Earth in the Universe

6.E.1 Understand the earth/moon/sun system, and the properties, structures, and predictable motions of celestial bodies in the Universe.

6.E.1.1 Explain how the relative motion and relative position of the sun, Earth and moon affect the seasons, tides, phases of the moon, and eclipses.

6.E.1.2 Explain why Earth sustains life while other planets do not based on their properties (including types of surface, atmosphere and gravitational force) and location to the Sun.

6.E.1.3 Summarize space exploration and the understandings gained from them.

Round and Round They Go!

How are Earth, the moon, and the sun related in space?

- Earth spins on its axis and orbits around the sun.

- A body that orbits a larger body is called a **satellite**.

- Smaller bodies that travel around planets are natural satellites called moons.

How are Earth, the moon, and the sun related in space?

- **Gravity** is the force that pulls all bodies that have mass toward other objects.

- Earth's gravitational pull on the moon keeps the moon in orbit, forming the Earth-moon system.

- The distance between Earth and the moon is roughly 383,000 km (238,000 mi).

What does the moon look like from Earth?

- The moon is only visible from Earth when it reflects sunlight.

- Only one side of the moon, often called the near side, faces Earth.

- The moon rotates once on its axis for every 28.5 days it takes to revolve around Earth.

It’s Just a Phase!

How does the appearance of the moon change?

- As the moon revolves around Earth, the portion of the moon that reflects sunlight back to Earth changes.

- The **lunar phases** are changes in the moon’s appearance due to its position in orbit around Earth.

How does the appearance of the moon change?

- Lunar phases cycle monthly and begin with a new moon.

- The new moon is hard to see because Earth, the moon, and the sun are lined up, making the moon unlit.

- As the moon moves in its orbit, it reflects more sunlight, and its crescent shape grows larger.

The Phases of the Moon

How does the appearance of the moon change?

- The moon waxes, or grows, until half of the near side is in sunlight. This is the *first quarter.*

- The *gibbous phase* is when the near side is more than half-lit but not fully lit.

- When the moon is fully lit, it is called a full moon.

How does the appearance of the moon change?

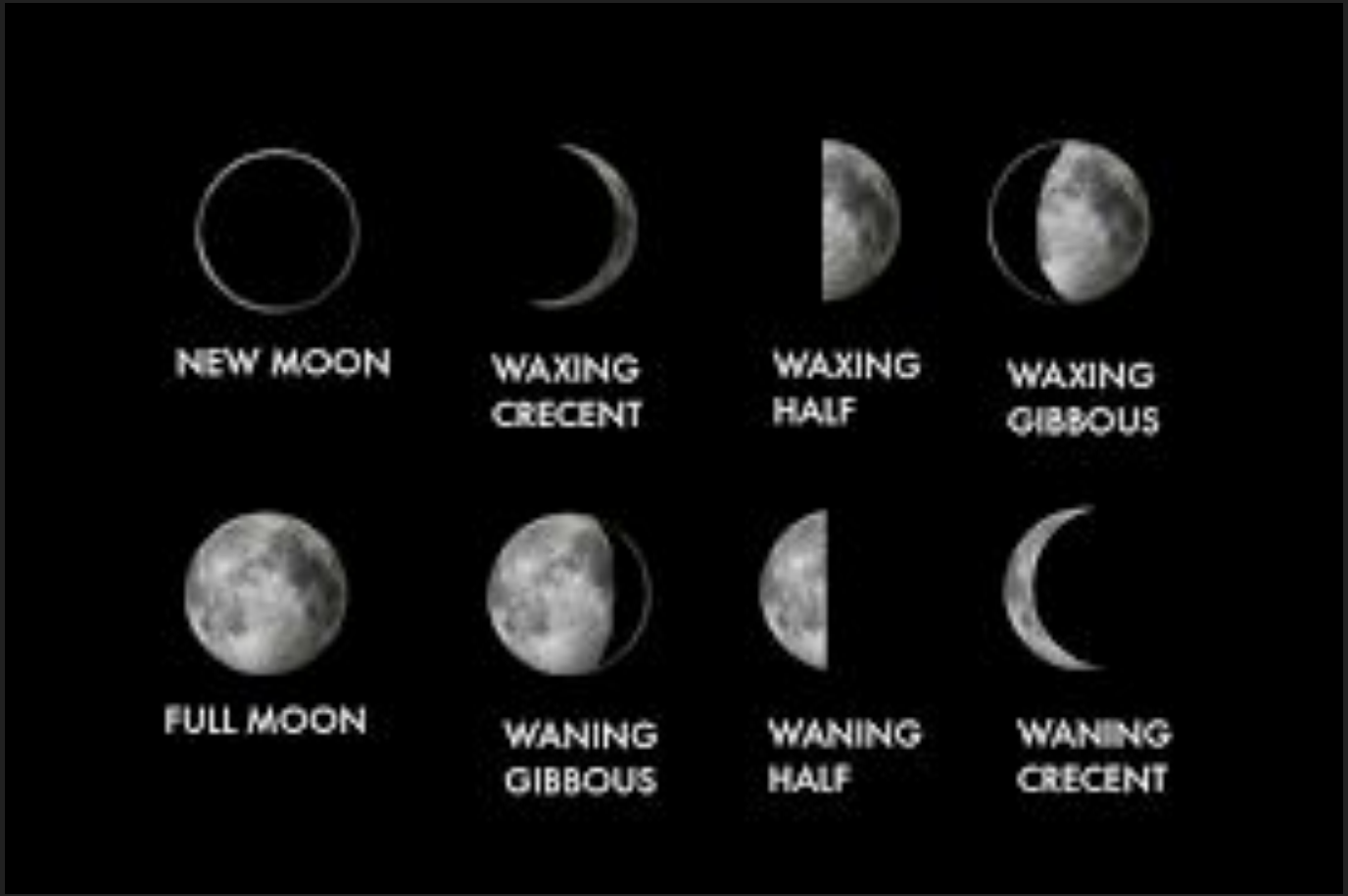
- The lit portion of the moon shrinks, or wanes, during the third week of the cycle.

- When the near side is only half-lit in sunlight, it is three-quarters through the cycle. The phase is called the *third quarter.*

How does the appearance of the moon change?

- When the moon is seen as waning crescent shapes, the cycle is almost complete.

- When the moon is again unlit as a *new moon,* the cycle is complete.


NEW MOON
WAXING CRECENT
WAXING HALF
WAXING GIBBOUS
FULL MOON
WANING GIBBOUS
WANING HALF
WANING CRECENT

Exploring Eclipses

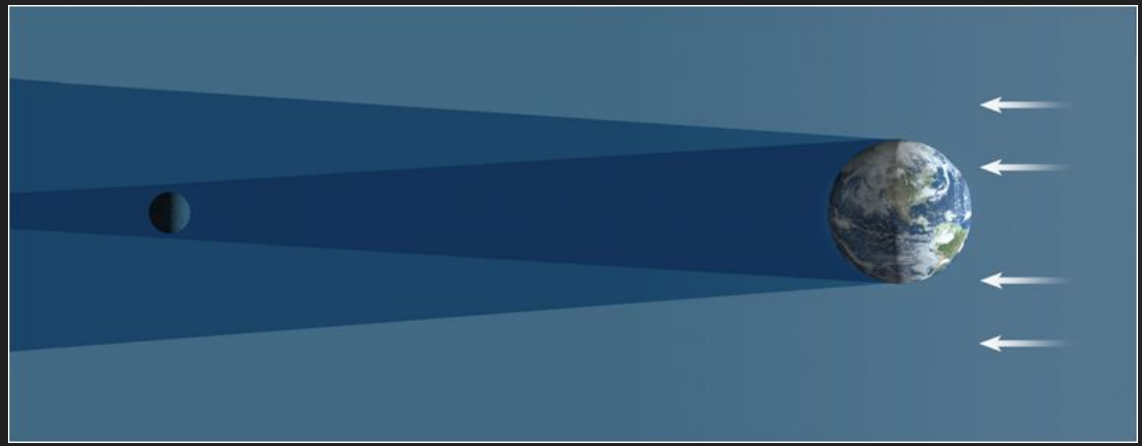
How do lunar eclipses occur?

•An **eclipse** is an event during which one object in space casts a shadow on another object.

•A lunar eclipse occurs when the moon moves through Earth’s shadow.

How do lunar eclipses occur?

•The **umbra** is the darkest part of a shadow. Around the umbra is a spreading cone of lighter shadow called the **penumbra**.



How do lunar eclipses occur?

- Before a lunar eclipse, the moon is a full moon.

- The moon moves into the penumbra shadow and becomes less bright.

- When the moon moves into the umbra, the moon is in total darkness.

How do lunar eclipses occur?

- A total lunar eclipse occurs when the moon moves completely inside the umbra.

- If the moon misses all or part of the umbra and a part stays lit, it is called a partial lunar eclipse.

- You do not see lunar eclipses each month because the moon’s orbit is tilted by about 5° relative to Earth’s orbit.

How do solar eclipses occur?

•When the moon is directly between the sun and Earth, the shadow of the moon falls on a part of Earth and causes a solar eclipse.

•When the sun’s light is completely blocked by the moon, it is a total solar eclipse.

•Outside the umbra, but within the penumbra, people see a partial solar eclipse.

How do solar eclipses occur?

•The moon’s umbra makes a shadow that is never more than a few hundred kilometers across.

•A total eclipse covers only a part of Earth and can only be seen in particular areas.

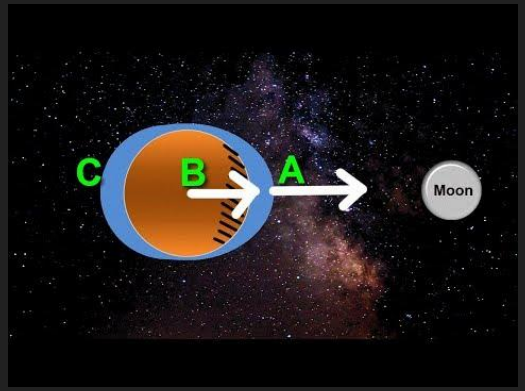
•A total solar eclipse happens somewhere on Earth every one to two years.

How do solar eclipses occur?

- Why is a total solar eclipse visible over only a small portion of Earth?

A Rising Tide of Interest

What causes tides?



- **Tides** are daily changes in the level of ocean water.

- Tides are caused by the difference in the gravitational force of the sun and moon across Earth.

- The difference in gravitational force is called the *tidal force.*

What causes tides?

•Because the moon is closer to Earth, the moon is mainly responsible for Earth's tides.

•Water on the side of Earth closest to the moon bulges toward the moon.

•A bulge is created on both the near side and the far side of Earth.

What are high tides and low tides?

- *High tide* is a water level that is higher than the average sea level.

- *Low tide* is a water level that is lower than the average sea level.

- Tidal bulges move around Earth following the motion of the moon.

Tide Me Over

What are two kinds of tidal ranges?

•The moon’s tidal force is greater than the sun’s tidal force, which results in different tidal ranges.

•A **tidal range** is the difference between the levels of ocean water at high tide and low tide.

What are two kinds of tidal ranges?

- **Spring tides** are tides that have the largest daily tidal range.

- Spring tides happen when the sun, moon, and Earth form a straight line.

- Spring tides happen during the new moon and full moon phases every 14 days.

What are two kinds of tidal ranges?

- What causes the large tidal range of a spring tide?

What are two kinds of tidal ranges?

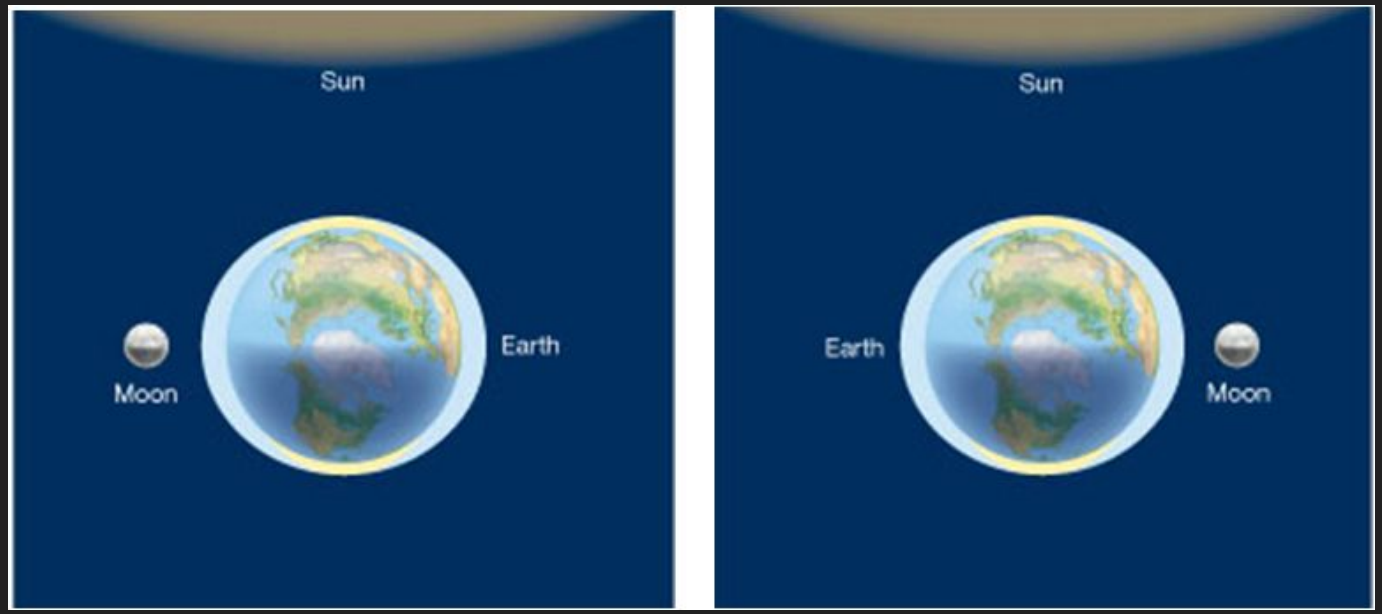
- **Neap tides** are tides that have the smallest daily tidal range.

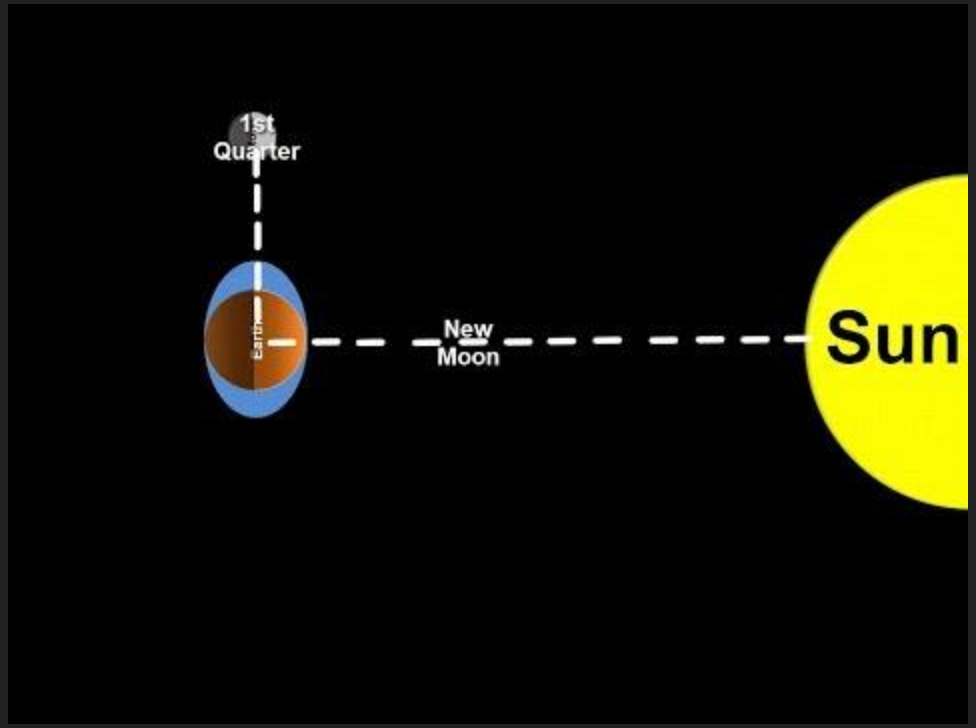
- Neap tides happen when the sun, moon, and Earth form a 90° angle.

- During a neap tide, the gravitational effects of the sun and moon on Earth do not add together.

What are two kinds of tidal ranges?

- During which moon phases do neap tides occur?




1st
Quarter
Earth
New
Moon
Sun

What causes tidal cycles?

- The moon revolves around Earth much more slowly than Earth rotates.

- A place on Earth facing the moon takes 24 h and 50 min to rotate to face the moon again.

- So, the cycle of high tides and low tides at that place happens 50 min later each day.

What causes tidal cycles?

- Because the tidal cycle occurs in 24 h and 50 min intervals, it takes about 6 h and 12.5 min for water in an area to go from high tide to low tide.

- It takes about 12 h and 25 min to go from one high tide to the next high tide.

Earth

•Earth is a special place because it has just the right combination of conditions to support life.

•The presence of air and water supports the growth and development of plants and animals.

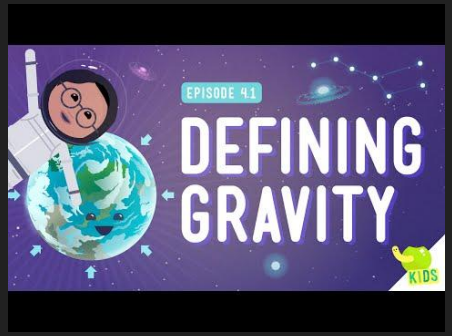
•The atmosphere contains an ozone layer that absorbs harmful solar radiation and other gases that keep Earth warm enough for life to exist.

Gravity

What is gravity?

•**Gravity** is a force of attraction between objects that is due to their masses and the distances between them.

•Every object in the universe pulls on every other object.



What is gravity?

•Objects with greater masses have a greater force of attraction than objects with lesser masses have.

•Objects that are close together have a greater force of attraction than objects that are far apart have.

•Gravity is the weakest force in nature, yet it is one of the most important forces in the universe.

What is gravity?

•Gravity accounts for the formation of planets, stars, and galaxies.

•Gravity also keeps smaller bodies in orbit around larger bodies.

•An **orbit** is the path that a body follows as it travels around another body in space.

What are Kepler's laws?

•The 16th century Polish astronomer Nicolaus Copernicus changed our view of the solar system.

•He discovered that the motions of the planets could best be explained if the planets orbited the sun.

•Like astronomers before him, Copernicus thought that the planets followed circular paths around the sun.

What are Kepler's laws?

•Danish astronomer Tycho Brahe used special instruments to accurately measure planetary motions over a period of 20 years.

•Using Tycho's data, Johannes Kepler discovered what we call *Kepler's laws of planetary motion*.

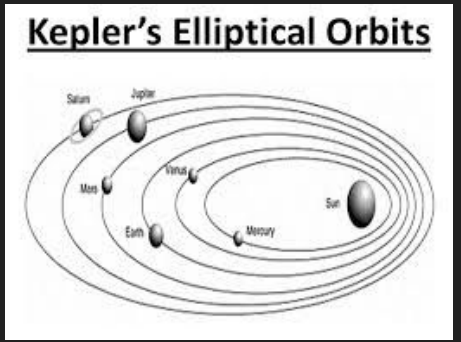
What are Kepler’s laws?

•Upon plotting the orbit of Mars, Kepler saw that it was a deformed circle.

•After eight years of work, he realized that it was an ellipse.

•Kepler then proposed that each of the planets has an elliptical orbit, with the sun at one focus of the ellipse.

•This is Kepler’s first law.

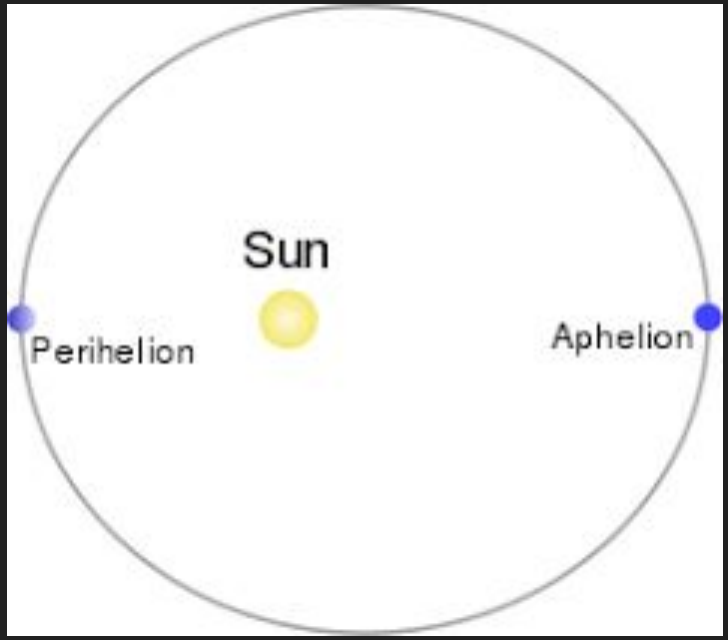


What are Kepler's laws?

•When an object follows an elliptical orbit around the sun, there is one point, called **aphelion**, where the object is farthest from the sun.

•There is also a point, called **perihelion**, where the object is closest to the sun.

•Today, we know that the orbits of the planets are only slightly elliptical, but the orbits of objects such as Pluto and comets are highly elliptical.



What are Kepler’s laws?

•Kepler found that a planet moves slower at aphelion, sweeping out a narrow sector on the ellipse.

•Conversely, a planet moves faster at perihelion, sweeping out a thick sector on the ellipse.

•As a planet moves around its orbit, it sweeps out equal areas in equal times. This is Kepler’s second law.

What are Kepler’s laws?

•Kepler looked at how long it took for the planets to orbit the sun. He also observed the sizes of their orbits.

•He discovered that the square of the orbital period is proportional to the cube of the planet’s distance from the sun.

•This principle is Kepler’s third law.

What is the law of universal gravitation?

•Using Kepler's laws, Sir Isaac Newton became the first scientist to mathematically describe how the force of gravity behaves.

•He reasoned that gravity is the force that accounts for both the fall of an apple from a tree and the movement of the moon around Earth.

•In 1687, Newton formulated the *law of universal gravitation*.

What is the law of universal gravitation?

•The law of universal gravitation states that all objects in the universe attract each other through gravitational force.

•The strength of this force depends on the product of the masses of the objects.

•Gravitational force is also inversely proportional to the square of the distance between the objects.

How does gravity affect planetary motion?

•If a ball is attached to a string and is swung around, it moves in a circular path.

•The inward force that causes an object to move in a circular path is called **centripetal force**.

•If the string breaks, the ball will move off in a straight line. When the string is intact, the centripetal force prevents the ball from flying off.

How does gravity affect planetary motion?

•When planets orbit the sun, a force similar to centripetal force prevents them from moving out of their orbits and into a straight line.

•The sun’s gravity is the force that keeps the planets moving in orbit around the sun.

Space: The Final Frontier

How did space exploration begin?

- In October of 1957, the Soviet Union launched the first satellite, *Sputnik I*, into low Earth orbit. It was the start of the "Space Age."
- In response, the United States launched its first satellite, *Explorer I*, on January 31, 1958. This started the Space Race.
- In the same year, the National Aeronautics and Space Administration, or **NASA**, was formed.

From Earth to the Moon

How have people explored space?

•*Suborbital* crewed spacecraft do not orbit Earth because they do not reach the required speed and altitude. They spend only a short time in space.

•The first crewed suborbital spaceflight missions were NASA's Mercury project in 1961.

•These missions included the suborbital flights of Alan B. Shepard, Jr., on May 5, 1961, and Virgil I. Grissom on July 21, 1961.

How have people explored space?

•*Orbital* crewed spacecraft completely orbit Earth. On April 12, 1961, Soviet air force pilot Yuri A. Gagarin became the first person to orbit Earth.

•On July 21, 1961, John H. Glenn, Jr., became the first American to orbit Earth.

•On June 16, 1963, Soviet cosmonaut Valentina V. Tereshkova became the first woman to fly in space and orbit Earth.

How have people explored space?

•The United States developed the Gemini program with two-person crews, partly to see if astronauts could spend longer periods of time in space.

•The Soviet Union extended their existing Vostok program to include multiperson spaceflights.

•On March 18, 1965, Soviet cosmonaut Alexei A. Leonov performed the first walk in space. On June 3, 1965, Edward H. White II became the first American to do so.

How have people explored space?

- On September 12, 1962, President John F. Kennedy committed the United States to land a man on the moon before the decade ended.

- In 1969, the *Apollo 11* spacecraft took astronauts Neil Armstrong, Edwin "Buzz" Aldrin, and Michael Collins to the moon.

- While Collins orbited the moon in the spacecraft, Armstrong and Aldrin landed on the moon's surface in a lunar module on July 20, 1969.

How have people explored space?

- The United States is the only nation that has sent astronauts to the moon.

- Six moon landings took place during the Apollo program of the late 1960s and early 1970s.

- In total, 12 astronauts have walked on the moon.

Where have people lived and worked in space?

- *Space shuttles* are crewed space vehicles that lift off with the aid of rocket boosters and land like airplanes.

- Space shuttles orbit Earth while in space. The shuttle and its rocket boosters are reusable.

- Shuttle missions have included gathering data, launching satellites, transporting materials, and docking with the *International Space Station*.

Where have people lived and worked in space?

•Space shuttle missions began with the launch of the shuttle *Columbia* in 1981.

•Six shuttles—*Enterprise*, *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavour*—have together completed more than 100 missions.

•Tragic accidents led to the loss of *Challenger* and its crew in 1986 and *Columbia* and its crew in 2003.

Where have people lived and worked in space?

- A *space station* is a long-term, crewed spacecraft that orbits Earth.

- It can be used to launch other vehicles and carry out scientific research.

- Astronauts live aboard a space station for a period of several weeks or months and conduct research and experiments.

Where have people lived and worked in space?

•The first space station, *Salyut-1*, was placed in orbit by the Soviet Union in April 1971. In 1973, the U.S. launched its first space station, *Skylab*.

•The Soviet/Russian space station *Mir* was built between 1986 and 1996 and operated in low Earth orbit until 2001.

•The *International Space Station*, as long as a football field, was built in low Earth orbit over a period of 13 years, starting in 1998.

Just Passing By

How have people used uncrewed vehicles to explore space?

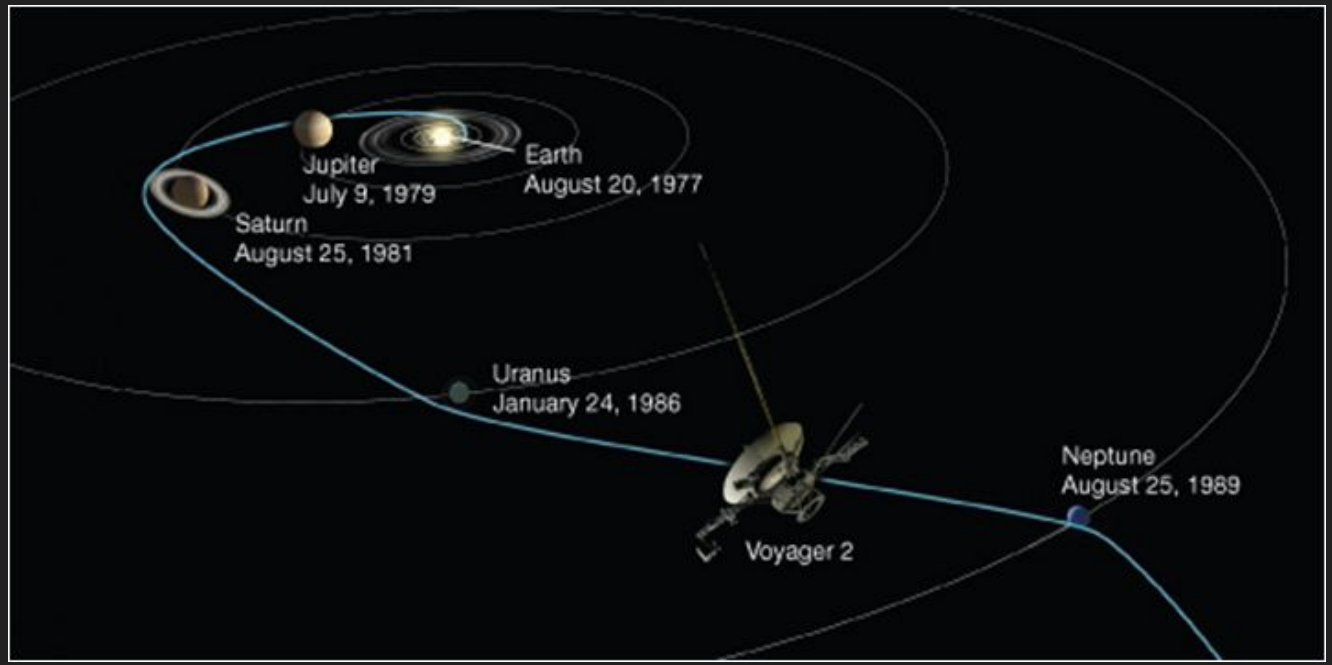
•Uncrewed vehicles, such as space probes and orbiters, are a safe way to explore distant bodies that could take years or decades to reach.

•Space probes carry scientific instruments and transmit data back to Earth.

•Scientists have used space probes to fly by the moon, Mercury, and Venus, to land on Mars, and to explore the far reaches of the solar system.

How have people used uncrewed vehicles to explore space?

- How did *Voyager 2* help with space exploration?



How have people used uncrewed vehicles to explore space?

•An *orbiter* is a spacecraft that travels to a planet and goes into orbit around it.

•Several orbiters have been exploring the features of Mars by mapping the Martian surface and collecting data about its chemical makeup.

•NASA's *Mars Reconnaissance Orbiter* has a powerful camera that could guide future spacecraft to make precise landings on Mars.

How have people used uncrewed vehicles to explore space?

•A *lander* is designed to land on the surface of a planet or other body and send data back to Earth.

•A *rover* physically explores the body's surface by moving about.

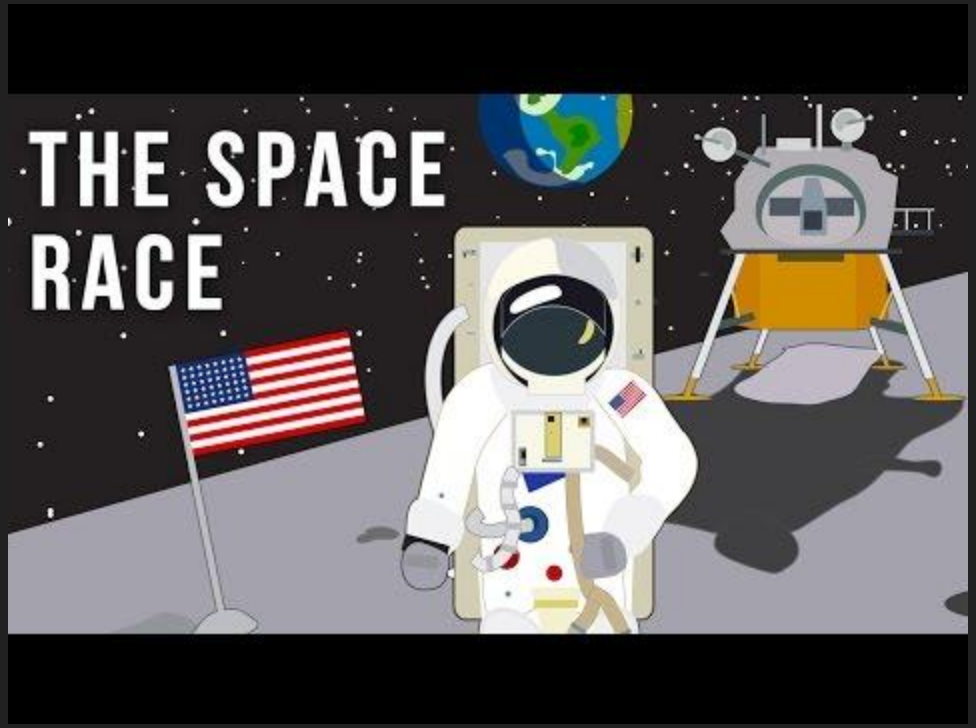
•Landers and rovers can conduct experiments on soil and rocks, and they can record surface conditions such as temperature and wind flow.

How have people used uncrewed vehicles to explore space?

•An *artificial satellite* is any human-made object placed in orbit around a body in space. Hundreds of active satellites currently orbit Earth.

•A satellite may collect weather data, relay TV and radio signals, assist in navigation, or study Earth’s surface.

•A system of orbiting global navigation satellites has been operated by the U.S. since 1978. They are used to determine precise locations on Earth.


THE SPACE
RACE