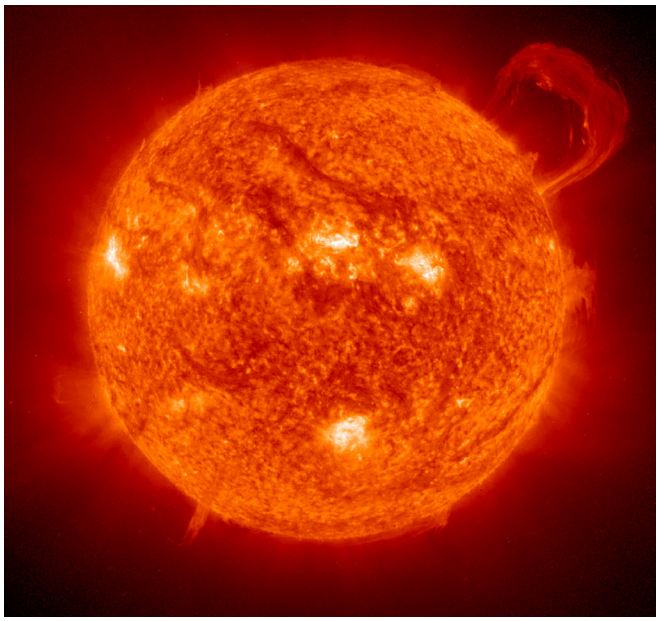
SUN

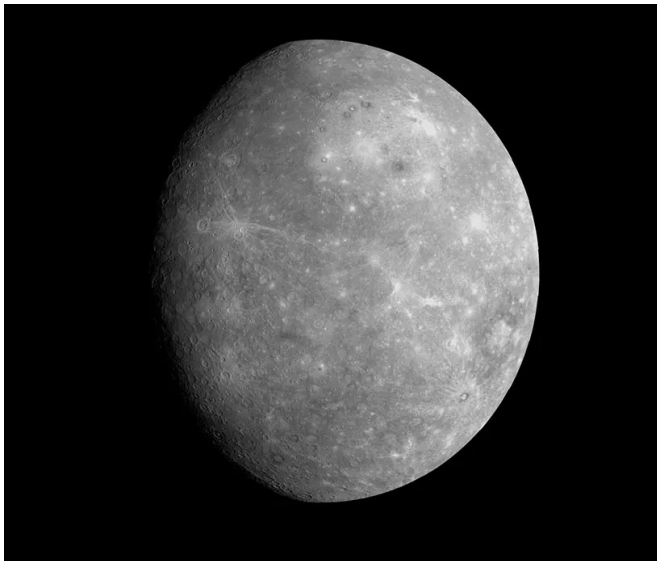


Credit: NASA/European Space Agency

SUN'S size,
where 1 inch = 100,000 miles

diameter: 8.5 in.

MERCURY



Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

The Sun

MERCURY'S size,
where 1 inch = 100,000 miles

diameter: 0.03 in.

SUN — the star of our solar system

8½-inch ball

1. If applicable, ask visitors, "Did you look through a solar telescope today? What did you see?"
2. Ask, "How many stars are in our solar system?" There's only one—the Sun. People often confuse *our solar system* (which consists of the Sun and everything it holds in with its gravity) with the *Milky Way galaxy* (which has billions of stars, including the Sun and all the stars you can see at night) with *the universe* (which has billions of galaxies, including the Milky Way galaxy).
3. We'll start our vacation at the Sun—the closest star to Earth and the only star in our solar system.
4. The Sun is a ball of hot, glowing gases at the center of our solar system. The Sun makes up 99.8% of all the mass in our solar system.
5. The Sun is big. More than 1 million Earths could fit inside it. Compare the relative sizes of the Earth bead and the Sun ball.
6. The Sun is hot. It's 15 million degrees Celsius (27 million degrees Fahrenheit) at the core, and it's 5,500°C (10,000°F) at the photosphere (the Sun's visible surface). That's way, way hotter than your oven at home.
7. The high temperature and pressure inside the Sun allow hydrogen to fuse into helium. This process, called nuclear fusion, releases a lot of energy—energy necessary for life on Earth.
8. Let's move away from the Sun so we don't get burned up. The next stop on our vacation will be the speedy planet that orbits the closest to the Sun.

➔ WALK 10 BIG STEPS TO MERCURY

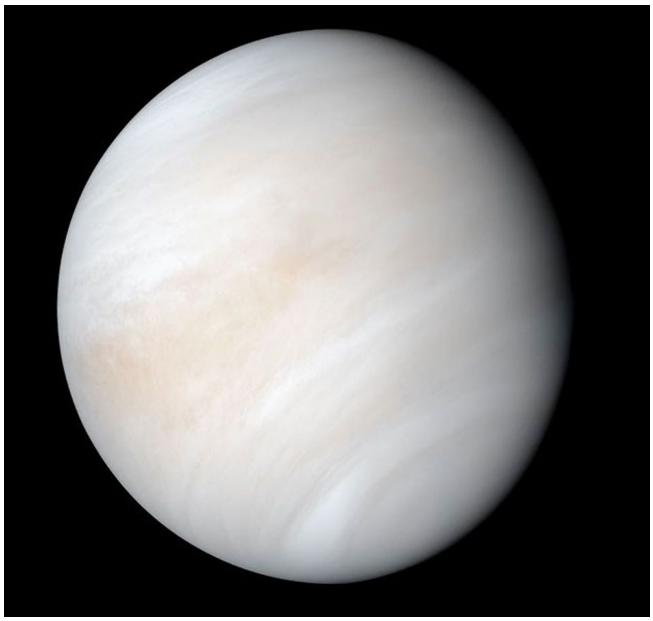
MERCURY — the speedy planet

0.03 in. or 0.7 mm on our scale; too small for a bead

1. Named for the swiftest of the ancient Roman gods
2. Hold up the image of Mercury. "What do you notice?" (People may say it looks like Earth's moon.) Mercury is slightly larger than our Moon and also has craters. Like our Moon, Mercury has very little atmosphere to protect it from impacts.
3. Bring a special spacesuit for your trip to Mercury. Temperatures on the daytime side can reach 800°F, but at night it can be more than a thousand degrees colder (as low as -290° F.) because there's very little air to hold in the heat when the Sun isn't shining. Be sure to pack long underwear for the nighttime.
4. Ask, "How long does Earth take to go around, or orbit, the Sun one time?" (365¼ days, or 1 Earth year). The closer a planet is to the Sun, the faster its orbit. Speedy Mercury takes only 88 Earth days to go around the Sun (1 Mercury year = about ¼ of an Earth year). Ask a child to volunteer their age. "If you'd lived your whole life on Mercury, your age on Mercury would be about 4 times that number, or ___ Mercury years old."
5. Visit a permanently shadowed crater on Mercury, and you may find some of the abundant water ice that the spacecraft MESSENGER discovered when it orbited Mercury.
6. In our sky: Mercury can be hard to see from Earth because Mercury is always close to the Sun from our point of view.
7. Our next stop is the hottest planet in our solar system.

➔ WALK 9 BIG STEPS TO VENUS

VENUS



Credit: NASA/JPL-Caltech

The Sun

VENUS' size,
where 1 inch = 100,000 miles

diameter: 0.07 in.

EARTH

Credit: NASA

The Sun

The Moon

EARTH'S size,
where 1 inch = 100,000 miles

diameter: 0.08 in.

VENUS — today's forecast: hot, cloudy, lethal

0.07-inch or 1.8-mm bead

1. Named for the Roman goddess of love and beauty
2. Venus has been called Earth's twin because the two planets are similar in some ways, such as size, mass, composition, and gravity.
3. But Venus is more like Earth's evil twin. Vacationing on Venus is a terrible idea. Rather than packing anything to take with you, instead leave something behind: your last will and testament.
4. How will Venus kill you?
   » *Heat.* Ask your visitors, "What's the hottest temperature you've experienced on Earth?" On the surface of Venus, it's nearly 900 degrees Fahrenheit. That's hot enough to melt lead. The thick atmosphere traps the Sun's heat.
   » *Crushing atmosphere.* The surface pressure would crush you to death.
   » *Toxic air.* The atmosphere will poison you, too. It's mostly carbon dioxide with clouds of sulfuric acid (the stuff in battery acid).
   » *Strong winds.* The upper atmosphere has hurricane-force winds.
5. But in the moment before you died, you might see some of the volcanoes on Venus, or perhaps an interesting sunrise or sunset, if only it weren't perpetually cloudy. Venus spins the opposite direction from Earth, so the Sun rises in the west and sets in the east.
6. In our sky: Venus appears brighter than any star in the night sky (describe where and when to look for Venus currently).
7. Our next stop will be our home planet.

➔ WALK 7 BIG STEPS TO EARTH

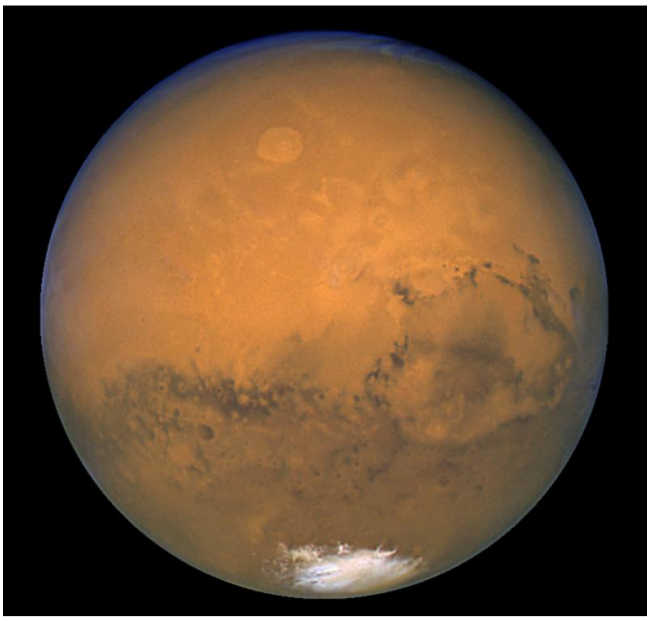
EARTH — there's no place like home

0.08-inch or 1.9-mm bead

1. *Have everyone look back to the Sun. Because this walk is to scale, the Sun ball will be the same apparent size as the real Sun in our sky.* "As you look back toward the Sun ball, hold your arm out straight. You should be able to cover up the Sun with just the tip of your pinky finger (as you would be able to with the real Sun in the sky...but don't stare at the real Sun)."
2. We're at our home planet and the only place in our solar system that we know for sure has life. Earth is a rocky planet, like Mercury, Venus, and Mars.
3. But we're different from those planets. Most of Earth is covered by water. The atmosphere is mostly nitrogen, also oxygen and a little carbon dioxide (but increasing) and other ingredients. Because of the water and our atmosphere, Earth is a home to plants and animals, including people.
4. Earth has one natural satellite, the Moon, which is the farthest humans have ever traveled. In our model, the Moon would be only about two and a half inches away (roughly 240,000 miles in reality).
5. Optional: mention recent or upcoming eclipses
6. In our sky: (describe when and where to look for the Moon currently, and what phase it is)
7. Next we'll head to the Red Planet.

➔ WALK 13 BIG STEPS TO MARS

MARS



Credit: NASA, J. Bell (Cornell U.) and M. Wolff (SSI)

The Sun

MARS' size,
where 1 inch = 100,000 miles

.

diameter: 0.04 in.

CERES

Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

The Sun

CERES' size,
where 1 inch = 100,000 miles

Too tiny to see but it's there!

diameter: 0.01 in.

MARS — the "Red Planet"

0.04-inch or 1-mm bead

1. Named for the Roman god of war
2. Mars looks reddish because its surface is rich in iron oxide (rust).
3. Mars is a cold desert world, with a thin atmosphere.
4. What to pack:
   » *Oxygen.* The atmosphere is mostly carbon dioxide, so you'll need oxygen to breathe.
   » *Soap and water.* Although Mars appears to have had a watery past, now liquid water can't exist for long on the surface. And you may want to take a bath—Mars can have dust storms covering much of the planet.
5. You'll have lots of time for sightseeing. The day is half an hour longer than Earth's, and the year is almost twice as long as Earth's.
6. What to see:
   » Like Earth, Mars has volcanoes and canyons. The Martian volcano Olympus Mons is 3 times as tall as Earth's Mount Everest. Have you ever been to the Grand Canyon? Mars has a canyon system, Valles Marineris, which is even grander—long enough to stretch from New York to California.
   » Maybe you'll get to see the two little moons of Mars, Phobos and Deimos, which may be captured asteroids.
7. In our sky: Mars looks reddish. (describe where and when to look for it currently)
8. On our next stop, we'll head to the asteroid belt and meet our first dwarf planet.

➔ WALK 32 BIG STEPS TO CERES

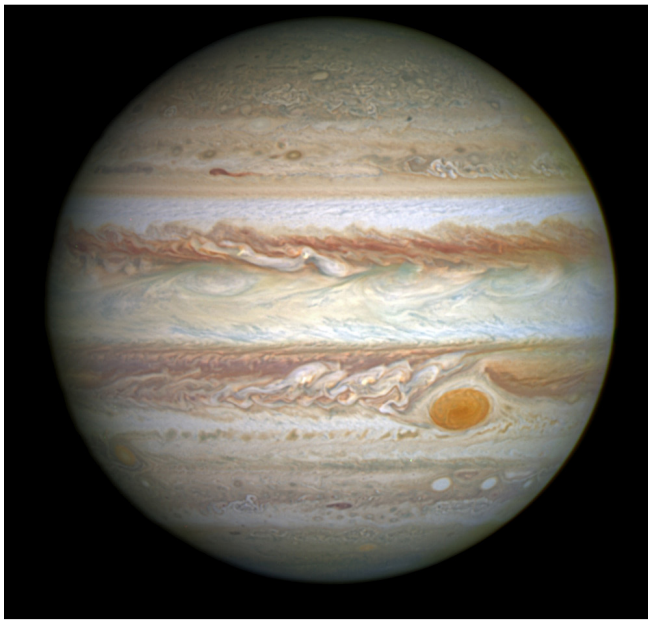
CERES — a dwarf planet in the asteroid belt

0.01 inches or 0.1 mm on our scale; too small for a bead

1. Ceres is the largest object in the asteroid belt between Mars and Jupiter. Asteroids are "space rubble," rocky remnants left over from the formation of our solar system about 4.6 billion years ago.
2. Have you heard of *planet* Ceres? After its discovery in 1801, Ceres was declared a planet. As astronomers found more objects in that part of the solar system, Ceres was re-classified as an asteroid. In 2006, Ceres was given another classification: dwarf planet. (More about dwarf planets when we visit Pluto.)
3. Visiting Ceres would be like going on a serious weight-loss diet. Even though it's the largest asteroid, Ceres is much less massive than Earth. So Ceres has much less gravity. On Ceres, a scale would show you weighing only 3% of what a scale on Earth would. Someone who's 60 pounds on Earth would weigh less than 2 pounds on Ceres.
4. On your visit to Ceres, don't expect to see other asteroids in the sky. Even though the main asteroid belt is estimated to contain millions of asteroids, they're mostly tiny and dispersed—not like they're often depicted in movies. If you combined them all into one ball, the ball would be smaller than Earth's Moon.
5. Ceres was the first dwarf planet to be explored by a spacecraft, NASA's Dawn mission.
6. In our sky: Through a telescope, you can see Ceres from Earth.
7. Our next stop is the biggest planet in our solar system.

➔ WALK 62 BIG STEPS TO JUPITER

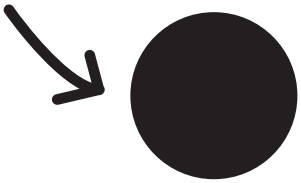
JUPITER



Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

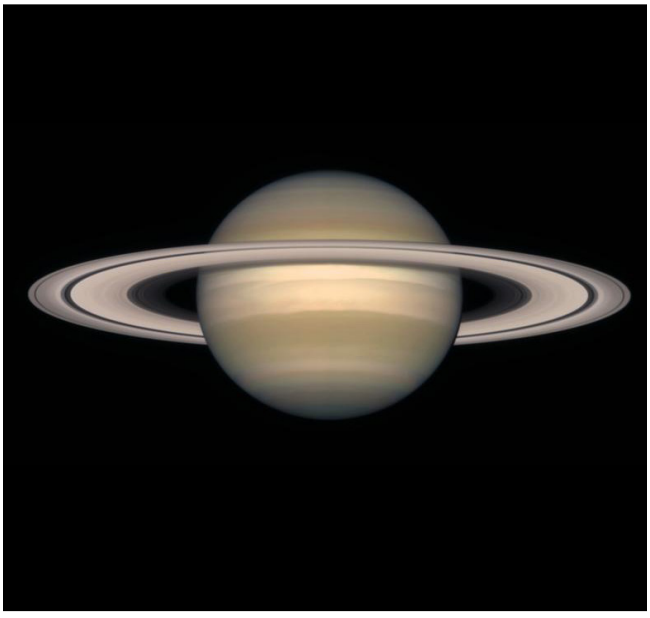
The Sun

JUPITER'S size,
where 1 inch = 100,000 miles



diameter: 0.9 in.

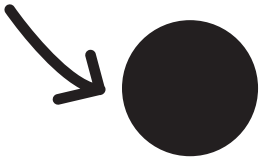
SATURN



Credit: NASA and The Hubble Heritage Team (STScI/AURA)

The Sun

SATURN'S size,
where 1 inch = 100,000 miles



diameter: 0.7 in.

JUPITER — has a storm bigger than Earth

0.9-inch or 22-mm bead

1. Named for the king of the Roman gods
2. Jupiter is a giant ball of mostly swirling gases and liquids. There's no solid surface for our spacecraft to land, and the atmosphere would poison us and crush our spacecraft.
3. The weather is terrible, too. Jupiter's Great Red Spot is a storm bigger than planet Earth.
4. Your days on Jupiter would whiz by, since each one lasts only 10 hours.
5. But the years are long. The farther away planets are from the Sun, the longer they take to complete a trip around the Sun. It takes 12 Earth years for Jupiter to complete one orbit. Ask, "Is anyone here 12 years old? You'd be celebrating your 1st birthday on Jupiter."
6. It'd take you a long time to explore Jupiter because it's so big. More than 1000 Earths could fit inside Jupiter.
7. In 2030, NASA's Europa Clipper spacecraft will reach Jupiter's moon Europa, an ocean world that may have the conditions to support life.
8. In our sky: Jupiter is very bright (describe where and when to look for it currently). A telescope can show you cloud bands on Jupiter and four of Jupiter's moons: Io, Europa, Ganymede, and Callisto.
9. Our next stop takes us to the planet in our solar system with the most spectacular ring system. (Note: Jupiter, Saturn, Uranus, and Neptune all have rings.)

➔ WALK 110 BIG STEPS TO SATURN

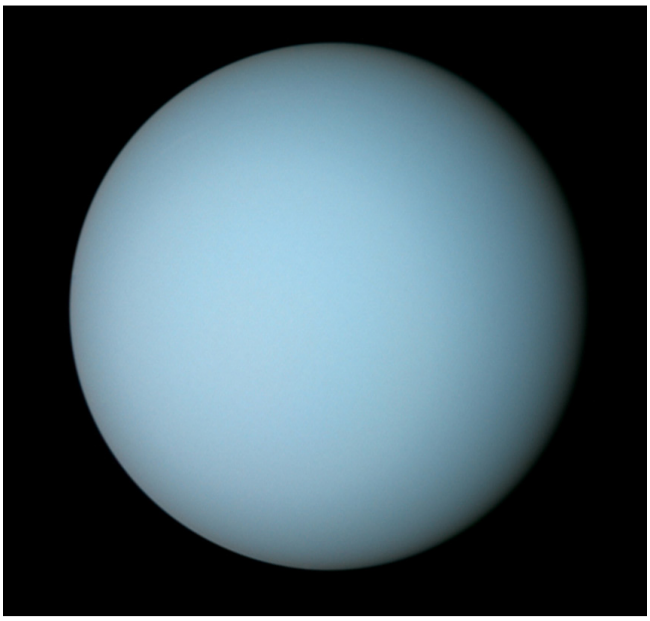
SATURN — most spectacular rings

0.7-inch or 18-mm bead

1. Named for the Roman god of agriculture
2. Visiting Saturn would be a lot like visiting Jupiter—no solid surface, poisonous and crushing atmosphere.
3. On your visit, be sure to check out the lovely rings. From Earth the rings look solid, but get close enough to them on your visit to Saturn and you'll see they're billions of individual pieces made mostly of water ice.
4. What to pack: Take with you a really, really big bathtub with water. Put Saturn in the tub. Because Saturn is less dense than water, Saturn will float. (Bad joke alert: Of course, it'll leave a ring.)
5. Be sure to visit Saturn's moon Titan, which is somewhat similar to Earth before life evolved on Earth. Titan is the only moon in our solar system with a thick atmosphere. It has methane rain and lakes, and hydrocarbon sand dunes.
6. Saturn takes 29½ years to orbit the Sun, so if you're under 29 here on Earth, you're not even 1 yet on Saturn.
7. In our sky: You can see Saturn with just the unaided eye, but use a telescope to see its rings (describe where and when to look for Saturn).
8. Our next stop takes us to a planet with an interesting name.

➔ WALK 245 BIG STEPS TO URANUS

URANUS



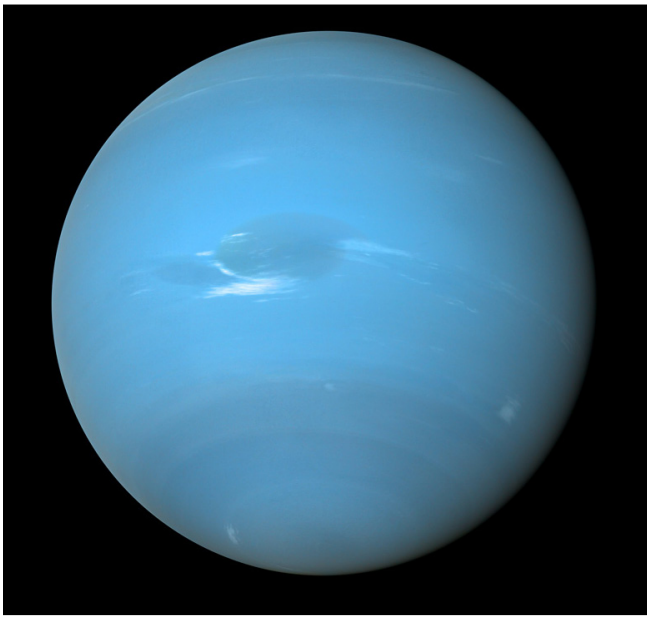
Credit: NASA / JPL-Caltech / Björn Jónsson

The Sun

URANUS' size,
where 1 inch = 100,000 miles

diameter: 0.3 in.

NEPTUNE



Credit: NASA / JPL-Caltech / Björn Jónsson

The Sun

NEPTUNE'S size,
where 1 inch = 100,000 miles

diameter: 0.3 in.

URANUS — the sideways planet

0.3-inch or 7-mm bead

1. Named after a Greek god of the sky
2. Uranus was discovered in 1781 by William Herschel. He wanted to name it "the Georgian star" after his patron, King George III. Herschel lived to be almost 84 years old, or almost exactly 1 year on the planet he discovered.
3. Uranus looks blue-green because methane in the atmosphere absorbs red light.
4. Uranus probably collided with a large object a long time ago. As a result Uranus is tilted over and rotates on its side – the "sideways planet."
5. Seasons on Uranus last more than 20 Earth years. But even if you're visiting during summer, bring warm clothes—Uranus is very, very cold.
6. In our sky: Uranus is not usually included in the list of planets visible to the unaided eye. But in fact, if you have dark enough skies and sharp eyesight, this planet can be spotted without a telescope.
7. Our next stop takes us to the planet with the fastest winds in our solar system, and our second-to-last stop.

➔ WALK 276 BIG STEPS TO NEPTUNE

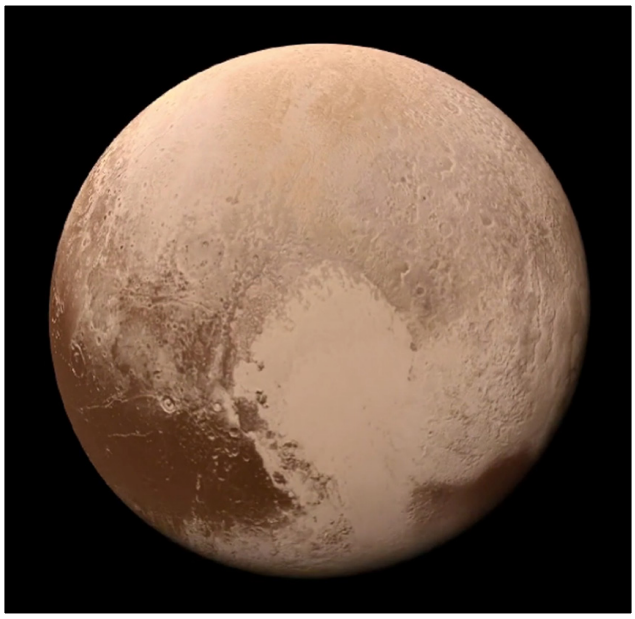
NEPTUNE — fastest winds in the solar system

0.3-inch or 7-mm bead

1. Named for the Roman god of the sea
2. Bring a windbreaker. Neptune is the windiest planet, with winds much faster than in the worst hurricanes on Earth.
3. Bring a bucket to collect some jewels. It may rain diamonds on Neptune (there may be diamonds on some other planets, too).
4. Neptune looks blue-ish because of methane in the atmosphere.
5. None of us is even 1 year old on Neptune yet. Neptune takes 165 Earth-years to complete one orbit. In 2011, Neptune finally completed its first orbit since being discovered in 1846.
6. In our sky: Neptune cannot be seen with the unaided eye.
7. Our next stop takes us into the Kuiper Belt. We'll stop for a visit at everyone's favorite former planet.

➔ WALK 240 BIG STEPS TO PLUTO

PLUTO



Credit: NASA

The Sun

PLUTO'S size,
where 1 inch = 100,000 miles

Too tiny to see but it's there!

diameter: 0.01 in.

PROXIMA CENTAURI

Credit: ESA/Hubble & NASA

The Sun

PROXIMA CENTAURI'S size, where 1 inch = 100,000 miles

diameter: 1.2 in.

PLUTO — our favorite former planet

0.01 inches or 0.3 mm on our scale; too small for a bead

1. Named by an 11-year-old girl for the Roman god of the underworld
2. Pluto was discovered in 1930 by Clyde Tombaugh at the Lowell Observatory in Arizona. Pluto was considered a planet until 2006, when the International Astronomical Union (IAU) reclassified it as a dwarf planet.
3. According to the IAU, to be a planet, you have to meet all the following criteria:
   - *You must orbit the Sun.* And you can't be someone else's satellite. ➔ Pluto not only orbits the Sun, it has several moons of its own.
   - *You must be round.* That is, you have to have enough mass for gravity to squash you into a nearly round shape. ➔ No problem, Pluto is round.
   - *You must have cleared other things out of the way of your orbital neighborhood.* ➔ This is where Pluto fails. It orbits the Sun among lots of other icy objects in the Kuiper ("KY-per") Belt.
4. Pluto is one of five recognized dwarf planets. The others are Ceres (which hasn't cleared its orbital neighborhood in the asteroid belt), Haumea, Makemake, and Eris.
5. Bring a really good winter coat on your visit to Pluto. Its average temperature is -387°F.
6. If you weigh 100 pounds on Earth, you'd weigh only 7 pounds on Pluto.
7. The New Horizons space mission launched to Pluto in early 2006, while Pluto was still a planet. Pluto is so far away that the spacecraft didn't arrive until 2015.
8. In our sky: Pluto is too tiny and far away to be seen with just your eyes. You need a big telescope.

WHILE AT THIS STOP, DISCUSS HOW FAR WE'D HAVE TO WALK TO GET TO THE NEXT STAR.

PROXIMA CENTAURI — the nearest star after the Sun

1.2 inches on our scale

1. *Hold up Sun ball.* Ask, "On our scale, how much farther do we have to walk to reach the nearest star beyond the Sun (Proxima Centauri)?" Take guesses.
2. Hand someone the Proxima Centauri Airlines ticket, and ask them to read it aloud. (The nearest star beyond the Sun, Proxima Centauri, is 4.24 light years away, meaning that it takes that star's light 4.24 years to reach Earth. That corresponds to a distance of 25 *trillion* miles. To get to Proxima Centauri on our scale [where 1 inch = 100,000 miles in reality] we'd have to travel nearly 4,000 miles—roughly the distance from North Carolina to London.)
3. Proxima Centauri is one of the stars other than the Sun known to have at least one planet orbiting it (an "exoplanet"). But don't plan a vacation to the exoplanet known as Proxima Centauri b. The star is prone to bright and frequent flares that may destroy the planet's ozone layer, which means you'd be cooked by ultraviolet radiation.
4. Proxima Centauri is too dim to be seen with the unaided eye.

INTRODUCTION TO THE SOLAR SYSTEM WALK

1. Welcome everyone and introduce your theme for the Solar System Walk: **We'll take a whirlwind vacation through our solar system.**
2. Ask your visitors, "What's the longest distance you've ever walked or hiked at once?"
3. Today, we'll hike 3.6 billion miles (6 billion kilometers) from the Sun to Pluto. We'll stop for a brief visit at each planet and dwarf planet along the way.
4. Obviously, we will need to scale things down to make the distances more manageable. We'll make a scale model of our solar system, similar to how a globe is a scale model of Earth.
5. On our scale, **1 inch in the model** (hold out your fingers an inch apart) **equals about 100,000 miles in reality.**
6. Ask for a volunteer: "Please take one big step (one yard long) . . . By taking one big step in our model, you just went 3.6 million miles through space!" [1 yard = 36 inches = 3,600,000 miles on this scale]
7. Tell your visitors the real distance they'll be walking (just over 1 mile roundtrip, if you go all the way to Pluto and back) and how long it'll take (allow up to 1 hour).
8. Explain safety rules, e.g., how you'll manage street crossings, whether you want everyone to stay together with no running ahead. Keep the small planet objects out of the hands and mouths of very young visitors.

For tips on leading this activity, refer to the Facilitator Guide. For additional interpretive information on each object, refer to NASA's Solar System Exploration website, ***https://science.nasa.gov/solar-system/*** *or to Space.com's series on living on other planets at* ***https://www.space.com/28355-living-on-other-planets.html***

CONCLUSION

1. Suggested conclusion: "I hope you've enjoyed our whirlwind vacation through our solar system. You've probably figured out that there's no place like home. Human beings can live easily only on Earth, so we'd better take care of our home planet."
2. Pass out the small handout that summarizes the solar system walk (number of steps, sizes of objects), so your participants can repeat the walk later on their own.

An optional add-on:

Show everyone a depiction of how the planets in our solar system are arranged today (Use **https://heavens-above.com/**, "solar system chart"). Designate someone to hold the Sun, and assign volunteers for each planet to place themselves in the proper locations. Don't worry about relative distances—you want everyone to be able to see and hear each other.

Questions to explore in the optional add-on:

- *Are the planets in a straight line out from the Sun?* No. We walked to the *orbit* of each object, not necessarily to the location of the object along its orbit on any one day.
- *Which planets can you see now in the sky?* You can see 5 planets with just your eyes (Mercury, Venus, Mars, Jupiter, Saturn), but from Earth's point of view, they need to have pulled away from the Sun's direction to be visible. Consider what the Earth volunteer can see from their vantage point:
  - » If, from Earth's point of view, a planet is in the same general line of sight as the Sun (either in front of or behind the Sun), that's a bad time to see that planet. The planet will be up mostly in the daytime and lost in the solar glare.
  - » If a planet is opposite the Sun from Earth's point of view, then that planet is visible all night.