Astronomy Alphabet

Educational video for children
https://vimeo.com/77309599

Teacher & Learner Guide

This guide gives background information about the astronomy topics mentioned in the video, provides questions and answers children may be curious about, and suggests topics for discussion.

A
Alhazen,

called the Father of Optics, performed experiments over a thousand years ago to learn about how light travels and behaves. He also studied astronomy, separated light into colors, and sought to explain why the Moon looks bigger near the horizon.

I've never heard of Abu Ali al-Hasan ibn al-Hasan ibn al-Hatham (Alhazen). Tell me more about him.

We don't know that much about Alhazen because he lived so long ago, but we do know that he was born in Persia in 965. He wrote hundreds of books on math and science and pioneered the scientific method of experimentation. The Book of Optics describes Alhazen's experiments in how vision works, and his theory is still followed today. This is why we call him the Father of Optics. A crater on the Moon is named after him.

NASA/Goddard/Lunar Reconnaissance Orbiter, Apollo 17

Can you find Alhazen crater when you look at the Moon?

*Why **does** the Moon look bigger near the horizon?*

Believe it or not, scientists still don't know for sure why we perceive the Moon to be larger when it lies near to the horizon. Though photos of the Moon at different points in the sky show it to be the same size, we humans think we see something quite different. Try this experiment yourself sometime! One possibility is that objects we see next to the Moon when it's near to them give us the illusion that it's bigger, because of a sense of scale and reference.

How many craters does the Moon have, and what are their names?

The Moon has a LOT of craters! Some of them are hundreds of miles across. One lunar crater, the South Pole–Aitken Basin, is almost 1,500 miles in diameter! Not all lunar craters have names, but the ones that do were named (and can only be named) by the International Astronomical Union.

Check out our other astronomy education resources at https://astronomy.nmsu.edu/geas

Quite a few are named after famous astronomers like Alhazen, and, as with constellations and stars, many others derive their names from Greek mythology.

What kinds of experiments did Alhazen do?
Alhazen spent much of his life performing experiments to explain how our eyes worked. An unusual aspect of his experiments was that he used mechanical design to formulate ideas about light and vision. For instance, he used projectiles to show how the angle at which an object hit a target greatly affected whether it would puncture the target. Alhazen hypothesized that light worked in a similar way, entering the eye at a perpendicular angle. He also devised an early pinhole camera to demonstrate that individual bits of light (or bits of optical information) could enter the eye without blending together, thus forming a distinct image.

B
Betelgeuse

The giant star Betelgeuse looks red and orange because of its low surface temperature. The name "Betelgeuse" may have come from the Arabic for "armpit of the giant."

Why does red/orange indicate a low temperature for a star?
We often associate the color red with hot temperatures here on Earth, but stars reach temperatures far beyond what we experience on a hot summer day. Astronomers classify stars according to the light they emit, where different colors of light indicate different temperatures. The hottest stars appear icy blue, and can reach temperatures near 30,000 kelvin. Betelegeuse's red-orange color indicates a "cool" temperature in the vicinity of only 3,000 kelvin, almost 5,000 degrees Farenheit, a temperature still way too hot for humans!

Is Betelgeuse part of a constellation?
Betelgeuse is part of the constellation Orion, visible above the equator in the winter sky.

Why did scientists decide "armpit of the giant" was a good name for a star?
Many names of stars have some relation to the constellations in which they appear. We aren't certain where the name Betelgeuse came from, but we can make an educated guess based on its location in the constellation named after the mighty hunter Orion. "Armpit of the giant" makes sense because Betelgeuse is located right along Orion's arm!

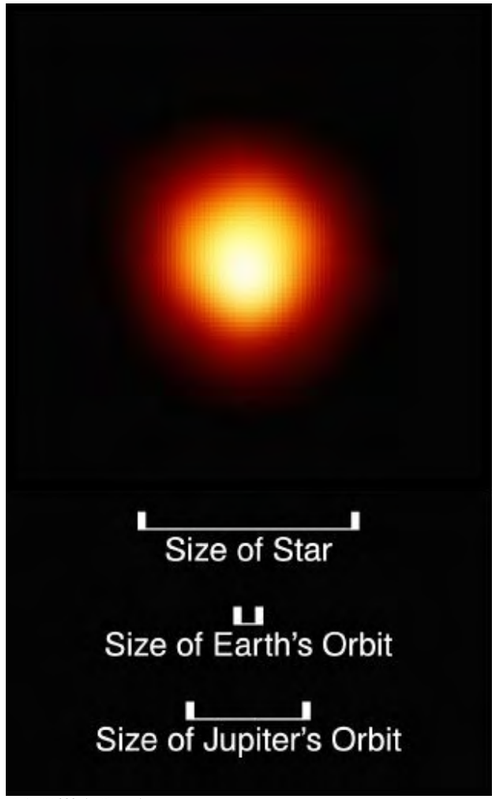
How do stars get their names?
Bright stars have names given to them by ancient astronomers, but if a star is named today, it must be done by the International Astronomical Union (IAU). Most stars named today are simply designated by a number, rather than a name like Betelgeuse. To learn more about this process, visit https://iau.org.

C
Constellation

A constellation is a group of bright stars which appear close together on the sky, forming a shape or pattern. Ancient civilizations told stories about the adventures of people and creatures they saw in these shapes, and used them to navigate the world.

What are some examples of constellations?
Betelgeuse, the star mentioned above, is part of the constellation Orion, which is a figure of an archer. Other examples of constellations are Ursa Major (a large bear), Pegasus (a winged horse), Leo (a lion), Cassiopeia (a queen), and Centaurus (half-horse, half-man).

Who first thought up constellations?
The earliest human beings identified patterns in the sky, but the named constellations we are familiar with today were primarily documented by the ancient Greeks. In the southern hemisphere, where the Greeks did not travel, one can find constellations such as Telescopium with more modern names.



NASA/Hubble (A. Dupree)

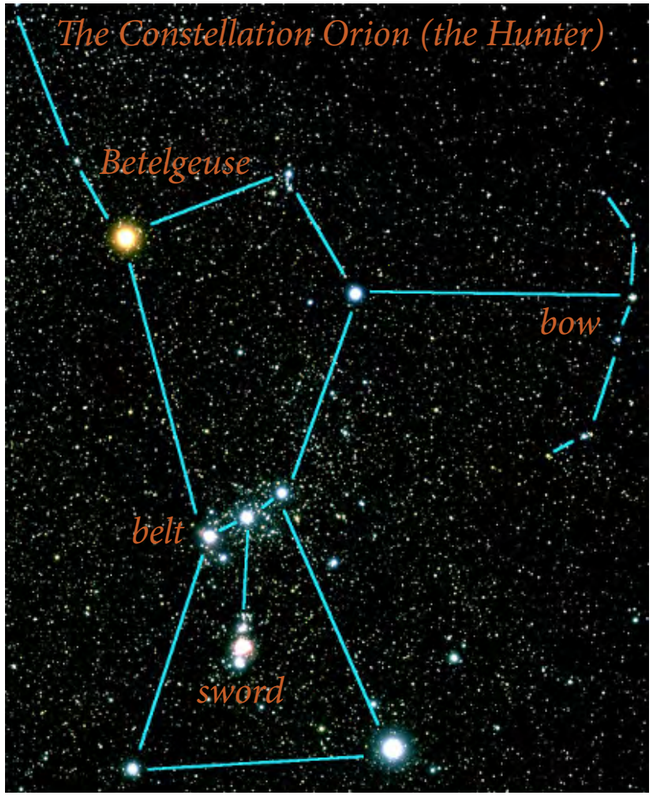


Photo credit Akira Fujii; annotated by Nicole Vogt

The red supergiant star Betelgeuse is found in the constellation Orion, along with other much bluer (hotter) stars.

Does every country have the same constellations or names for constellations?
In the scientific world, every country uses the constellation names adopted by the International Astronomical Union, but as with plants and animals, there are also common names that vary from country to country. Orion is often named as an archer, but was a shepherd to the Babylonians, a pharaoh to the Egyptians, and a bison to the Lakota.

Do people in different places see the same stars?
No! Your view of the night sky varies depending upon where on Earth you are and what time of year it is. Different stars appear overhead over the course of the year, and as you travel north and south across the Earth different constellation will appear and disappear in your sky. That is why star maps are adjusted for time and for place. For instance, on the iPad *Star Chart* app, you can choose the city nearest to you in order to see the correct stars for your location.

What are the 12 constellations of the zodiac?

Aries, the ram	**Libra, the scales**
Taurus, the bull	**Scorpius, the scorpion**
Gemini, the twins	**Sagittarius, the centaur**
Cancer, the crab	**Capricornus, the goat**
Leo, the lion	**Aquarius, the water carrier**
Virgo, the maiden	**Pisces, the fishes**

A siren sounds to our ears like it's changing pitch as an ambulance approaches and then recedes from us.

GEAS Project

D
Doppler Shift

When an object emitting sound or light moves in relation to an observer, the change in wave frequency that the observer hears or sees is called a Doppler shift. For example, we can hear a change in pitch when ambulance sirens race past us.

I'm confused. Can you explain more?

Think about what happens when an ambulance or fire engine goes past you with its siren blaring. As the siren approaches and then passes by, the sound changes. The object is emitting sound, and, as it moves, sound waves pile up (are compressed) in front of it. This causes them to shorten (they sound higher) as the object approaches. In contrast, sound waves behind the object are spread out as it moves away from them.

Why is this effect called a Doppler shift?

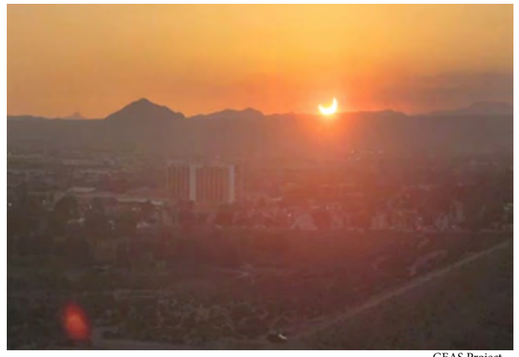
This phenomenon is named after the Austrian physicist Christian Doppler because he was the first to describe it, in 1842.

What is it like when the Doppler shift is visual (seen) instead of auditory (heard)?

Imagine a boat moving through calm water, triggering circular ripples around it. You can see waves being compressed in front of the boat, and spacing themselves out behind it. Try to create a visual Doppler shift yourself by moving a toy through the water in a bathtub.

What does the Doppler shift have to do with astronomy?

Celestial objects are so far away that we can't measure their movements with the same tools we use to measure the movements of cars or someone walking. Instead, we look at changes in wavelengths of emitted light to determine if stars (and galaxies!) are moving toward us or away from us. The red end of the visual electromagnetic spectrum has long wavelengths, and the blue end has short ones. When we see a shift toward the red end of the spectrum, that indicates a celestial object is moving away from us. When we see a shift toward the blue end of the spectrum, that indicates an object is coming toward us.



GEAS Project

Observe the occulted Sun during a solar eclipse.

E
Eclipse

When the Moon passes between the Sun and the Earth, it temporarily blocks our view of the Sun. This is called a solar eclipse. Here we see a partial solar eclipse observed from Las Cruces, New Mexico.

What are the other kinds of eclipses?

When one celestial body blocks another celestial body from being seen, that is an eclipse. On Earth, we can experience lunar and solar eclipses. During a solar eclipse, the Moon comes between the Sun and the Earth and blocks the Sun's light from reaching the Earth. During a lunar eclipse, the Earth comes between the Sun and the Moon and blocks the Sun's light from shining on the Moon (casting a shadow across the Moon). Eclipses can occur from vantage points on other planets or satellites as well.

> To see when eclipses are scheduled to occur and when they've occurred in the past, visit NASA's eclipse website:
>
> **NASA**
> **https://eclipse.gsfc.nasa.gov**

How often do eclipses occur?

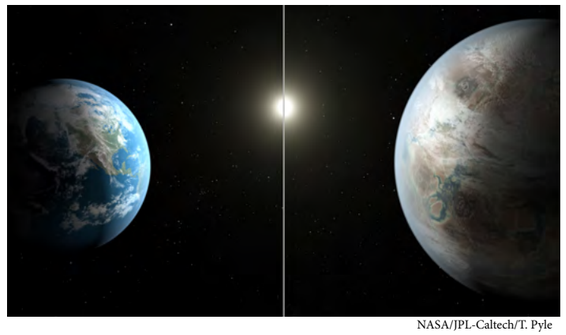
Eclipses are more common the closer you lie to the equator. Because eclipses require the Sun, Earth, and Moon to line up, a particular eclipse will only be visible from a small region on Earth for a short time. Eclipses are often partial instead of total because, from a given point, the Sun or Moon is only partially obscured. Several partial solar eclipses and many lunar eclipses occur each year.

F
Fireball

A fireball is a very bright meteor, a brief flash of light caused by debris burning up in our atmosphere. From our viewpoint on Earth, a fireball may briefly light up a large portion of a dark sky. People also call them shooting stars (though they are not actual stars), and often wish on them for good luck.

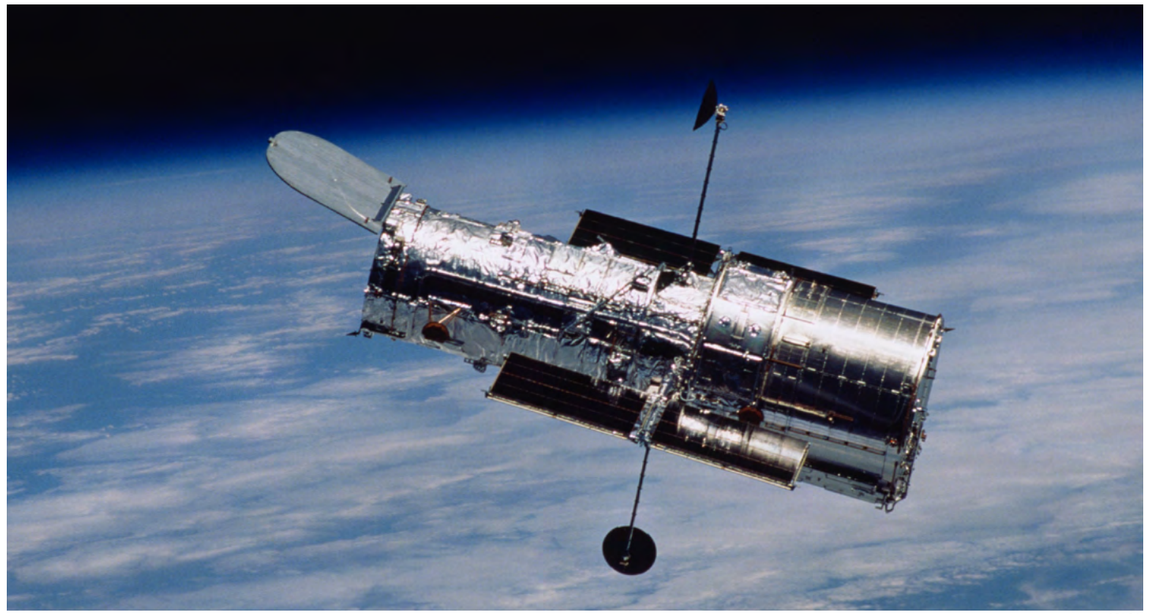
What is a meteor?

A meteoroid is a hunk of rock, metal, or ice traveling through space. It might have broken off from a comet



NASA/JPL-Caltech/T. Pyle

What sort of life might exist on earthlike Kepler-452b?



NASA

Astronomers are thrilled to observe stars and galaxies with the Hubble Space Telescope, and treasure the experience.

or a larger rocky body, like an asteroid. When a meteoroid hits the Earth's atmosphere, it grows hot, burns, and gives off light (a meteor event).

What makes a fireball occur?

The same circumstances create meteors and fireballs — a piece of solar system debris gets caught and falls through the Earth's atmosphere. Fireballs are brighter due to their composition, velocity, and/or heat.

G
Goldilocks Planet

A planet that is like Earth, that isn't too far from a star, or too near to it, but is at just the right distance to be able to support life ... is called a Goldilocks planet. It is not too cold, not too hot, but "just right"!

Are there other Goldilocks planets besides Earth?

Yes! Scientists hypothesize that there are many, but that they are far away from us, orbiting around other stars. Astronomers have a short list of planets they believe are habitable. One of these, Kepler-452b, was covered in the news in Summer 2015 shortly after scientists announced their findings. Kepler-452b lies almost 1,400 light years away from us (it takes even light a full 1,400 years to travel here from there).

How can we tell if a planet can support life unless we visit it?

Scientists can observe planets and moons through powerful telescopes to estimate how hot or cold they are, what their air is composed of, and if there is liquid water available to support life. They are able to do this based upon what we know from looking at our own planet and the planets and moons near us. Astrobiology is the scientific field that encompasses the search for and study of habitable planets.

H
Hubble Space Telescope

The Hubble Space Telescope was lifted into space, away from the Earth's lights and atmosphere, so that it—and we—could have a better view of stars and galaxies throughout the Universe.

Why can't we see that well from Earth? What do our lights and atmosphere have to do with it?

If you have ever had the opportunity to compare the night sky in a big city and in a remote area with few nearby lights, you'll know that when there are lots of city lights, the stars appear dimmer. Think of an iPad, one with a screen which is difficult to see in bright sunlight but easy to see at night when you turn off the lights.

Our most powerful telescopes are located as far as possible from human sources of light. The Earth's atmosphere, even when it's not polluted, contains particles that get in the way of our seeing clearly. Stars and galaxies are incredibly far away, and are so faint that even these tiny particles affect how much detail a telescope can see.

How big is the Hubble Space Telescope?

NASA's website (https://nasa.gov) includes some fun facts about the Hubble Space Telescope: its mirror (lens) is nearly 8 feet in diameter, the telescope itself is longer than a super-huge school bus, and the telescope weighs 24,500 pounds!

Why is it called Hubble?

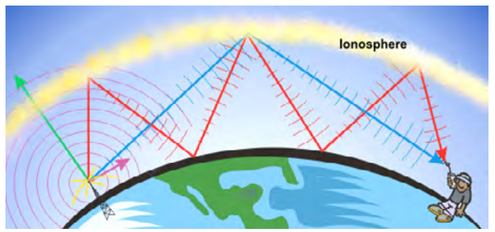
It is named after Edwin Hubble (1889–1953), a famous American astronomer who studied galaxies like our own Milky Way.

Why can't we invent a way to see better from here?

Special telescope and computer systems (adaptive optics) can help us to counteract the effects of blurring in the atmosphere, but it makes very good sense to put telescopes in space as well.

I
Ionosphere

The ionosphere is a seething cauldron of charged (ionized) particles that bounces radio waves around our planet.



The ionosphere bounces radio waves around Earth.

How does the ionosphere get so full of charged particles?

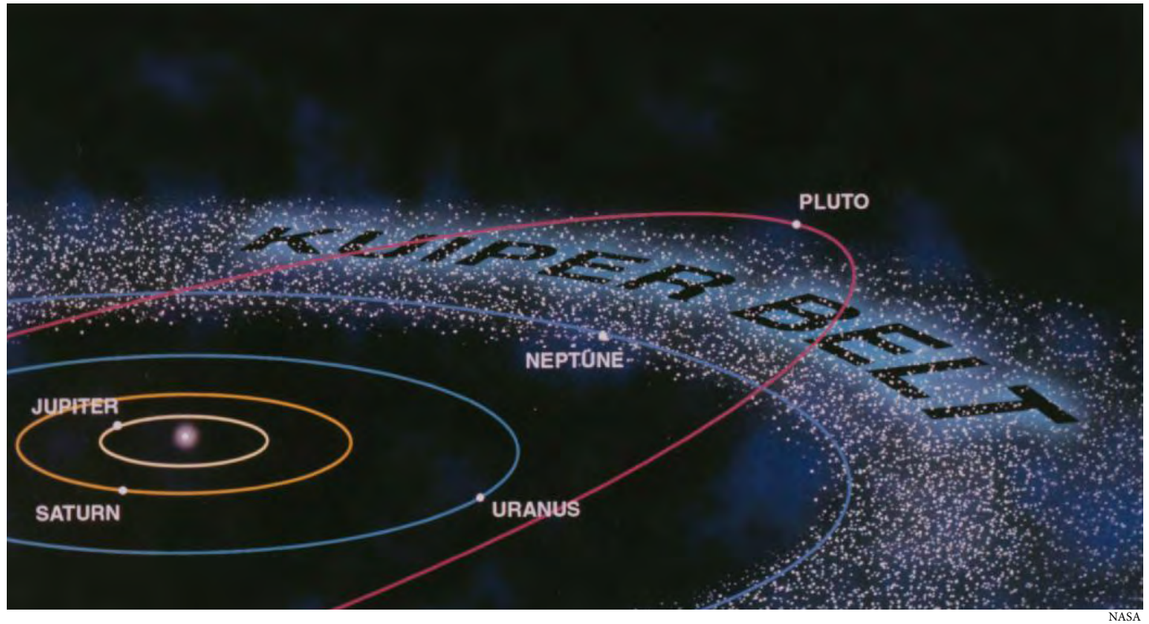
Imagine solar radiation as a physical force. When this radiation hits the atoms and molecules that make up our atmosphere, it shakes electrons off of them and the affected layer of the atmosphere is left charged.

What are the other parts of our atmosphere?

Our atmosphere has five primary layers: the exosphere, thermosphere, mesosphere, stratosphere, and troposphere. The ozone layer and the ionosphere are secondary layers. The ionosphere varies in size, depending on the amount of sunlight.

Why is the ionosphere important?

Because the ionosphere is charged, it can refract radio waves and affect how they travel around the Earth. Radio broadcasters need to understand it to choose the best frequency for broadcasting their signals clearly.



NASA

The Kuiper Belt is the wild west of the solar system, full of icy cometary debris left over from the epoch of formation.

Why is it called the ionosphere?
An ion is an atom or molecule that contains a charge due to the loss or gain of an electron. Solar radiation knocks electrons off of the atmospheric atoms and molecules and creates ions, creating the ionosphere.

If you want to learn more about the ionosphere, go to the NASA website and type "ionosphere" into the search field. Videos and other resources hosted there will let you explore this fascinating portion of our atmosphere.

NASA
https://nasa.gov

J
Jupiter

The fifth, and largest, planet from the Sun is named Jupiter. It is one of the brightest objects we can see in the night sky.

Why does Jupiter look so bright?
One of the reasons Jupiter looks so bright is that it lies relatively near to us. Another reason is that Jupiter is huge (by far the biggest planet in our Solar System) and therefore reflects a lot of light. The cloud cover on Jupiter also increases reflectivity.

Can we always see Jupiter?
We can easily see Jupiter from Earth on many nights. When Jupiter appears near to the Sun in the sky, however, it can become much harder to see. Sometimes the Sun blocks our view of the planet entirely.

Why is it called Jupiter?
The planet was named after the Roman god Jupiter, the king of the gods, as well as the god of the sky.

How large is Jupiter? How many Earths would fit inside it?
Jupiter is about 89,000 miles in diameter (ten times as wide as the Earth), and a thousand planet Earths could fit comfortably inside it.

K
Kuiper Belt

The Kuiper belt contains remnants from our solar system's formation. It lies far beyond the last planet, Neptune.

What kind of remnants?
The Kuiper belt is made of up of large (over 60 miles in diameter!) chunks of icy methane, ammonia, and water.

How do we know this material comes from the formation of the solar system?
For a long time astronomers lacked the tools to see as far out into the solar system as the Kuiper belt, and they thought the area beyond Neptune and Pluto might be relatively empty. Since 1950, astronomers have been better able to look at the Kuiper belt. From the density and pattern of the icy bodies and planetoids out there, astronomers think that when the planets formed around the Sun, the area closer to the Sun was more densely populated with planets and other bodies. The far-flung material was scattered – just like when you drop a glass of water and most of the water lands in a big puddle with fewer droplets the farther out you go – and didn't form planets.

NASA's New Horizons spacecraft reached Pluto in 2015, and is now surveying the Kuiper belt. It recently flew by the ancient peanut-shaped asteroid Arrokoth, a primitive relic of the early history of the solar system.

Why is it called the 'Kuiper belt'?
The Kuiper belt is named after the Dutch-American astronomer Gerard Kuiper (1905–1973), who discovered satellites of Neptune and Uranus. In the 1950s, he came up with a hypothesis (a good idea) about what we would find in the region beyond Pluto.

How far away is Neptune?
Neptune lies about 30 astronomical units (AU) from the Sun. An astronomical unit is the average distance between the Earth and the Sun. Neptune is therefore about thirty times as far from the Sun as we are. The Kuiper belt extends to about 55 AU from the Sun.

To learn more about the phases of the moon and access an interactive animation, visit:

GEAS Project
https://astronomy.nmsu.edu/geas/hci/html/welcome.shtml

L
Lunar

***Lunar* means related to the Moon. The changing faces of the Moon we see over the course of a month are called lunar phases.**

Where does the word "lunar" come from?
As with many things in astronomy, the origin of the word *lunar* is Latin (the Moon's Latin name is *Luna*).

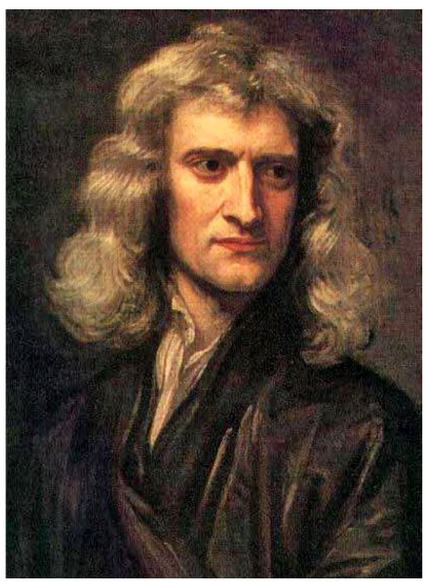
Why does the Moon go through phases?
The Moon doesn't actually get larger and smaller over the month, but it can look that way to us on Earth. One side of the Moon faces the Sun and is illuminated by sunlight, but the portion of that illuminated side which faces toward us on Earth varies over the month, as the Moon moves in a circle around us. As we see different fractions of that illuminated side, the Moon appears to wax and wane (grow and shrink) through its phases.

Why is the lunar cycle a month long?
The lunar cycle is determined by how long it takes the Moon to orbit the Earth. An orbital cycle, or a full cycle of all eight lunar phases, takes 29 1/2 days, or approximately a month.

M
Milky Way

The Milky Way is a bound system of billions of stars, a galaxy, in which the Sun and our solar system are located—it's our home.

Are there other solar systems in our galaxy?
The word *solar* is derived from the word *sol*, which is Latin for *sun*. Because the Sun is the center of our planetary system, our system is called the solar system. Thus, ours is the only solar system in our galaxy. Other systems made up of planets orbiting a star are called "stellar systems" or "planetary systems." An example of one in our galaxy is PSR B1257+12, a pulsar with several planets.



Isaac Newton in a portrait by Godfrey Kneller, 1689. Newton's England was engulfed in a civil war and ravaged by plague. At Cambridge University, he took refuge in the poetry of mathematics and science. He created small, lightweight telescopes by replacing lenses with mirrors.

How many planetary systems are in a galaxy?
There are so many that we can't count them all! We are just now discovering many other planetary systems, and it is likely that we'll discover quite a few more in the coming years. One of the wonderful things about astronomy is that we're developing more powerful telescopes for the exploration of celestial bodies, and there's so much more to discover.

Why is our galaxy called the Milky Way?
Our galaxy appears in the sky as a long, extended cloud with a "milky" white appearance. Legends say it is made of milk that was spilled across the sky.

N
Newton

Sir Isaac Newton studied gravity and motion, built an early reflecting telescope, and helped to confirm the idea that the Earth revolves around the Sun.

Who was Newton? When did he live?
Isaac Newton, an English scientist, was born in 1642 and died in 1727. He lived in an exciting time when huge discoveries were being made about basic properties of the Universe. Newton performed experiments to understand the basic laws of motion. You might have heard the story of an apple falling on Newton's head, leading him to formulate his ideas about gravity. While we don't know for certain if the apple story is true, we do know that Newton's work on the laws of motion were of major importance in astronomy because they defined the motions of the planets around the Sun.

What is a reflecting telescope?
There are many kinds of telescopes, all of which collect some kind of electromagnetic radiation. A reflecting optical telescope uses mirrors to reflect (bend) light (radiation in the visible portion of the spectrum) to form an image.

What did people believe before scientists like Newton provided support for the idea of the Earth revolving around the Sun?
People originally believed that the Earth was the center of our planetary system, and that the Sun and other celestial bodies revolved around it.

O
Oort cloud

We think that this "cloud" of tiny, icy planets lies at the very edge of our solar system, almost a light year (the distance light travels in a year) from the Sun.

"Oort" is a really funny word. What does it mean?
Oort is the last name of Dutch astronomer Jan Oort (1900–1992), who made huge inroads into our understanding of the Milky Way. His ideas suggested the presence of many comets in a region beyond Pluto's orbit before we found them.

What does it mean that we "think" the Oort Cloud is at the edge of our solar system? Why don't we know? How will we know when we do find the edge of the solar system?
We haven't actually seen the Oort Cloud, but because we have an understanding of how the solar system formed and how the inner and outer solar system differ from each other, we can make educated guesses about what lies beyond what we can observe. NASA's New Horizons spacecraft reached Pluto in 2015 and is heading outward. We will soon have better data from the far reaches of our solar system and should be able to assemble a more accurate picture of the Oort Cloud.

How long have we known about the Oort Cloud?
Jan Oort came up with his ideas about the outer solar system in 1950.

Why is the Oort Cloud important?
The more we know about the distant reaches of our solar system, the more accurate we can be in describing its formation. Knowledge of the Oort Cloud will also aid in our understanding of comets. Recently, research into what lies beyond Pluto caused scientists to think differently about what defines a planet. Learning more about the Oort Cloud could further our most basic ideas about the solar system.

P
Pluto

Near to the Kuiper belt lies Pluto, which for many years was considered the ninth planet in our Solar System. Pluto is made of ice and rock and is a similar size to other tiny planet-like objects recently discovered in the Kuiper belt.

What made scientists change their mind about Pluto being a planet?
In 2003, a celestial body named Eris was found. Eris was bigger than Pluto, but located farther out in the solar system. Since Pluto was a lot smaller than the other eight planets designated in our solar system at the time, scientists discussed redefining the term planet. The consensus was that Pluto and objects like it should be called dwarf planets. A dwarf planet possesses many of the same characteristics as a regular planet, but it isn't massive enough to clear other celestial bodies out of its orbit. Who knows? As we learn more about the Universe, other things we've accepted for a long time may change too!

What is the difference between a planet and a "planet-like object"?
The International Astronomical Union (IAU) provides official definitions to the astronomy community. The IAU defines a planet as a body that orbits the Sun, is massive enough to form a round shape (due to gravity), is not a

moon circling another planet, and is massive enough to clear other bodies from its orbital path. A dwarf planet or planet-like object shares the first three characteristics, but is not massive enough to knock other bodies out of its way or accrete them.

If you'd like to read more about the shifting definition of "planet," visit:

NASA
https://solarsystem.nasa.gov
International Astronomical Union
https://iau.org

Q
Quasar

A quasar is the dense center part of a certain type of galaxy.

Why is a quasar so dense—why is the center of a galaxy denser than the outer parts?

The short answer is: gravity. Gravitational forces are strongest at their source, and because gravity pulls mass toward a center, that area becomes most dense. It is thought that part of the intensity of the energy we see emitted by quasars is due to the presence of supermassive black holes, where matter is being accreted and energy is being released on an unimaginable scale.

What is a quasar made of?

A quasar is a compact central region in a galaxy, one that emits huge amounts of energy. It can't be described in the same way you might describe a planet (as "rocky" or "icy" or "made of methane") because it is a very different construct.

Where does the word "quasar" come from?

"Quasar" is a contraction (shortening) of the word "quasi-stellar." When quasars were first discovered, they were called "quasi-stellar radio sources" because astronomers detected radio waves from objects that

ESO/M. Kornmesser

Quasars are extremely luminous objects found in the cores of galaxies.

seemed as small as stars. Quasars have very different spectra than stars; they emit large amounts of radiation in both the visible and radio portions of the spectrum.

R
Rainbow

A rainbow is an arc of light of many colors caused by light reflecting in drops of water in the Earth's atmosphere.

Why can we only see rainbows some of the time?

A rainbow occurs when the Sun is shining, but there is also water in the air. In a desert spot like Arizona, you're unlikely to see a rainbow because there's plenty of sunshine but not much rain. When it is pouring rain out, you're also unlikely to see a rainbow because there isn't much sunlight. Rainbows are more frequent in environments where there is a mixture of moisture and sunshine. The moisture doesn't have to be from rain; it can also be from mist or spray from a waterfall. As long as sunlight is shining through some kind of moisture the basic conditions for a rainbow exist, but you're more likely to observe a rainbow when the rays of light

Warren Woodfin

A rainbow illuminates the shining city of Zurich, Switzerland.

form a low angle instead of shining from above. Because there are such specific conditions for creating rainbows, you won't see them that frequently unless you live in a place like Hawaii or Florida, where there is abundant sunshine and rain.

What causes a double rainbow?

A double rainbow requires even more stringent conditions than a single rainbow because the angle of the sunlight passing through the rain or mist must be just right. When you see a single rainbow, you're observing light refracting (bending) off of raindrops, but when you see a double rainbow, not all of the light gets refracted. Instead, some of it gets "trapped" in the raindrops and refracts again, causing a fainter second rainbow to occur. Because the light is refracted twice, its wavelengths and colors are reversed, forming VIBGYOR (for violet through red) instead of ROYGBIV (red through violet).

Are there places on Earth where rainbows never occur?

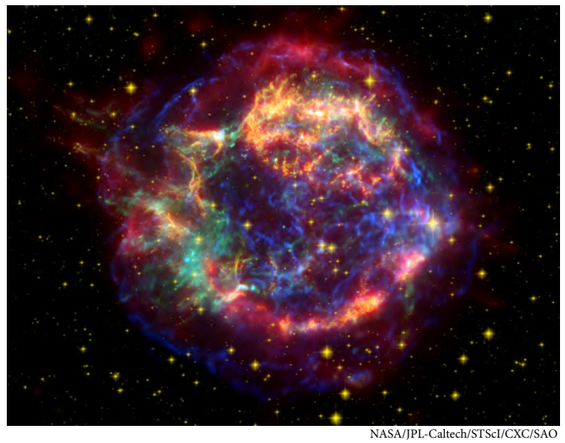
In theory a rainbow may occur in any location where there is both sunshine and rain, but in a dry place like Death Valley, it is very unlikely that you'd ever see a rainbow. You're also unlikely to see a rainbow in the Arctic, where there is little liquid precipitation, because frozen moisture doesn't refract light in the same way as liquid.

S
Supernova

A supernova is a type of star that explodes upon death, giving off a huge, brief burst of light and energy.

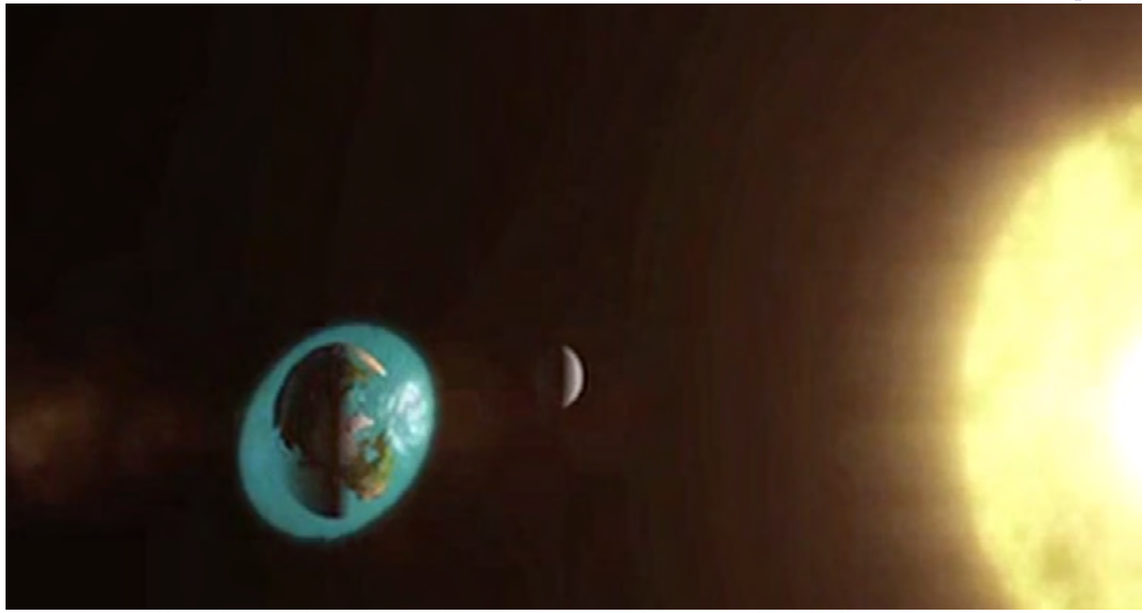
Supernovas are so bright that amateur astronomers like you can easily look for them. If you want to find out more, look up "supernova" at:

NASA
https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-supernova.html



NASA/JPL-Caltech/STScI/CXC/SAO

Supernova remnants shine on, long after the initial explosion.



A simulation of how the Moon's gravitational attraction tugs on the oceans of Earth, distorting its shape. GEAS Project

What causes a star to explode?

Think of a star as a dense ball of different elements, generating energy. If the balance between gravity and output energy is stable then the star stays in a stable state, but if they start to get out of balance an explosion can occur. A star's equilibrium can be affected when it runs out of key elements. For example, a star's core may run out of fuel, which causes heavier materials to move inward. This affects the balance of gravity in the star and essentially creates a lot of pressure deep in the center of a very hot and energetic mass. As you might guess, under these conditions, a huge explosion can happen!

Nova versus supernova?

The word *nova* means "new star" because when one occurs a hitherto unknown star can temporarily become bright enough to be seen by eye or with small telescopes. A nova is the explosion of a white dwarf (a small, dense star), causing a burst of light that astronomers can observe. Nova Centauri 2013, a star within the constellation Centaurus, recently accumulated enough matter from a neighboring star to cause an instability. It then exploded, becoming very bright for a short time.

A supernova is far more massive and bright than a nova. One type is basically a bigger and brighter nova that happens as one star in a binary system gathers matter from the other star in the system, making it unstable and leading to an explosion. This kind of supernova occurs when the star is relatively young, but a second kind of supernova can occur toward the end of a star's life. A single massive star can become so dense at its core that the resulting gravitational force causes the star to collapse, and then explode outward.

T
Tides

The Earth and its oceans are pulled on by the gravitational attraction of the Moon and Sun, causing tides, the rise and fall of the oceans.

What causes the Moon to have gravity?

Gravity exists everywhere. The more mass an object has, the stronger its gravitational pull. That's why enormous objects like moons, planets and stars exert so much force. If you've ever seen astronauts walking on the Moon, you'll have noticed that the Moon exerts less of a gravitational pull than the Earth does. That's why lunar astronauts leap and bounce when they walk, much more than they would on Earth.

How is the Moon's gravity able to pull on something so far away?

Gravitational attraction weakens with distance, so the Moon's pull isn't very powerful here on Earth, but oceans are more easily moved than solid rock. The stronger gravitational pull of the Earth keeps the oceans from floating away; otherwise we might be in trouble! Tides are also affected by the gravitational pull of the Sun.

Does the Moon's gravity pull other things?

It does! The Moon's gravity exerts force on our entire planet, but the effect is so small that we can't see it as we walk around every day. The Earth exerts more force on us than the Moon does, and the Earth's gravity is what we notice when we jump in the air or drop something to the ground.

Why do the tides change depending on the time of day and the time of year?

Tides are affected by how far the Earth is from the Moon and the Sun. The Earth's orbit is not a perfect circle, so there are times when our planet is closer to or farther from the Sun. Since a full orbit takes a year, our orbital position creates annual patterns in the tides.

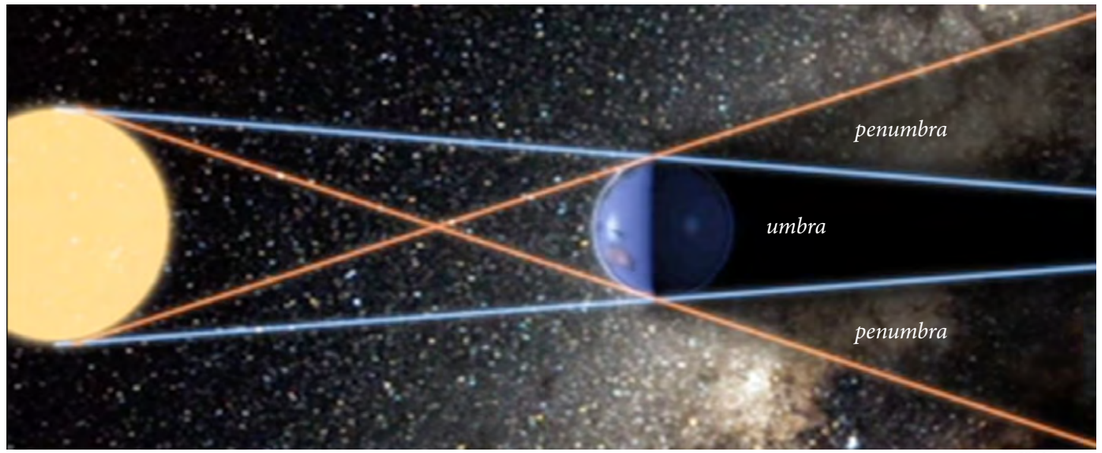
Tides are also affected by the Earth's rotation on its axis. Since the Earth makes a full rotation each day, there are daily patterns in the tides.

U
Umbra

An umbra is a part of the shadow cast by an object in the sky, such as the Moon when it blocks the light from the Sun during a solar eclipse.

What is the difference between an umbra and a penumbra?

Umbra means "shadow," and *penumbra* means "almost



Observe the umbra (the dark shadow directly behind the Earth) and penumbra (the lighter shadow above and below it) during a lunar eclipse. GEAS Project

NASA

The surface of planet Mars has huge valleys gouged into it; the gigantic Valles Marineris dwarfs the Grand Canyon found here on Earth.

shadow." If you were to stand with your back to a giant light, you'd see two kinds of shadows in front of you: a dark shadow with the outline of your body and a lighter shadow (also shaped like your body) where the light is only partially blocked. *Umbra* come from the Latin for "shade."

What's with the fancy name? Why not just say "shadow"?

The two words are ways of describing different kinds of shadows. If we just had the word *shadow*, we wouldn't have a way to describe the difference between the shadow cast when the Moon blocks the Sun, and the shadow from the light that shines around the side of the Moon.

How often does the Moon block the Sun's light?

The Moon blocks the Sun's light during a solar eclipse. Solar eclipses can be partial, total, or annular. In a partial eclipse, the Moon blocks some of the Sun; in a total eclipse, the Moon completely covers the Sun; in an annular eclipse, the Moon appears smaller than the Sun, a thin ring of sunlight seeping around the Moon.

As mentioned above under the letter **E**, eclipses occur for only part of the planet at a time. Therefore, the frequency of solar eclipses depends on where you live. Total solar eclipses are rare, while partial ones are more common. Several partial solar eclipses occur each year. Total solar eclipses are visible every 18 months or so somewhere on the planet.

What is happening when the Moon blocks the Sun's light? Why doesn't this happen all the time?

The Moon orbits around the Earth, and because the Sun is farther away from Earth than the Moon is, the Moon sometimes passes between the Sun and Earth. The Moon doesn't always pass directly in front of the Sun when it comes between the Sun and the Earth because orbits aren't perfect circles, nor do orbits lie in a perfectly flat plane. The Moon might only block some of the Sun's light when it passes between us and the Sun. During most of the orbital cycles of the Earth and the Moon, the three bodies (Earth, Moon, and Sun) don't line up perfectly. That's why we don't see eclipses every day.

V
Valleys

Valleys are carved into the surface of planet Mars, forming patterns similar to the distribution of river valleys on Earth, though Martian vallleys are much deeper.

Why are Mars valleys so much deeper than the ones on Earth?

The short answer is that Mars has a lower surface gravity than Earth, and so some features are exaggerated in size. The geological history of Mars is something scientists are just beginning to piece together as exploratory craft like the Mars Rovers gather detailed data about the planetary surface.

What carved the valleys on Mars?

It's likely that valley formation occurred in a similar way to valley formation on Earth: the forces of hydrologic erosion, glacial activity, and wind may all have contributed to the Mars landscape. Because we have so little data, scientists must make deductions based on the limited information we have. Even though there is no liquid water on Mars right now, there is evidence that water once flowed over areas of the planet.

Has a Mars Rover gone down into these valleys to see what's there? If so, what did it find?

The rover Curiosity is designed so that it can handle inclines or declines of up to 45 degrees, but internal sensors help it to avoid anything steeper than 30 degrees. These limitations mean that Curiosity can't do some things a human could do, but Curiosity is exploring some areas where it looks like water once flowed. We will need more agile robots in order to explore deep within the Martian valleys.

W
Wolf-Rayet Stars

Wolf-Rayet stars are extremely large, extremely hot stars which lose mass at a rapid rate due to high-speed winds.

Why are these stars called Wolf-Rayet stars?

They are named after two French astronomers, Charles Wolf and Georges Rayet, who first discovered them.

What makes the winds so fast on these stars? Do the stars themselves cause the winds?

Wolf-Rayet stars generate huge amounts of heat and energy inside their cores. That energy makes its way to the surface of the star, gathering radiation on the way. This process creates wind. If you've ever opened the oven while something is cooking at a high temperature, you might have experienced a huge rush of hot air in your face. Imagine this kind of movement on a massive scale and with temperatures of at least 25,000 kelvin (whew!).

Why are Wolf-Rayet stars losing mass?

The winds created by these stars are so powerful that they strip matter from the very surfaces of these stars. You're probably familiar with how big gusts of wind can shift piles of leaves and tree branches. On a Wolf-Rayet star, wind removes something close to the mass of an entire Earth every year!

Why are Wolf-Rayet stars so hot? Is it because they're big? Are bigger stars hotter?

Wolf-Rayet stars are twenty times the size of the Sun, but greater size doesn't necessarily mean greater heat. More massive stars are, however, able to fuse heavier metals than smaller stars, and this kind of fusion generates a lot of heat.

If you want to keep in touch with the adventures of Mars Rover Curiosity, you can follow it on Twitter!

https://twitter.com/@MarsCuriosity

GEAS Project

Astronomer Nikki Nielsen estimates the distance from the local horizon to the zenith overhead using her fists, as ancient navigators did while crossing the wide seas. She places her fists on top of each other in turn, blocking out almost 10 degrees with each fist.

You too can use this technique, to measure the distance above the horizon of the Moon, a bright star, or your favorite constellation. What astronomical objects do you look for in the sky during the day, or at night?

X
X-rays

X-rays are a form of high-energy electromagnetic radiation that can penetrate the surfaces of many objects, showing us what lies beneath.

Where did the term "x-ray" come from?

When scientists first encountered x-rays, they had no idea what they were. Because the letter "x" often indicates the unknown, they were called "x-radiation."

How do these rays penetrate objects' surfaces?

X-rays are a type of electromagnetic radiation with very high energy and short wavelengths. (In contrast, visible light has longer wavelengths.) This means that x-rays can drive through objects without being absorbed or scattered.

What other kinds of rays are there?

Electromagnetic radiation is classified by wavelength. You are probably most familiar with the visible spectrum of radiation – optical light. Radio waves are another kind of "ray" or electromagnetic radiation. Other types include microwaves, ultraviolet rays, gamma rays, and infrared radiation.

What is electromagnetic radiation?

Electromagnetic radiation, often referred to as light, can come from tiny electrically charged particles. As these particles move, they emit – radiate – waves. Shorter wavelength radiation has greater energy. As mentioned above, x-rays have quite high energy. Radio waves, with much longer wavelengths, contain much less energy.

Y
Years

An Earth year is the number of days it takes our planet to make a complete orbit around the Sun. On other planets, the local year may be longer or shorter, depending on how far they lie from their parent stars (and how massive those stars are).

Earth is moving faster than Jupiter and the other gas giants, but slower than inner planets Mercury and Venus. A year on Mercury lasts only 88 days, while a single year on Neptune or Pluto would last multiple human lifetimes!

If the years are longer on other planets, are the days also longer?

Not necessarily! The length of a day depends on how long each planet takes to make a full rotation on its axis. Many variables determine its speed of rotation. For example, Jupiter's day lasts only 10 Earth hours, while Venus's lasts an astonishing 243 Earth days.

What is the length of a local day on each planet in our solar system?

Mercury,	**59 days!**	**Jupiter,**	**10 hours**
Venus,	**243 days!**	**Saturn,**	**11 hours**
Earth,	**24 hours**	**Uranus,**	**17 hours**
Mars,	**25 hours**	**Neptune,**	**16 hours**

What is the length of a local year on each planet, in Earth days?

Mercury,	**88 days**	**Jupiter,**	**4,333 days**
Venus,	**225 days**	**Saturn,**	**10,759 days**
Earth,	**365 days**	**Uranus,**	**30,687 days**
Mars,	**687 days**	**Neptune,**	**60,190 days (165 Earth years)**

Each planet's year is defined as how long it takes the planet to orbit the Sun.

Is a year the same all the time? Why are some Earth orbits around the Sun longer than others?

The Earth's orbit is slightly variable, which means that the length of the year can change over time. This process happens slowly, however, and won't affect the frequency of birthday cakes in your lifetime. The effects of orbital variation are only noticeable on the scale of thousands of years. This variation is tied to the gravitational pull of the other planets. As they move in relation to Earth, their gravity exerts more or less force on us.

Z
Zenith

The zenith is the highest point of an object's path or orbit through the sky.

If the zenith is the highest point in an orbit, what is the lowest?

The lowest point in an object's path is called the nadir.

Are there names for other parts of an orbit?

If you've ever had classes where you've gotten to use a protractor or figure out the area or size of a sphere, then you might know some terms related to zenith. In astronomy, the zenith is the point right above you in the sky. The nadir lies 180 degrees from the zenith (below you). The celestial meridian traces a path from north to south and passes directly overhead. You also have an astronomical horizon, which is what you see when you look out all around you. These definitions are important to stargazing because your position on the Earth's surface affects where you'll find the stars in the sky on different nights.

Where does the word "zenith" come from?

Zenith is a word that has undergone a lot of changes from the Arabic for "the road over one's head," *samt arrās*. Medieval writers thought *samt* was supposed to be *senit*, a word that closely resembles the modern *zenith*.

Thank you, Young Astronomers, for walking with us from A to Z through the Astronomical Universe!

For more information about our educational film series or to discuss its use in an educational setting, please contact the GEAS Project at New Mexico State University.

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