

Reflect

On Earth, each day begins at sunrise and ends at sunset. You see the Sun “come up” or rise in the morning and “go down” or set at night. When we use these phrases, what do you think they imply about the way our solar system works? Does the Sun really rise and set in the sky throughout the day?

Rotation

Rotation is a term that describes the motion of a spinning object. Each of the planets and moons in our solar system rotates about an axis. An *axis* is an imaginary line about which each planet or moon spins. This imaginary line marks the center of a planet or moon’s rotation.



Rotation can describe the motion of a spinning top (left). You can think of an axis as the center peg of a spinning top. This top’s axis is tilted like Earth’s. A globe (right) is a model of Earth that represents how the planet rotates about a tilted axis.

In space, there is no such thing as up or down. An object’s position can be measured only relative to other objects. The Sun is the center of our solar system. Therefore, the motion of the planets and other objects in our solar system can be measured relative to the Sun. Like the other planets, Earth rotates about an axis. Earth’s axis is not a perfectly vertical, or *perpendicular*, line. Instead, our planet tilts at an angle of 23.5° relative to its path around the Sun. The northern end of Earth’s axis, known as the geographic North Pole, always points at the North Star.

A day is the amount of time a planet takes to complete one full rotation. Earth takes 24 hours to complete one full rotation, so one day on Earth is 24 hours.



This clementine orange is an oblate spheroid. Earth is more rounded than this clementine, but it is still an oblate spheroid.

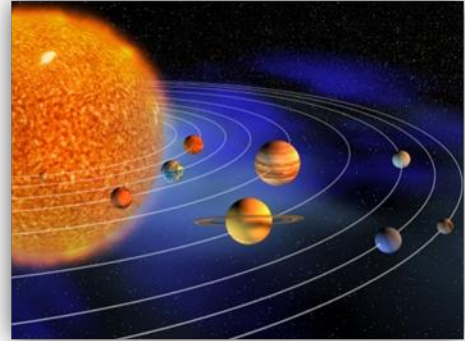
Because Earth rotates, different parts of the planet face the Sun at different times. When the Western Hemisphere is facing the Sun, it is daytime there and nighttime in the Eastern Hemisphere. When the Western Hemisphere is facing away from the Sun, it is nighttime there and daytime in the Eastern Hemisphere.

Even though you can’t feel it, Earth rotates very fast. Earth’s rotation is so fast, it causes the planet to bulge out slightly at the equator and shrink slightly at the poles. Therefore, Earth is not a perfect sphere. Earth’s circumference is slightly wider at the equator than it is at the poles. This shape is called an *oblate spheroid*. In most photographs and diagrams that you will see, Earth probably looks like a perfect sphere.

Revolution

Revolution is a term that describes the motion of one object as it moves around another object. While each planet rotates about its axis, it is also revolving around the Sun. Even though the Sun appears to move across the sky each day, Earth is actually moving around the Sun.

For many years, people believed that the Sun and other planets revolved around Earth. This was called the *geocentric model* of the Solar System. *Geo-* means “Earth,” so *geocentric* means “Earth-centered.” Later, scientists discovered the motion of the planets makes much more sense if the Sun is the center of the solar system. This is called the *heliocentric model* of the solar system. *Helio-* means “Sun,” so *heliocentric* means “Sun-centered.” This is now the accepted model of the solar system. The term *solar* means “of the Sun,” so *solar system* means a system driven by the Sun.



The Sun is the center of the solar system. All of the planets revolve around the Sun.

A year is the amount of time a planet takes to complete one full revolution around the Sun. Earth takes 365.25 days to complete one full revolution. We usually define one Earth year as 365 days. Because a full Earth year is actually 365.25 days, every four years we have a “leap year.” During a leap year, we make up for this extra quarter-day by adding an extra day to the calendar. A leap year has 366 days instead of the normal 365 days.

While the planets in our solar system all revolve around the Sun, each of the moons in our solar system revolves around a planet. Some planets have several moons, but Earth has just one. Earth’s moon is called simply the Moon. The Moon takes 28 Earth days to complete one full revolution around Earth.



We see the same side of the Moon every night as it orbits Earth.

What Do You Think?

The Moon has many recognizable features, such as craters, that you can see from Earth. You may have noticed that you always see the same recognizable features every night. This means that each night the same side of the Moon is facing you. Why do you think this is? Do you think the Moon does not rotate as it revolves around Earth? If not, how else can you explain this phenomenon? You can read the scientific explanation prior to the What Do You Think? section of this companion.

Orbits

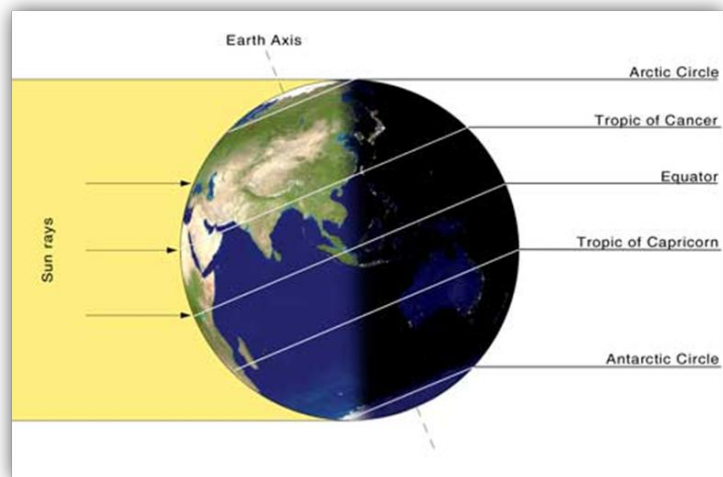
Because the Sun is so massive, it has very strong gravity. The force of the Sun's gravitational pull holds all of the objects in the solar system—including the planets—in its orbit. An *orbit* is the path an object takes as it revolves around another object. Each planet in our solar system revolves around the Sun in a predictable orbit. These orbits are not perfect circles—they are *elliptical*, or oval shaped. This means that each planet is sometimes closer to and sometimes farther from the Sun. The diagram titled “Seasons in the Northern Hemisphere,” below, shows an example of an elliptical orbit.

Look Out!

The fact that Earth's distance from the Sun changes throughout the year might seem like a good explanation for the seasons. You might think that Earth is colder when it is farther from the Sun and warmer when it is closer to the Sun. However, this explanation is incorrect. Not every part of Earth experiences the same seasons at the same time. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. What, then, causes the seasons?

Seasons

If Earth's axis were not tilted, we would not experience different seasons. However, Earth's axis is tilted at a 23.5° angle. As Earth revolves around the Sun, sometimes the Northern Hemisphere is tilted toward the Sun. When the Northern Hemisphere is tilted toward the Sun, it receives more direct rays of sunlight. It is summer. In summer, days are longer and weather is warmer in the Northern Hemisphere. Plants there have plenty of sunlight for photosynthesis, and animals have plenty to eat.

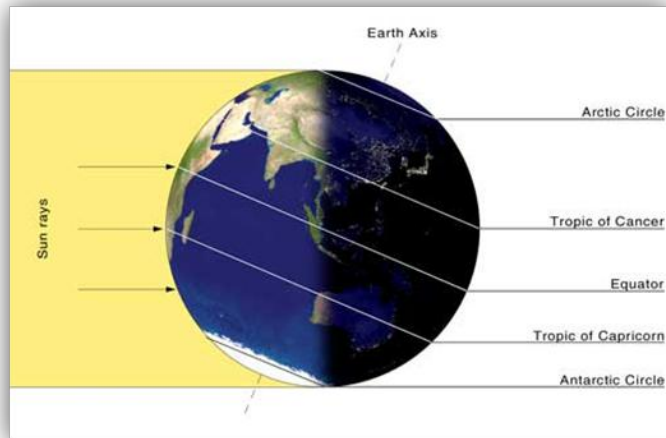


When the Northern Hemisphere is tilted toward the Sun, it receives more direct rays of sunlight than the Southern Hemisphere. During this time, the Northern Hemisphere experiences summer and the Southern Hemisphere experiences winter.

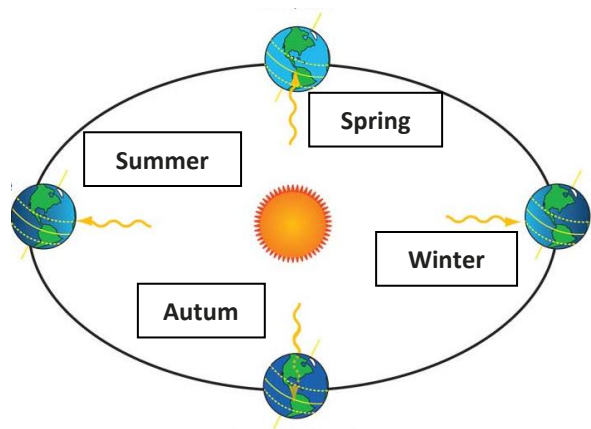
At the same time, the Southern Hemisphere is tilted away from the Sun and receives fewer direct rays of sunlight. As a result, days are shorter and weather is cooler in the Southern Hemisphere. It is winter. Plants there grow less actively, and many lose their leaves. Animals are also less active; some hibernate, or sleep through the winter.

When Earth reaches the opposite side of its orbit—a process that takes about six months—the Southern Hemisphere will be tilted toward the Sun. It will receive more direct rays of sunlight, and the Northern Hemisphere will receive fewer. As a result, the Southern Hemisphere will experience summer and the Northern Hemisphere will experience winter. Therefore, Earth's tilted axis and Earth's revolution around the Sun—not Earth's distance from the Sun—cause seasons.

Seasons are more noticeable in places that are farther from the *equator*—the imaginary line around the horizontal center of the planet. No matter where Earth is along its orbit, the equator is never tilted away from the Sun. It receives direct rays of sunlight year-round. This is why climates are generally warmer near the equator. While there is some variation, temperatures near the equator stay relatively constant from month to month.



When the Southern Hemisphere is tilted toward the Sun, it receives more direct rays of sunlight than the Northern Hemisphere. During this time, the Southern Hemisphere experiences summer and the Northern Hemisphere experiences winter.



You can see how Earth's orbit is elliptical in this diagram. As Earth revolves around the Sun, the planet's tilted axis causes the seasons. When the Northern Hemisphere is tilted away from the Sun, it experiences winter. As the planet moves to the opposite end of its orbit, the northern hemisphere passes through spring into summer. During summer, the Northern Hemisphere is tilted toward the Sun. It then passes through autumn (or fall), making its way back to winter. Remember: The Northern Hemisphere and the Southern Hemisphere are opposites. When the Northern Hemisphere is experiencing summer in the diagram above, the Southern Hemisphere is experiencing the opposite season, which is winter.

Looking to the Future: Changes in Earth's Tilt

Although Earth's axis is currently tilted at 23.5° , this angle is not always constant. Earth wobbles slightly over time as it revolves around the Sun. This wobble causes the angle of Earth's tilted axis to shift between 22° and 25° . This does not happen fast enough to be noticed on a human timescale. Rather, the shift between 22° and 25° takes about 41,000 years. This process is called a *Milankovitch Cycle*, named after the astronomer who theorized that changes in Earth's tilted axis affect the seasons.

According to Milankovitch's theory, when Earth's tilt increases, there is a greater difference between summer and winter. A strong winter can lead to significant build-up of ice at the poles. This ice can reflect the Sun's radiation, blocking it from warming Earth's surface. This can cause temperatures to drop even more. Eventually, this can lead to an ice age. When Earth's tilt decreases, the seasons become milder.

It is important to realize that many factors contribute to climate on Earth. Although Milankovitch cycles likely play a role in climate change, scientists do not think their effects will be strong enough to produce a new ice age during the next 50,000–100,000 years, and possibly longer.

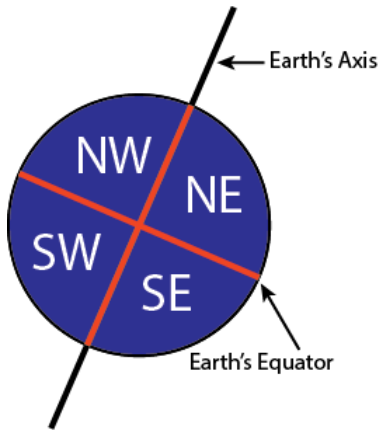
What Do You Think?

Why do we see the same side of the Moon every night from Earth? The answer is the Moon rotates about its axis at the same rate that it revolves around Earth. In other words, the Moon takes about 28 days to complete one rotation and about 28 days to complete one revolution. Due to its revolution, every night the Moon appears in a different part of Earth's sky. However, the Moon has rotated just enough on its axis to prevent us from seeing it from a different perspective.

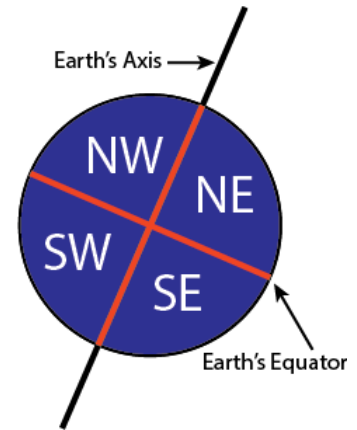
What Do You Know?

Earth's rotation and revolution affect day/night cycles as well as the seasons. The following diagram shows Earth at two positions in its orbit around the Sun. (This diagram is not drawn to scale.)

Position 1:



Position 2:



For each position, decide whether each hemisphere is experiencing day or night and winter or summer. Write your answers in the charts below.

| Position 1 | | | | Position 2 | | | |
|---------------|-------------------|---------------|-------------------|---------------|-------------------|---------------|-------------------|
| NE Hemisphere | | NW Hemisphere | | NE Hemisphere | | NW Hemisphere | |
| Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? |
| | | | | | | | |

| Position 1 | | | | Position 2 | | | |
|---------------|-------------------|---------------|-------------------|---------------|-------------------|---------------|-------------------|
| SE Hemisphere | | SW Hemisphere | | SE Hemisphere | | SW Hemisphere | |
| Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? | Day or Night? | Winter or Summer? |
| | | | | | | | |