



SPACE

HANDBOOK





Space is big, REALLY big. It took 36 years for the NASA spacecraft Voyager to reach the edge of our solar system. Our solar system is just one of billions in the Milky Way galaxy. There is so much to explore, discover, and learn about what is out there!

Astronomers, scientists who study space and all of the stars, planets, asteroids, galaxies, and other stuff in it, have learned a lot about space so far. Astronomers use tools, like telescopes, cameras, detectors, and radio telescopes, to study space from far away. Some tools are here on Earth and some tools are on spacecraft, vehicles that travel into space, like NASA's Voyager. Some spacecraft study a planet by circling around it and taking pictures and measurements of it. Some spacecraft carry vehicles like Curiosity, which is currently on Mars, to other planets. These vehicles, called rovers, explore the surface of a planet and take samples. The rover analyzes these samples and sends information back to scientists on Earth.

Astronomers study space to try and find out if there is, ever was, or could be life on other planets. Studying planets in our solar system can also help us understand solar systems that are farther away. As much as we know about space and our solar system, there is still a lot to learn. Even what we do know can change. Until 2006, Pluto was considered the ninth planet in our solar system. Now we know it is a dwarf planet. What will we discover next?



IN THE APP

In *Tinybop's Space*, you have a spacecraft and a set of tools to study each planet with, just like scientists do. Visit each planet, observe closely, use your tools, and see what you can learn.



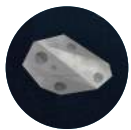
Drag your spacecraft over a planet.

See and study the surface up close.



Drag the snowman or tin can onto a planet.

Observe if it melts, stays solid, or sinks below the surface. This will tell you how hot or cold a planet is and what it is made of.



Drag or toss rocks at a planet.

The rocks might get caught by the planet's gravity and go into orbit as they fall toward the planet's surface. If a planet has an atmosphere (a layer of gas around it), the rock will burn (as a result of friction when it hits the air). If a planet has no atmosphere, the rock will land and form a crater on the surface.

DISCUSSION QUESTIONS

How are the planets in our solar system similar to each other?

How are they different?

What does the surface of each planet look like compared to Earth's surface?

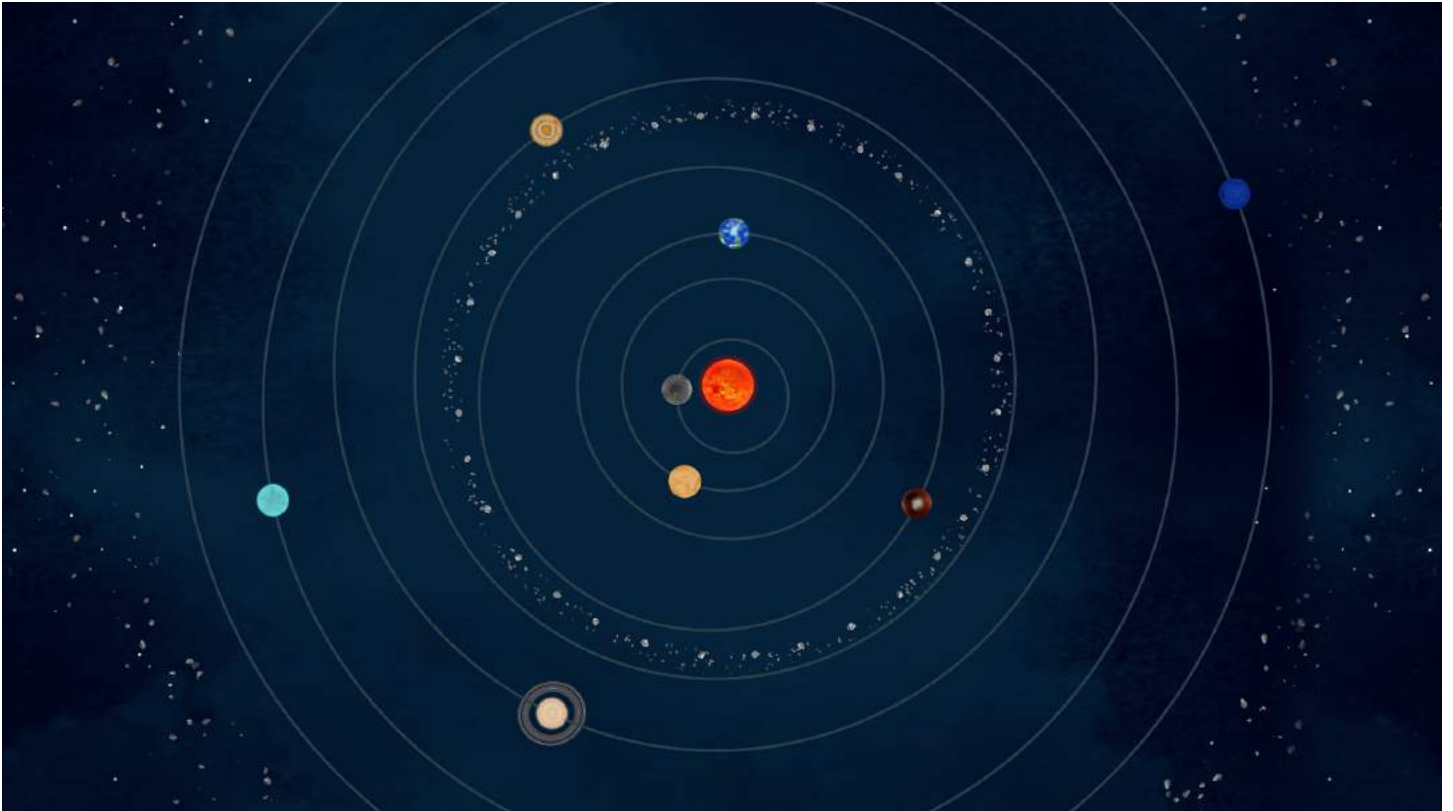
Do you think you could walk on the surface of each planet?

Why or why not?

Do you think other planets have air we can breathe?

Why or why not?

Do you think people could live on any other planet in our solar system? Why or why not? What challenges might they face?





Our solar system

We live in the **Milky Way** galaxy, a cluster of many stars with more than 500 solar systems – and counting! Scientists estimate there are at least 200 billion galaxies and possibly 10 times that number in our universe.

In our solar system, we live on planet Earth, which orbits around a big star we call the sun. We can see other stars in the Milky Way galaxy from Earth, but the sun is the only star in our solar system. Our solar system also includes the planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune. There are also moons, asteroids, and dwarf planets, like Pluto.

All of these planets, moons, and stars were formed by gravity. Gravity brings pieces of matter (the stuff everything is made of) together. Gravity also makes planets orbit their sun. And gravity holds us all together in our swirling galaxies.

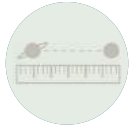
IN THE APP



Observe all the planets in our solar system, each spinning on its axis, and orbiting around the sun. See the length of each planet's year.



Drag a planet or the sun into each circle to see how big or small they are compared to each other.



Measure the distance between each planet and the sun.

Because the planets are so far apart from each other, scientists use a special measurement for distance in space called the **Astronomical Unit**. One Astronomical Unit (abbreviated as AU) is the distance between the sun and Earth, or 149,597,871km (92,955,807.3mi). It is much easier to say that Jupiter is 5.2 AUs from the sun than 777,908,928km from the sun.



Drag planets onto the scales to compare their masses.

Mass is a measure of how much matter, or stuff, the planet is made of. A planet has gravity, meaning it pulls objects standing on it toward its center. The more mass a planet has, the stronger its gravity is. This is why we don't float away from Earth and into space. Mass is different than weight. Weight is a measure of the strength of gravity's pull on an object. Your mass is the same on Earth as it is on Mercury. But your weight would be lower on Mercury because Mercury's gravity is weaker. If it were possible to stand on Jupiter, you would weigh much more than you do on Earth because Jupiter's gravity is stronger.

DISCUSSION QUESTIONS

Do all planets orbit the sun at the same speed? Why do you think some are faster or slower?

Do all planets spin on their axes at the same speed?

How big is the sun compared to Earth? How big or small are other planets compared to Earth?

How close or far away from the sun is each planet? What happens to the distances between planets farther and farther away from the sun?

Which planet is the most massive? The least? Which planets have similar masses?

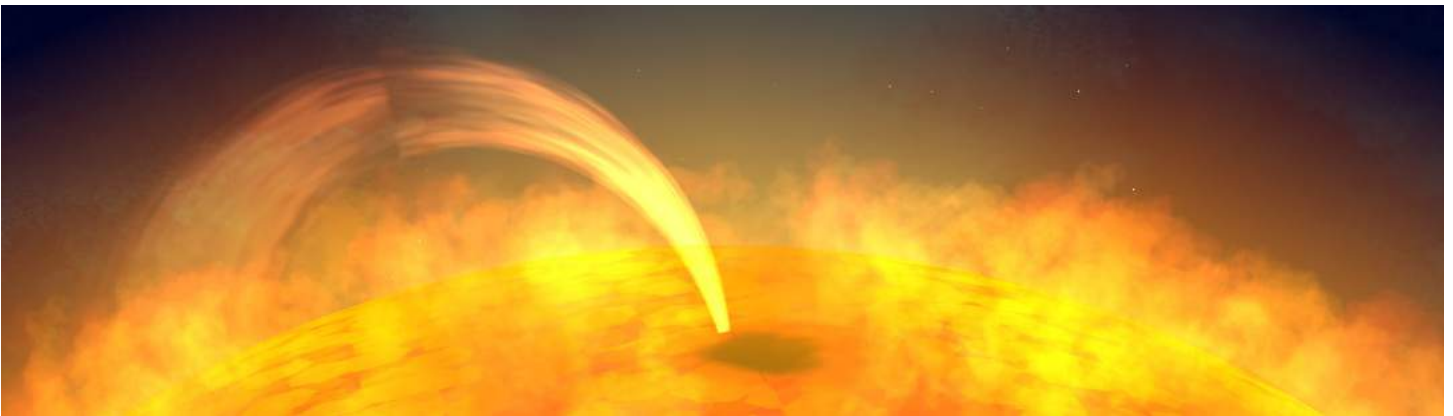
THE SUN



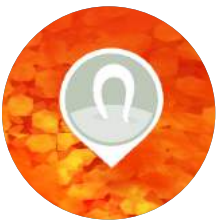
The sun is a star. Stars are dynamic spheres of very hot, glowing gases. There are billions of stars in the Milky Way galaxy, but the sun is the only star in our solar system. Our sun is about 27 million degrees Fahrenheit at its core. It is made of 91.0% hydrogen gas and 8.9% helium gas.

The sun is essential to life on Earth. In a process called nuclear fusion, stars create a lot of light and energy. Light and energy from our sun travel 93 million miles to Earth and even farther to reach distant planets. The sun provides us with energy, light, and heat to support all life on Earth.

The surface of the sun is always spinning, moving, and changing. On the surface of the sun, solar flares, prominences, and sunspots appear and disappear.



IN THE APP



Tap or swipe sunspots.

Sunspots are relatively cool, dark spots on the sun's surface. They can last for days or weeks. Groups of sunspots often create solar flares or prominences, spots of energy that burst from the sun's surface. Solar flares are short-lived but powerful. They only last for a few minutes or hours, but they can create as much energy as a billion tons of dynamite.

OTHER CELESTIAL BODIES

Along with the sun and planets, a few other celestial bodies live in our solar system.



The **asteroid belt** is a bunch of **asteroids**, airless rocks that are too small to be planets; even smaller rocks that never joined together to become a planet; and one dwarf planet, Ceres, that all orbit the sun. The **Kuiper belt** is a bunch of icy bits, rocks, comets, and dwarf planets, including Pluto, that also orbit the sun.

A **comet** is a relatively small, icy object that orbits the sun. In sunlight, ice from a comet can turn to a vapor of dust and gas, giving it the appearance of a tail as it travels. (Occasionally, we can see these in the sky above.)



A **meteoroid** is a small rock that falls off a comet or asteroid and continues to orbit the sun. If a meteoroid enters a planet's atmosphere and breaks up or catches on fire, it becomes a **meteor**, or what we sometimes call a shooting star. If a meteoroid survives its trip through a planet's atmosphere and lands on the planet's surface, we call it a **meteorite**. When many rocks fall into our atmosphere and burn up at the same time, we call the effect we can see from Earth a **meteor shower**.

PLANETS

The name "planets" comes from the Greek word "Planetes" which means wanderer. Early Greeks noticed that some things in the sky moved differently than stars; they "wandered." Now we know that the planets we see in our solar system are not wandering, they are circling around, or orbiting, the sun. Planets in our solar system include Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

All planets are round, orbit a star (in our solar system, the sun), and have their own unique orbits. The time it takes a planet to orbit once around the sun is a year. A planet closer to the sun will have a shorter year than a planet far away from the sun.

As each planet orbits the sun, it is also spinning on its axis. The time it takes for a planet to make a complete spin on its axis is a day. Just like on Earth, during a full spin on its axis, part of a planet will face the sun and be bright (day), and part of the planet will face away from the sun and be dark (night).

We put the planets in one of two categories, depending on where they are in the solar system: inner planets or outer planets. Inner planets have similar qualities to each other and outer planets also share similar qualities. But every planet is different.

Mercury is tiny while Jupiter is gigantic. Venus is incredibly hot while Neptune is freezing cold. Some planets are rocky, like Earth, while others are shifting balls of gas that would be impossible to stand on. Every planet has a different atmosphere (a layer of gas around it). Some planets, like Earth, have a moon or many moons, smaller objects that circle it instead of orbiting the sun. Moons are held in place by the planet's gravity. Some planets, unlike Earth, have rings. Rings are floating circles of pieces of rocks, dust, and ice, that orbit around a planet.



The inner planets

Inner planets are close to the sun and close to each other, compared to the outer planets. The inner planets are rocky, meaning you could hypothetically stand on them. They are small, have no rings, and few or no moons.

MERCURY



Distance from the sun: .39AU

Moons: 0

Rings: 0

Atmosphere: thin

Year: 88 Earth days

Day: 59 Earth days

Mercury is the closest planet to the sun. It is also the smallest planet. Because Mercury's atmosphere is very thin, it gets very hot (602-845°F) during the day and very cold (-280°F) at night.

Mercury's thin atmosphere does not provide the planet good protection from meteoroids. Many rocks hit the surface, forming craters. The white streaks around craters are lighter material that is blown out when a meteorite hits. Caloris Basin is the largest crater on Mercury. Astronomers think that the impact of the meteorite that formed it was so great that shockwaves from it rippled through the small planet and produced hills on the opposite side of the impact.

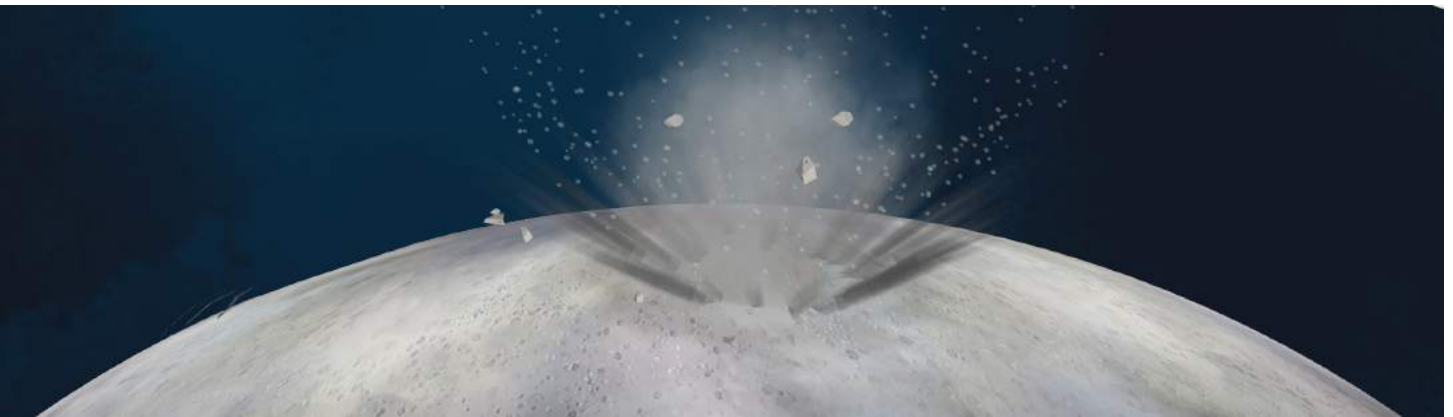


IN THE APP

Tap the pin. Take a closer look at a Mercury's surface.
Throw rocks and see how they form craters on the planet.

DISCUSSION QUESTIONS

What do you think scientists can learn about meteorites by studying craters?



VENUS



Distance from the sun: .723AU

Moons: 0

Rings: 0

Atmosphere:
very dense, carbon dioxide, nitrogen

Year: 225 Earth days

Day: 244 Earth days

Venus is the closest planet to Earth. It is the brightest object in the sky after the sun and moon. Its reflective atmosphere makes it easy to see, even without a telescope. But it is very different from Earth. It even spins in the opposite direction of Earth!

Venus' carbon dioxide rich atmosphere is 92 times more dense than Earth's atmosphere at the surface. This atmosphere causes a greenhouse effect, trapping heat. Temperatures reach 735 Kelvin (462 degrees Celsius or 863.6 degrees Fahrenheit). The dense atmosphere also creates air pressure so intense that it crushes spacecraft that land on Venus within a few hours.

Venus' air is clear and slow moving, but it is so dense that it acts like a liquid, forming a kind of sea and dragging dust and stones across

the ground. Clouds surrounding Venus are made from yellow droplets that may be sulfuric acid.

Venus is so hot and dense that its atmosphere burns up most rocks that move near it. So, there are not many craters on its surface.

IN THE APP



Tap and swipe the clouds.

Venus' snow caps are made of metal!



Tap the white snow caps.

Venus' snow caps are made of metal! The surface of the planet is hot enough to vaporize metal, which condenses again on the peaks of Venus' mountains.



Tap a volcano.

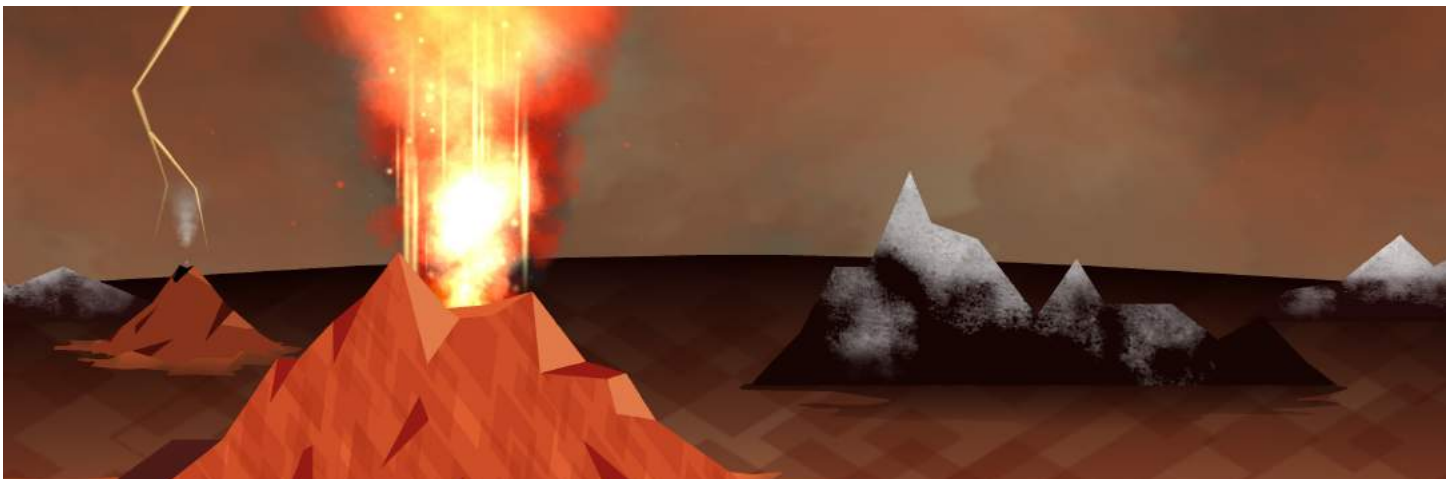
Active volcanoes on Venus spew sulfur and lava.

DISCUSSION QUESTIONS

Venus is our nearest neighbor. Would you want to visit?

Why or why not?

How does the greenhouse effect affect life on Earth?



EARTH



Distance from the sun: 1AU

Moons: 1

Rings: 0

Atmosphere: thin, nitrogen (78%), oxygen (21%), other gases (1%)

Year: 365 Earth days

Day: 1 Earth day, 24 hours

If you look at Earth from space, you can see that most land on Earth is grouped in continents that appear green, with some brown areas of deserts and mountains. You can see oceans (Earth is the only planet known to have vast, liquid water oceans). You can see white ice caps on the North and South Pole. You can see weather and clouds. Sometimes you can even see hurricanes moving over oceans! Lights from large cities glowing at night are also visible from space.

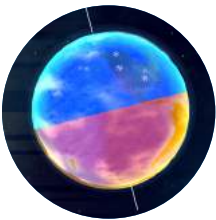
Earth has one moon. Unlike Earth, the Earth's moon has no atmosphere. In Earth's dense air, helium balloons float and feathers glide slowly to the ground as air resists their fall. But on the moon, with no atmosphere, both fall rapidly to the ground when dropped. Gravity is also weaker on the moon. If you jumped on the moon, you would go higher than you would on Earth.

IN THE APP

Drag the moon around Earth.

While it may look like the moon changes shapes, from a full circle, to a half circle, to smaller slivers, then bigger again, it does not. The moon is always a full sphere; we just can not always see all of it.

As it travels around the Earth, we see the moon because it reflects light from the sun. So, we only see the part of the moon that faces us and is lit up by the sun. We see a full moon when the sun's light hits the entire side of the moon facing us. We see a half moon when only half of it is illuminated.



Drag Earth's axis back and forth to change its tilt.

Earth's axis does not stand up straight. It is tilted. As Earth orbits the sun, different parts of it are hit more or less directly by the sun's rays. This gives us seasons. Summer happens in June in the Northern Hemisphere when the sun's rays hit that part of Earth more directly. Winter happens in December in the Northern Hemisphere when the sun's rays are hitting the South Pole instead.



Visit the moon! Drag and drop a piano and a balloon onto its surface

Both the piano and balloon sink quickly to the ground. The air in the balloon is more dense than the moon's atmosphere (remember, the moon doesn't have an atmosphere), so it sinks directly to the ground at the same rate as the piano.

DISCUSSION QUESTIONS

Look at the axes of other planets in our solar system.

Do you think they all experience seasons? Why or why not?

Why do you think a balloon drops quickly to the moon's surface but people bounce as they walk on it?

MARS



Distance from the sun: 1.52AUs

Moons: 2

Rings: 0

Atmosphere: thin, carbon dioxide (95%), nitrogen (3%), and other gasses (2%)

Year: 687 Earth days

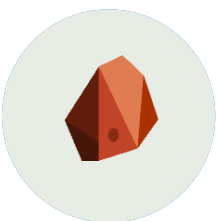
Day: 1 Earth day + 40 minutes

Mars' thin atmosphere leaves it relatively unprotected from meteoroids. Its cratered surface is mostly reddish brown in color from iron oxide (rust on Earth) rocks. The craters, volcanoes, and chasms on Mars' surface have led scientists to think that the planet has a history of impacts, seismic activity, and running water.

Mars has the largest known volcano in our solar system. The volcano, called Olympus Mons, is dormant now, but it is huge! It is more than six times as wide as Mauna Loa, the largest volcano on Earth. Like Earth, Mars is tilted and has seasons. Its permanent white ice caps grow during the winter of each hemisphere and shrink in the summer.

Right now, the NASA rover called Curiosity is stationed on Mars. Her mission is to find out if there is or ever was life and liquid water on Mars. Curiosity has found signs of water, but no signs of life, so far.

IN THE APP

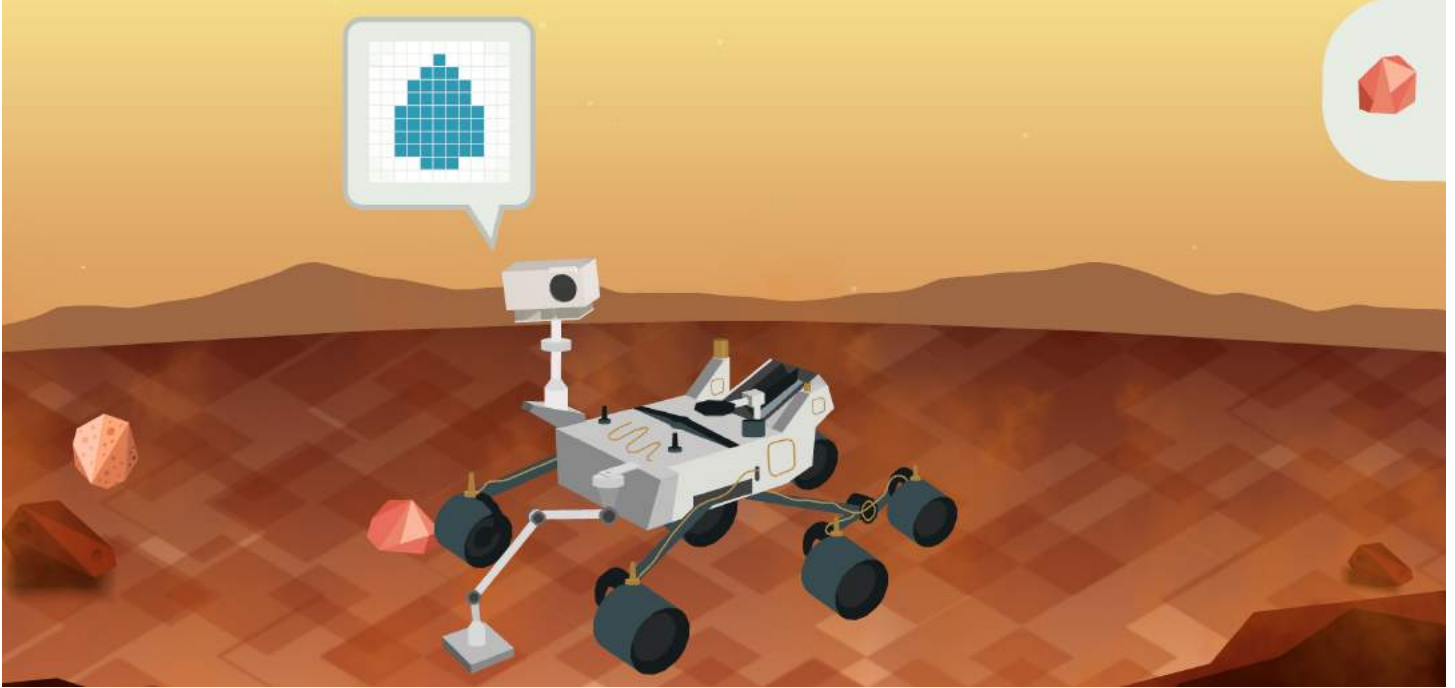


Drag rocks to the surface of Mars.

Curiosity scans the rocks with her laser. She is looking for signs of water and shares her findings with scientists on Earth.

DISCUSSION QUESTIONS

Why do you think Curiosity is looking for water on Mars?





The outer planets

All of the outer planets have rings and at least 10 moons, are made mostly of hydrogen and helium gases, and do not have solid surfaces you could stand on. The distance between each outer planet is greater than the distances between the inner planets.

JUPITER



Distance from the sun: 5.2AU_s

Moons: 53 named moons, 14 others discovered but not named

Rings: delicate, barely visible, made of dust

Atmosphere: thick, hydrogen (90%), helium (10%)

Year: 12 Earth years

Day: 9 hours & 50 min

Like all the gas giants, Jupiter has no solid outer surface to stand on. It is stormy and very cold (average of -163°F). You can see bands of clouds, storms, and jet streams moving around the planet in multi-colored swirls.

Jupiter has four large moons and many smaller moons, possibly as many as 67 (only 53 are confirmed as of this writing). In the Space app, you can see Ganymede, Europa, Callisto, and Io. These four moons were first spotted by astronomer Galileo Galilei with an early version of the telescope, in 1610. They are still some of the most interesting bodies in our solar system. Ganymede is the largest moon in our solar system (it is even bigger than Mercury). Through the Hubble telescope, scientists have seen jets of water erupting from Europa, indicating there may be a liquid-water ocean beneath its frozen crust. Scientists think this water might have the ingredients for life, making it a tempting place to explore.

IN THE APP



Tap the pin. Drag a balloon, piano, or confetti into the storm.

Jupiter's Great Red Spot is a giant (twice the diameter of Earth!), powerful hurricane that has stormed for at least 150 years, with winds up to 400 mph. Using what they know about how storms form on Earth, scientists have developed hypotheses about how the Great Red Spot works. Basically, on Earth, hurricanes weaken when they go over ground. Because Jupiter is mostly gas with a liquid ocean around its core, there is no solid ground to weaken storms.



SATURN



Distance from the sun: 9.54AUs

Moons: 60+

Rings: Yes

Atmosphere: thick, hydrogen (96%), helium (3%), other (1%)

Year: 29 Earth years

Day: 10 hours, 42 minutes

Saturn is mostly gas. It is the least dense of all the planets in our solar system—it could float in water!

Saturn has at least 60 moons, including Titan, Rhea, and Enceladus. Titan is bigger than Mercury, and it is the only moon in our solar system with a significant atmosphere. Enceladus is small, and melted ice erupts in geysers around its south pole.

Saturn's rings are the biggest and brightest. Made of ice fragments, the rings are flat and unevenly spaced. There are 9 major rings, all named with letters. B is the very biggest and brightest. The rings were first spotted by Galileo with his telescope, in 1610. In 1997, NASA's Cassini spacecraft launched and traveled for seven years to reach Saturn. Once there, it took incredible pictures of the

planet's rings.

Saturn's surface is stormy. Red and blue cloud bands swirl around the planet at different speeds. Astronomers can tell what each band is made of based on its color. Red ones are mostly ammonium hydrosulfide and blue ones are mostly water. A blue storm shaped like a hexagon has hovered over Saturn's north pole for decades, maybe even centuries.

IN THE APP



Tap the pin. Explore Saturn's rings.

Saturn's rings are not solid. They are made of billions of pieces of ice, dust, and rocks of all different sizes. Scientists think they could be pieces of comets, asteroids, or even moons that are destroyed by Saturn's strong gravity before they can reach the planet.

DISCUSSION QUESTIONS

Jupiter, Uranus, and Neptune have rings, too, but we can not see them from Earth. Why do you think Saturn's rings are so easy to see?

Do you think you could stand on one of Saturn's rings? Why or why not?



URANUS



Distance from the sun: 19.19AUs

Moons: 27

Rings: 13

Atmosphere: thick, hydrogen (83%), helium (15%), other (2%)

Year: 84 Earth years

Day: 17 hours, 14 minutes

Even though it is closer to the sun than Neptune, Uranus is the coldest planet.

Uranus spins on its axis on its side, with a tilt of 97.77 degrees, at nearly at a right angle to its orbit. This unique tilt—possibly the result of a collision with an Earth-sized object long ago—causes the most extreme seasons in the solar system. For nearly a quarter of each year on Uranus, the sun shines directly over each pole, leaving the other half of the planet in a 21-year-long, dark winter.

Most of Uranus' 27 moons are named after Shakespearean characters. The biggest are Titania and Oberon. Titania is the largest; a dirty, ball of ice and rock, covered in valleys and craters. Oberon is also covered in craters with unidentified dark material on the floor of many craters.

Only one spacecraft, NASA's Voyager 2, has ever made a close approach to Uranus, so we do not know a lot about it. Photos from that mission showed methane clouds blowing across a very smooth and featureless surface.

IN THE APP



Drag the slider to reveal the interior of Uranus. Tap the core.

You hear a twinkling sound because there may be diamonds on the inside of Neptune. The rare gemstones may form as a result of the intense pressure inside the planet.

DISCUSSION QUESTIONS

Would you visit Uranus? Why or why not?

NEPTUNE



Distance from the sun: 31AUs

Moons: 13

Rings: Yes

Atmosphere:
hydrogen (80%),
helium (19%), other
(1%)

Year: 165 Earth
years

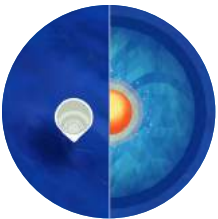
Day: 16 hours

Astronomers discovered Neptune by observing Uranus. Because Uranus did not circle the sun the way they thought it should, astronomers thought the gravitational pull of another object was affecting its orbit. When they started looking for that other planet, they found Neptune. It was the first planet located by mathematical predictions instead of observations of the sky.

Neptune has bands of swiftly moving clouds and a Great Dark Spot, a swirling storm similar to Jupiter's Great Red Spot.

Neptune has 13 confirmed moons. Triton, Neptune's largest moon, orbits the planet in the opposite direction of the rest of the moons. Triton is extremely cold (about -235 degrees Celsius / -391 degrees Fahrenheit). Even though it is totally frozen, the spacecraft Voyager 2 discovered geysers shooting icy material upward more than 8 kilometers (5 miles).

IN THE APP



Drag the slider to reveal the interior of Neptune. Tap the core.

You hear a twinkling sound because there may be diamonds on the inside of Uranus. The rare gemstones may form as a result of the intense pressure inside the planet.

DISCUSSION QUESTIONS

Would you visit Neptune? Why or why not?

SOURCES

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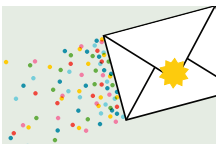
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