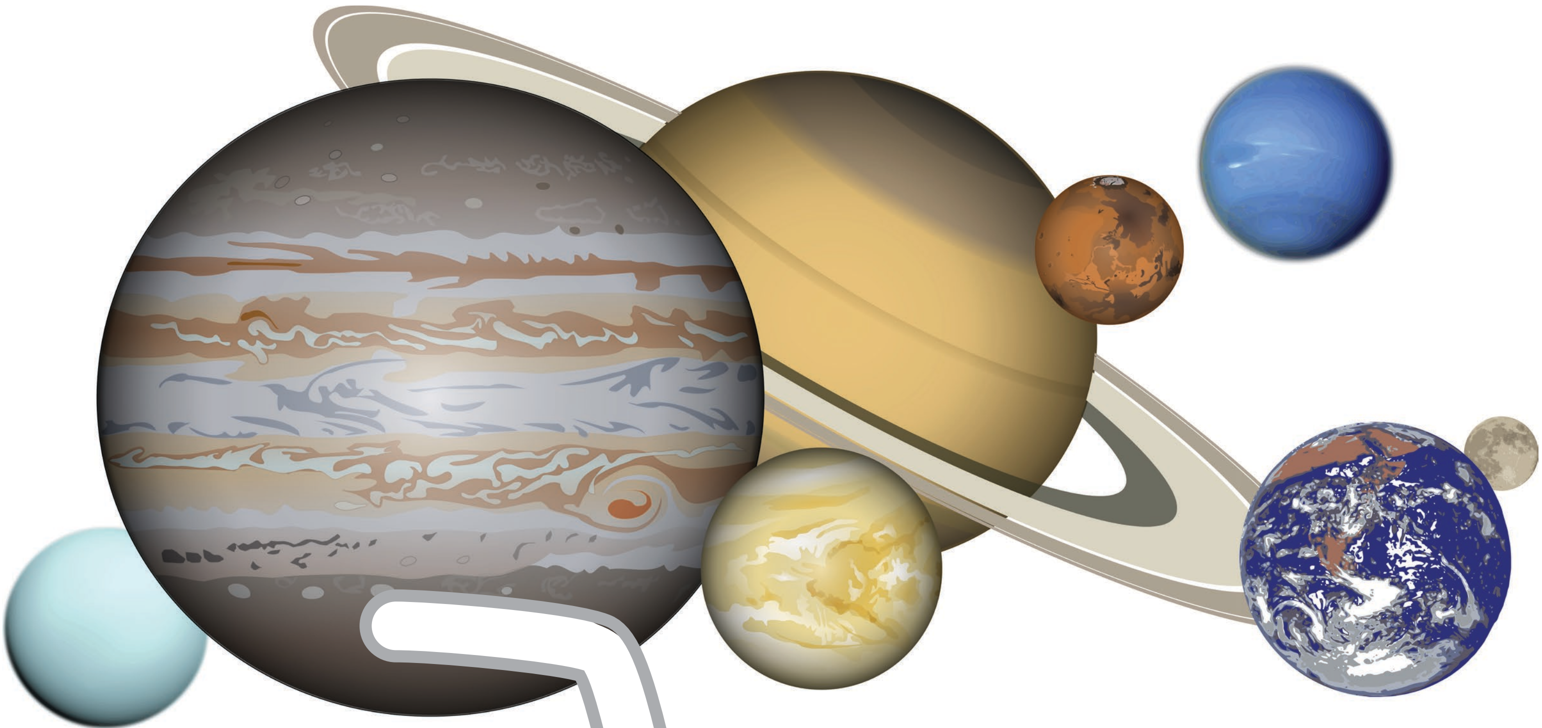
PLANETS



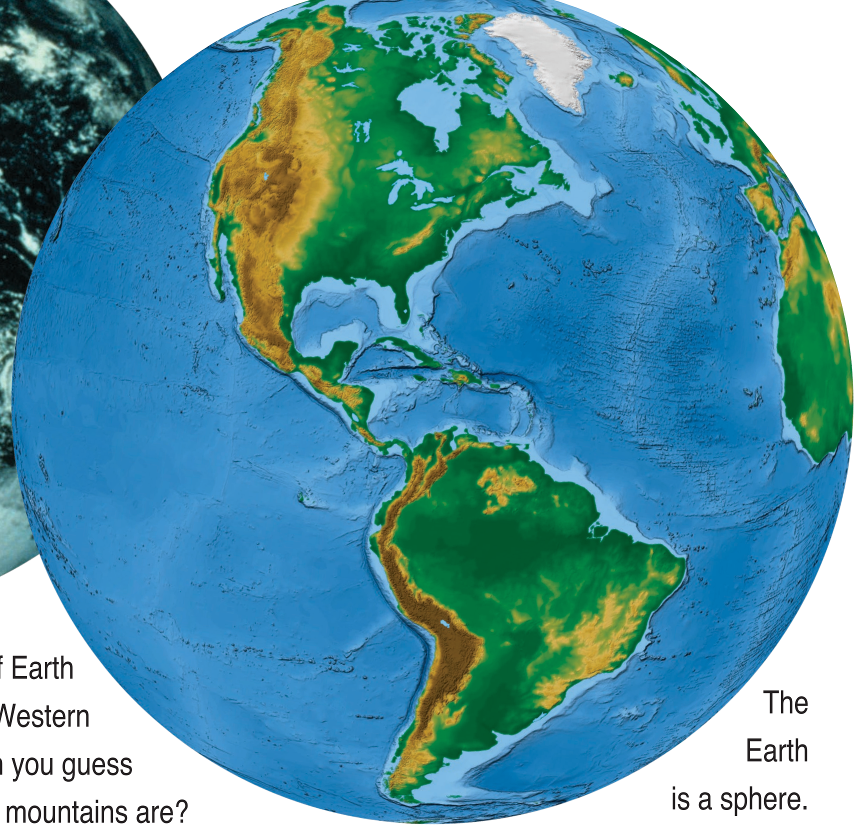
Supermarket Science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

SHOW

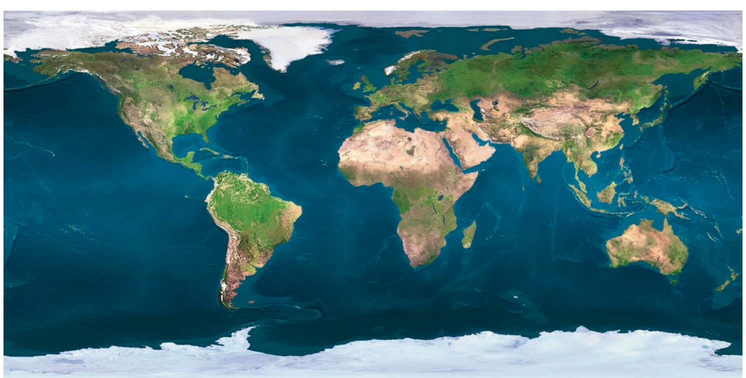
Earth

This is an image of Earth taken from space. You can see most of the African continent and the top part of Antarctica. Note the spiral cloud formations.

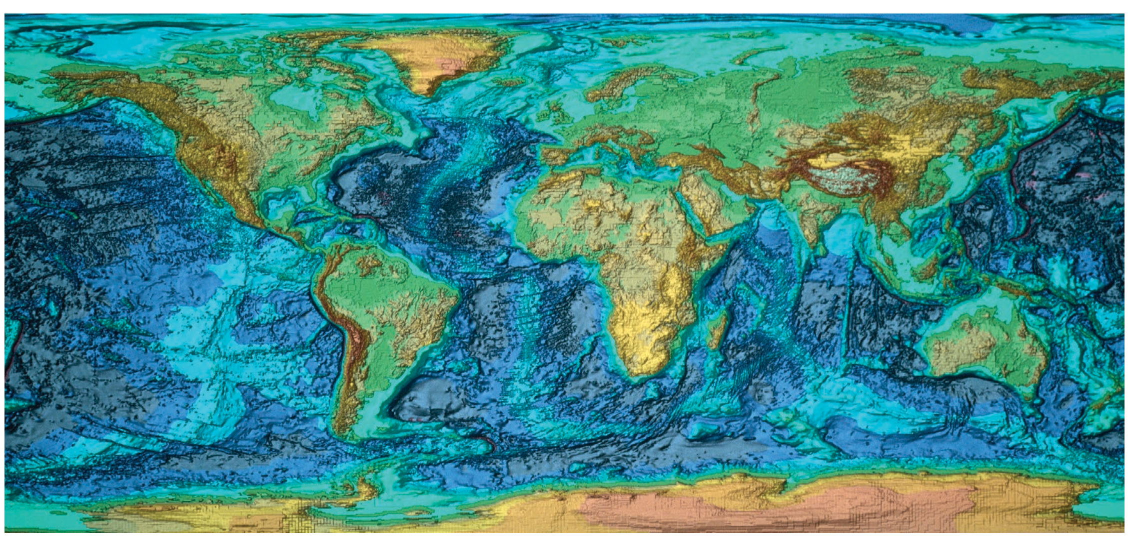


This is a globe of Earth showing the Western Hemisphere. Can you guess where the mountains are?

The Earth is a sphere. This makes it hard to make a flat map of its surface. The parts next to the poles get stretched out from a point on the globe to the whole (longest) side of the map! Can you see these distortions? How does this flat map compares with the actual photograph of the Earth?



Mapping instruments placed in orbit around the Earth allow us to make detailed elevation maps of its surface.



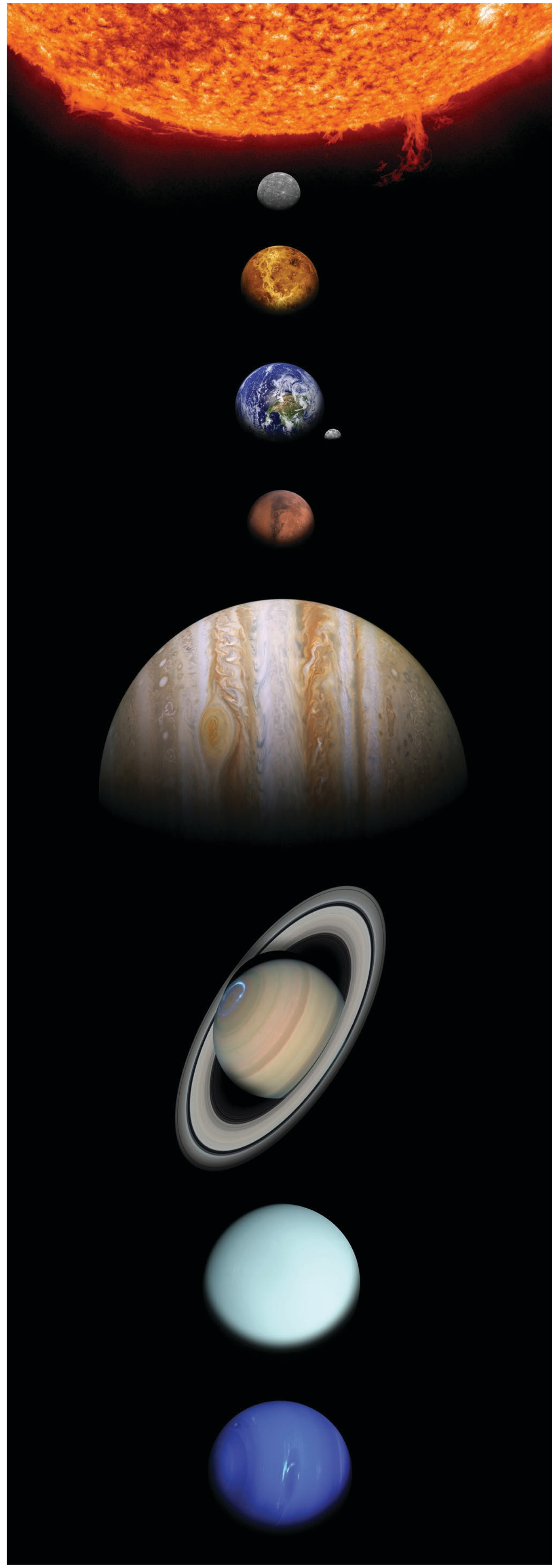
Supermarket science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

LEARN

A Quick Tour of Our Solar System

Starting at the very top, you can see the curved surface of our sun and a small gray Mercury just below; then there's orange-colored Venus, almost the same size as the Earth; Earth comes next with its moon; Mars is the last rocky planet in our Solar System; Jupiter is easily recognized by its big red spot; Saturn has the rings; Uranus is the smallest of the four gaseous giants in our system; Neptune has a visible storm system just like Jupiter. Pluto is a dwarf plant and is not shown in the illustration on the right.



Our planetary system has one star and eight planets...as far as we know. Pluto has been declassified as a dwarf planet and is no longer included in the total count of planets in our Solar System. Sometimes, scientists change their minds based on data and reclassify the subjects of their study. That's what happened to Pluto. There are many people who are still sore about this. On the other hand, our Solar System gained a bunch of new dwarf plants.

The planets move in elliptical orbits around the Sun. The Sun is at the center of one of the ellipsis focal points. The planets are distributed in a disk around the Sun, rotating at different speeds. Each planet goes around the Sun in one planetary year. Each planet's year has a different duration. The Earth takes 365 Earth days to complete one revolution around the Sun. But the day on Mercury last its entire year!

We now have very good image data of the surface of most planets. This allows us to make flat maps of the planets just like we do for the Earth. These maps are made from the photographs we were able to take of these planets. Notice how stretched these maps are at the poles. This is because a flat map can't represent a spherical planet without errors.

Consider visiting a Solar System Simulator:

space.jpl.nasa.gov/

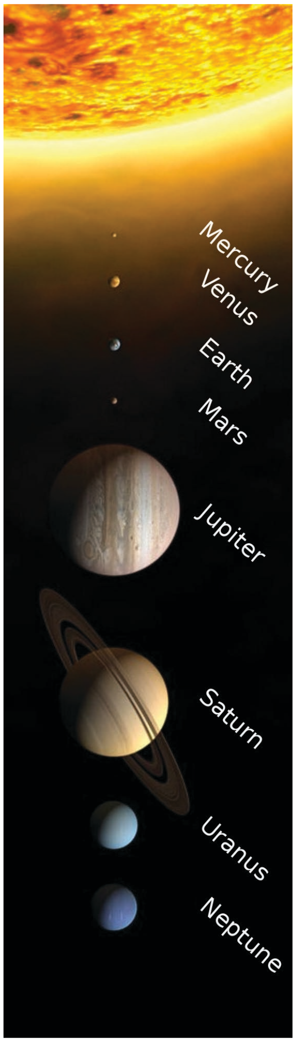
or

solarsystem.nasa.gov/solar-system/our-solar-system/overview/

Supermarket Science

LEARN

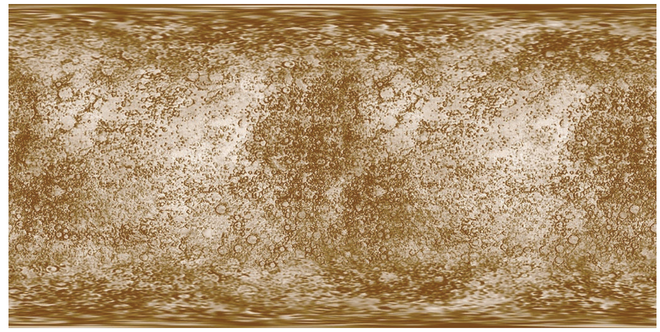
Rocky Planets



While the relative size of the planets and the sun are to scale, the distances are NOT. WP/Wikimedia Commons

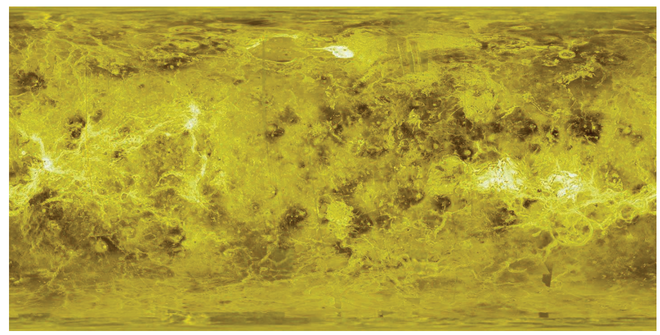
Mercury

Mercury is the closest planet to the Sun. Its radius is one third the size of Earth's radius, and it is about 20 times less massive. Its year is about 88 Earth days, but its own day is almost 59 Earth days! There is a 600°C difference between the temperature in the sunlight versus the shade. It's possible that there's even ice in the shadowed cold canyons. Mercury doesn't have any moons, and it is almost three times closer to the Sun than the Earth.



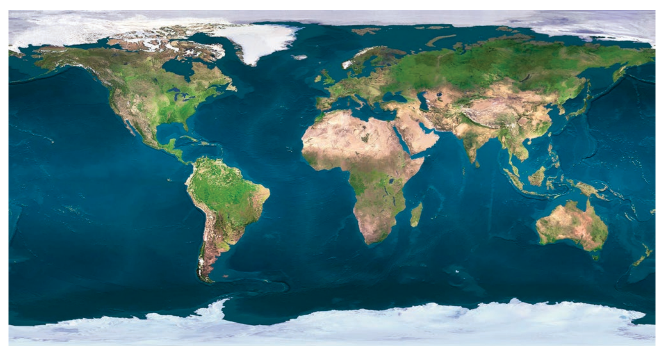
Venus

Venus is almost the same size as the Earth. It is a little more that two thirds of the way from the Sun to the Earth. Venus day is almost the same as its year: 243 Earth days for every Venus day and 225 Earth days for every Venus year. But it rotates backwards: Earth rotates left to right on its axis and Venus right to left. The temperature on the surface of Venus is 456°C, that's over four times hotter than the temperature at which the water boils on Earth.



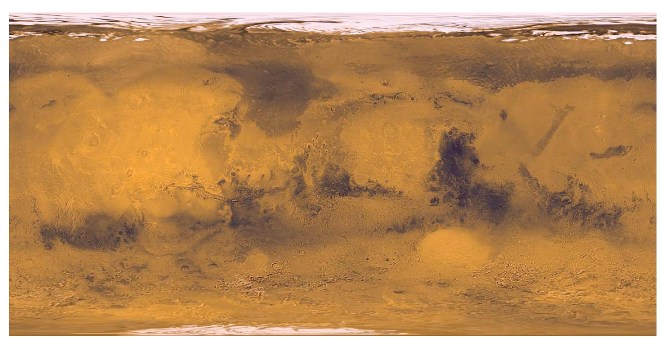
Earth

Earth is our home planet. We orbit 150,000,000 kilometers away from and around the Sun. Our average speed is 30 kilometers per second or 108,000 kilometers per hour! That's pretty fast. And we are the only planet that we know for sure has life—pretty special.



Mars

Mars is half again as far away from the Sun as the Earth. And it is almost 10 times less massive. While it's cold there (-90°C to -5°C), there are places on Earth that have recorded similar temperatures. Mars' year is about twice as long as the Earth—687 Earth days. But Mars' day is almost the same—24 hours and 37 minutes. Mars has two small, irregular-shaped moons—Phobos and Deimos.



Supermarket science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

SHOW

Earth

Surface Area: 196.94 million mi²

Radius: 3,958.8 miles

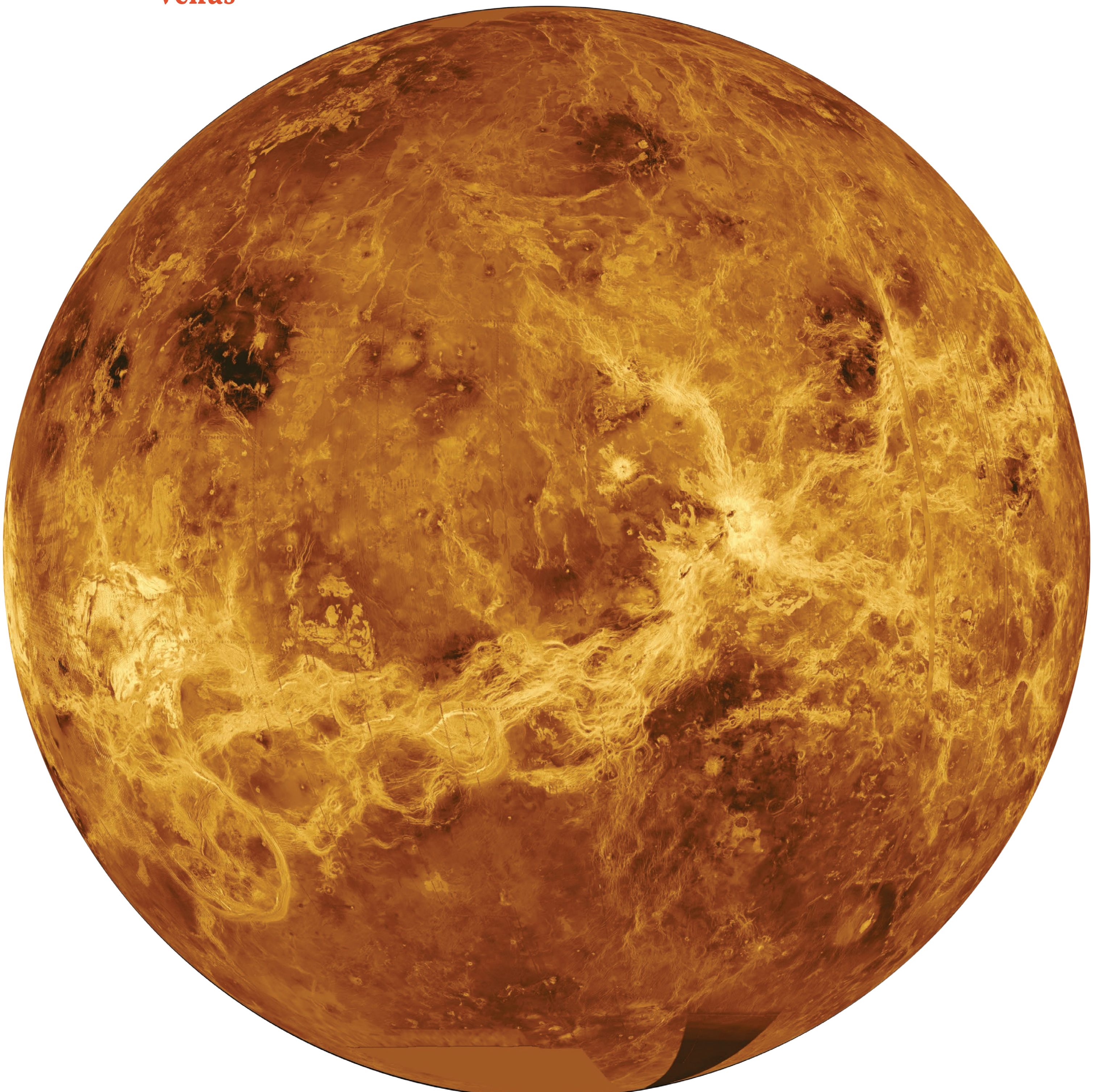
Distance from Sun: 94.3 million miles

Orbital Period: 365 days

Length of Day: 24 hours

SHOW

Venus



Surface Area: 177.7 million mi²

Radius: 3,760.4 miles

Distance from Sun: 67.4 million miles

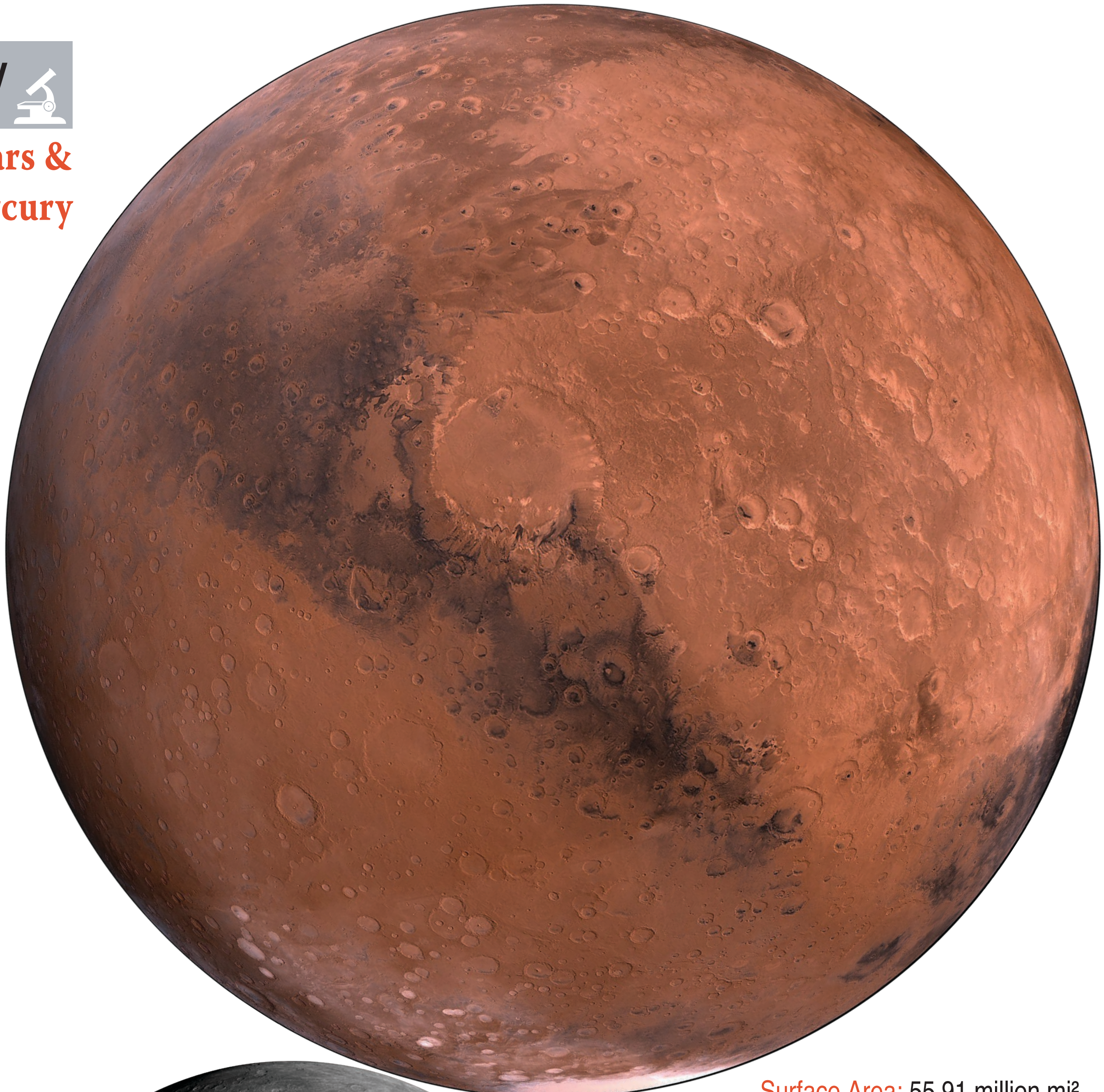
Orbital Period: 225 days

Length of Day: 116 days, 18 hours, and 0 minutes

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

SHOW

Mars & Mercury



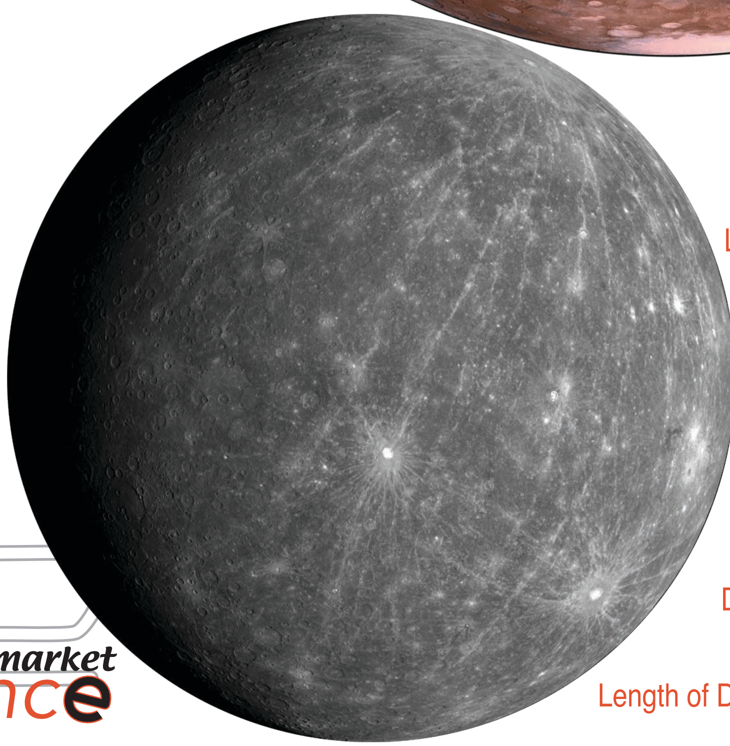
Surface Area: 55.91 million mi^2

Radius: 2,106.1 miles

Distance from Sun: 141.6 million miles

Orbital Period: 687 days

Length of Day: 1 day, 0 hours, and 37 minutes



Surface Area: 28.88 million mi^2

Radius: 1,515 miles

Distance from Sun: 35.98 million miles

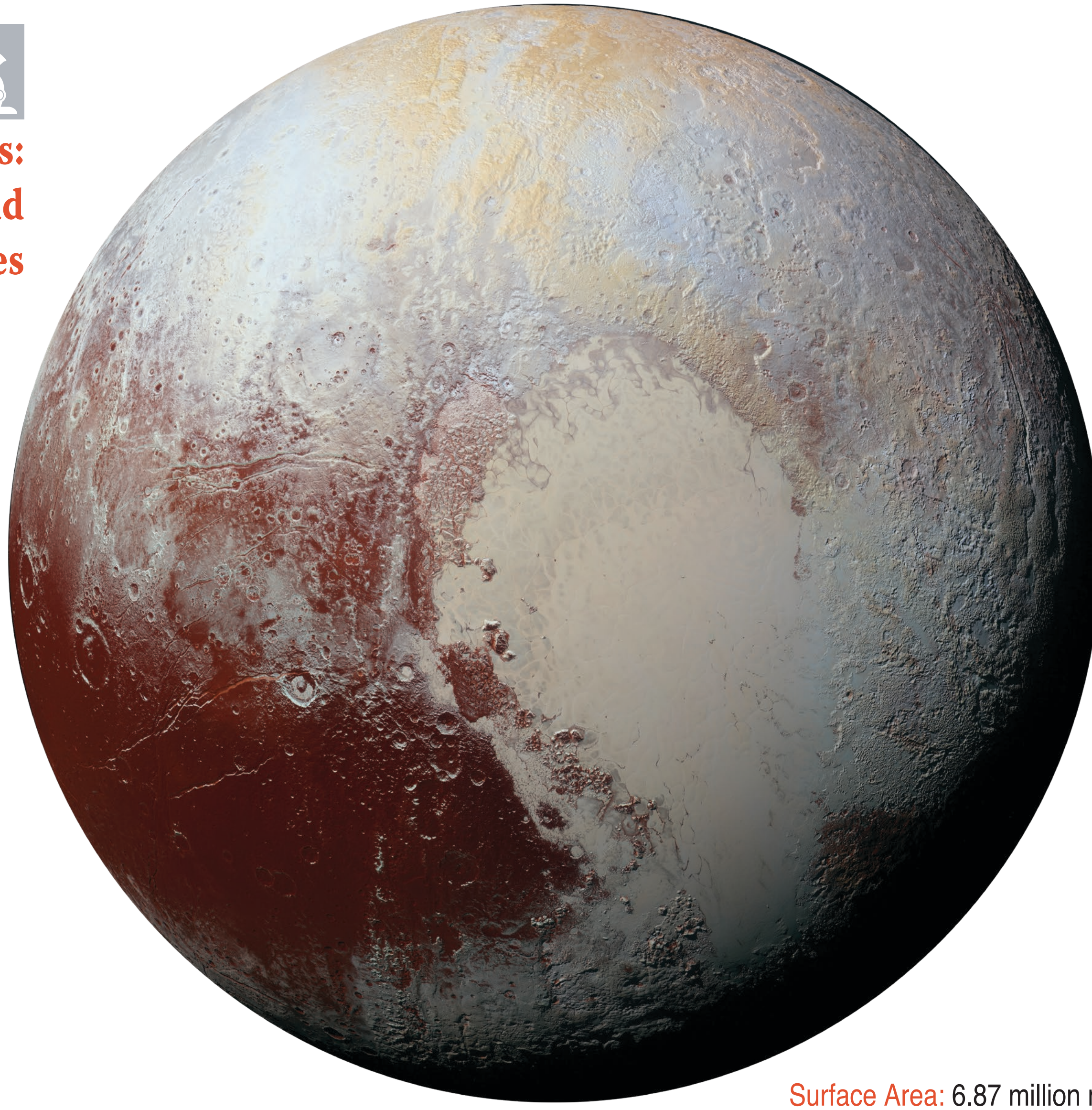
Orbital Period: 88 days

Length of Day: 58 day, 15 hours, and 30 minutes

Supermarket Science

SHOW

Dwarf Planets: Pluto and Ceres



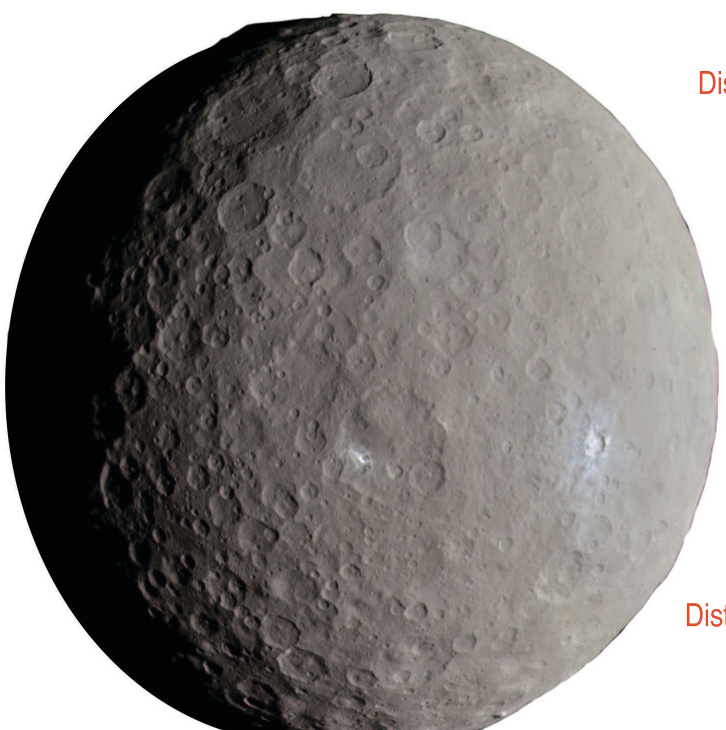
Surface Area: 6.87 million mi²

Average Radius: 738.38 miles

Distance from Sun: 3.7 billion miles

Orbital Period: 248 years

Length of Day: about 153 hours



Surface Area: 1.72 million mi²

Average Radius: 296 miles

Distance from Sun: 257 million miles

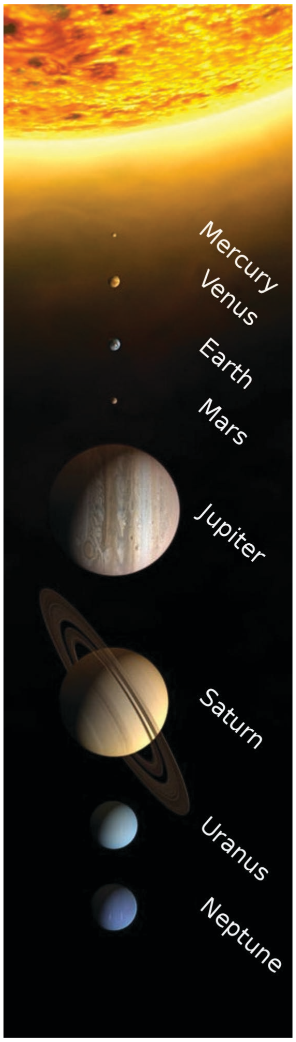
Orbital Period: about 1,682 days

Length of Day: 9 hours

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

LEARN

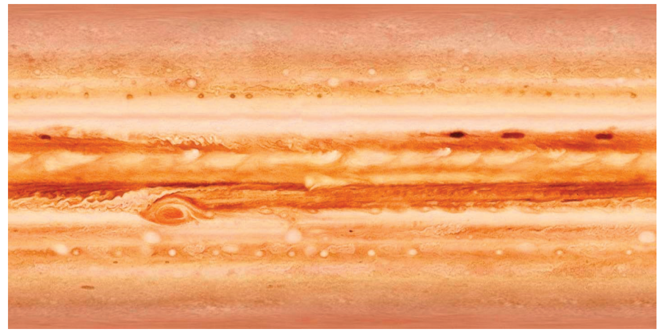
Gas Giants



While the relative size of the planets and the sun are to scale, the distances are NOT. WP/Wikimedia Commons

Jupiter

Jupiter is a gas giant. It would take more that 1,000 Earths to fill up the sphere of Jupiter. It is almost 320 times more massive that the Earth. If Jupiter was just 100 times bigger than it is, it would have become a star. Even now, Jupiter generates more heat in its interior than it gets from the distant Sun. Jupiter has no surface—just a swirling ocean of dense gas getting thicker and thicker towards its core. There are more than 30 moons orbiting Jupiter with some being almost as big as our planet Earth. And we keep finding more!

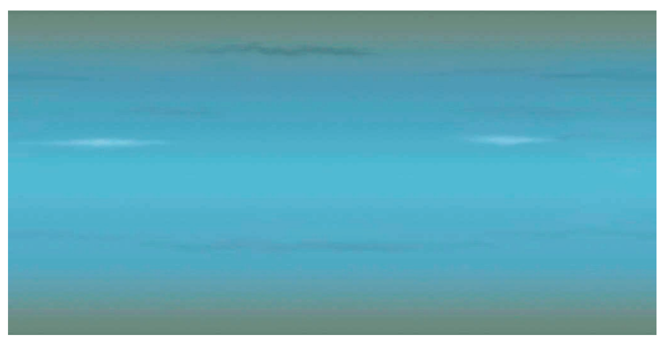


Saturn

Saturn is one of the prettiest planets to look at through a telescope. Like Jupiter, it is a gas giant, but unlike Jupiter, it is surrounded by an amazing network of hundreds of rings. The rings of Saturn have mystified astronomers for centuries. Since we sent an unmanned spacecraft to Saturn, we now know that the rings are made of bits of rock and ice orbiting around Saturn and kept in check with tiny shepherd moons. Saturn has 17 major moons and many minor ones.

Uranus

Uranus is almost 20 times as far from the Sun as the Earth. At that distance, our Sun looks like a big star and not much of its heat reaches Uranus's surface. It takes Uranus about 84 Earth years to go around the Sun.



Neptune

Neptune is 30 times as far from the Sun as the Earth, and it takes about 165 Earth years to orbit once around the Sun. It has 8 moons, that we have discovered so far.

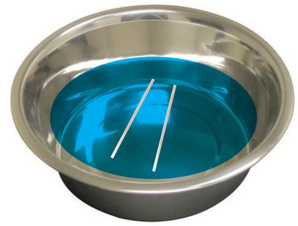
Supermarket Science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

LEARN

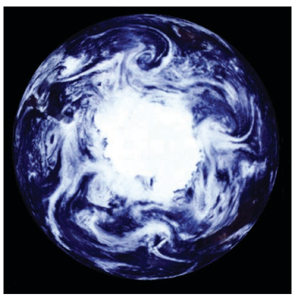
Global Weather on a Rotating Planet

The planet Earth is big ball of rock with a thin outer shell of gas rotating in space. It is rotating around the axis that goes from pole to pole. It takes 24 hours for any point on the surface of the Earth to go all the way around in space—that's the duration of our day. Other planets may rotate faster or slower, and the time it takes for them to turn all the way around their axes is the duration of their day. So a day on Jupiter, for example, could be longer or shorter than a day on Earth (it's shorter—only 10 hours long).



If you take a ball and spin it with a finger on the top and a finger on the bottom, you will notice that the points on the ball's equator move faster than the points closest to your fingers, the poles. The same is true for our Earth—people living on the equator ride faster and farther each day than people who live close to the poles.

The Earth's atmosphere, the gas shell of our planet, rotates as well. But unlike a solid piece of rock, the atmosphere can't rotate as a single whole. Take a big bowl of water, for example, and float a toothpick in it. Now start rotating the bowl and watch the toothpick in the water. The toothpick doesn't move as fast as the bowl. Water, like gas, doesn't move as a one big whole thing. Different parts rotate at different speeds. And that's true of our atmosphere.

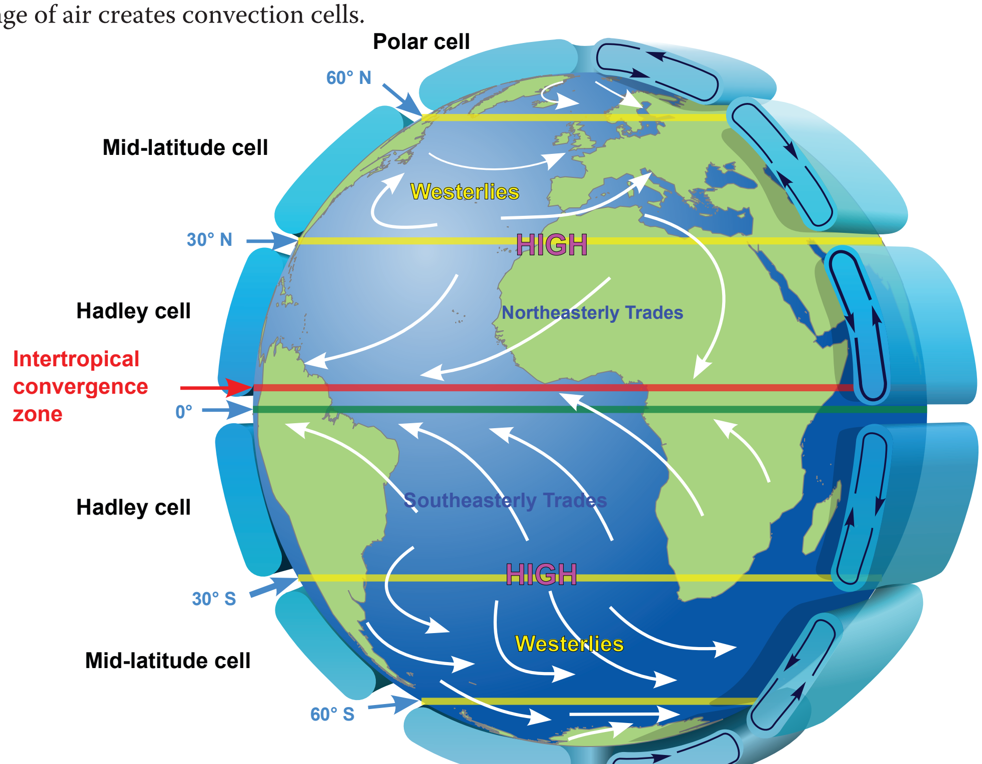


A view of the Earth's South Pole from space shows the circular wind patterns.
Image: JPL

The global wind patterns on Earth and on other planets with atmosphere develop because the atmosphere doesn't rotate as one whole thing. If the North Pole is at the top, Earth rotates from left to right. The atmosphere over the equator lags behind the rotation of the surface of the Earth. This causes the Easterly winds around the equator—the Tropical Easterlies (diagram below).

In the Northern hemisphere, these winds come from the *North East*. In the Southern hemisphere, these winds come from the *South East*. At higher latitudes, closer to the poles, the atmosphere overshoots and rotates slightly faster than the surface of the Earth. And we get Western winds—the Prevailing Westerlies. The weather in America always moves from *West* to *East*. At the poles, the surface of the Earth doesn't move much at all and the atmosphere tries to adjust accordingly. The result is the formation of little cyclones—circular wind patterns surrounding the poles. These are the Polar Easterlies.

While the rotation of the Earth explains the Eastern and the Western direction of the wind, the heat from the sun explains the Northern and Southern wind patterns. Because the Earth is not a flat disk but round like a ball, the sun heats the tropical regions near the equator a lot more than the polar regions. Because of this imbalance in temperature, the hot winds blow both *North* and *South* away from the equator. As the hot air leaves the tropics, the cold air from the poles is sucked down. This constant exchange of air creates convection cells.



NASA's diagram of winds flowing around the Earth at different latitudes.

Supermarket science

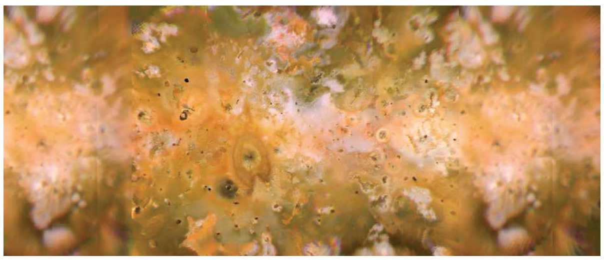
LEARN

Galilean Moons

Jupiter is a gas giant. It would take more that 1,000 Earths to fill up the sphere of Jupiter. It's almost 320 times more massive that the Earth. If Jupiter was just 100 times bigger than it is, it would have become a star. Even now, Jupiter generates more heat in its interior than it gets from the distant Sun. Jupiter has no surface—just a swirling ocean of dense gas getting thicker and thicker towards its core.

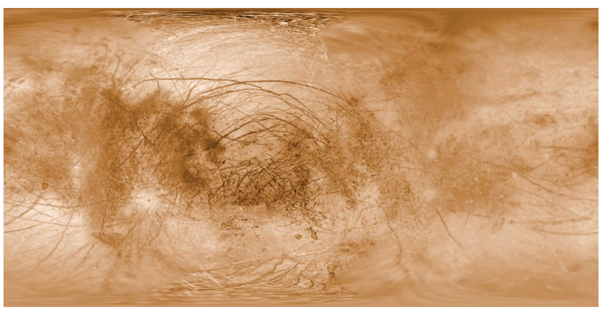
In 1610, Astronomer Galileo Galilei discovered four moons orbiting Jupiter. That was the first time in history that objects the size of planets were observed moving around another planet. This caused quite a stir among scientific and religious communities. It was hard enough to accept that it was the Earth that went around the Sun instead of the other way around.

Galileo wasn't very popular with the religious leaders of the time. To improve his chances of moving back to Florence, Italy, he named Jupiter's moons Medicean Stars, after the ruling Florentine family Medici. But the name didn't stick. Today, we use the names Io, Europa, Ganymede, and Callisto for the moons Galileo discovered. These names were given to these moons by Simon Mayr, who lived around the same time as Galileo and claimed he made their discovery first. These moons are now called Galilean Moons and are the only moons of Jupiter that are visible through a hand-held telescope.



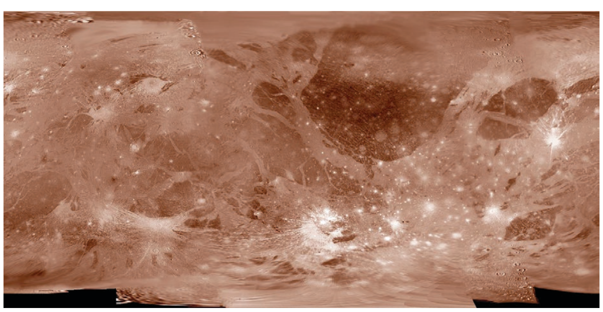
Io

Io, Jupiter's closest moon, has more volcanoes than any other planet in our system. Some volcanoes visibly stick out of its sides as this moons is observed during its rotation. The eruptions give off giant plumes that eject material into Io's orbit! The volcanic activity on Io is the result of the pull of Jupiter's gravity as it is ripping at it and turning it inside out. From space, Io looks like pepperoni pizza—orangy-yellow with red, brown, and white spots all over. It orbits 253,200 miles from Jupiter. In comparison, our moon, Luna, is 238,900 miles away from Earth.



Europa

Europa is Jupiter's second moon, circling it from 402,000 miles away. It's just a little smaller than the Earth's moon, with diameter measuring 1882 miles. Europa is covered by thick oceans crusted over with miles of ice. It is possible that life evolved in those oceans, but we will need to send a probe that can drill through all that ice to find out for sure. Scientists are very worried that such a probe can introduce microscopic life that originated on Earth, thus contaminating this Jovian moon with alien (to it) life. When searching for life in our Solar System, we have to be very careful.

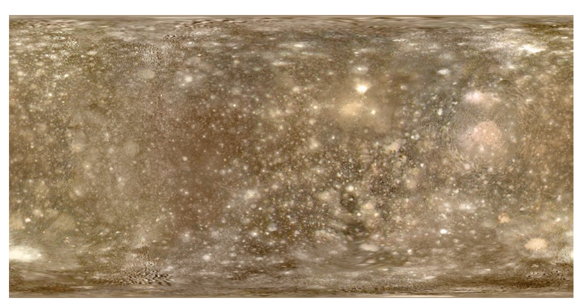


Ganymede

Ganymede is the largest of Jupiter's moons and the largest moon of our Solar System! It is even larger then the planet Mercury. Ganymede's diameter is 3,157 miles (our Moon's diameter is just 2,085 miles) and it's 642,000 miles away from Jupiter. Ganymede has a liquid iron core, just like Earth, surrounded by rocky mantle, covered by a layer of ice. It's surface is covered with craters—scars from meteor impacts. The black patches on the bottom right and left of Ganymede's map image are just places on the surface where we don't visual information. It's difficult to photograph the surface of a moon of a far away planet!

Callisto

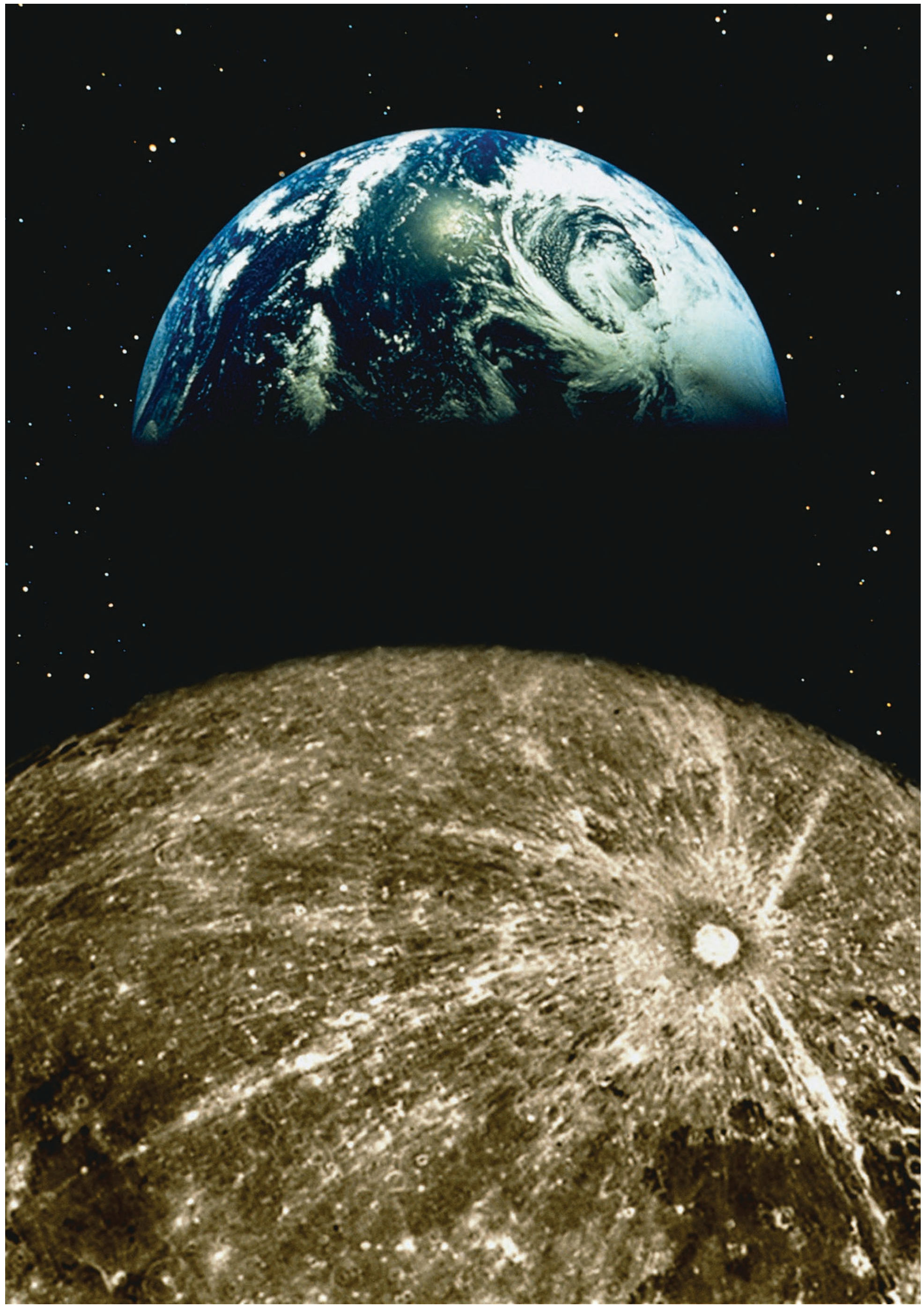
Callisto is the second largest moon and is almost the same size as Mercury. It's 2,880 miles in diameter—larger than our moon. It orbits Jupiter from a distance of 1,129,800 miles—that's more than four times the distance from Earth to our moon! Callisto is heavily cratered and looks much more like our moon than like its sister moon Ganymede.



Supermarket science

SHOW

The Moon



Our planet Earth has one moon—Luna—but every one just calls it the Moon. It orbits our planet at an average distance of 240,000 miles. It is a relatively large moon, compared with other moons in our Solar System, with a diameter of 2085 miles. It's even larger than the dwarf planet Pluto.

Because Luna doesn't have an atmosphere, all the impact craters from millions of meteors are still visible. The moon's entire history is etched into its surface! The large, star-shaped crater seen in this photograph can be easily observed from Earth. This is Tycho Crater. The rays emanating from the crater are fractures resulting from the collusion with a large asteroid.

As the moon moves around the Earth, it sweeps up all the Solar System debris that's floating out there, saving our planet from numerous impacts and certain disasters! One theory of lunar formation is that it is the result of a giant collision between the Earth and an enormous asteroid some 4 billion years ago. This collision almost destroyed the Earth and kicked up enough material into orbit to form our moon! This is why lunar rocks are just like the Earth rocks—have the same composition—from billions of years ago.

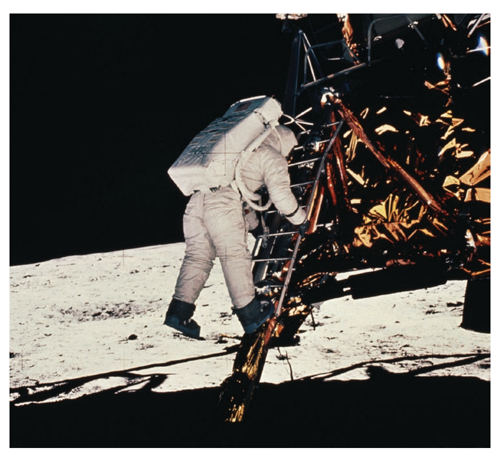
Brain Teaser:
Was this photograph of the moon taken from Earth?

Supermarket Science

SHOW

On Our Moon

The moon is very different from Earth. For one thing, it doesn't have an atmosphere—there is no air to breathe or blow sand and dust around on the surface. The foot prints of human visitors will remain on the moon's surface until a meteor smashes it out of existence (which could be thousands of years from now).



Supermarket Science

Our moon is the only other object in our Solar System than we have visited in person (as opposed to sending a robot). How do you think we got these photographs?

LEARN

Gravity

Mass Versus Weight

We all know how much we weigh here on Earth (or at least we can find out pretty easily). But what about our weight on the moon? Or on Mars? Or on Jupiter? Would we *feel* the same if we suddenly found ourselves on another planet? Well, we know that people feel much lighter on the Moon than they do on Earth—we read about it and we watched video of Neil Armstrong jumping up and down on the surface of the moon like a bunny rabbit. What changed? It's pretty clear that Neil's body didn't get smaller when he got to the moon. So it must be the moon. The moon is a much smaller than the Earth. Not only is it smaller is size, but there is also not as much stuff making the moon as the Earth. And what makes us feel heavy or light doesn't only depend on how big we are and how much we eat, it also matters where we are and how strong the pull of gravity is on our bodies there.

In general, the bigger the planet, the stronger the pull of gravity, the heavier we feel. So it makes sense to separate the quantity of how much of us there is from the quantity of how heavy we feel. The first quantity is called mass and the second weight.

**Our mass is the same wherever we go,
but our weight changes depending on where we are.**

We can calculate the difference in weight by multiplying it by the effects of gravity for a particular location. We call this number little g. So the formula for the weight is:

weight = mass times "little g"

"Little g"

What does the strength of gravity depend on? Well, it clearly depends on how much "stuff" the planet's got—the higher the mass of an object the stronger its gravitational field. It also depends on how far away from the center of gravity you are (since we live on an almost perfect ball, it's the center of the Earth for us). The farther away you are from the center of gravity, the less gravitational attraction you feel. People living on the coast of an ocean feel heavier than people who live high up in the mountains although their mass remains the same no matter where they travel (and the different is tiny).

And now that we have the formula for weight, it would be nice to have the formula for "little g."

$$\text{"little g"} = \frac{\text{(Gravitational Constant) x (Mass of the Planet)}}{\text{(Distance to Center of Gravity)}^2}$$

The Gravitational Constant = 6.67 x 10-11 N m2/kg2

The Gravitational Constant is a very small and strange looking number, but it's important to make things work out right. It is also one of the laws of our universe. The force of gravity is proportional to Gravitational Constant. Since we are mostly interested in finding out the weight on the surface of a particular planet, the distance to the center of gravity number is just the radius of the planet. Below are radii, masses, and "little g's" of the planets in our Solar System.

Planet	Radius	Mass	"little g"
Mercury	2,439 km	33.022 x 1022 kg	3.61 m/s2
Venus	6,051 km	486.9 x 1022 kg	8.83 m/s2
Earth	6,378 km	567.42 x 1022 kg	9.8 m/s2
Mars	3,397 km	64.191 x 1022 kg	3.75 m/s2
Jupiter	71,492 km	189,920 x 1022 kg	26.0 m/s2
Saturn	60,268 km	56,865 x 1022 kg	11.2 m/s2
Uranus	25,559 km	8,684.90 x 1022 kg 1	0.5 m/s2
Neptune	24,760 km	10,235 x 1022 kg	13.3 m/s2
Pluto	1,123 km	1.36 x 1022 kg	0.61 m/s2

DO

Jumping Around the Solar System

What kind of athlete would you make on another planet?

Get a friend to help you and measure how high you can jump. Have your friend mark your highest jump on the wall with a bit of tape, and then measure how high you've managed to jump with a ruler.

What You Need:

How high can you jump? ______________________________

Your muscles are used to carrying you around our planet Earth. But on other planets, you weigh a different amount (even as your mass remains the same). On some planets, your muscles have to work very hard just to move. On others, with the same strength you use on the Earth, you can leap up high into the air.

Below are amounts by which your jump would change if you were to leap on different planets. Use these amounts to convert the height of your Earth jump to the approximate height of your jumps on other planets.

On Mercury, you can jump almost twice as high: ______________________________

On Venus, you can jump just a little higher: ______________________________

On Earth, you can jump: ______________________________

On Mars, you can jump almost twice as high: ______________________________

On Jupiter, you can jump almost three times lower: ______________________________

On Saturn, you can jump a little lower: ______________________________

On Uranus, you can jump a little lower: ______________________________

On Neptune, you can jump a little lower: ______________________________

On Pluto, you can jump almost 20 times as high: ______________________________

On the Moon, you can jump almost four times higher: ______________________________

Of course on the gas giants, you wouldn't be able to jump at all—those planets don't have surface!

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

DO

Jumping Around the Solar System, Do the Math!

Get a friend to help you and measure how high you can jump. Have your friend mark your highest jump on the wall with a piece of tape and then measure it with a ruler.

How high can you jump?_______________________

What would be a more accurate measure of how high you can jump of different planets? We can make the calculation—it's easy!

Just like in the previous activity, we will ignore the presence of atmosphere, the type of ground you are jumping on, and how far away you are from the center of mass, and all of the other variables that can contribute to variations. (*I had a ton sugar, so I can really jump!* or *I qualified for the Olympics in High Jumps!*) All we will focus on are the differences in gravity on different planets of our Solar System.

In the Gravity LEARN page, we calculated little g's for various bodies on our Solar System. We can use those numbers to figure how much higher you can jump. Here's the basic calculation:

1. The height of your jump on another planet would be directly proportional (that's the curvy symbol) to how high you can jump on Earth:

   Height on Earth $\propto$ Height on Another Planet

2. But how can figure it out more accurately? Well, we know that our weight changes on different planets, depending on the gravity:

   Weight = Mass x (little g)

3. So on Earth, you can find your weight by just standing on the scale: ________________
4. So your mass is just:

   Mass = Weight ÷ (little g)

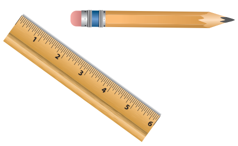
5. So now you can figure what you would weigh on any other planet where we know little g.
6. But you don't even need to know your mass—it doesn't change from planet to planet! All we need to know is how high you can jump on the Earth and the little g's for all the other planets:

(Height of Earth) x (Mass) x (little g for Earth) = (Height on Planet) x (Mass) x (little g for Planet)

7. This means that the formula to calculate the height of the jump on another planet is just:

   (Height on Planet) = (Height on Earth) x (little g for Earth) ÷ (little g for another Planet)

What You Need:



Easy!

You can check that this is a correct way of thinking about it because if you plug in all of the numbers, the height of your jump on Earth would be as you've measured it—an equality.

On Mercury, you can jump: ____

On Venus, you can jump: ____

On Mars, you can jump: ____

On Jupiter, you can jump: ____

On Saturn, you can jump: ____

On Uranus, you can jump:____

On Neptune, you can jump: ____

On Pluto, you can jump: ____

On the Moon, you can jump:____

Supermarket Science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0

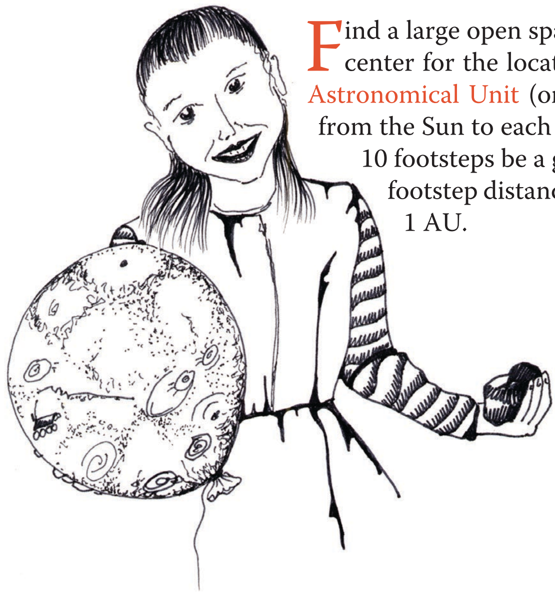
DO

The Human Solar System

Balloon Planets

Blow up 8 balloons. Choose the colors and sizes that would best represent the 8 planets of our Solar System. You can include the dwarf planets, if you like and have enough people. Use permanent magic markers to decorate the balloons with the most interesting features of those planets. You can draw the Red Spot on Jupiter, for example. Make sure that you clearly label each balloon with the name of the appropriate planet.

Orbit Positions



Find a large open space that would be safe for a Human Solar System Model. Mark an approximate center for the location of the Sun. Astronomers call the distance from the Earth to the Sun One Astronomical Unit (or AU). Using the distance from the sun in AUs, mark approximate distances from the Sun to each planet with chalk. Use the length of your footsteps as a measuring tool. Would 10 footsteps be a good distance for the Earth's orbit? So 10 footsteps may be 1 AU. Calculate the footstep distances to the other planets based on the number of footsteps you chose to represent 1 AU.

Sun to:	AUs	Footsteps
Mercury	*.4*	______
Venus	*.7*	______
Earth	*1*	______
Mars	*1.5*	______
Jupiter	*5*	______
Saturn	*10*	______
Uranus	*20*	______
Neptune	*30*	______
Pluto	*40*	______

What You Need:

The Human Solar System

Give everyone in your class (or family or group of friends) a planet balloon. Let everyone go to their orbiting positions marked out with chalk. Start orbiting! Remember that planets and the Sun rotate around their axes. Make sure that everyone is orbiting in the same direction. Avoid planetary collisions!

Moons & Comets & Asteroids

If you have more than 9 people, create moon balloons and let people orbit around their planet as well as the Sun. Try to keep the number of moons to no more than 3 per planet—it's very hard to have a model of all of Jupiter's moons at the same time. Allow some individuals in your group to become giant boulders and ice chunks and create the Asteroid Belt between Mars and Jupiter. Make a tail out of tissue paper, and fly toward the Sun as a comet.

For more accuracy, you can add information on how fast each planet orbits the sun.

Supermarket Science

©Pipsqueak Productions 2020, SupermarketScience.com, version: 2.0.0