OUR SOLAR SYSTEM | LESSON 2

# Earth and Moon

Day and night, seasons, Moon phases, eclipses and tides, explained by three bodies in motion.

Grades 4-8 | About 15 minutes of narrated flight, plus discussion stops | 8 stops | Start: learn.allseeing.space/earth-and-moon

## What students will see and do

Students watch Earth spin and tilt, fly to the Moon to see where it came from and why it has phases, return to Earth for tides, line up the Sun for eclipses, and stand on the Moon to feel its gravity.

## Learning objectives

- Explain day and night with Earth's rotation
- Explain the seasons with Earth's tilt, not its distance from the Sun
- Model the Moon's phases and explain why eclipses do not happen every month
- Describe how the Moon causes tides

## NGSS connections

| | |
|---|---|
| **MS-ESS1-1** | Develop and use a model of the Earth-Sun-Moon system to describe lunar phases, eclipses and seasons. |
| **5-ESS1-2** | Patterns of daily changes in shadows, day and night, and seasonal appearance of the Moon and stars. |
| **MS-ESS1-2** | Gravity of the Moon and Sun produces tides and holds the system together. |
| **DCI ESS1.B** | Earth and the Solar System. |

## 40-minute class plan

1. 5 min: pre-lesson prompt. Before we fly: why do you think it is colder in winter? Write your idea down so you can check it later.
2. 18-20 min: run the lesson. Keep discussion stops short (1-2 minutes each) or turn them off in the Lessons menu.
3. 8 min: whole-class discussion using two of the questions below.
4. 5 min: Exit ticket: Draw the Sun, Earth and Moon in position for a full Moon. Then explain in one sentence what causes the seasons.

## Full exploration (about 60 minutes)

1. 5 min: pre-lesson prompt, recorded so students can revisit it.
2. 25-30 min: run the lesson with every discussion stop at full length.
3. 15 min: follow-up activity. Lamp and ball phases: a lamp is the Sun, a student's head is Earth, a ball on a stick is the Moon; act out a full month.
4. 10 min: revisit the pre-lesson ideas, then the exit ticket.

## Before the lesson

Before we fly: why do you think it is colder in winter? Write your idea down so you can check it later.

## Discussion stops: timing and key points

**At Why we have seasons (3-5 min):** Earth is actually closest to the Sun in early January. If distance caused the seasons, what would winter be like in the north? What really causes the seasons?

- If distance caused seasons, the whole Earth would have summer in January; instead the north has winter then.
- Tilt changes how directly sunlight hits the ground and how long the days are.
- The two hemispheres always have opposite seasons.

**At Phases of the Moon (4-6 min):** The Moon makes no light of its own. Using what you heard, explain why we see a full Moon on some nights and a thin crescent on others.

- Half the Moon is always lit by the Sun.
- As it orbits Earth, we see different amounts of that lit half.
- Full Moon: Earth is between the Sun and Moon. New Moon: the Moon is between Earth and the Sun.

**At Eclipses (3-4 min):** The Moon goes around Earth every month. Why don't we have a solar eclipse every month?

- The Moon's orbit is tilted about five degrees to Earth's orbit.
- Most months the Moon's shadow passes above or below Earth.
- Eclipses happen only when a new or full Moon lines up with that crossing point.

## More questions for after the lesson

1. Why does the same side of the Moon always face Earth?
2. Why do lunar eclipses look red?
3. Why will total solar eclipses be impossible in the distant future?

## Vocabulary

rotation, revolution, axis, tilt, equinox, solstice, phase, eclipse, tide

## Exit ticket

Exit ticket: Draw the Sun, Earth and Moon in position for a full Moon. Then explain in one sentence what causes the seasons.

## Follow-up activities

- Lamp and ball phases: a lamp is the Sun, a student's head is Earth, a ball on a stick is the Moon; act out a full month.
- Flashlight angle: shine a flashlight straight down and at a slant on graph paper and count the lit squares.
- Moon journal: sketch the Moon every clear night for two weeks and label the phases.

## Full transcript

## Introduction

Welcome to Earth and Moon. Every day of your life is shaped by two worlds moving together through space: the planet you live on, and the Moon that circles it. In this lesson we will discover why you have day and night, seasons, Moon phases, eclipses, and tides.

Here is our question. The Sun, the Earth, and the Moon are always moving. How do their positions explain the patterns you see in your sky?

## 1. A spinning planet

Here is Earth. It spins once on its axis about every twenty four hours. That spin is why you have day and night. At any moment, half of Earth faces the Sun and has daytime, and the other half faces away into the dark.

Earth spins toward the east. That is why the Sun, the Moon, and the stars all seem to rise in the east and set in the west. They are not really moving across your sky. You are turning underneath them.

At the equator, the ground is carried around at about sixteen hundred and seventy kilometers per hour. You do not feel it, because everything around you, the air, the oceans, and you, is moving along together.

Earth's spin is very slowly slowing down. The Moon's pull on the oceans acts like a gentle brake, making each day about two thousandths of a second longer every century. Hundreds of millions of years ago, a day on Earth was only around twenty two hours long.

Earth also carries an invisible shield. Molten iron flowing deep in its core creates a magnetic field that reaches far into space. It deflects most of the charged particles streaming from the Sun. Near the poles, some of those particles slip in and make the air glow in shimmering curtains of green and red light, the auroras.

## 2. Why we have seasons

Now look at how Earth is tilted. Its axis leans about twenty three and a half degrees, and it keeps pointing the same way in space as Earth travels around the Sun for a whole year.

For part of the year, the northern half of Earth leans toward the Sun. Sunlight hits it more directly, like a flashlight pointed straight down, and the days are longer. That is northern summer. Six months later, the north leans away. Sunlight comes in at a low angle, spreads out, and days are shorter. That is northern winter.

The southern hemisphere always has the opposite season. When it is summer in California, it is winter in Australia and Argentina.

Many people think seasons happen because Earth gets closer to and farther from the Sun. But Earth's orbit is almost a circle, and Earth is actually closest to the Sun in early January, in the middle of northern winter. The tilt is what matters.

Twice a year, around March twentieth and September twenty second, neither hemisphere leans toward the Sun, and day and night are nearly equal everywhere. Those days are the equinoxes. The longest and shortest days of the year, around June twenty first and December twenty first, are the solstices.

**Discussion stop:** Earth is actually closest to the Sun in early January. If distance caused the seasons, what would winter be like in the north? What really causes the seasons?

## 3. Where the Moon came from

Now we fly to the Moon, about three hundred and eighty four thousand kilometers away. It is about one quarter as wide as Earth, the fifth largest moon in the solar system, and unusually large compared to its planet.

Most scientists think the Moon formed about four and a half billion years ago, when a body about the size of Mars slammed into the young Earth. Molten rock and debris were thrown into orbit and gathered together into the Moon. Rocks brought back by the Apollo astronauts are very similar to Earth rocks, which supports this idea.

The Moon has no air and no liquid water on its surface, so nothing erases its history. Its craters record billions of years of impacts. The dark patches you can see from home, called maria, are huge plains of ancient lava. The bright areas are older, heavily cratered highlands.

The Moon is not completely dead. Seismometers left by Apollo astronauts recorded moonquakes, some caused by Earth's tides squeezing the Moon, and some by the Moon slowly shrinking as its interior cools.

### 4. Phases of the Moon

The Moon makes no light of its own. It shines because sunlight reflects off its gray, dusty surface. Half of the Moon is always lit by the Sun, just like half of Earth.

As the Moon travels around Earth, we see different amounts of its lit half. When the Moon is between Earth and the Sun, its lit side faces away from us, and we see a new Moon. As it moves around its orbit, we see a thin crescent, then a half Moon called the first quarter, then a gibbous Moon, and finally a full Moon, when Earth is between the Sun and the Moon.

Then the pattern runs backward until the next new Moon. The whole cycle of phases takes about twenty nine and a half days. That cycle is the origin of the word month.

The Moon also spins exactly once for every trip around Earth, so the same side always faces us. The far side is not dark, though. It gets just as much sunlight. We simply never see it from Earth. In twenty nineteen, China's Chang'e four became the first spacecraft to land on the far side.

**Discussion stop:** The Moon makes no light of its own. Using what you heard, explain why we see a full Moon on some nights and a thin crescent on others.

### 5. Tides

Back to Earth, to the oceans. The Moon's gravity pulls on Earth, and it pulls a little harder on the side of Earth facing the Moon than on the far side. That difference stretches Earth's oceans into two bulges, one facing the Moon and one on the opposite side.

As Earth spins through those bulges, most coastlines get two high tides and two low tides about every day. Because the Moon moves along its orbit, the tides arrive almost an hour later each day.

The Sun creates tides too, about half as strong as the Moon's. When the Sun, Earth, and Moon line up, at new Moon and full Moon, their pulls add together and make extra-large tides called spring tides. When they form a right angle, at the quarter Moons, the tides are smaller, called neap tides.

The shape of a coastline can make tides enormous. In the Bay of Fundy in Canada, the water can rise and fall about sixteen meters, as tall as a five story building, twice every day.

### 6. Eclipses

Here is a beautiful coincidence. The Sun is about four hundred times wider than the Moon, but it is also about four hundred times farther away. So from Earth, they look almost exactly the same size in the sky.

That is why a total solar eclipse is possible. When the new Moon passes directly between the Sun and Earth, it can cover the Sun completely. For a few minutes, day turns to twilight, the temperature drops, and the Sun's glowing outer atmosphere, the corona, appears. You must never look at the Sun without proper eclipse glasses, except during the brief moment of totality.

A lunar eclipse happens at full Moon, when Earth's shadow falls on the Moon. The Moon often turns a deep red, because a little sunlight bends through Earth's atmosphere and reaches it. In that moment, the Moon is lit by every sunrise and sunset on Earth at once.

Eclipses do not happen every month, because the Moon's orbit is tilted about five degrees compared to Earth's. Most months, the Moon passes just above or below the line between Earth and the Sun.

A total solar eclipse happens somewhere on Earth about every year and a half. But the Moon's shadow is narrow, so any one town sees a total eclipse only about once every few hundred years. People travel around the world to stand in that shadow.

**Discussion stop:** The Moon goes around Earth every month. Why don't we have a solar eclipse every month?

### 7. Walking on the Moon

What would it be like to stand here? The Moon's gravity is only about one sixth of Earth's. A student who weighs thirty six kilograms on Earth would feel like six kilograms on the Moon. Apollo astronauts found that hopping like a kangaroo was easier than walking.

There is no air to carry sound or to soften sunlight. The sky is black even in the daytime. A day on the Moon, from one sunrise to the next, lasts about twenty nine and a half Earth days, so the surface bakes in sunlight for two weeks, reaching over one hundred degrees Celsius, then freezes for two weeks to well below minus one hundred degrees.

Radio signals take about one and a quarter seconds to travel between the Moon and Earth, so every conversation with home has a small delay. From the Moon, Earth hangs in the sky in nearly the same place all the time, going through its own phases, just like the Moon does for us.

### 8. The Moon is moving away

One last secret. The Moon is slowly drifting away from Earth, about three point eight centimeters every year, roughly as fast as your fingernails grow. Scientists know this by bouncing laser beams off mirrors that Apollo astronauts left on the Moon and timing how long the light takes to return.

Far in the future, the Moon will look a little smaller in the sky, and total solar eclipses will no longer be possible. You live in a lucky moment in Earth's history, when the Moon fits over the Sun almost perfectly.

### Wrap-up

So day and night come from Earth's spin. The seasons come from its tilt. The Moon's phases come from how much of its sunlit side we can see. Eclipses come from shadows, and tides come from gravity. All of it is the same three bodies, the Sun, the Earth, and the Moon, moving in patterns you can predict.

Tonight, look up and find the Moon. Can you tell which phase it is in, and where it will be in a week? Press L to choose another lesson.

Positions are computed live from real orbits. Narration is checked against public scientific sources; full credits at learn.allseeing.space/credits.html. Standards are listed as connections to NGSS, not formal alignments. Report an issue: info@allseeing.space