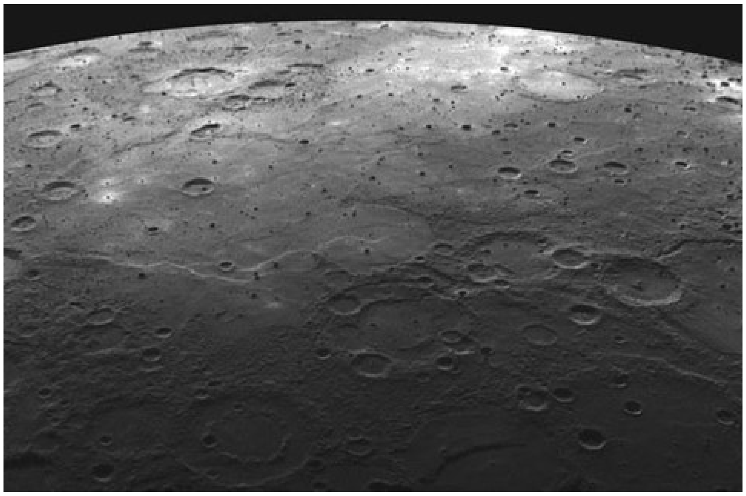
Image not to scale. The relative sizes of the orbits of planets in the solar system. The inner solar system and asteroid belt is on the upper left. The upper right shows the outer planets and the Kuiper belt.

Planets

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

- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn
- Neptune

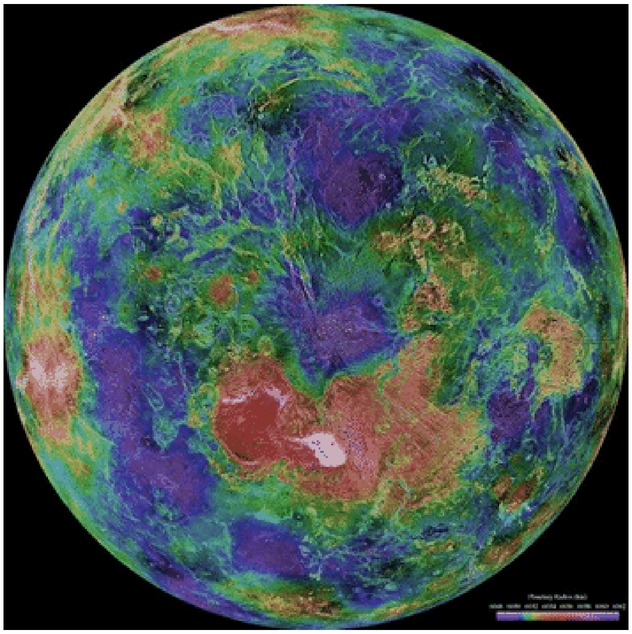
Mercury



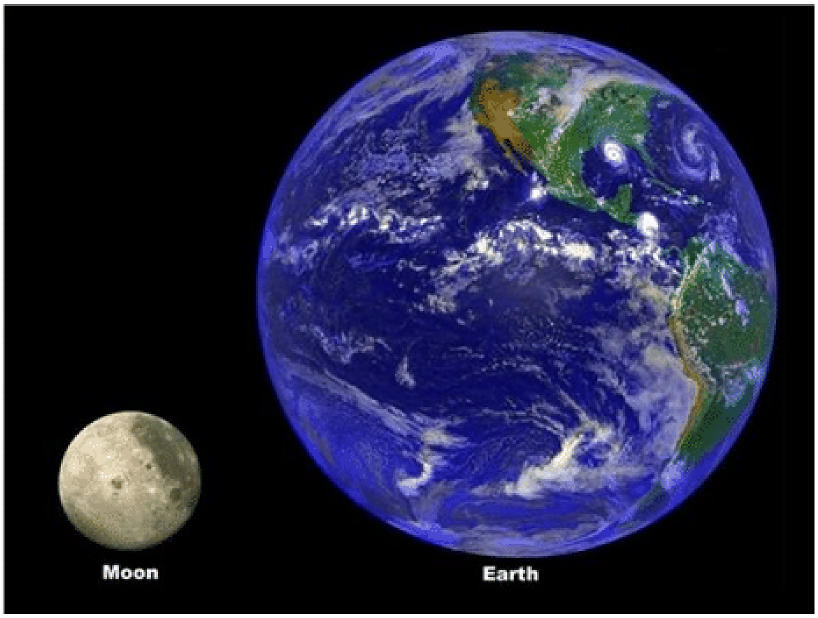
- It is the nearest planet to the Sun.
- Our moon and Mercury's surface look similar.
- It has a very thin atmosphere. It has no moons.
- It has the greatest range of temperature, 662˚F (day) to -274˚F (night) = 936˚.
- Rotation: 58.7 Earth days.
- Revolution: 88 Earth days.
- Distance from Sun: 0.39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

Venus

- 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.
- VERY FEW craters on Venus.
- It has no moons.
- Rotation: 243 Earth days.
- Revolution: 224.7 Earth days.
- 0.72 AU's.



Earth



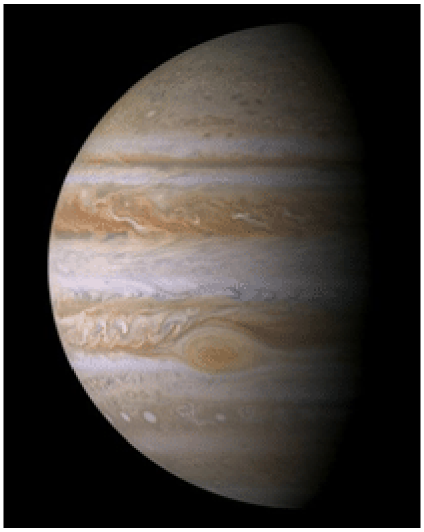
- It is the third planet from the sun
- It is covered by about 70% water and 30% land
- It has 1 large moon
- It has the only conditions necessary for life as we know it in our solar system
- It has volcanoes, mountains, earthquakes and a few craters
- Rotation: 24 hours
- Revolution: 365.25 days
- 1 AU

Mars

Phobos and Deimos

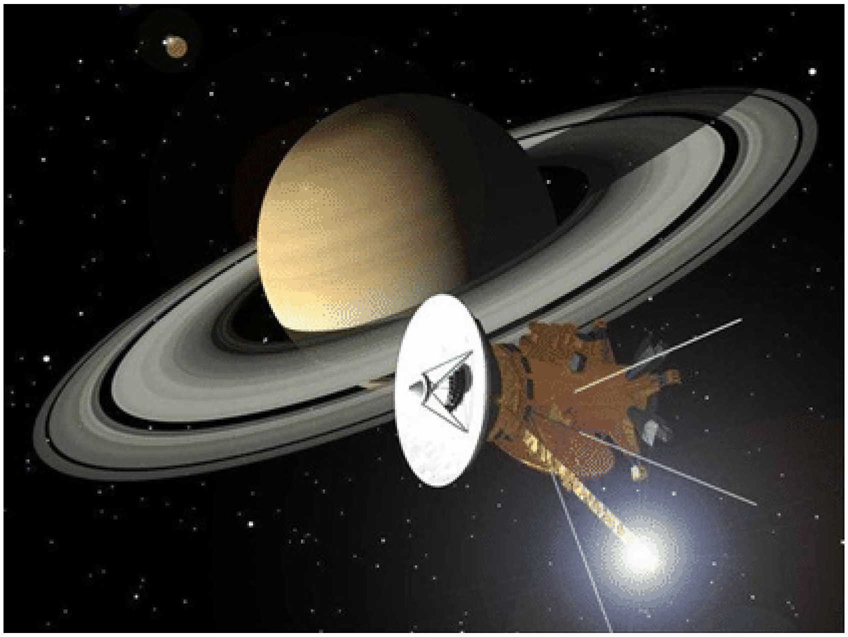
- It is the fourth planet from the sun.
- Iron oxides (rust) cause its surface to be reddish in color.
- It has polar ice caps made of frozen carbon dioxide and water ice.
- It has 2 small moons. (Phobos and Deimos)
- It has a thin atmosphere, less than 1% of Earth's.
- Huge dust storms sometimes cover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

Jupiter



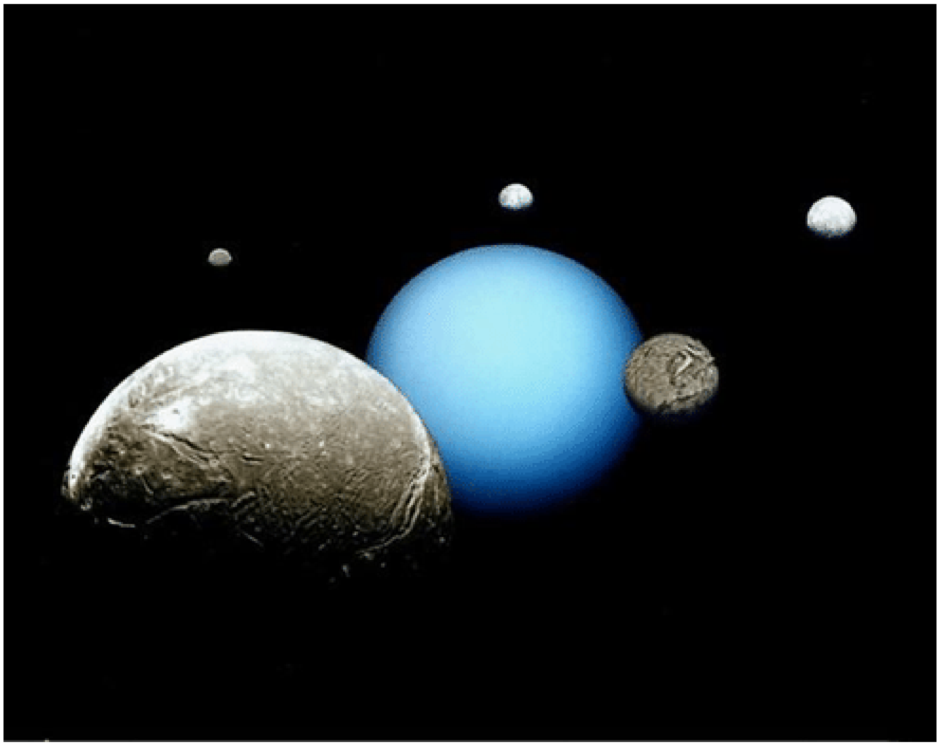
- It is the fifth planet from the sun.
- Its atmosphere is made mostly of hydrogen, helium and methane.
- Its Great Red Spot is a storm, which has lasted for at least 400 years.
- It has a very small and faint ring system.
- It has 4 large and 59 small moons for a total of 63 moons. Historically, each time humans sent another space probe to Jupiter, more moons were discovered!
- It is the largest planet in our solar system.
- Rotation: 9.9 hours.
- Revolution: 11.9 Earth years.
- 5.2 AU's.
- 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.

Saturn



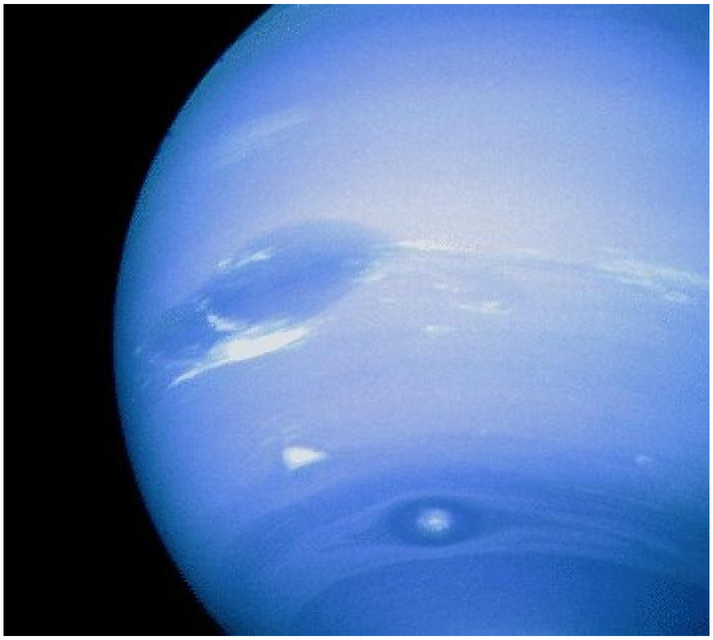
- It is the sixth planet from the sun
- It is the second largest planet
- It has an atmosphere of hydrogen, helium and methane
- It has 53 officially named moons
- The largest moon, Titan, is larger than Mercury
- It is not very dense, so if it were set upon Earth's oceans, it would float
- It has a large ring system. Saturn and rings would fit between the Earth and the Moon
- Rotation: 10.7 hours
- Revolution: 29.4 Earth years
- 9.58 AU's

Uranus



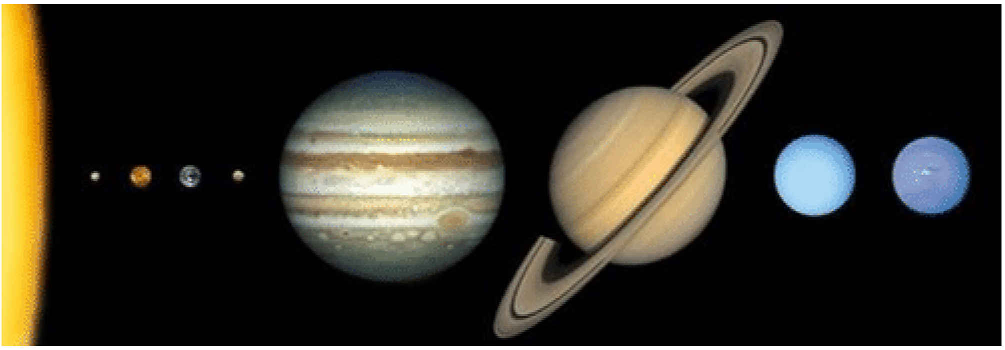
- It is the seventh planet from the sun
- It is the third largest planet in our solar system
- It has a small faint ring system
- Its axis points toward the sun, so it rotates on its side
- It has 27 moons
- It has an atmosphere of hydrogen, helium, and methane
- Methane causes Uranus to appear blue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

Neptune



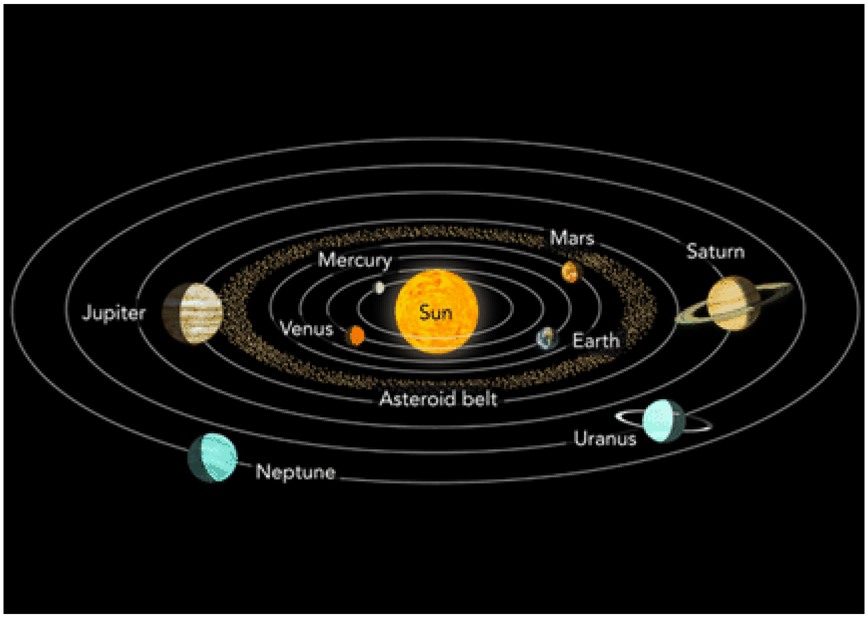
- It is the eighth planet from the sun
- It sometimes has a Great Dark Spot that is a huge storm system as large as Earth
- It has the fastest winds in the solar system
- Its atmosphere is made of hydrogen, helium and methane
- Methane causes Neptune to appear blue in color
- It has 14 moons
- Its moon,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

Comparing the Eight Planets



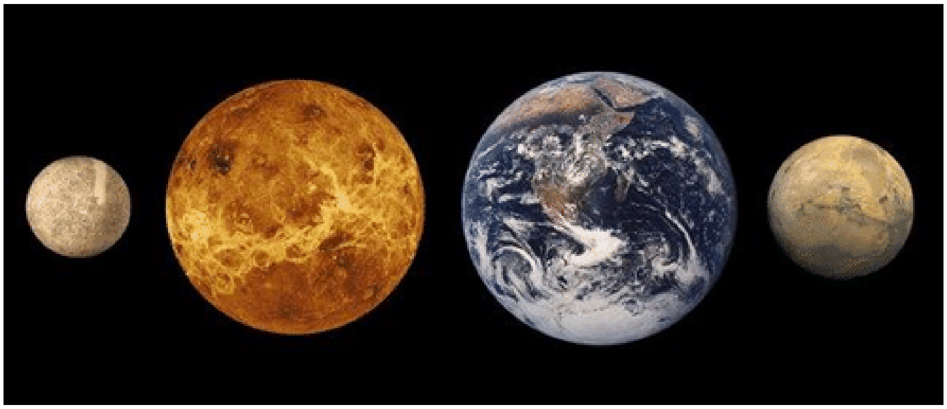
The sizes of the planets in this picture are shown to scale. The planets are compared to give us an accurate idea of their size. The distances between the planets are not to scale.

Using a scale to compare these objects helps show how the sizes of the planets compared Earth. We have some ideas of how large Earth is because we live and travel on it. Our knowledge of Earth helps us understand the sizes of the planets.



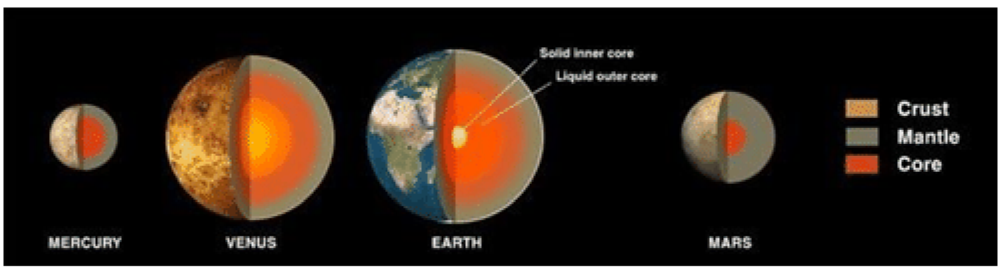
The planets are arranged within the solar system because of their individual properties.

Look at the picture of the solar system again. The four planets closest to the Sun are called the inner planets. They all are made of rock; some of them have a thin layer of gas on the outside.



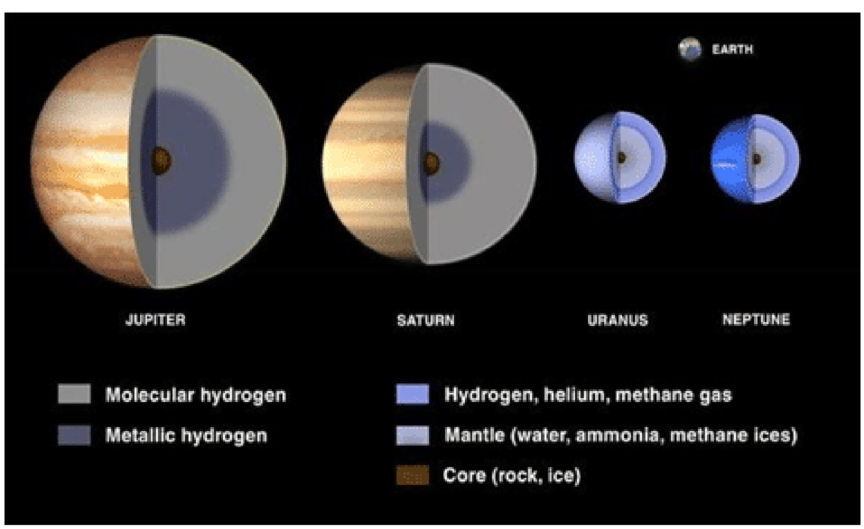
These are the four inner rocky planets. This shows their sizes compared to each other. Can you name them?

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.

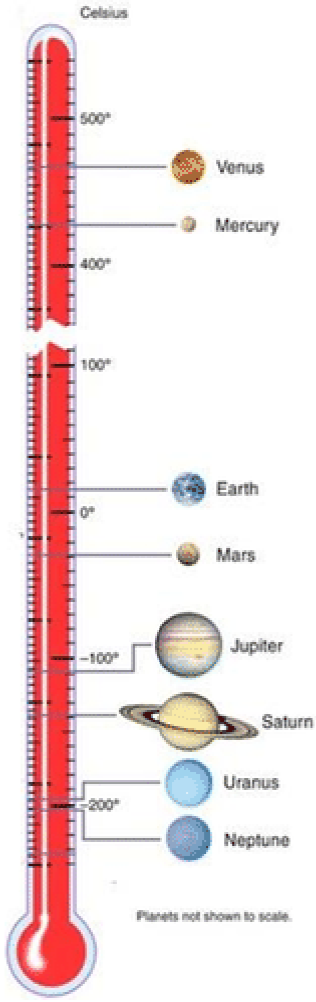


Inner planets

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.



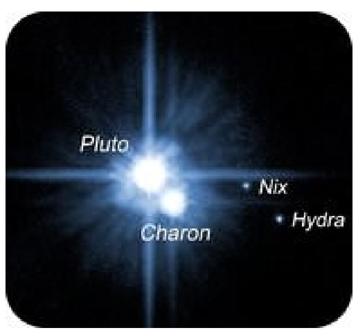
Outer Planets



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. This is because of the dense atmosphere of Venus which acts like a greenhouse and traps the Sun's energy in the atmosphere.

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.



Pluto and its moon, Charon, are actually two objects.

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. 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

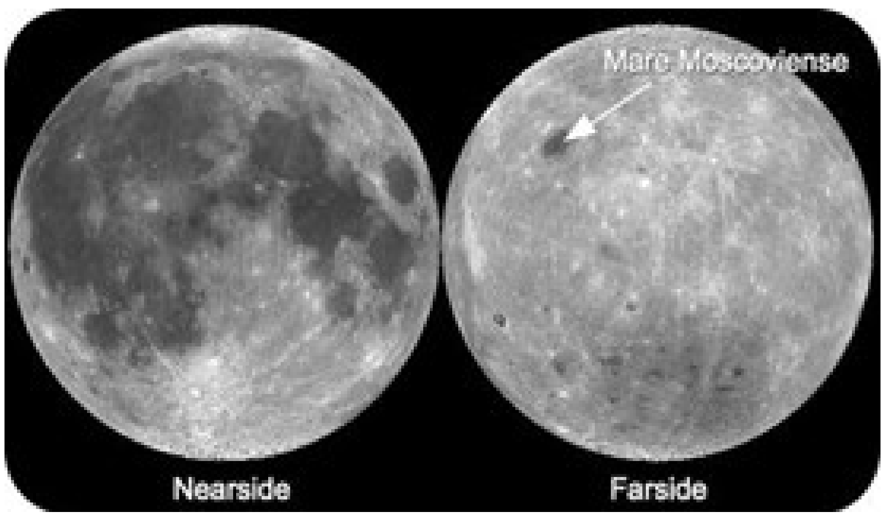
*diameter of the dwarf planet along its longest axis.
**estimate based on current data

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!

Natural Satellites

Earth's Moon

The surface of the 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.

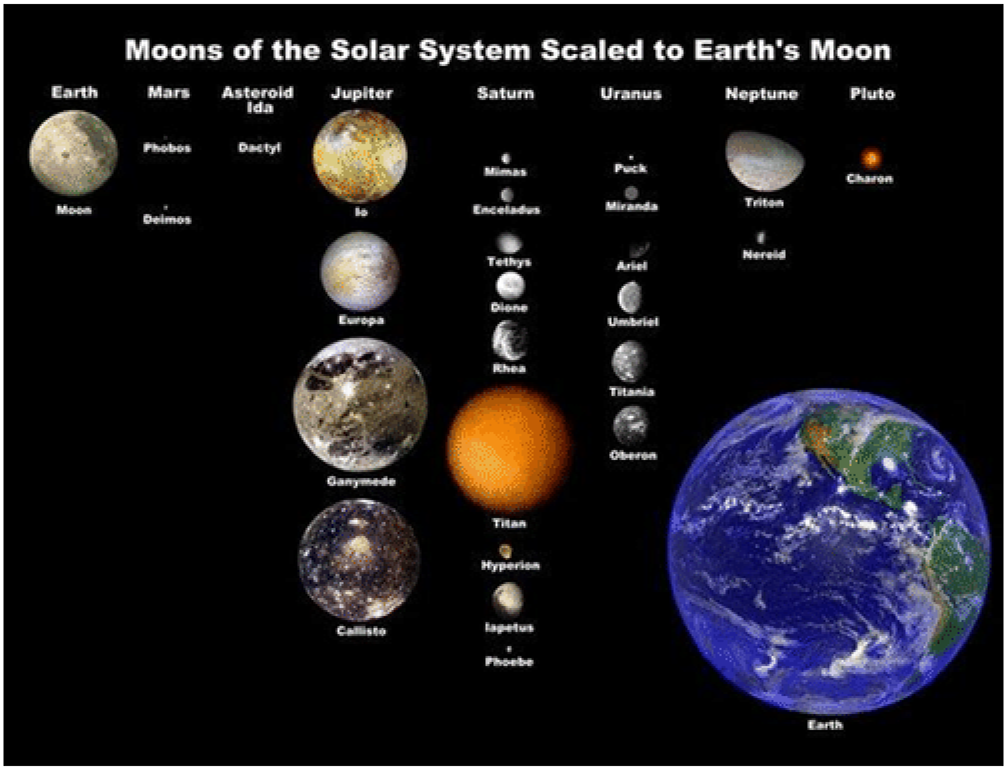


The first astronauts to walk on the Moon stepped into fine, powdery dust. They collected rock samples to bring back to Earth. The footprints from the astronauts who first walked on the Moon are still there! There is no wind on the Moon to blow them away. Those footprints will be on the moon in many thousands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

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

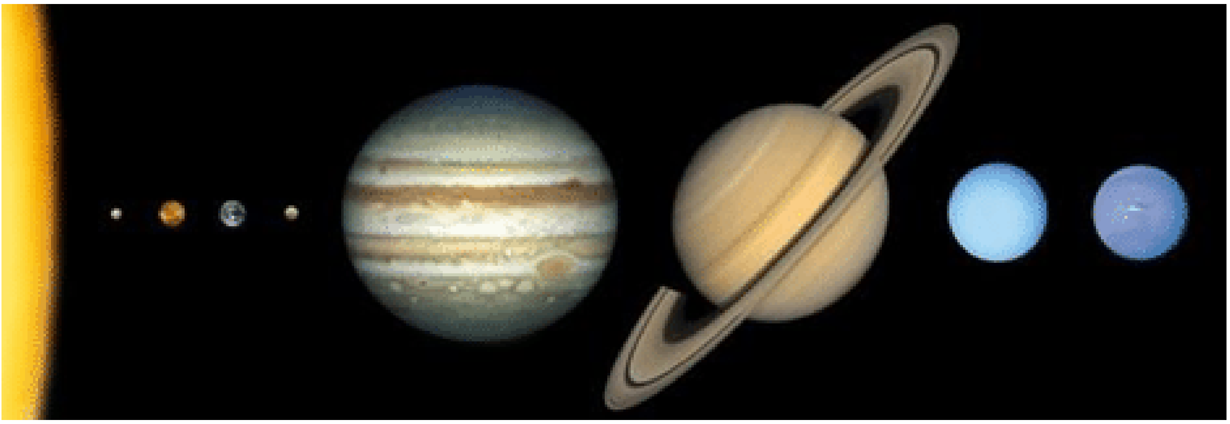
Other planets have moons too. Below is an image showing some of the moons in our solar system. Not all of them are shown here. They are at the correct size scale so they can be compared to Earth and our Moon.



Focus Questions

1. What patterns can you identify among planets that have a larger diameter?
2. What properties differentiate a dwarf planet and a planet?
3. What is an astronomical unit? Why is this unit used to measure distances in the solar system?

Putting It Together



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, what is useful about this model for understanding the solar system?

What are the limitations of this model?

2.4 References

1. Ee Shawn. Phases are but part of the journey .

2. Brandy. Moon and planet .

3. Phillipe Put. https://flic.kr/p/q21yDV .

4. Adapted from https://commons.wikimedia.org/wiki/File:Lunar-Phase-Diagram.png .

5. https://c1.staticflickr.com/3/2898/13920257368_607b115131_b.jpg .

6. The moon's position during a lunar eclipse.

7. A lunar eclipse is shown in a series of pictures.

8. https://c1.staticflickr.com/3/2898/13920257368_607b115131_b.jpg .

9. The moon's position during a solar eclipse.

10. A solar eclipse shown as a series of photos.

11. Picture of a total solar eclipse.

12. http://www.ck12.org/earth-science/Seasons/lesson/Seasons-MS-ES/ .

13.http://www.ck12.org/physical-science/Orbital-Motion-in-Physical-Science/lesson/Orbital-Motion-MS-PS/ .

14. https://pixabay.com/en/earth-solar-sun-moon-universe-1281025/ .

15. The relative sizes of the Sun and planets in the Solar System.

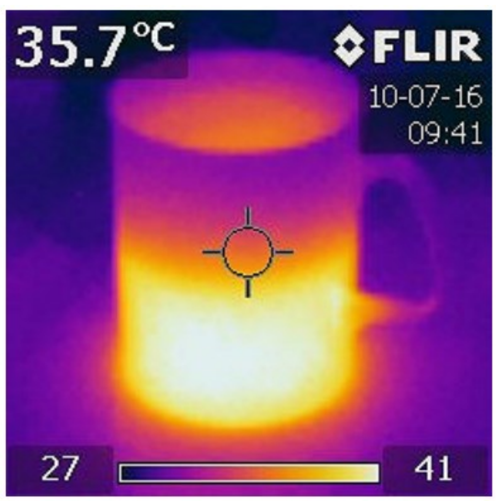
16. The relative sizes of the orbits of planets in the solar system.

17. Pluto and its moon, Charon, are actually two objects.

CHAPTER 3

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.

3.1 Atoms and Molecules (6.2.1)

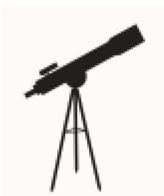
Explore this Phenomenon

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 (H2O), atmospheric oxygen (O2), and carbon dioxide (CO2).



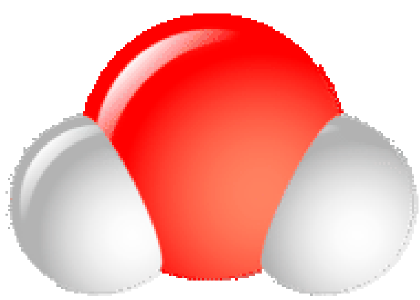
In this section focus on proportions and quantities. There are differences between atoms and molecules. It is important to develop models that show how different proportions and quantities of atoms form different molecules.

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 we 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 figure on the right shows a water molecule that has two hydrogen atoms (shown in gray) bonded to one oxygen atom (shown in red).



To help develop your model of 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.

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.

3.2 States of Matter (6.2.2)

Explore this Phenomena

Observe the clothes that have been put out on a clothesline to dry. Record your observations and questions in the chart below.

Observations	Questions

Draw a model to explain why clothes dry while out on a clothesline.

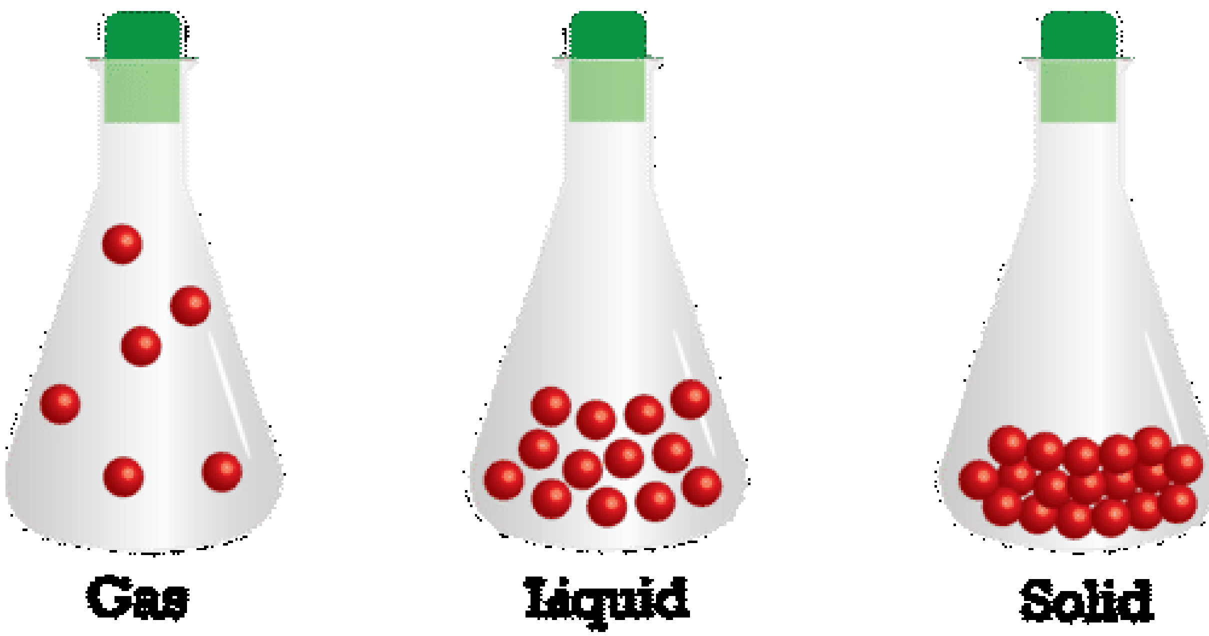
6.2.2 States of Matter

Develop a model to predict the effect 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).

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.



Solids are defined by the following characteristics:
- Definite shape (rigid)
- Definite volume
- Particles vibrate around fixed axes

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

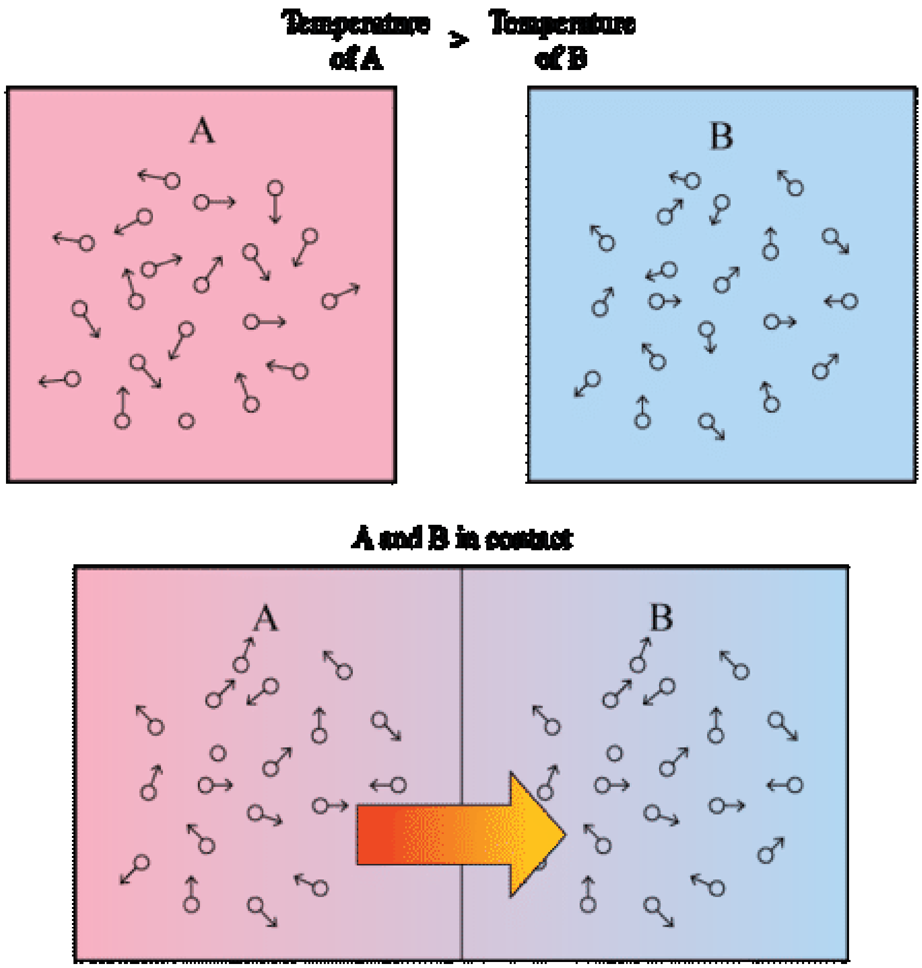
Gases have the following characteristics:

- 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 figure below.



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.

As thermal energy is transferred, materials expand as temperature increases. 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 and the arrangement of particle 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 figure to the right. 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.

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.

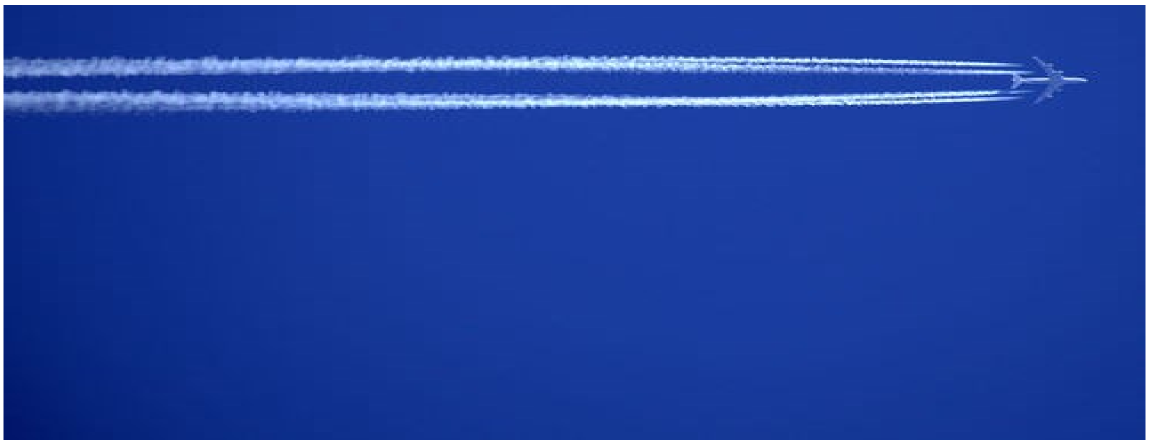
As energy in a substance is transferred, it causes a change in its state. In the previous example, ice was added to a cola. The energy was transferred from the warmer cola to the cooler ice. This caused the ice to melt and change from a solid to a liquid.

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 figure below.



This picture shows the contrail (condensation trail) left behind by a jet. Water vapor in its exhaust gases condensed on dust particles in the air.

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.

Focus Questions:

1. Draw a model that shows the motion of particles in a solid, liquid and a gas.
2. What is the effect as heat energy is added to a bar of chocolate?
3. Ice floats in water. What does this tell us about the ice's density?

Putting It Together

Review your initial explanation from the beginning of this section. Revise your model for why clothes dry while out on a clothesline based on what you have learned about phase changes and particle motion.

3.3 Heat Energy and Particle Motion (6.2.3)

Explore this Phenomena

Above are two different bodies of water that are close in 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.

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.

The soup is boiling hot and has a temperature of 100 °C, whereas the water in the tub is just comfortably warm, with a temperature of about 38 °C. 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 those 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 thermal energy? Explain your reasoning.
3. What is the difference between thermal energy and temperature?

Putting It Together

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.

3.4 Engineering Design (6.2.4)

Explore this Phenomena

Have you ever noticed that when you walk on a tile floor it feels colder than walking 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.

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 limitations, or constraints, on the design must be taken into account. These might include factors such as the cost or safety of the new product or process. Making and testing a model of the design are also important. These steps ensure that the design actually works to solve the problem. This process also gives the designer a chance to find problems and modify the design if necessary. No solution is perfect, but testing and refining a design assures that the 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 and constraints they will need to consider. In order to generate many possible solutions, engineers brainstorming

Consider the problem of developing a solar-powered car. Many questions would have to be researched in the design process. For example, what is the best shape for gathering the sun's rays? How will sunlight be converted to useable energy to run the car? Will a back-up 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.

Besides the heating element inside a toaster, another example of a thermal conductor is a metal radiator, like the one in the figure below. 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.

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

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

Focus Questions

1. What are some examples of thermal conductors?
2. What are some examples of thermal insulators?
3. What materials would be useful in maintaining the temperature in a home?

Putting It Together

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

3.5 References

1. chris UK. Rain Faces

2. Andrew Barclay. IR_0150 cup half full

3. ttfnrob. layering liquids - 09

4. https://pixabay.com/p-548647/?no_redirect

5. http://www.ck12.org/physical-science/Hydrogen-and-Alkali-Metals-in-Physical-Science/rwa/Salt-Shakeup/

6. Structure of a water molecule.

7. Ice cubes in cola cause the cola to lose thermal energy.

8. Condensation trail behind a jet.

9. Ponds and Lakes

10. Ponds and Lakes

CHAPTER 4

Strand 3: Earth's Weather Patterns and Climate

Chapter Outline

All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. Heat energy from the Sun, transmitted by radiation, is the primary source of energy that affects Earth's weather and drives the water circle. Uneven heating across the Earth's surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

4.1 Water Cycle (6.3.1)

Explore This Phenomena

Every school has drinking fountains. You need water. Think about the water that you drink. Where did the water come from before you drank it? Where will it go when you are done with it? How long has the water been here on Earth?

Where do you think the water you are drinking today has been? Draw a model that shows where your water has been.

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.

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

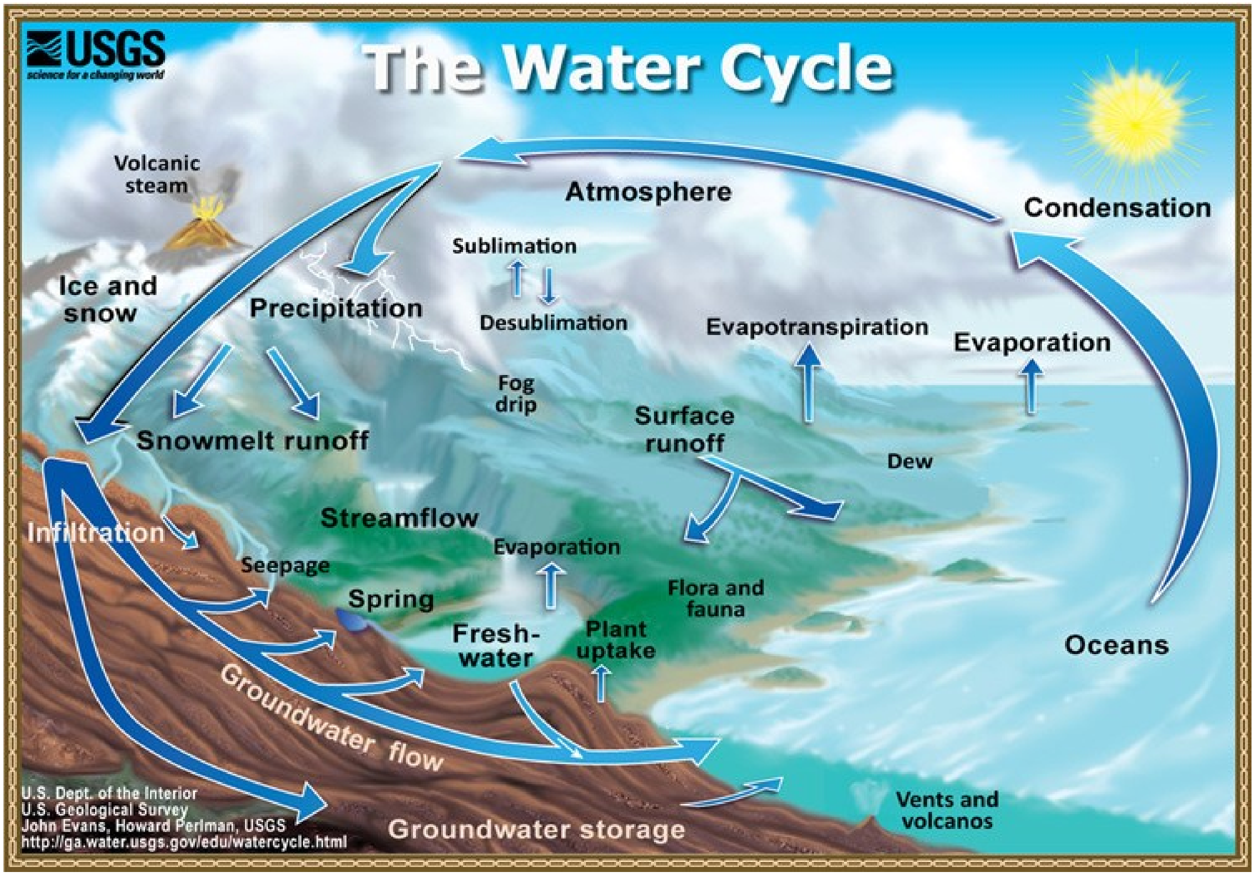
The water molecule found in your glass of water today could have erupted from a volcano early in Earth's history. In the intervening billions of years, the molecule probably spent time in a glacier or far below the ground. The molecule surely was high up in the atmosphere and maybe deep in the belly of a dinosaur. Because of the unique properties of water, water molecules can cycle through almost anywhere on Earth. Where will that water molecule go next?

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

- Water evaporates from the surface of the ocean. As the water vapor rises, it collects and is stored in clouds.
- As water cools in the atmosphere it condenses to form clouds. Condensation is when water vapor turns into liquid water.
- Water leaves the atmosphere as precipitation. Precipitation includes rain, snow, hail, and sleet. Precipitation returns the water to the Earth's surface.
- When precipitation falls to the surface, the water can sink into the ground to become part of the underground water reservoir, also known as groundwater. Much of this underground water is stored in aquifers, which are porous layers of rock that can hold water.

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 also moves through the living organisms. Plants soak up large amounts of water through their roots. The water then moves up the plant and evaporates from the leaves in a process called transpiration. Another name for transpiration is evapotranspiration. The process of 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 an input of energy. The Sun directly impacts the water cycle by supplying the energy needed for evaporation.

Density

As clouds accumulate more water they become more dense. Water will fall from the clouds as precipitation to the surface of the Earth.

Gravity

Clouds will move water from the ocean to the tops of the mountains. Water evaporated from the ocean will be deposited on land as precipitation. Gravity pulls the water down to the oceans where the process continues.

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

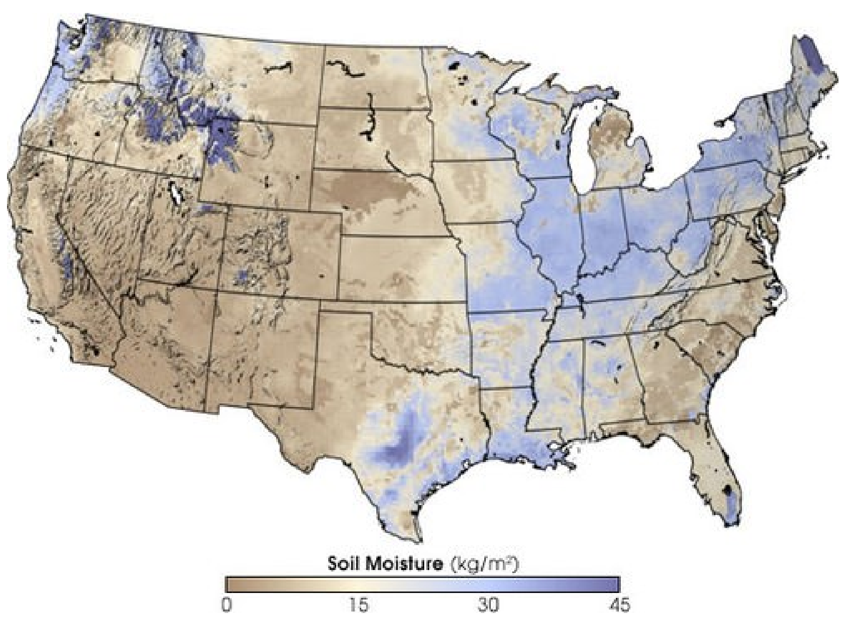
When water absorbs energy it will change from a liquid to water vapor. The Sun's energy can evaporate water from the ocean surface or from lakes, streams, or puddles on land. The water vapor remains in the atmosphere until it condenses to become tiny droplets of liquid. The droplets gather in clouds, which are blown about the globe by wind. As the 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 (Figure below). Water trapped in soil is important for plants to grow.



The moisture content of soil in the United States varies greatly. (From ck12)

Groundwater

Water may seep through dirt and rock below the soil and then through pores infiltrating the ground to go into Earth's groundwater system. Groundwater enters aquifers that may store fresh water for centuries. Alternatively, the water may come to the surface through springs or 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 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 will 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?

Putting It Together

Where do you think the water you are drinking today has been?

Review your initial model, now draw a revised model that shows where your water has been based on what you have learned.

4.2 Pressure and Air Masses (6.3.2)

Explore This Phenomena

Everybody loves a picnic. Your friends and you are headed up the canyon to enjoy the mountains. While driving you feel a slight discomfort in your ears which goes away as soon as your ears “pop”. What happened? Why were your ears hurting?

Write an explanation for why your ears were hurting as you drove into the mountains and stopped hurting once they “popped”.

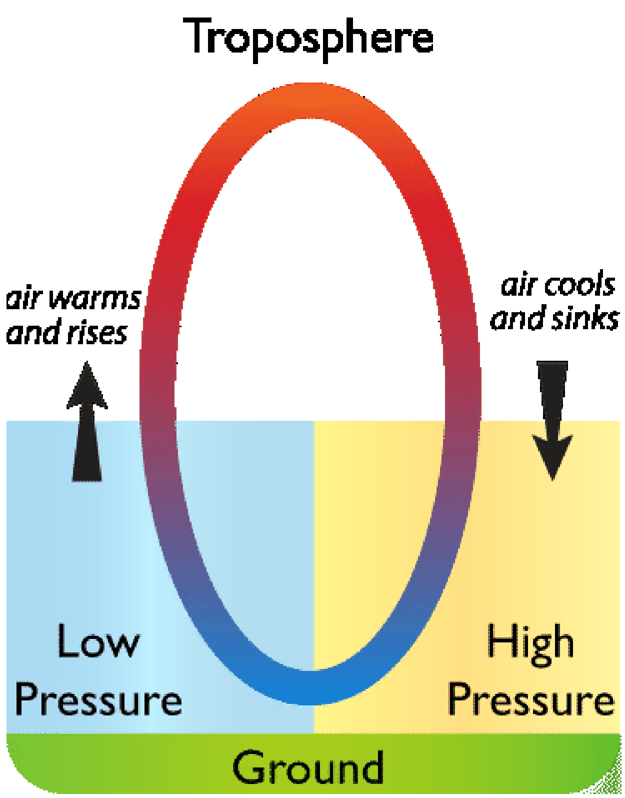
6.3.2 Air Pressure

Investigate the interactions between air masses that cause 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.

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 is 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 rises, creating a low pressure zone; cool air sinks, creating a high pressure zone

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. Since it can then hold more moisture, the descending air will evaporate water on the ground.

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.

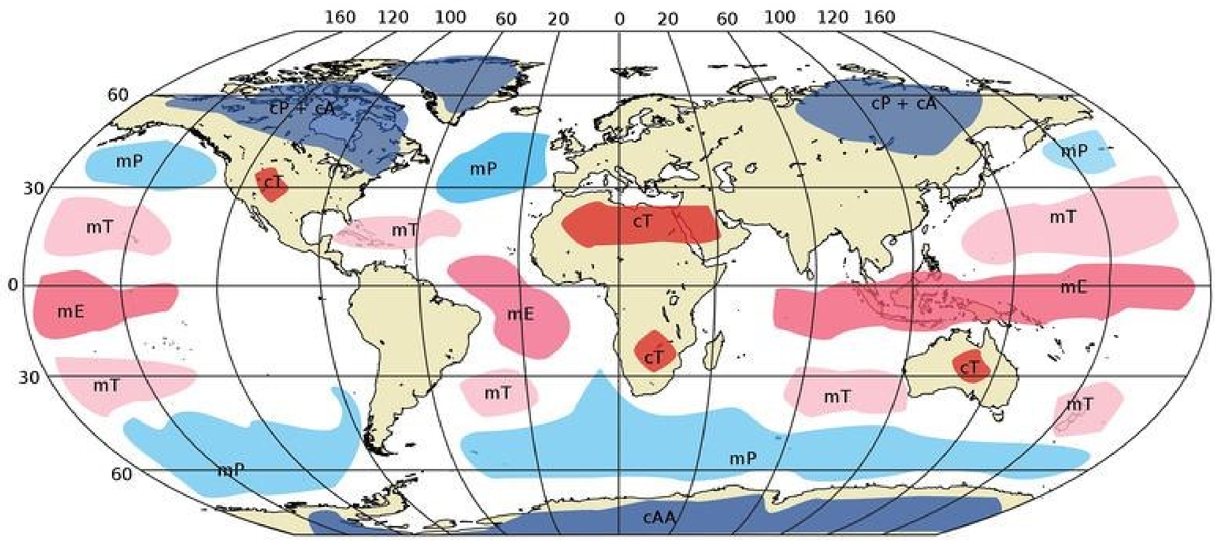
This bottle was closed at an altitude of 3,000 meters where air pressure is lower. When it was brought down to sea level, the higher air pressure caused the bottle to collapse.

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 they form.

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.

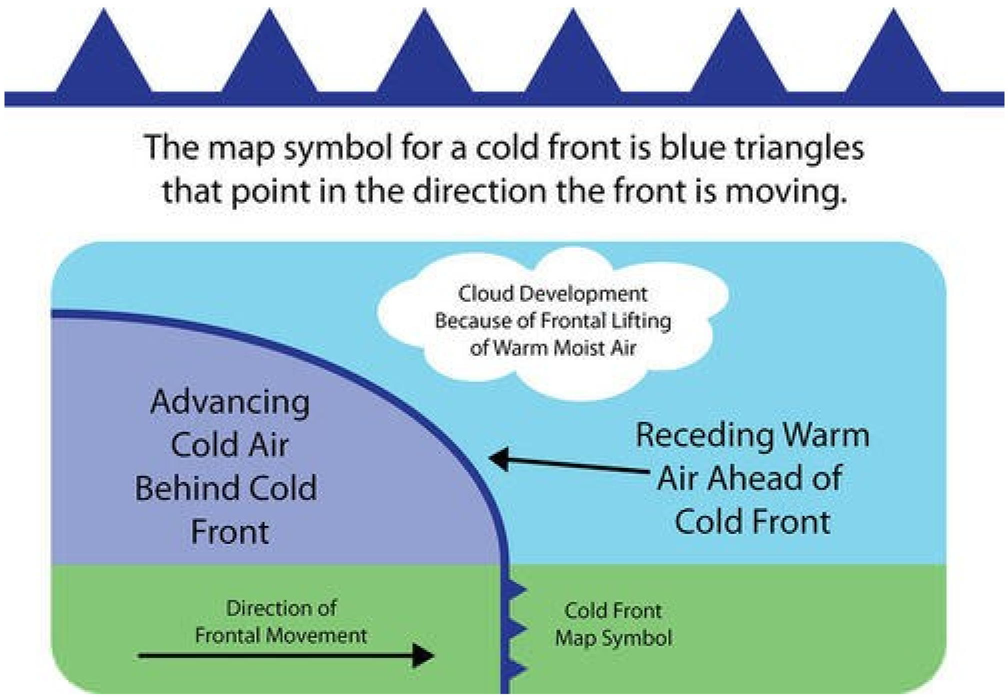
Fronts

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 (Figure below).



The cold air mass is slides beneath the warm air mass and pushes it up.

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

The weather at a cold front varies with the season.

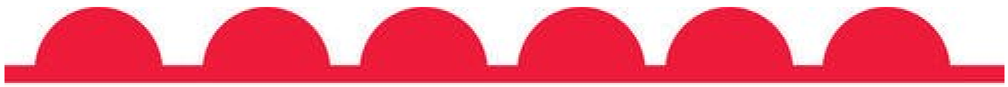
- Spring and summer: the air is unstable so thunderstorms or tornadoes may form.
- Spring: if the temperature variation is high, strong winds blow.
- Autumn: strong rains fall over a large area.
- Winter: the cold air mass is likely to have formed in the frigid arctic, so there are frigid temperatures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

Warm Fronts

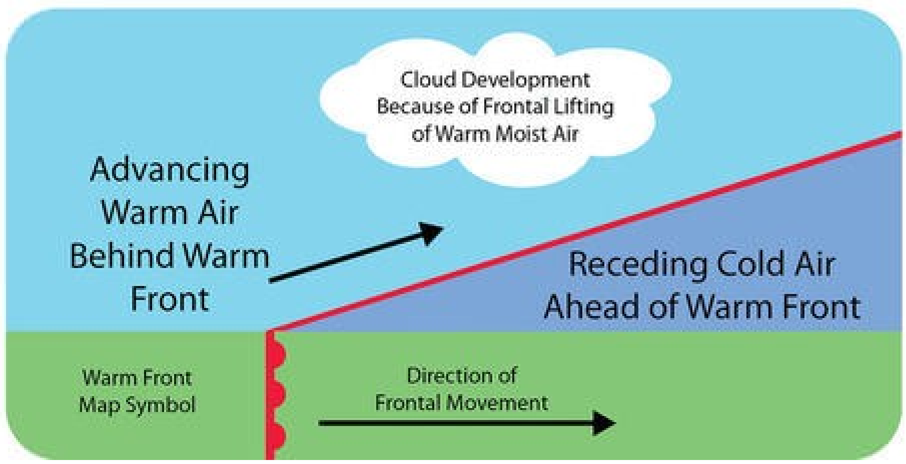
At a warm front, a warm air mass slides over a cold air mass (Figure below). When warm air moves over the colder air the atmosphere is relatively stable.

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, so 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.



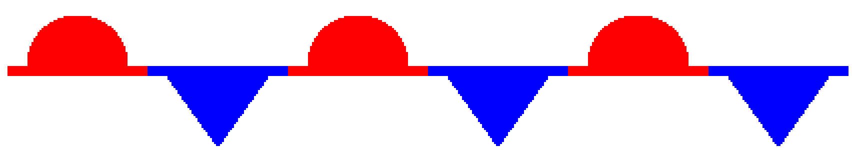
The map symbol for a warm front is red half-circles that point in the direction the front is moving.



Warm air moves forward to take over the position of colder air.

Stationary Fronts

At a stationary front the air masses do not move (Figure below). 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

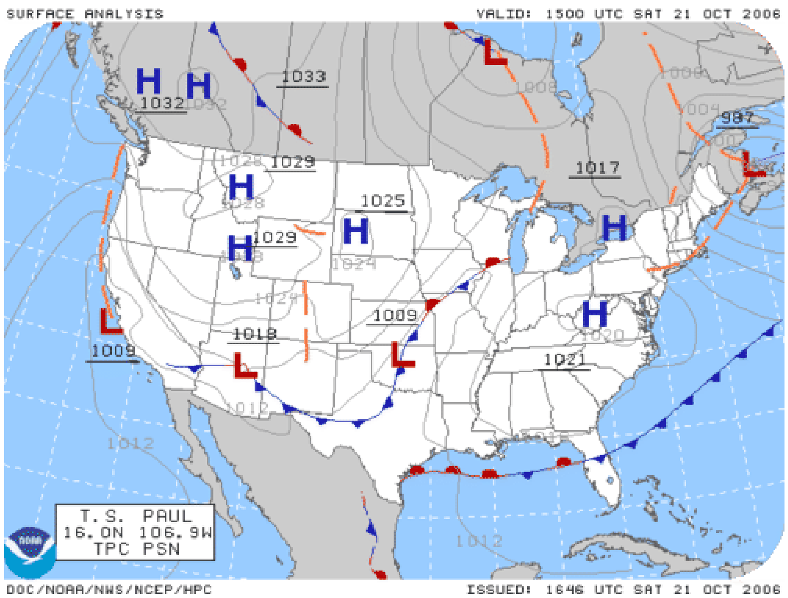
An occluded front usually forms around a low pressure system (Figure below). The occlusion starts when a cold front catches up to a warm front. The air masses, in order from front to back, are cold, warm, and then cold again.

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 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?



Putting It Together

Everybody loves a picnic. Your friends and you are headed up the canyon to enjoy the mountains. While driving you feel a slight discomfort in your ears which goes away as soon as your ears "pop". What happened?

Why were your ears hurting?

Review your initial explanation about why your ears stop hurting once they popped. Based on what you have learned, write a revised explanation for why your ears were hurting as you drove into the mountains and stopped hurting once they "popped."

4.3 Climate (6.3.3)

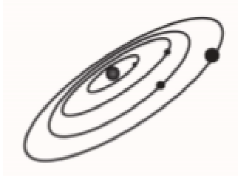
Explore this Phenomena

The same sun shines on the entire Earth.

Explain why these two areas have such different climates.

6.3.3 Climate

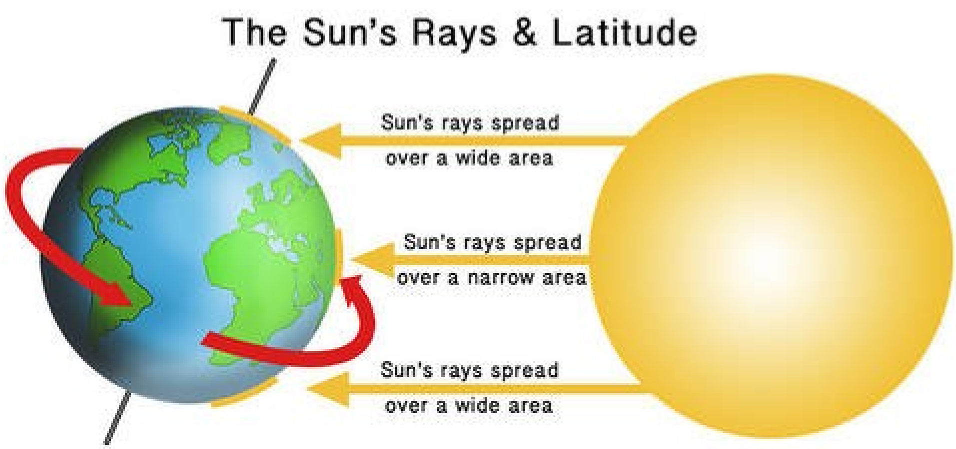
Develop and use a model to show how unequal heating of the Earth's systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional weather patterns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



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.

Energy and Latitude

Different parts of Earth's surface receive different amounts of sunlight (Figure below). 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.



The lowest latitudes get the most energy from the Sun. The highest latitudes get the least.

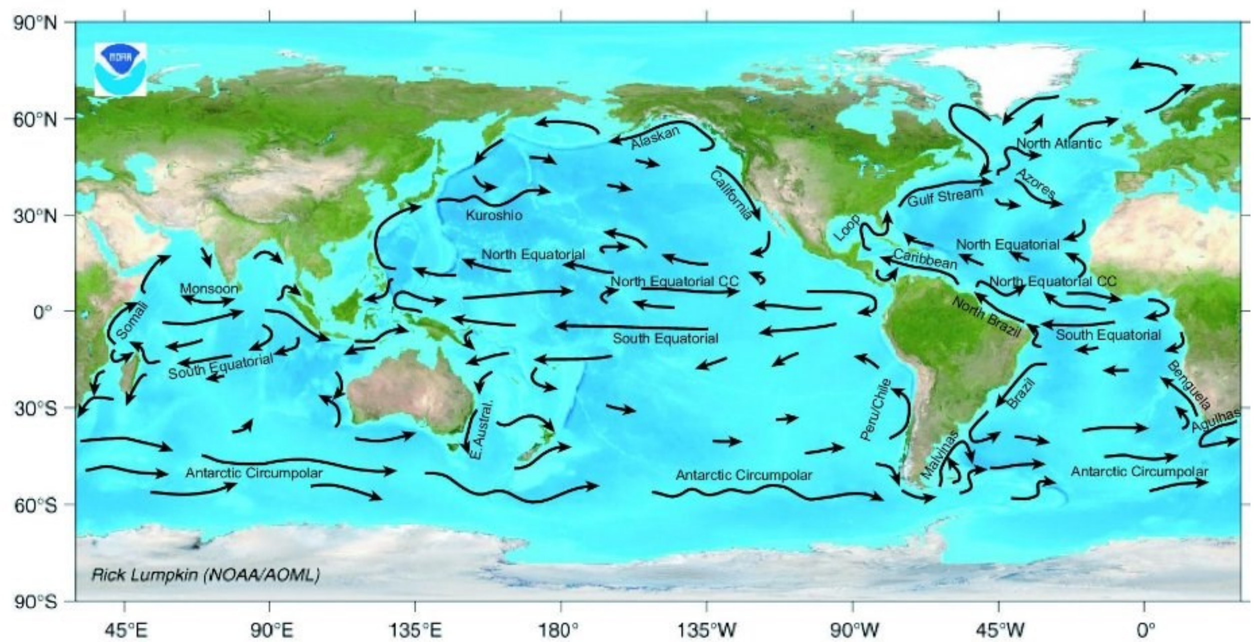
The difference in solar energy received at different latitudes caused unequal heating of Earth's surface. Places that get more solar energy will be warmer. Places that get less solar energy will be cooler. Warm air rises and cool air sinks. This principle means that air moves around the planet. The Earth's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

Circulation of the Atmosphere and the Ocean

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.

Ocean water moves in predictable ways along the ocean surface. Surface currents can flow for thousands of kilometers and can reach depths of hundreds of meters. These surface currents do not depend on the weather; they remain unchanged even in large storms because they depend on factors that do not change. Surface currents are created by global wind patterns and the rotation of the Earth. Surface currents are extremely 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 directions all the time and are related 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

Surface currents play an enormous role in Earth's climate. Even though the Equator and poles have very different climates, these regions would have extremely different climates if ocean currents did not transfer heat from the equatorial regions to the higher latitudes.

An example of how ocean current effect an area's climate is the Gulf Stream. The Gulf Stream is a river of warm water in the Atlantic Ocean, 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, which raises the air temperatures over land between 3 to 6°C (5 to 11°F). London is at about six degrees further south than Quebec. However, London's average January temperature is 3.8°C (38°F), while 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. In contrast, Quebec is much drier and receives its precipitation as snow.

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.

Review what you wrote about the climates in these two pictures. Based on what you have learned, explain why these two areas have such different climates.

4.4 The Greenhouse Effect (6.3.4)

Explore this Phenomena

Summer is a great time of year. The weather is warm. People spend a lot of time outside. Eventually you have to return home. Imagine you have spent the entire day playing outside, while your car was parked in a parking lot. You open the door to climb in your car. It feels like you are climbing into an oven!

Based on your own experiences record observations and questions about this phenomena.

Observations	**Questions**

Explain why the inside of a car that is parked outside during the summer can become so hot.

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.

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.

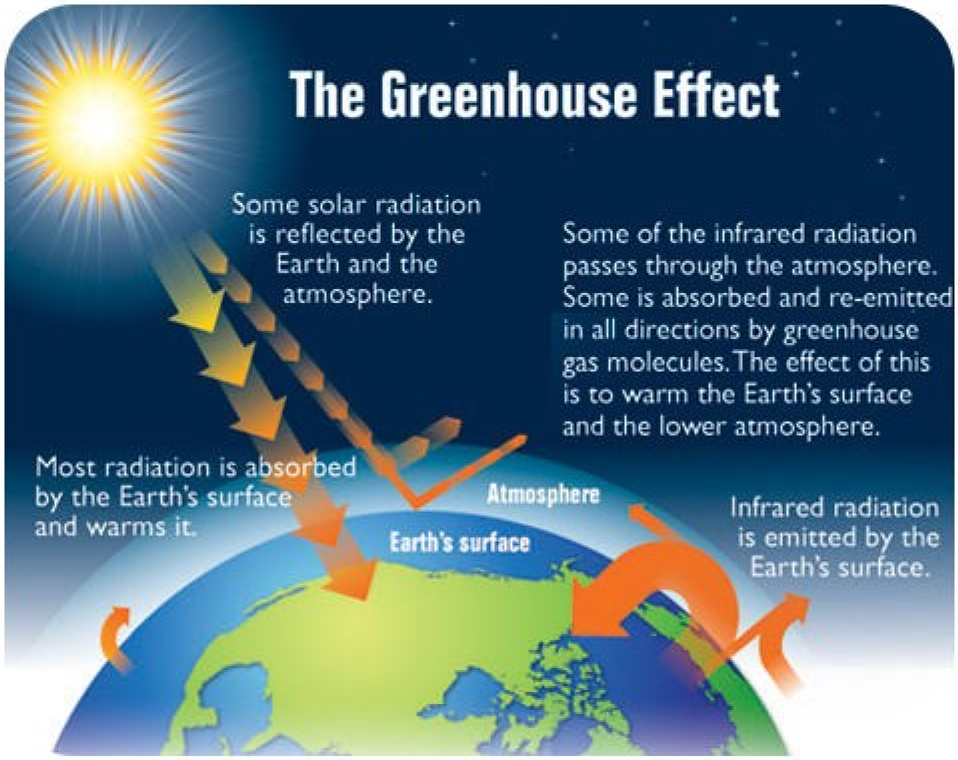
What is the Greenhouse Effect?

When sunlight heats Earth's surface, some of the heat radiates into the atmosphere. Some of this heat is absorbed by gases in the atmosphere. This is the greenhouse effect, and 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. Like a blanket on a sleeping person, greenhouse gases act as insulation for the planet. The warming of the atmosphere is because of insulation by greenhouse gases. Greenhouse gases are the component 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) a temperature far too cold to support life as we know it. With the greenhouse effect, Earth's surface temperature averages 15°C (5°F), and it is this temperature range to which today's diversity of life has adapted.

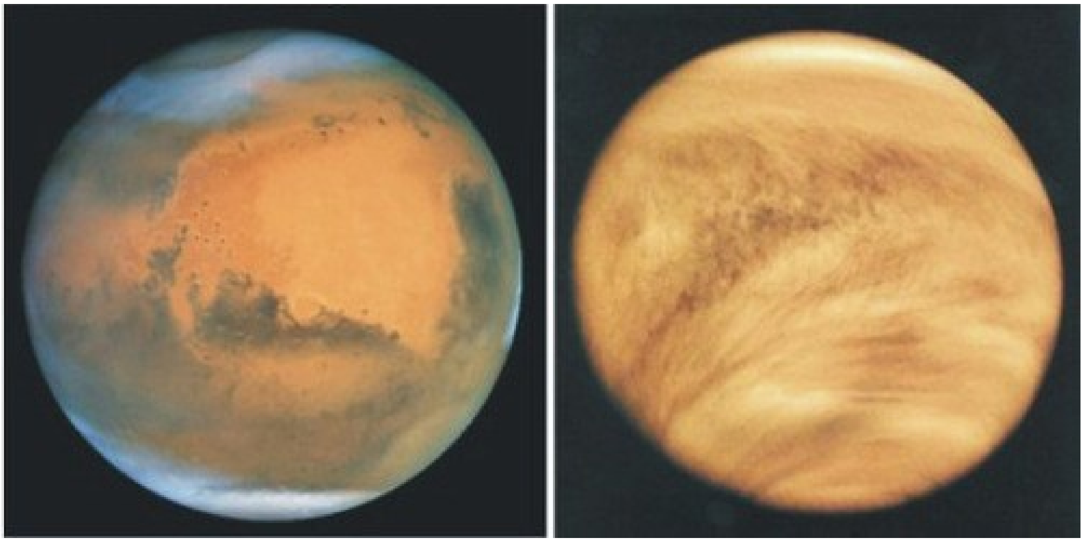
The movement of energy due to the greenhouse effect is summarized in the figure below. Of the solar radiation which reaches the Earth's surface, as much as 30% is reflected back into space. About 70% is absorbed as heat, warming the land, waters, and atmosphere. If there were no atmosphere, most of the heat would radiate back out into space as infrared radiation. Earth's atmosphere contains molecules of water (H_2O), carbon dioxide (CO_2), methane (CH_4), and ozone (O_3), which absorb some of the infrared radiation. Some of this absorbed radiation further warms the atmosphere, and some is emitted, radiating back 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 an equilibrium which maintains a constant average temperature for the Earth.



The Greenhouse Effect. 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.

If we compare Earth's atmosphere to the atmospheres which surround Mars and Venus (Figure below) we can understand why the composition of the Earth's atmosphere is important. Mars' atmosphere is very thin, exerting less than 1% of the surface pressure of the Earth. As you might expect, the thin atmosphere cannot hold heat and the average surface temperature is -55°C (-67°F) – even though that atmosphere is 95% CO_2 and contains a great deal of dust. Daily variations in temperature are extreme, because the atmosphere cannot hold heat.

In contrast, Venus' atmosphere is much thicker than Earth's, exerting 92 times the surface pressure of our own. Moreover, 96% of the atmosphere is CO_2, so a strong greenhouse effect heats the surface temperature of Venus as high as 500°C, hottest of any planet in our solar system. The thick atmosphere prevents heat from escaping at night, so daily variations are minimal.



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 -55oC. Venus (right) has a far more dense atmosphere than Earth, and surface temperatures reach 500oC.

Focus Questions

1. Explain how the atmosphere keeps the Earth warm?
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

Summer is a great time of year. The weather is warm. People spend a lot of time outside. Eventually you have to return home. Imagine you have spent the entire day playing outside, while your car was parked in a parking lot. You open the door to climb in your car. It feels like you are climbing into an oven!

Review your explanation for why a car parked outside during the summer can become so hot. Based on what you have learned, revise your explanation for why a car can become so hot, and explain what you can do to prevent a car from becoming too hot during the summer.

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13. Symbol for an occluded front

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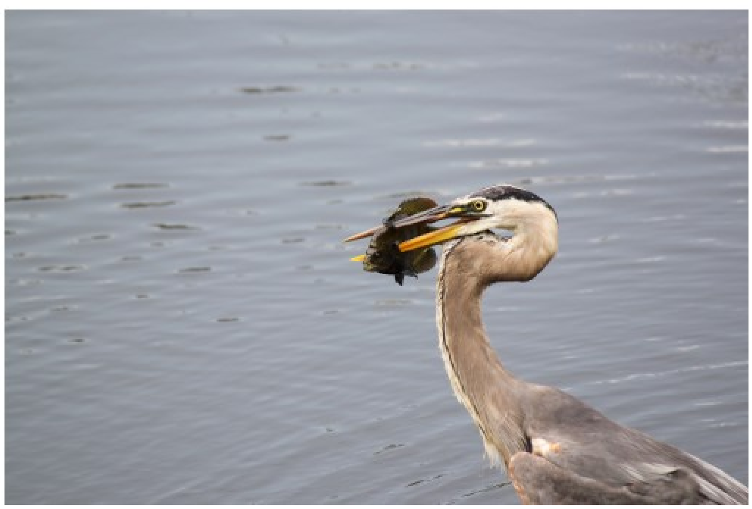
18. Philip Ray. Honda EP 9 Type R 16

CHAPTER 5

Strand 4: Ecosystems

Chapter Outline



The study of ecosystems includes the interaction of organisms with each other and with the physical environment. 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.

5.1 Ecosystems (6.4.1)

Explore this Phenomena

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 effects 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.

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?

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. 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, such as all the species of plants, animals, and fungi, as well as all the microorganisms. Nonliving factors are called abiotic factors. Abiotic factors include temperature, water, soil, and air.

You can find an ecosystem in a large body of fresh water or in a small aquarium. You can find an ecosystem in a large thriving forest or in a small piece of dead wood. Examples of ecosystems are as diverse as the rain forest, the savanna, the tundra, or the desert (Figure below). The differences in the abiotic factors, such as differences in temperature, rainfall, and soil quality, found in these areas greatly contribute to the differences seen in these ecosystems.

Desert Botanical Gardens in Phoenix, Arizona.

Different organisms live in different types of ecosystems because they are adapted to different conditions. Lizards thrive in deserts, but no reptiles are found in any polar ecosystems. Amphibians can't live too far from the water. Large animals generally do better in cold climates than in hot climates.

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. Distinguish between abiotic and biotic factors. Give examples of each.
3. 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.

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. Support your claim with evidence and/or reasoning.

5.2 Interactions among Organisms (6.4.2)

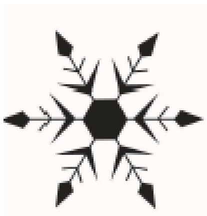
Explore this Phenomenon

The images show a frog and an insect and a wolf pack surrounding a bison. Do you notice any patterns?

Explain the interactions between the organisms that is shown in each image.

6.4.2 Interactions among Organisms

Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments, such as competition, predation, and mutualism.



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 it 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.

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

The images show a frog and an insect and a wolf pack surrounding a bison. Do you notice any patterns?

Review the explanation you wrote at the beginning of this section. Based on what you have learned write a revised explanation that describes the interactions between the organisms shown in each image.

5.3 Matter and Energy in Ecosystems (6.4.3)

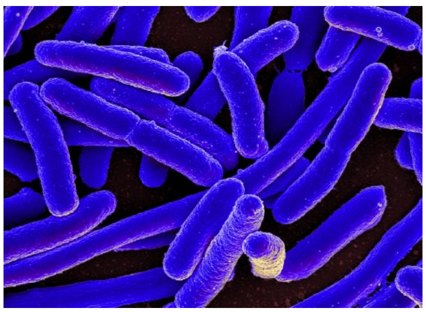
Explore this Phenomenon

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

Brine shrimp

Green algae

Bacteria



Brine flies

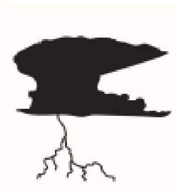
Eared grebe

California Gull

Develop an initial model that describes the cycling of matter and flow of energy among these organisms.

6.4.3 Matter and Energy

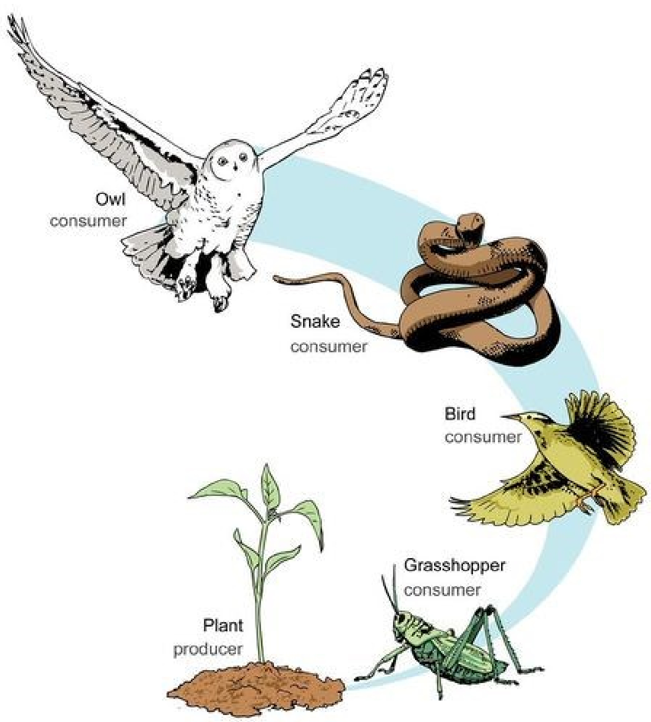
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands,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



Energy and matter play an important role in many of Earth's systems, including ecosystems. As you read this section, focus 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:



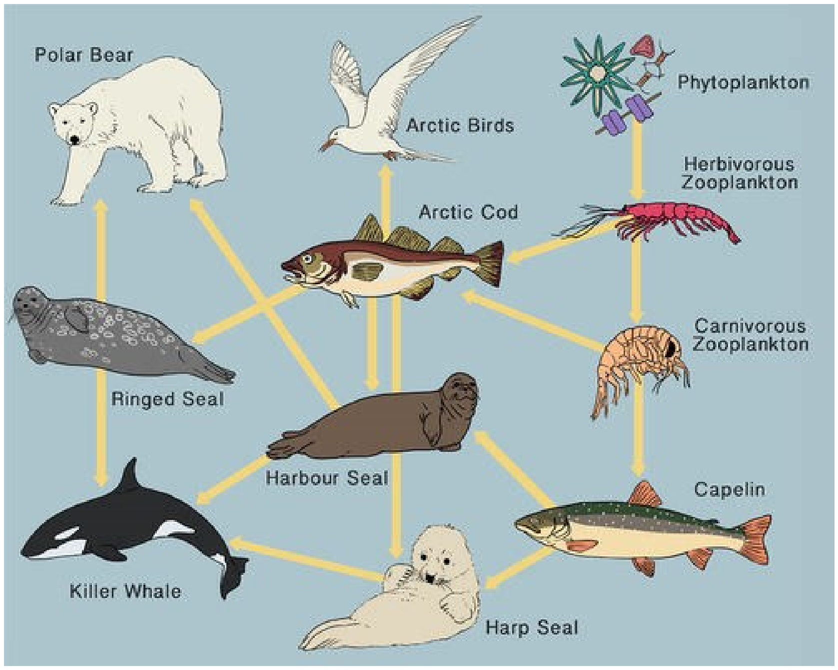
Add decomposers (bacteria and fungi, could use the fungi below) to the food chain above. Arrows from animals and plant to the decomposers.

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.

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. Wastes 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 (figure below) shows the feeding relationships between many organisms in an ecosystem. For example, the arctic cod is eaten by the harbour 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.

Focus Questions

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

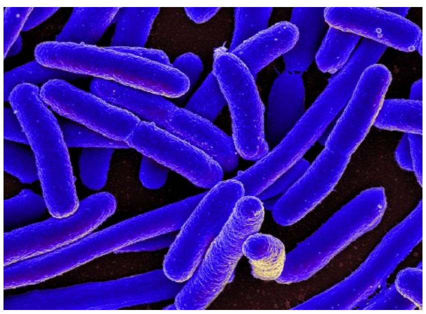
Putting It Together

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

Brine shrimp

Green algae

Bacteria



Brine flies

Eared grebe

California Gull

Review your initial model of the cycling of matter and flow of energy among the organisms that live in and around Great Salt Lake. Based on what you have learned, create a revised model that describes the cycling of matter and flow of energy among these organisms.

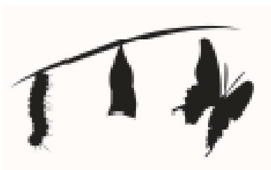
5.4 Stability of Populations in Ecosystems (6.4.4)

Explore this Phenomenon

The population of cottontail rabbits in an ecosystem has decreased in the past decade. Develop an initial claim for why the population may have decreased?

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.



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.

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 elks 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 are 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.

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. This is what happens in nature. But in nature, organisms that cannot get food 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.

In nature, when the population size is small, there is usually plenty of food and other resources for each individual. When there is plenty of food and other resources, 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.

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. Can you think of some other factors that limit populations?

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 use of pesticides and herbicides, and habitat destruction.

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

Putting It Together

The population of cottontail rabbits in an ecosystem has decreased in the past decade. Reread your initial claim for why the population may have decreased. Based on what you have learned, revise your claim, provide evidence from the text or other experiences and reasoning to support your claim.

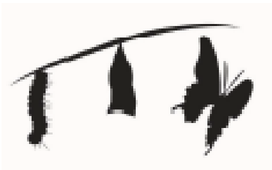
5.5 Stability and Change (6.4.5)

Explore this Phenomenon

Phragmites are plants that grow near many of Utah's waterways. These plants are causing concern for the Division of Natural Resources because they overtake native species of plants. Develop an initial claim for why phragmites are a problem in Utah and for how the Division of Natural Resources might address this problem.

6.4.5 Stability and Change

Evaluate competing design solutions for preserving ecosystem services that protect 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.



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 ecosystems 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.

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: https://wildlife.utah.gov/habitat/ans/

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 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.

Focus Questions

1. Describe an ecosystem services 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

Phragmites are plants that grow near many of Utah's waterways. These plants are causing concern for the Division of Natural Resources because they overtake native species of plants.

Review your initial claim, then write a revised claim for why phragmites are a problem in Utah. Be sure to support your claim with evidence. Then explain how the Division of Natural Resources might address this problem.

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Student Notes

Utah Science with Engineering Education Standards