# Earth Science

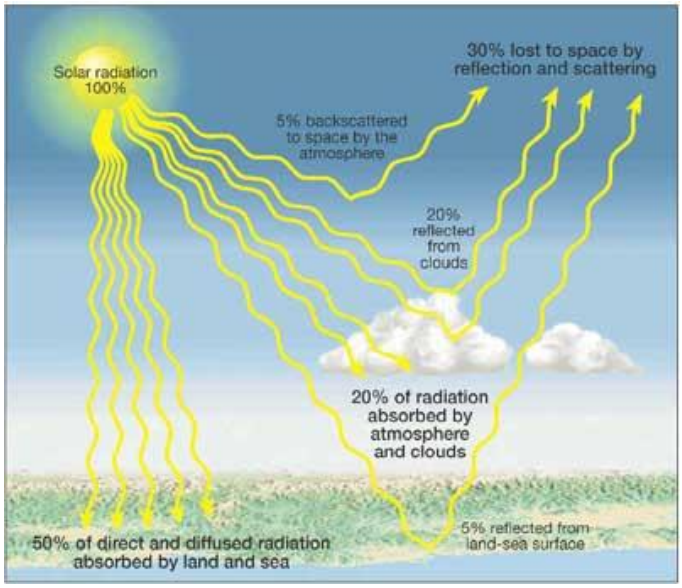
# Energy in Earth's Atmosphere

Big Idea: Earth's atmosphere interacts with solar energy. (6.3a-c)

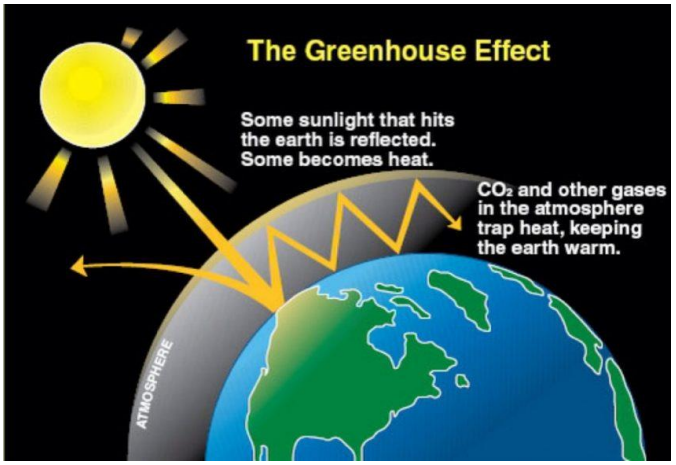
A. Earth receives radiant energy from the sun.

- Sun's energy is made of electromagnetic radiation that includes visible light, infrared, and ultraviolet (UV) radiation.
- Only a small part of the Sun's solar energy reaches the Earth.
- Earth's energy budget—describes what happens to the solar energy coming in. About one-third (1/3) is reflected back into space; one-half (1/2) is absorbed by Earth's surface and changed into thermal energy; and the rest is absorbed by Earth's atmosphere and clouds.
- Greenhouse effect—gases in the atmosphere (water vapor, carbon dioxide, methane, nitrous oxide, and ozone) trap solar energy and keep it from going back into space. This is what makes the Earth's temperature suitable for life. However, too much energy trapped can cause a rise in the atmosphere's temperature.

Earth's Energy Budget




The Greenhouse Effect




B. Climate—long-term weather patterns in a region. Influenced by distance from the equator (latitude), elevation above sea level (altitude), how close to large bodies of water; and mountain ranges that create a difference in

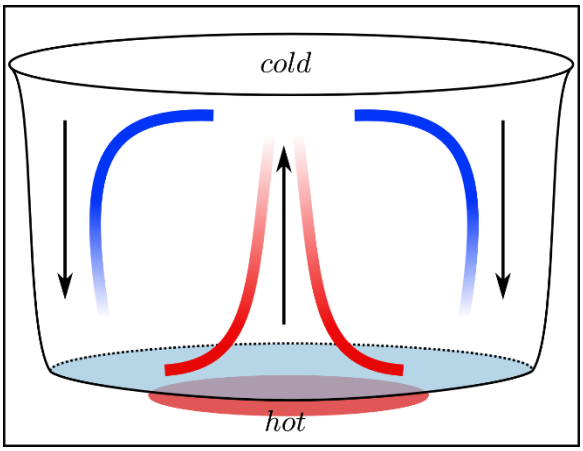
conditions on the windward size of the mountains (cooler and wetter) and the leeward side of the mountains (warmer and drier).

C. How does a large body of water in a region affect the climate there?
Water absorbs a great deal of solar energy, but since the body of water is so large, it has to absorb a lot of energy before it starts to heat up. In the summer the body of water absorbs a lot of energy slowly, then slowly releases it during the winter (it takes a while to cool off). This gradual cooling keeps the temperature in a fairly stable range.

D. Solar energy causes the circulation of air in Earth's atmosphere (called wind), and in the ocean (currents), and many processes on Earth's surface, such as photosynthesis.

- Global winds blow from the poles (under high pressure) toward the equator (low pressure). As they blow, Earth is turning, causing the blowing wind to curve. This is the Coriolis effect.
- When a substance like air or water is heated, the molecules move faster and further apart, becoming less dense. The cooler part of the substance is denser and move down, causing the less dense warmer portions to rise. Air and water on Earth do this, causing motion called convection currents.

The blue part is the cooler part of the substance; it is denser and moves down. The red part is warmer and less dense, so it rises. This causes a circular pattern of motion.




- The unequal distribution of thermal energy in the atmosphere and convection currents also play a key role in creating severe storms such as hurricanes and thunderstorms.

# Test Your Knowledge

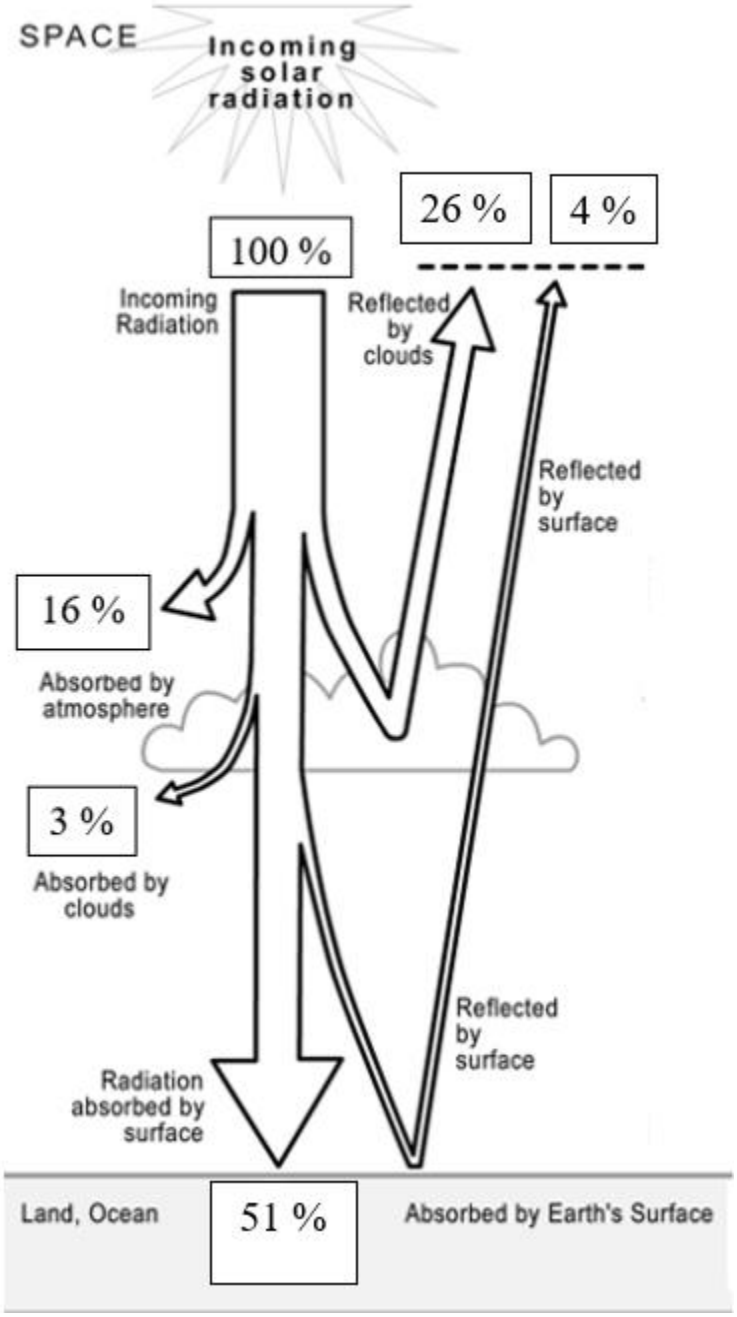
A budget refers to a plan that describes how a resource is distributed and used. The diagram below shows what happens to the Sun's radiation that comes toward Earth.

1. How does the amount of energy received by Earth from the Sun compare with the amount of energy that leaves Earth?

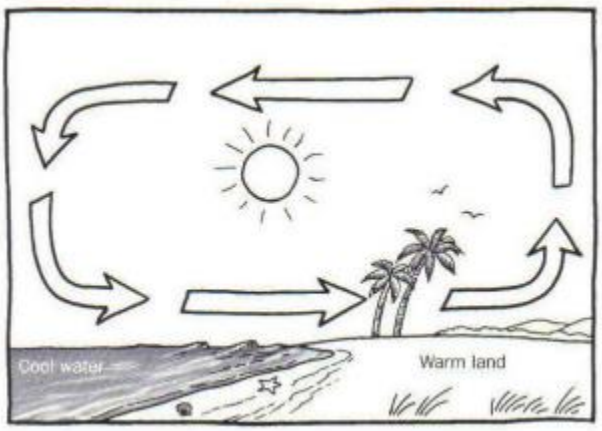
2. What do you predict would happen if there was a shortage of incoming solar energy?

3. What would happen if Earth retained more thermal energy?

Earth's Energy Budget



4. Below is a diagram of a type of local wind called a sea breeze. Explain how convection causes this type of local wind.




5. Why are towns along the coast warmer than inland towns?

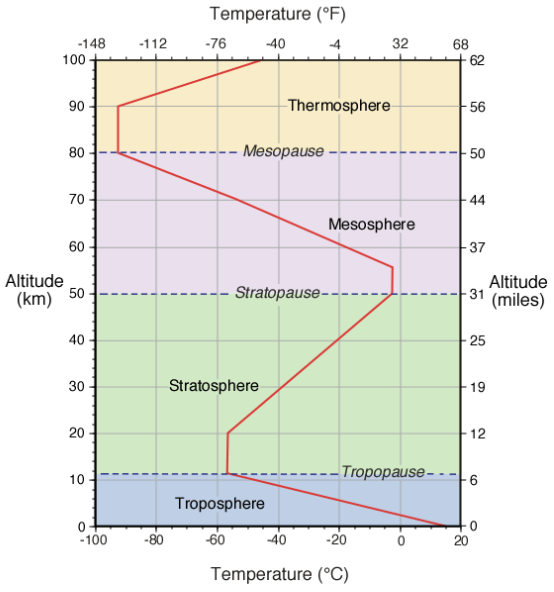
Big Idea: Earth's atmosphere is a mixture of gases commonly called air and has certain properties. Air quality is affected by many things. (6.6a-d)

A. Air is a mixture of gases.

- Air is mostly nitrogen (78%) and oxygen (21%). The other 1% is made of other gases (carbon dioxide, argon, and ozone (a form of oxygen).
- Humidity refers to the amount of water vapor in the air. It varies with changes in the air temperature and the amount of moisture available in the surrounding area.
- Relative humidity is a measure of the actual amount of water vapor as compared to the greatest amount of water vapor that air could hold at a given temperature.100% relative humidity means the air is fully saturated with water vapor. If some of the vapor cools, fog can form.

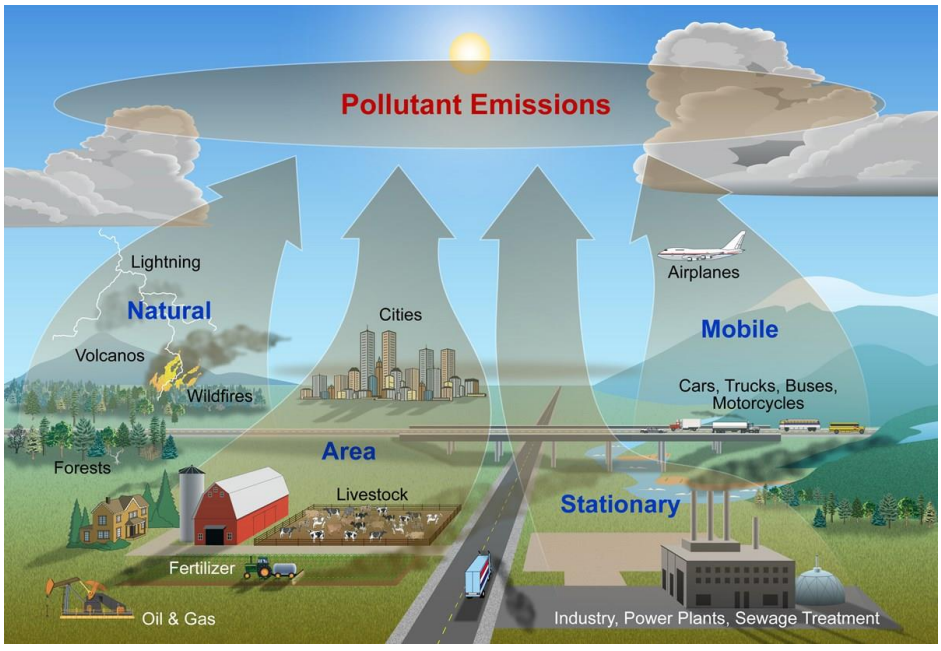
B. Earth's atmosphere is made of layers of air held by Earth's gravity.

- Thermosphere
  - Merges with space
  - Temperature increases with altitude; can exceed 2,000 ◦C
  - Produces Aurora borealis (Northern Lights)
  - Space shuttle and satellites orbit here
- Mesosphere
  - Coldest layer
  - Temperature decreases with altitude
  - Meteors burn up here
- Stratosphere
  - Temperature increases with altitude
  - Most jet planes fly here
  - Thin layer of ozone here
  - Protects life from UV radiation
- Troposphere
  - Temperature decreases with altitude
  - Bottom third contains 50% of all gases
  - Weather and life exist here



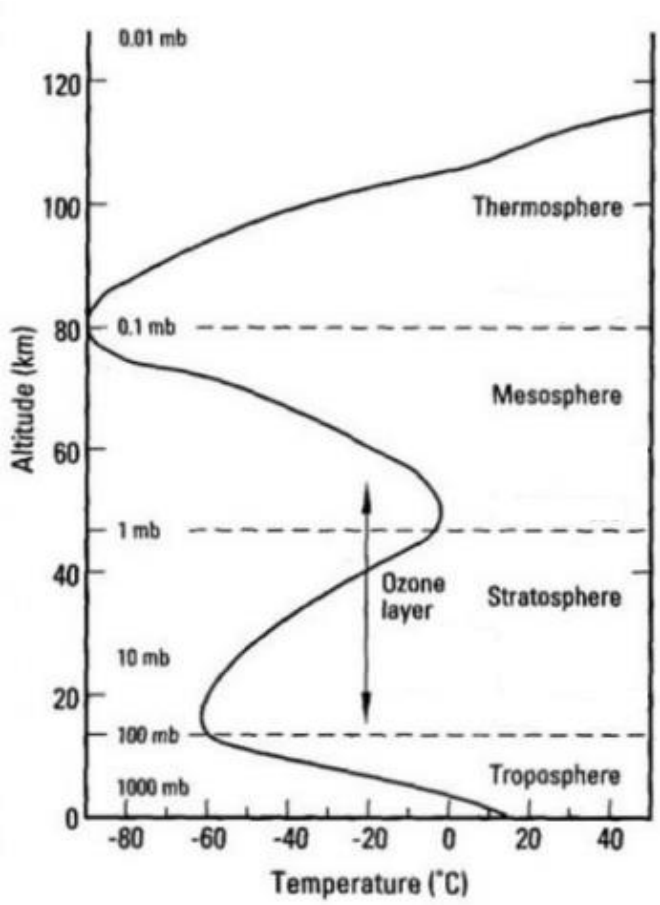
C. The make-up and quality of air can change.

- There is a lot of ozone ($O_3$ molecules) in the stratosphere. This ozone protects living things by absorbing UV radiation from the Sun. The ozone layer is getting thinner and developing "holes," from gases in aerosol cans and emissions from cars and factories.
- Gases and particles that are naturally released can affect the quality of the atmosphere. Some natural causes come from forest fires, volcanic eruptions, plant pollen, and dust from the wind.
- Gases and particles can also be released from human activities such as producing energy by burning coal, factories that release gases into the air, and exhaust from cars and trucks. The exhaust can cause ozone to form. Ozone near the surface of Earth causes smog that makes it hard to breathe and contributes to health problems.
- People need to use less energy, fuel, water and other natural resources and make air-friendly products to reduce impact on the environment.



# Test Your Knowledge

1. The graph below shows the four layers of Earth's atmosphere. Use this graph to answer the questions that follow.




A. What would be a good <u>title</u> for this graph?

B. Identify the layer where the temperature decreases to the lowest point. What is that lowest temperature?

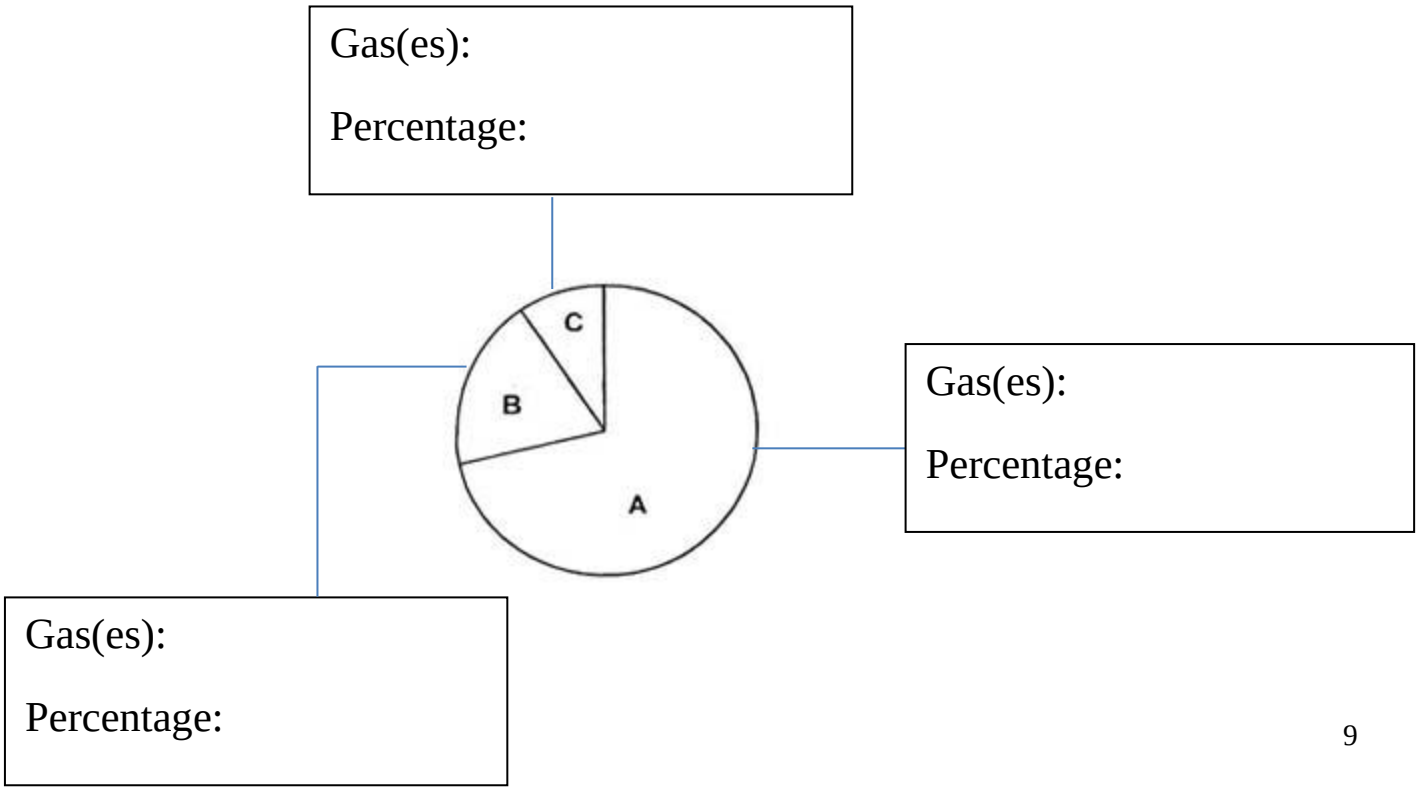
C. Name the layer(s) of the atmosphere where the temperature decreases as the height above Earth increases.

D. Explain why air is most dense in the troposphere.

2. List two to three important facts about each atmospheric layer.

| | |
|---|---|
| Troposphere | |
| Stratosphere | |
| Mesosphere | |
| Thermosphere | |

3. Label the pie chart to identify the gas(es) that make up our atmosphere and the approximate percentages in which they are found.



4. Human activities (from transportation, production of electric energy, and manufacturing) affect air quality. Give at least three examples or actions that can be taken by people or governments to protect and preserve air quality.

A. Transportation:

B. Electricity Production:

C. Manufacturing:

5. List and briefly describe at least three natural and human-caused changes that can impact the quality of air.

| Natural | Human-Caused |
| --- | --- |
| | |

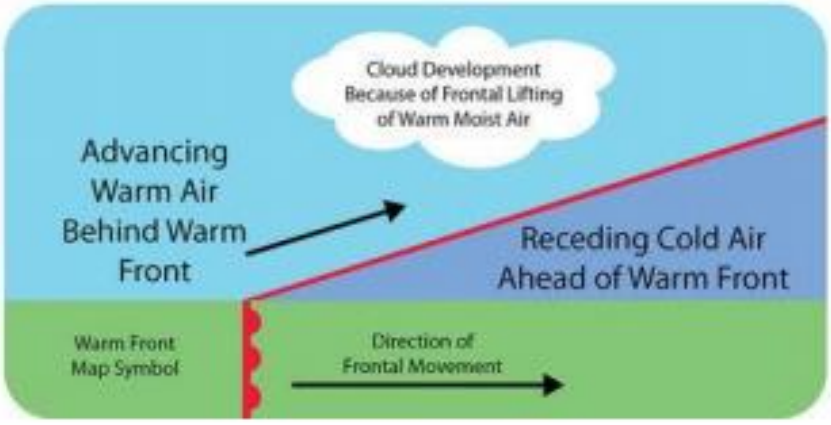
# Weather and Climate

Big idea: Weather can be described, and patterns of weather can be studied and predicted. (6.3d, 6.6e)

Weather describes the condition of the atmosphere at a given time and place. A weather map is a visual display used to study and predict weather. Weather maps use symbols to represent weather conditions.

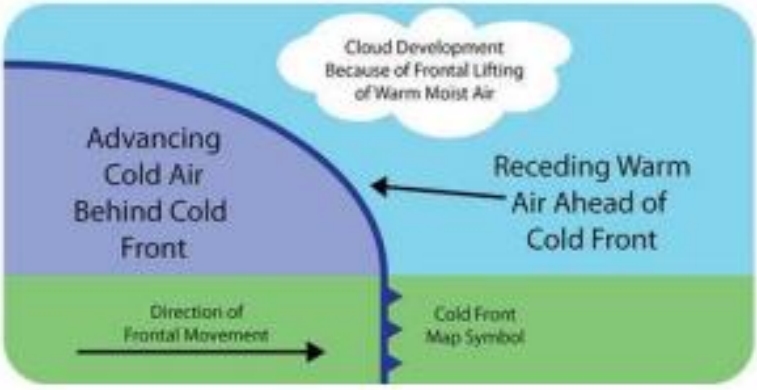
- An air mass is a large volume of air that has similar temperature, pressure, and humidity. Fronts are boundaries that separate warm, moist air from colder, drier air masses. When an air mass advances, the warmer, less dense air is forced up, and the cooler, dense air is the wedge that lifts up the warm air.
- A warm front is the boundary formed when warm air moves in to replace cold air. As the warm, less dense air advances and moves over the denser cold air ahead of it, the air cools and clouds form from water vapor. Precipitation (rain, snow, sleet, freezing rain) can result.

Warm front symbol: circles point inthe direction the front is moving.

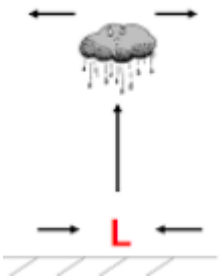


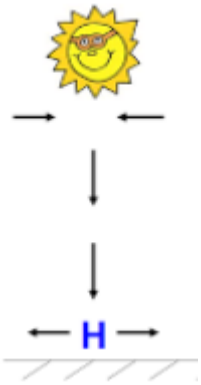

- A cold front is the boundary formed when cold air replaces warm air. If the rising air is warm enough, there may be precipitation. Friction between the air masses makes the cold front have a steeper wedge. In the summer, this may trigger thunderstorms. The amount of precipitation is much greater at a cold front than a warm front.

Cold front symbol: triangles point in the direction the front is moving.

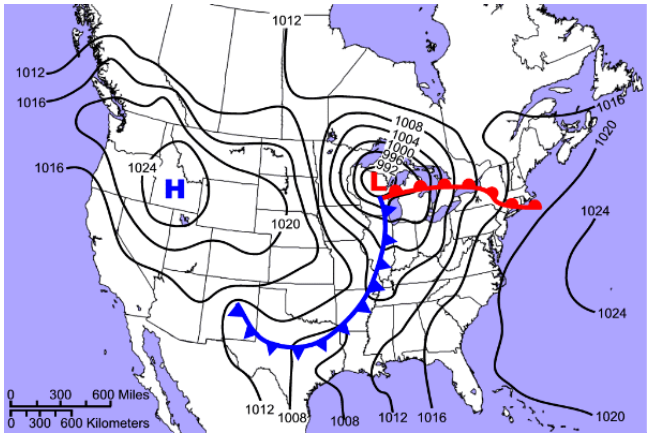



- A stationary front does not move or barely moves. It is a boundary between two air fronts, where neither is strong enough to displace the other. These fronts often bring cloudy, wet weather that may last a week or more.
- A low pressure system (labeled "L" on a weather map) may develop along fronts. These systems are formed by a mass of warm air being forced up by cold air. Winds circulate in a counterclockwise direction. These systems can be gentle or have heavy rain and strong winds.



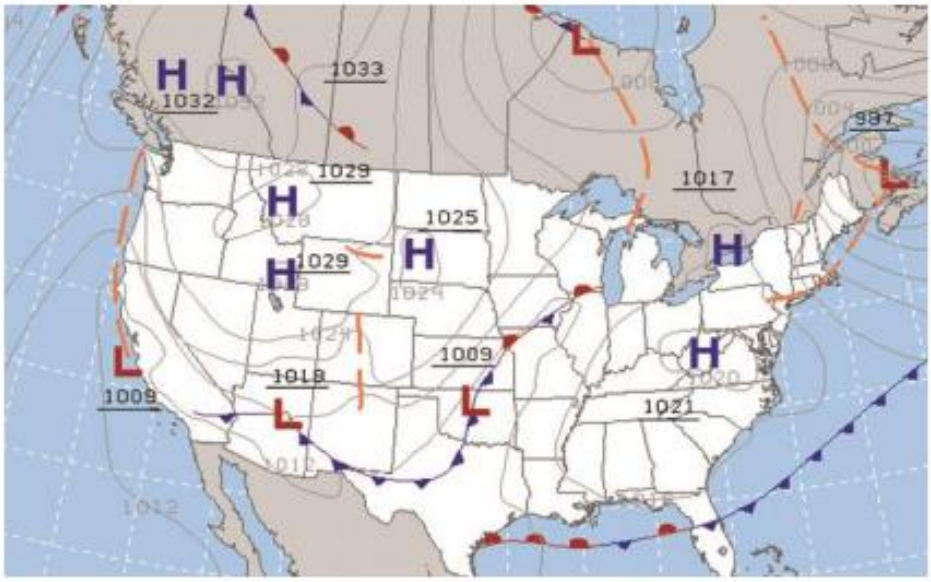




- A high pressure system (labeled "H" on a weather map) means there will be sunny days and calm weather, with little precipitation because air sinks, keeping clouds from forming. Air flows clockwise.
- Weather maps show curved lines (isobars) that connect points of equal air pressure. Isobars that are close together mean strong winds and low pressure systems. Isobars that are farther apart indicate calm, high pressure systems.



# Test Your Knowledge

1. On the weather map below, mark with an X a state that is most likely to experience a clear day. Give the reason for your answer.




2. Use the map above to answer the following questions.

   A. What type of front is over the central United States?

   B. What type of weather is the central U.S. most likely experiencing?

   C. What type of air mass is behind the front that is passing in a southeasterly direction across Texas?

   D. Predict the type of weather that is currently moving across Texas. Explain.

Clouds

Big Idea: Clouds are a collection of small water droplets or ice crystals suspended in air. Clouds are classifed by shape and altitude and can be indicators of weather conditions. (6.3d)

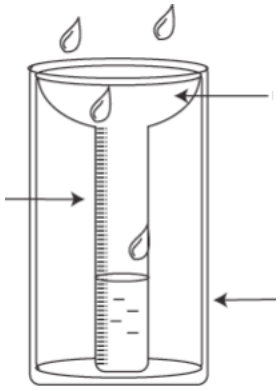
| | |
|---|---|
| Cirrus | High-level; made of ice crystals; feathery, wispy appearance.<br>Predict fair weather until they begin to thicken due to a drop in barometric pressure. |
| Cumulus | Individual, puffy, white with fairly flat bases. Form at different heights in the troposphere.<br>Seen on dry, sunny days. |
| Stratus | Layers or sheets; may cover the entire sky. Found in low levels of the atmosphere.<br>Produce light rain or drizzle. |

Alto- in the cloud name means the cloud is a middle-layer cloud in the atmosphere. An altostratus cloud is a mid-level, layered cloud. Nimbus means rain or snow is falling from the cloud.

Cumulonimbus clouds are thunderheads. They have a flat base and an anvil top that bring thunderstorms, lighning, hail, and tornadoes. (Source of picture: https://aviation.stackexchange.com)

Clouds form as warm air rises over a body of water (ocean, lake, stream, etc.), expands, and cools. If the air rises high enough, the rate of evaporation is equal to the rate of condensation. Dust, salt, soil, and smoke in the clouds give the water droplets a place to condense.

Precipitation occurs when water vapor condenses in clouds and is pulled to Earth by gravity as rain, hail, snow, or sleet, depending on the temperature.
A rain gauge measures precipitation (funnel, measuring scale, overflow container)



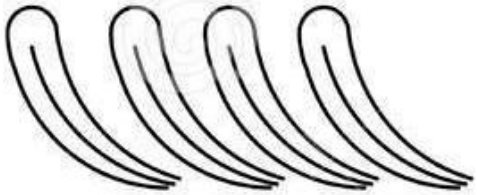
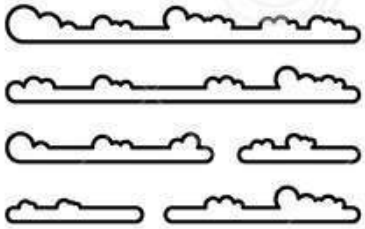
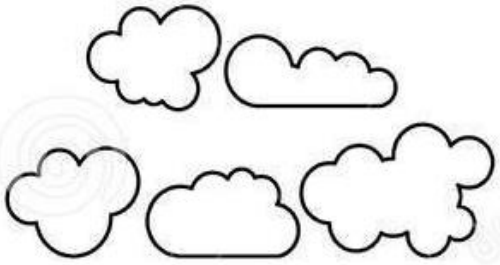
Severe Weather

Big Idea: Living things are directly affected by thunderstorms, hurricanes, and tornadoes. They cause damage to property and are dangerous to living things. (6.3e)

| Storm Description | Formation Conditions | Where and When |
|---|---|---|
| Thunderstorm:<br>A storm that does not last long; dangerous because it produces lightning and heavy rain (flash floods), strong winds, tornadoes | • Moisture (to form clouds and rain)<br>• Unstable air (warm air that can rise quickly)<br>• Lift (fronts, sea breezes, and mountains to lift air) | Can form anywhere; most likely to happen in the spring and summer late in the day |
| Hurricane:<br>A large, severe tropical storm lasting over a week; spins counter-clockwise in the northern hemisphere; high wind speed, storm surges, and flooding rains make it dangerous | • Low pressure system over warm ocean water (provides energy and moisture)<br>• Convection (rising warm air forms clusters of thunderstorms)<br>• Affected by the Coriolis effect (rotation of Earth) | Form over warm ocean water; weaken over land when they no longer get thermal energy from the waters |
| Tornado:<br>The most violent type of storm; appears as rotating funnel-shaped clouds that stretch from the base of the storm cloud to the ground; high winds; path on the ground is difficult to predict; usually lasts a few minutes. | • Associated with thunderstorms (produced by similar conditions)<br>• Rapid rotation of updrafts within a thunderstorm | Occur at anytime of year and just about anywhere in the world where thunderstorms happen over land; many happen in stormy spring when warm and cold air masses collide |

# Test Your Knowledge

1. Identify each cloud type and the weather each predicts or produces .

| Cloud Name | Cloud Shape | Weather Type |
|---|---|---|
| |  | |
| |  | |
| |  | |

2. Draw and label a diagram to show the process of cloud formation.

3. Identify each severe weather phenomenon.

   A. This rise in sea level forms in the ocean during a severe storm and crashes onto shore, endangering lives and causing property damage.

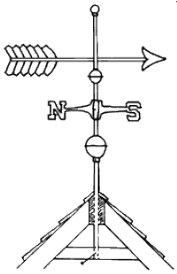
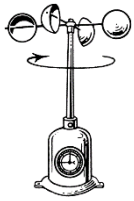
   B. This is an intense local storm during which there are lightening discharges.

   C. This violently rotating column of air is seen as a funnel-shaped cloud.

   D. This large, rotating tropical weather system has high wind speeds.

Weather Instruments

Big Idea: Weather can be measured. (6.3f)

| Weather Feature | Measurement Tools | Influences on Features |
|---|---|---|
| Air Temperature: Measures the amount of thermal energy (average kinetic energy) in the air molecules | Thermometer (Degrees Celsius)  | • Location on Earth<br>• Amount of radiation from the sun |
| Air Pressure: Weight of air pressing down on Earth's surface | Barometer Average at sea level (=1 bar)  | • Gravity<br>• Altitude<br>• Density of air<br>• Temperature of air |
| Wind: Movement of air from an area of high pressure to an area of low pressure; described by speed and direction | Wind Vane (wind direction)   Anemometer (wind speed) | • Differences in the amount of radiation from the sun, resulting in convection<br>• Earth's rotation |
| Moisture: Water in the atmosphere may be solid, liquid, or gas<br><br>Humidity: Amount of water vapor in the air<br><br>Relative Humidity: Amount of water vapor in air compared to the amount it could hold at a given temperature | Hygrometer (humidity)  Psychrometer (relative humidity)  | • Air temperature<br>• Humidity<br>• Temperature |

# Test Your Knowledge

Match the weather instrument below with the correct description. Some of the letters will not be used. Some numbers need more than one letter.

1. Hygrometer
2. Thermometer
3. Barometer
4. Psychrometer
5. Anemometer
6. Wind vane

A. An instrument that measures the height of cloud layers and estimates cloud cover.

B. An instrument that measures air pressure.

C. An instrument that measures wind direction.

D. An instrument that measures temperature.

E. A balloon-born package of sensors that gathers upper level weather data.

F. An instrument that measure relative humidity.

G. An instrument that measures humidity.

H. Measures in Degrees °C

I. Does not measure in units; indicates direction

J. Measures the ratio of the current humidity to the highest possible humidity (percent)

K. Measures in bars

L. An instrument that measures wind speed.

M. Measures in miles per hour.

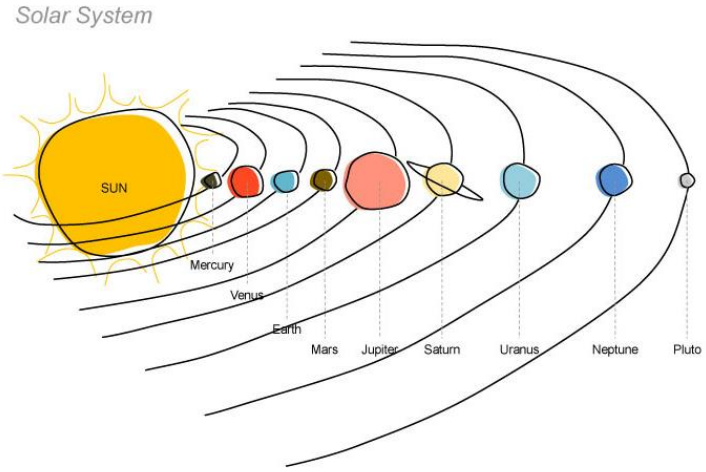
# The Solar System

Big Idea: Planets and other bodies in space form systems and relate to each other in a variety of ways. (6.8)

## The Solar System

The star in the middle of our solar system is the Sun. Our solar system includes the Sun, Earth, Earth's moon, other planets and their moons, dwarf planets, meteors, asteroids, and comets.

This diagram shows the position of planets and Pluto, a dwarf planet, relative to the Sun and each other. The planets and the distances between them are not drawn to scale.

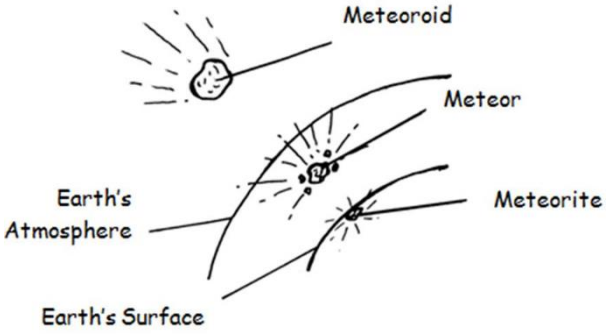



The Sun is a giant spinning ball of very hot gas fueled by nuclear reactions. Radiant energy from the Sun heats Earth and makes life possible. Sunspots and solar flares can affect Earth's atmosphere and disrupt communication systems.

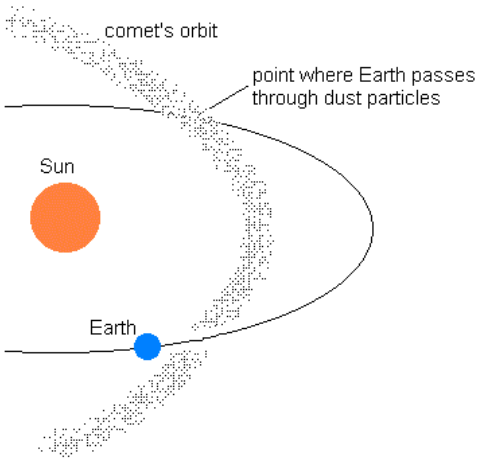
The planets in our solar system are visible from Earth because they reflect the Sun's light. Distance from the sun and the make up of the atmosphere around each planet determine the characteristics of the planet. The first four planets (Mercury, Venus, Earth, Mars) are terrestrial planets because they are rocky; the last four (Jupiter, Saturn, Uranus, Neptune) are larger gas giants.

Pluto was discovered in 1930 and was considered the last and smallest planet. In 2006 Pluto was reclassified as a dwarf planet. It revolves around the Sun but is so small and has little gravity so it can't exert much force on other objects. There are many dwarf planets in our solar system.

Other bodies in the solar system include asteroids (rock fragments that revolve around the sun). Most asteroids are found between Mars and Jupiter.




When a space rock enters Earth's atmosphere, it burns, causing a meteor or "shooting star." If the meteor doesn't burn up completely, a chuck of rock called a meteorite lands on Earth's surface.



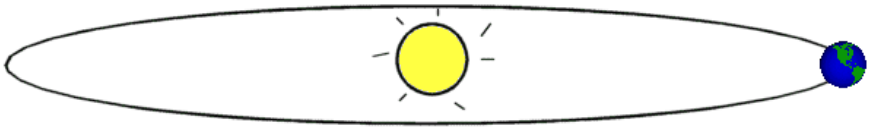

Comets are made of ice, gas, and dust. They orbit Earth in an elliptical path. A comet is only visible when it is near the Sun. The comet's tail reflects the Sun's light.

Gravity acts on all objects in the universe. The more massive Sun has stronger gravity than other objects in our solar system. This pull holds the Earth and planets in place.

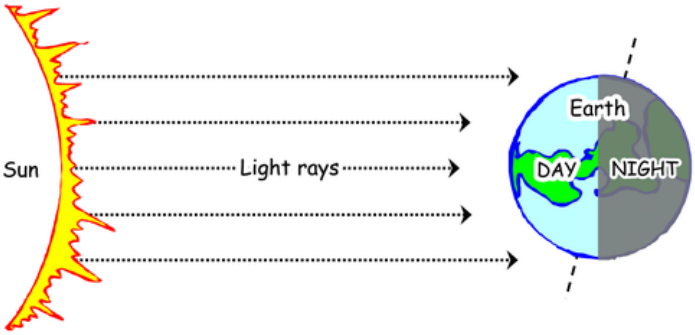
The time it takes a planet to travel once around the Sun is its revolution. It takes Earth 356 and 1/4 days to revolve around the sun (one year).

Planets and moons rotate upon an axis (an imaginary line through the planet). Earth rotates, and as it rotates, half of the Earth is in the light of the Sun while the other side is away from the sun and dark. This makes Earth experience day and night. Each rotation of the Earth takes about 24 hours (a day).

Revolution

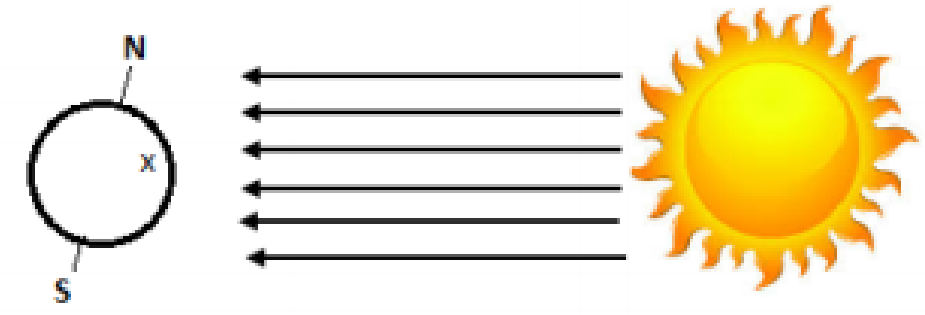


Rotation



# Test Your Knowledge

1. Consider each of the following statements about this diagram of Earth and the Sun. The "X" on the Earth is approximately Virginia's location. If the statement is true, write "true" and explain how you know it is true. If the statement is false, write "false" and tell why it is false.




   A. It is winter in Virginia.

   B. It is daytime in Virginia.

   C. Earth is rotating around the Sun.

2. Compare and contrast the "gas giants" with the "terrestrial planets." You may use a chart, diagram, or mind map to explain their similarities and differences.

3. The following statements refer to one or more types of objects in the solar system: star, planet, moon, asteroid, comet, and meteor. After each statement, write the object(s) for which the statement applies.

   A. Gives off its own light.

   B. Burns up when it gets too close to Earth.

   C. Rotates on an axis.

   D. Rock fragament that revolves around the Sun in a belt-like region.

   E. Has a tail that reflects the Sun's light.

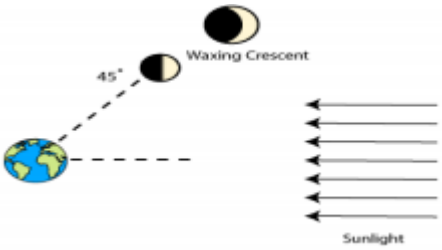
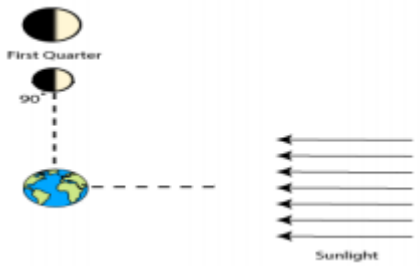
   F. Revolves around Earth.

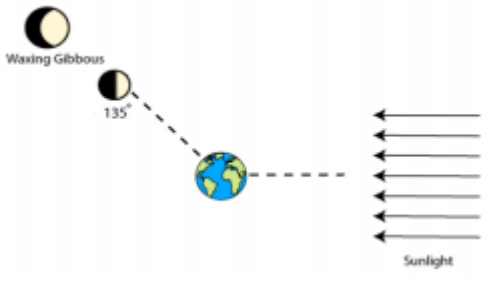
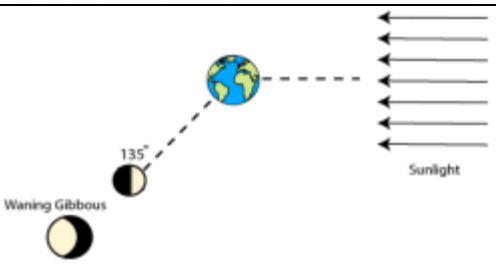
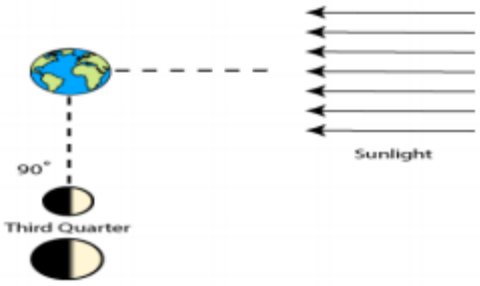
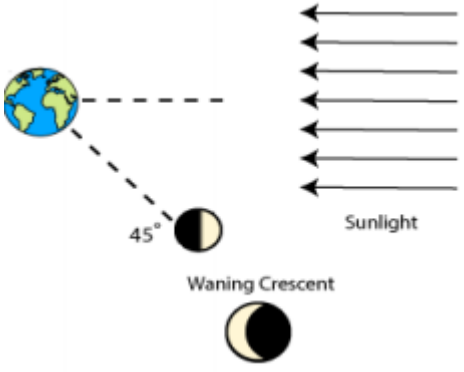
   G. Path is influenced by gravity.

Phases of the Moon

- Moon phases are caused by the moon's position relative to Earth and the Sun. It takes the moon about 29.3 days to revolve around the Earth.
- As the moon orbits Earth, it is also rotating on its axis. It takes about the same time for the moon to rotate as it takes to orbit Earth; therefore, the same side of the moon always faces Earth.
- The moon reflects light from the Sun. Half of the moon's surface is in the Sun's light at all times. As the moon revolves around Earth, different amounts of its lighted side are seen.

These diagrams show the positions of Earth, Sun, and moon at different times.

| What the moon looks like to us on Earth | Explanation | Positions from space |
|---|---|---|
| New Moon  | Appears dark from Earth; not visible in the night sky. Lines up between Earth and Sun; Sun blocks moon's reflected light from Earth. |   |
| Waxing Crescent  | Moon revolves counter-clockwise around Earth, a thin sliver (crescent) of light appears on the right. Lit portion is growing larger. |   |
| Waxing First Quarter  | The lighted portion keeps growing (waxing). When the Earth, moon, and Sun form a 90° angle, the right one-half of the moon is lit. We see only the "front" of the right side (one quarter of total moon). |   |

| What the moon looks like to us on Earth | Explanation | Positions from space |
|---|---|---|
| Waxing Gibbous  | The moon continues to revolve around Earth, more than half of the moon is lit, forming a gibbous shape. The lit portion is still growing (waxing). |   |
| Full Moon  | Earth is between the moon and the Sun; the side we see is fully illuminated. |   |
| Waning Gibbous  | The lit part of the moon seen from Earth begins to wane (grow smaller). More than half is still lit, forming a waning gibbous shape. |   |
| Third Quarter or Last Quarter  | The lit portion continues to wane (decrease). The sun, moon, and Earth form a 90° angle, the left half is lit (don't see the back of the left half; see a quarter of it) |   |
| Waning Crescent  | The lit portion decreases to a sliver of light on the left, growing smaller (waning). The moon will once again be between the Sun and Earth, back to a new moon. |   |

# Test Your Knowledge

Reflect on the locations of the moon, Sun and Earth during a new moon phase and answer the questions below.

1. Explain why the moon is not visible from Earth during the new moon phase.

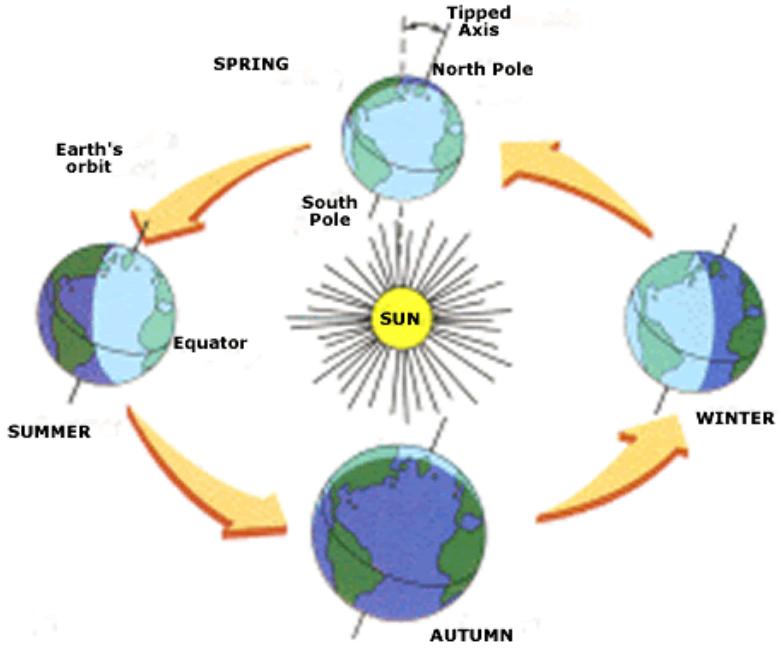
2. Explain why some of the moon will be visible in a day or two.

3. Draw and name the next phase of the moon.

## The Seasons

The tilt of Earth's axis and the revolution of Earth around the Sun causes the seasons.

- The axis always points in the same direction, toward the North star, while Earth orbits the Sun. The Northern Hemisphere is tilted toward the sun during part of the year, and away from the sun during the other part of the year.
- Many people think that in the summer, Earth is closer to the Sun. This is a misconception. In summer we receive more direct sunlight because Earth is tilted toward the Sun. We also receive more hours of daylight. This results in warmer weather. In the winter Earth is tilted away from the Sun. We get indirect rays of light from the sun, resulting in cooler weather.

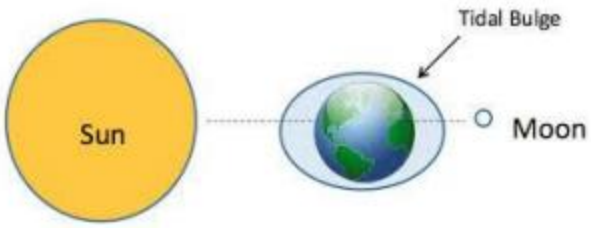



## The Tides

- Tides are caused by the gravitational pull from the moon and the Sun on Earth's waters. Because the moon is much closer to Earth that the Sun, it has a greater effect.
- The level of the ocean rises and falls in a cycle. When the moon's gravity pulls on Earth, two "bulges" form in Earth's oceans. One bulge is on the

side of Earth facing the moon; the other is on the side facing away from the moon. The higher water level in the bulges produces high tides. Between the bulges the water level is lower, producing low tides.

- It takes about 6.25 hours for the water level to change from high to low tide, and another 6.25 hours for the water to rise to high tide again.
- When all three bodies (Earth, Sun, and moon) are aligned, the pull from both the Sun and the moon causes the highest and lowest tides.




## Testing Your Knowledge

Imagine you are at a beach in Maryland at exactly low tide.

1. Where is the moon with respect to your position on Earth?

2. Where is there another low tide on Earth at the same time?

3. About how long will it be before the next low tide?

4. What has to happen to cause a high tide at your location on the beach?

Contributors to Our Knowledge of the Solar System

Aristotle (Greece, 384-322 B.C.): believed Earth was the center of the solar system (geocentric model). Believed that all objects in space moved in perfect circles around Earth.

Ptolemy (Greece, 85 AD-165 AD): also believed Earth was the center of the solar system. He applied math to what he observed about the stars to predict the movements of the planets.

Copernicus (Poland, 1473-1543): did not agree with Ptolemy that stars orbit Earth. He believed Earth rotated, which made the stars appear to move. He proposed that Earth is the third planet from the Sun. He believed the Sun was the center of the solar system (heliocentric model).

Galileo (Italy, 1564-1642): first person to observe the moon with a telescope. He discovered four of the moons circling Jupiter; studied Saturn; observed the phases of Venus; and studied sunspots.

More Recent Accomplishments

| | |
|---|---|
| 1955 | • First satellite launched (Russian Sputnik) 1957 |
| 1960 | • First manned spacecraft orbits Earth 1961<br>• First man in space (Russian, Gagarin) 1961<br>• First manned orbital mission of the USA (Glenn) 1962 |
| 1965 | • Manned spacecraft orbits the moon 1968<br>• First many walks on the moon (USA, Armstrong) 1969 |
| 1970 | • First USSR space station 1971<br>• First soft landing on Mars 1971<br>• USA space station launched (Skylab) 1973 |
| 1975 | • Viking probe lands on Mars 1976 |
| 1980 | • Space shuttle launched (Columbia) 1981<br>• First probe travels beyond our solar system 1983 |
| 1985 | • Mir space lab launched 1986<br>• First probe to reach Neptune (Voyager 2) 1989 |

| | |
|---|---|
| 1990 | • Hubble telescope in orbit 1990 |
| 1995 | • Space shuttle docks with Russian Mir (USA Atlantis) 1995<br>• Mars explored (Pathfinder mission) 1997<br>• International Space Station created 1998 |
| 2000 | • Mars explored (Rover mission) 2004 |
| 2005 | • First orbit of Saturn 2005<br>• First soft landing on Titan, the largest moon of Saturn 2005 |

## Test Your Knowledge

How have advances in technology played a part in space exploration over the last half century?