Explore Jupiter's Family Secrets: JUMP TO JUPITER

OVERVIEW —

Participants jump through a course from the grapefruit-sized "Sun," past poppy-seed-sized "Earth," and on to marble-sized "Jupiter" — and beyond! By counting the jumps needed to reach each object, children experience first-hand the vast scale of our solar system.

WHAT'S THE POINT?

- The solar system is a family of eight planets, an asteroid belt, several dwarf planets, and numerous small bodies such as comets in orbit around the Sun.
- The four inner terrestrial planets are small compared to the four outer gas giants.
- The distance between planetary orbits is large compared to their sizes.
- Models can be used to answer questions about the solar system.

MATERIALS —

Facility needs:

- ☐ A large area, such as a long hallway, a sidewalk that extends for several blocks, or a football field (see Preparation section for setup options)
- ☐ A variety of *memorable* objects used to represent the Sun and planets, such as (use *Jump to Jupiter: Planet Sizes and Distances* to identify an appropriately-sized substitutes as needed):
  - ☐ 1 (4 inch) grapefruit
  - ☐ 2 (½ inch) marbles
  - ☐ 2 peppercorns
  - ☐ 2 poppy seeds
  - ☐ 3 pepper flakes
  - ☐ 1 pinch of fine sand or dust

Credit: Enid Costley, Library of Virginia

- ☐ 1 set of solar system object markers created (preferably in color) from:
  - 1 set of *Jump to Jupiter: Planet Information Sheets* OR
  - Posters created by the participants OR
  - Optional: 1 set of Our Solar System lithographs (NASA educational product number LS-2013-07-003-HQ): http://solarsystem.nasa.gov/docs/000-SolarSystemLithosCombined_Rev1_FC.pdf
- ☐ 12 (3') stakes or traffic cones or sign stands

For each child:

- ☐ 1 *Jump to Jupiter poem*
- ☐ 1 pencil or pen

For the facilitator:

- ☐ Measuring wheel
- ☐ 1 meter- or yard-stick

- ☐ Mallet or heavy object (for placing stakes in the ground)
- ☐ Tape
- ☐ Examples of the objects used in the solar system scale model course:
  - ☐ 1 (4 inch) grapefruit
  - ☐ 2 (½ inch) marbles
  - ☐ 2 peppercorns
  - ☐ 2 poppy seeds
  - ☐ 3 pepper flakes
  - ☐ 1 pinch of fine sand or dust
- ☐ *Jump to Jupiter: Planet Sizes and Distances*

Participants use one-meter jumps or very large steps to measure the distances between markers. Credit: Lunar and Planetary Institute

PREPARATION —

- Determine how many planets your space accommodates before you start.

- Set up a solar system course using *Jump to Jupiter: Planet Sizes and Distances*
  - It does not have to be in a straight line. The course may fold back on itself. (Uranus is half way between the Sun and Pluto, so have the participants turn back at the Uranus marker.)
  - *You do not have to use all the planets!* You can modify the course by using only the inner planets and Jupiter.
  - It is helpful to have the grapefruit "Sun" visible at the beginning of the course.
  - Mark each object's position with a stake, traffic cone, or sign stand.

- Alternatively, create your own larger or smaller course; use the Exploratorium museum's online calculator (http://www.exploratorium.edu/ronh/solar_system) to determine the scaled sizes and distances of the planets. A larger course will make the planets larger and easier to see; a smaller course may fit in tighter location.

- Another alternatively, invite the participants create their own course! Provide children ages seven and up with solar system information and materials to create the markers, and ask tweens and teens to determine the scaled sizes of the solar system objects, as well as their relative distance from the Sun.

- Attach the information sheet or lithograph for each solar system object to the appropriate stake, traffic cone, or sign stand.

ACTIVITY —

1. **Share ideas and knowledge.**
   - Frame the activity with the main message: Space is full of…SPACE!
   - Explain that the participants will use a scale model to explore the distances between solar system objects. Use open-ended questions and invite the participants to talk with you and each other about their prior experiences with scale models.

   - Invite the participants to offer questions to the group about planets, the dwarf planets Ceres and Pluto, and asteroids in our solar system. As the participants name the different objects, ask them to choose the best representative — based on size — from the beads, salt crystals, etc. that were used to construct the solar system course.

As much as possible, encourage the participants to offer information and questions. This model can be used to answer questions such as:

- How do the planets compare in size?
- How does big does the Sun appear to be from Earth? From Jupiter?
- How does the distance between the Sun and Pluto compare to the distance between the Sun and the next closest star system (Alpha Centauri)?
- Which destination is closer for a spacecraft: Venus or Mars?
- Are some planets closer together than others?
- Could an accurate model of the solar system fit on my bookshelf at home?

2. **Guide the participants as they explore the solar system scale model to answer their questions.** Optional: If the distances are large, have facilitators at each marker to guide the children with questions and information and keep them moving to other markers.
   a. Leave the "Sun" at the beginning of the course for their reference.
   b. Provide the meter- or yard-stick for the children to practice jumping that length.
   c. Offer the "Jump to Jupiter" poem and pencils or pens. Ask the children to count the total number of (one-meter) jumps from the Sun it takes to get to each marker. Explain that the poem has a place for them to enter each distance.
   d. Suggest that the participants find information about each solar system object by reading the signs.

Engage participants at the markers with questions such as:

- How many jumps did it take to arrive at this planet (or asteroid belt or Pluto)?
- How big does the grapefruit "Sun" look from here? Imagine what the real Sun would look like in the sky of this planet/dwarf planet!
- What do you think is happening to the temperature as you travel further away from the Sun?
- At the last marker of the course, compare the immense scale of our solar system to the even larger distances to other stars. At this scale, Alpha Centauri A would be slightly larger than a grapefruit and about 1,800 miles (3,000 kilometers) away — roughly the distance between Washington, D.C. and Mexico City!

3. **Have the participants describe what they discovered by exploring the model.**

4. **Remind the participants that the model isn't perfect.** In space, the planets are in motion as they orbit the Sun. Only rarely do four or more planets "line up." Have them imagine the circles that each planet would trace! Or, if desired, invite a few participants to carry a selection of planet models in large circles around the "Sun" to demonstrate their orbits.

5. **Conclude.** Draw on the participants' discoveries to summarize the experience, including:
   - Space is full of…SPACE! The planets are small compared to the Sun, and they are spread far, far apart.
   - Jupiter is the largest planet.
   - Ceres is the largest asteroid in the asteroid belt, but it is smaller than Pluto and much smaller than the planets.
   - The inner terrestrial planets — Earth, Mercury, Mars, and Venus — are relatively close together. Venus is Earth's closest neighbor (after the Moon). The giant planets (Jupiter, Saturn, Uranus, and Neptune) get farther and farther apart.
   - There is an enormous distance between the Sun and even the closest stars.
   - Temperatures can reach a scalding 800°F (425°C) on Mercury and even warmer on Venus (850°F!) due to its thick atmosphere. After Earth's balmy –125 to 130°F (-87 to 54°C), the

temperatures begin to plummet rapidly. It is –234°F (–145°C) at Jupiter's cloud tops, and a frigid –387°F (–233°C) on Pluto.

- From each marker, the grapefruit "Sun" will look just like it does in the sky of that object. From "Earth," *the real Sun appears to take up half a degree (or arc) in the sky. The grapefruit "Sun" appears to be the same size; it can be covered with a pinkie finger held at arm's length.*

CORRELATION TO STANDARDS

Next Generation Science Standards

Disciplinary Core Ideas:

ESS1.B: The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

Science and Engineering Practices

- Developing and Using Models: Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).
- Developing and Using Models: Identify limitations of models.
- Analyzing and Interpreting Data: Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
- Using Mathematics and Computational Thinking: Use counting and numbers to identify and describe patterns in the natural and designed world(s).

Crosscutting Concepts

- Patterns: Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
- Scale, Proportion, and Quantity: Natural objects exist from the very small to the immensely large.
- Scale, Proportion, and Quantity: Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale.

The Nature of Science

- Scientific Investigations Use a Variety of Methods: Science investigations use a variety of methods and tools to make measurements and observations.

Jump to Jupiter!
Planet Sizes and Distances

The chart below gives the scaled sizes and distances of the planets, Pluto, and asteroid belt if the Sun was the size of a softball or grapefruit. One very large jump is roughly equal to a meter. As you can see, most of space is just that, SPACE! It gets awfully cold out there as you travel away from the Sun!

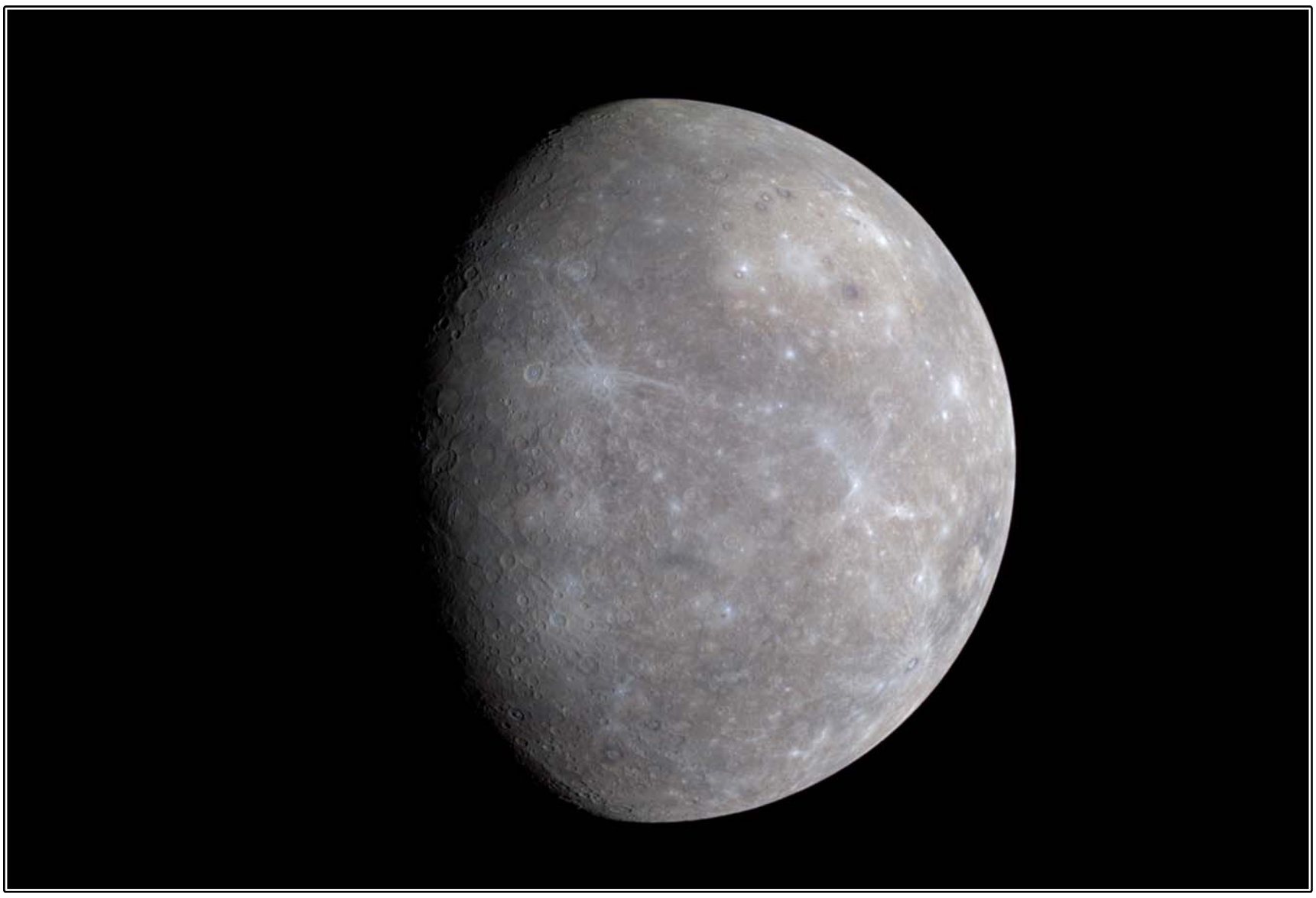
	Scaled Diameter (reduced by a factor of 10 billion)	**Scaled Average Distance from Sun** (reduced by a factor of 10 billion)	**Approximate Total Number of Jumps from Sun**
Sun	5.5” (14 cm) (softball or grapefruit)	-	-
Mercury	0.02” (0.049 cm) (pepper flake)	5.8 m	6
Venus	0.05” (0.12 cm) (poppy seed)	10.8 m	11
Earth	0.05” (0.13 cm) (poppy seed)	15.0 m	15
Mars	0.03” (0.068 cm) (pepper flake)	22.8 m	23
Ceres (Asteroid Belt Object)	0.004” (0.1 mm) (dust)	41.4 m	41
Jupiter	0.5” (1.4 cm) (marble)	77.8 m	78
Saturn	0.5” (1.2 cm) (marble)	142.4 m	142
Uranus	0.2” (0.51 cm) (peppercorn)	287.1 m	287
Neptune	0.2” (0.50 cm) (peppercorn)	449.8 m	450
Pluto	0.023 cm (pepper flake)	590.6 m	600

Jump to Jupiter!

I'm the one star in this special place. You'll find me in the center. Just guess my name to start this game, Then you may surely enter……	Star's name: _____ Total jumps: _____
I orbit fast, but s l o w l y turn, With a 1,400-hour day! I'm the first. My name is _____, I'm small and I am gray.	Total jumps: _____
Because my ghastly atmosphere is mainly CO_2, It's like a scorching greenhouse of 900 degrees. It's true! My name is _____, I'm yellow and the hottest, And all I can say is, "Whew!"	Total jumps: _____
I'm glad I'm home to boys and girls, Even though I do seem "blue", I'm planet_____. and a little larger than Venus (that's your clue!)	Total jumps: _____
I'm reddish-rust, with rocks and dust And a 24-hour day. I'm _____ and I am close in size To Mercury, I'd say!	Total jumps: _____

I'm a band that's full of rocks and dust That travel in between the inner and outer solar system's planetary scene. And because I'm a band of asteroids, I felt, I should be called the _____ _____.	Total jumps: _____
I'm full of gas, with colorful stripes, And a really enormous girth. I am mighty _____ and I'm over ten times as wide as Earth!	Total jumps: _____
I'm yellow and my ammonia haze covers each and every thing. I'm _____and my beauty's found within my icy rings!	Total jumps: _____
Methane gas colors my atmosphere blue. My axis is tilted so I spin on my side. I'm_____! Next to Saturn, I'm small, Compared to neighbor Neptune, I'm a little wide.	Total jumps: _____
It takes me over sixty thousand days to go one whole year through! I'm the last giant planet. I'm _____, and just a little darker blue.	Total jumps: _____
With comets and other dwarf planets I orbit in an oval path Count the miles to get to _____ — It will take a lot of math!	Total jumps: _____

Mercury



MESSENGER, a recent robotic explorer, was able to show us this side of Mercury, which we've never seen before. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.

Fun facts:

- Mercury is the smallest planet in our solar system - only slightly larger than the Earth's Moon.
- Mercury has a solid, cratered surface, much like the Earth's Moon.
- Mercury has a huge core! The width (diameter) of the core is approximately 75% of that of the entire planet (Earth's is about 54%).
- Mercury does not have any moons or rings.

Robot explorers:

- *Mariner 10* – flew by Mercury three times in 1974-1975, giving us our first glimpse of the innermost planet in the solar system. The same side of Mercury was sunlit during the flybys, so Mariner 10 only saw one side of the planet.
- *MESSENGER* – launched from Earth in 2004, the MESSENGER spacecraft flew past Mercury three times before going into orbit around Mercury in 2011. It was the first spacecraft to orbit Mercury, providing pictures and data from all over the planet.

Distance: 36 million miles (58 million km) from the Sun.

Venus

Because we cannot see beneath Venus' clouds, scientists use radar to learn about the surface. They then used computers to make radar information into this global picture of Venus. Credit: NASA/JPL.

Fun facts:

- Venus' thick and toxic atmosphere is made up mostly of carbon dioxide (CO_2) and nitrogen (N_2), with clouds of sulfuric acid (H_2SO_4) droplets.
- Venus is the hottest planet in the solar system. Its surface experiences extremely high temperatures of almost 480°C (900°F), more than hot enough to melt lead!
- Venus spins backwards (retrograde rotation) when compared to the other planets. This means that the Sun rises in the west and sets in the east on Venus.

Past robot explorers:

- *Mariner 2* – flew by Venus in 1962, becoming the first spacecraft to send back information from another planet.
- *Magellan* – in orbit around Venus from 1990 to 1994, it mapped 98% of the Venusian surface using radar.
- *Venus Express* – European Space Agency mission that arrived in orbit around Venus in 2006 and studied the atmosphere and surface of Venus until 2015.

Future robot explorers:

- *Akatsuki / PLANET-C* – Japan Aerospace Exploration Agency mission that will study the atmospheric circulation of Venus.

Distance: 67 million miles (108 million km) from the Sun.

Earth

A 'Blue Marble' image of the Earth taken from the VIIRS instrument aboard NASA's Earth-observing satellite Suomi NPP. This global picture of the Earth's surface was created using many pictures taken by the satellite. From orbit, it is easy to see features relatively unique to Earth: our atmosphere (the clouds) and liquid water on the surface (everywhere that's blue). Credit: NASA/NOAA/GSFC/Suomi NPP/VIIRS/Norman Kuring.

Fun facts:

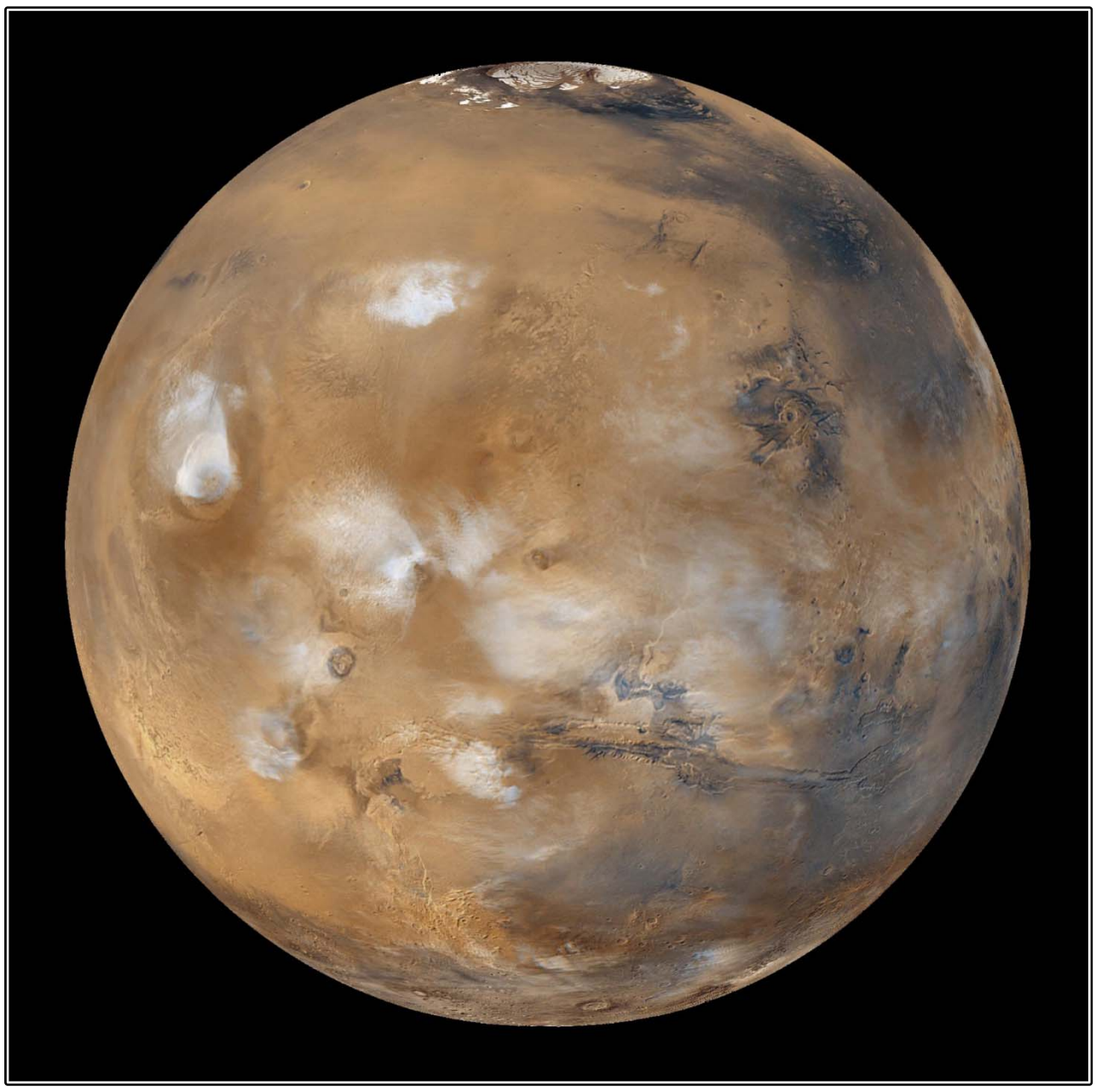
- Earth is a rocky planet, also known as a terrestrial planet, with a solid and constantly changing surface of mountains, valleys, canyons, plains, and much more.
- Earth is different from other terrestrial planets in our solar system because it has oceans. Seventy percent of our planet is covered in water.
- Earth is the only place in the universe known to harbor life.

Current robot explorers:

- *Landsat* – Landsat spacecraft have been photographing Earth for over 40 years. Such a long record of images is useful for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also used for emergency response and disaster relief.
- *Orbiting Carbon Observatory 2 (OCO-2)* – studies atmospheric carbon dioxide.
- *Soil Moisture Active Passive (SMAP)* – measures soil moisture and freeze/thaw cycles.

Distance: 93 million miles (150 million km) from the Sun.

Mars



Twelve orbits a day provided the Mars Global Surveyor MOC wide angle cameras a global "snapshot" of weather patterns across the planet. Here, bluish-white water ice clouds hang above the Tharsis volcanoes. Credit: NASA/JPL-Caltech/MSSS.

Fun facts:

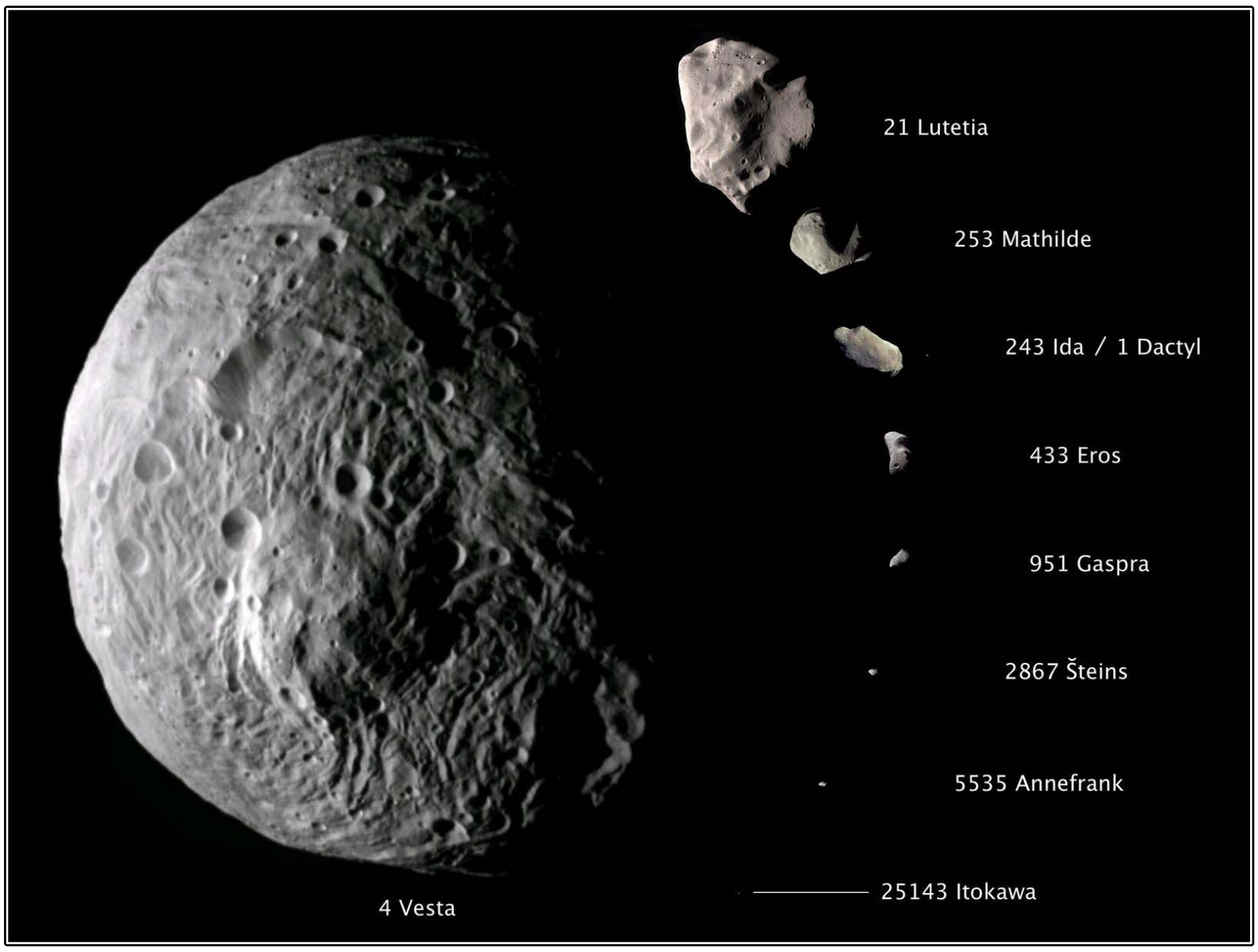
- Mars' solid surface has been altered by volcanoes, impacts, crustal movement, and dust storms.
- At this time in the planet's history, Mars' surface cannot support life as we know it. Current robot explorers studying Mars on the surface and from orbit are determining Mars' past and future potential for life.
- Mars has two moons named Phobos and Deimos.
- Mars is known as the Red Planet because iron minerals in the Martian soil oxidize, or rust, causing the soil – and the dusty atmosphere – to look red.

Current robot explorers:

- *Curiosity* – demonstrated new heavy-load Mars landing technologies, found ancient Mars could have had the right chemistry to be a suitable home for life, and found evidence that water once flowed knee-deep in an ancient streambed in Gale Crater.
- *Mars Reconnaissance Orbiter (MRO)* – in orbit around Mars since 2005, it has revealed that Mars is a world more dynamic and diverse than was previously realized.
- *MAVEN* – studies Mars' atmosphere to determine the history of Mars' atmosphere and climate and liquid water.

Distance: 142 million miles (228 million km) from the Sun.

Asteroids



This composite image shows the comparative sizes of nine asteroids. Vesta, which is also considered a protoplanet because it's a large body that almost became a planet, dwarfs all other small bodies in this image, with its diameter sizing up at approximately 330 miles (530 km). Credit: NASA.

Fun facts:

- Asteroids are solid, rocky, irregular bodies that do not have atmospheres.
- More than 150 asteroids are known to have a small companion moon (some have two moons). The first discovery of an asteroid-moon system was of asteroid Ida and its moon Dactyl in 1993.
- Asteroids that pass close to Earth are called near-Earth asteroids (NEOs).

Current robot explorers:

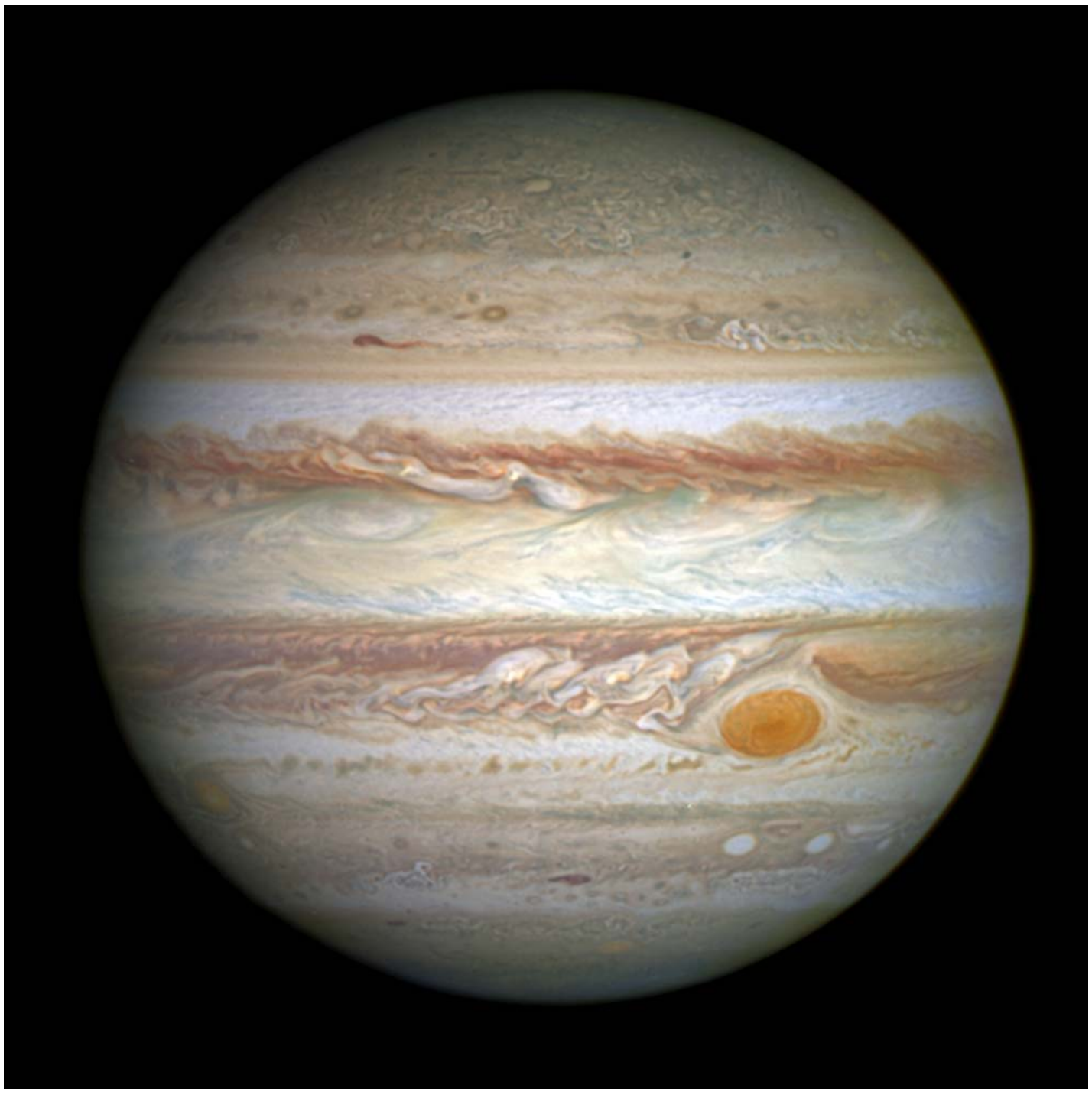
- *Dawn* – orbited large asteroid Vesta for one year before traveling to dwarf planet Ceres, becoming the first spacecraft to orbit two bodies and the first to visit a dwarf planet.
- *Hayabusa 2* – Japan's Hayabusa 2 is designed to study asteroid 1999 JU3 from multiple angles, using remote-sensing instruments, a lander and a rover. It will collect surface and possible subsurface materials and return the samples in a capsule to Earth for analysis.

Future robot explorers:

- *OSIRIS-REx* – launching in 2016, it will use a robotic arm to pluck samples from an asteroid to help better explain our solar system's formation and how life began.

Distance: 197 million miles (329 million km) to 287 million miles (479 million km) from the Sun.

Jupiter



Jupiter's monster storm, the Great Red Spot, was once so large that three Earths would fit inside it. But new measurements by NASA's Hubble Space Telescope reveal that the red spot, which has been raging for at least a hundred years, is only the width of one Earth. Credit: NASA/ESA/A. Simon (Goddard Space Flight Center).

Fun facts:

- Everything visible on the planet is a cloud. The parallel reddish-brown and white bands, the white ovals, and the large Great Red Spot persist over many years despite the intense turbulence visible in the atmosphere.
- Jupiter's width (diameter) is eleven times that of Earth, so even its smallest storms are comparable in size to the largest hurricanes on Earth.

Past robot explorers:

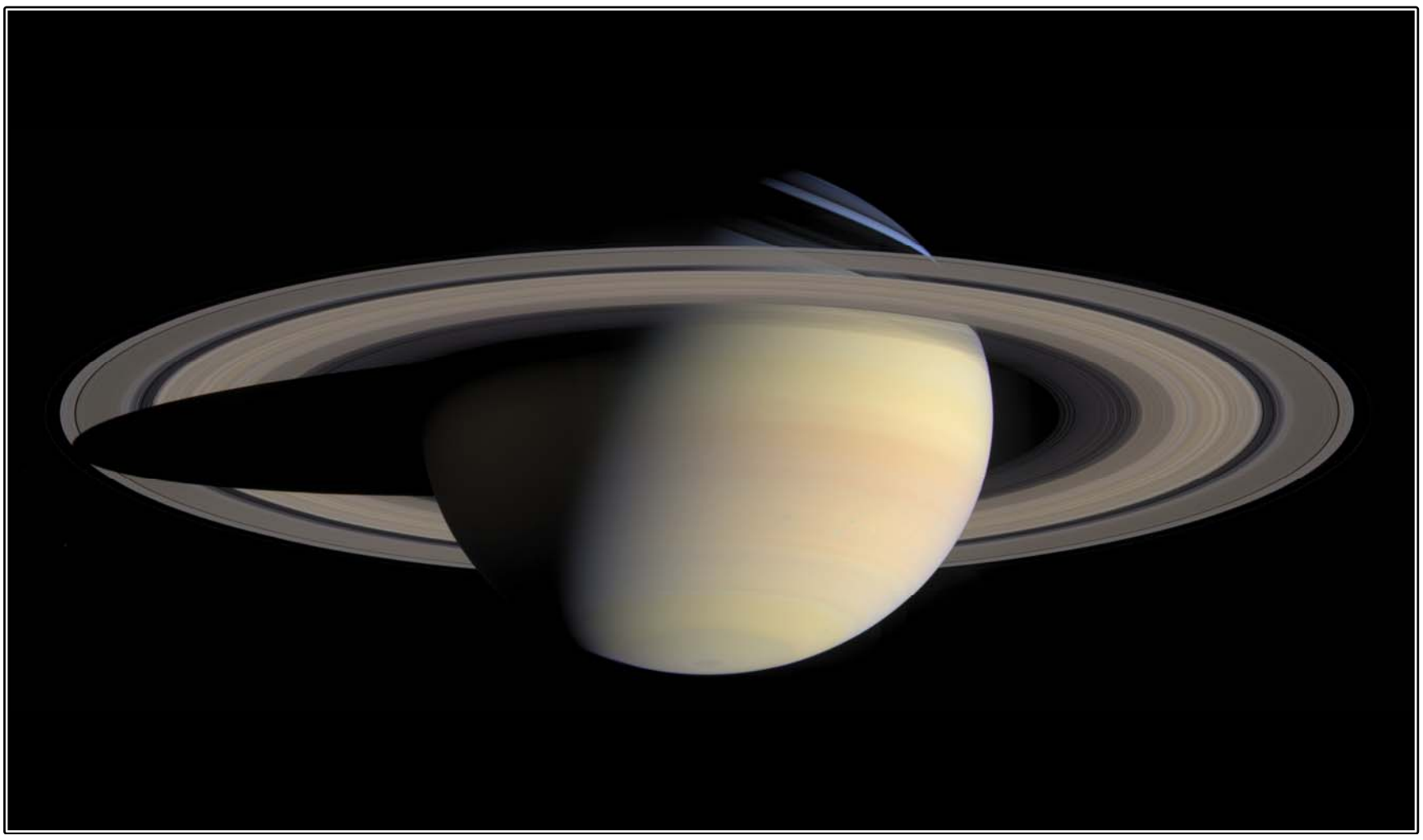
- *Galileo* – the first spacecraft to orbit Jupiter, Galileo discovered an intense radiation belt above Jupiter's cloud tops.

Future robot explorers:

- *Juno* – arriving in orbit around Jupiter in 2016, it will observe Jupiter's gravity and magnetic fields, atmospheric dynamics and composition, and the coupling between the interior, atmosphere and magnetosphere that determines the planet's properties and drives its evolution.

Distance: 483 million miles (778 million km) from the Sun.

Saturn



This global picture of Saturn and its rings was created using many pictures taken by the Cassini spacecraft over many orbits. In this picture, Saturn blocks the light from the Sun, casting a shadow on the rings behind the planet. Credit: NASA/JPL/Space Science Institute.

Fun facts:

- Saturn's atmosphere is made up mostly of hydrogen (H_2) and helium (He).
- Saturn has 53 known moons with an additional nine moons awaiting confirmation of their discovery – that is a total of 62 moons!
- Saturn has the most spectacular ring system of all the giant planets, which is made up of seven rings with several gaps and divisions between them.
- When Galileo Galilei was observing the planet Saturn in the 1600s, he couldn't see the rings clearly. At first, he thought the rings were two other planets next to Saturn and drew them in his notes. Later, he thought Saturn was a planet with arms or handles. These "handles" were, in fact, the rings of Saturn.

Past robot explorers:

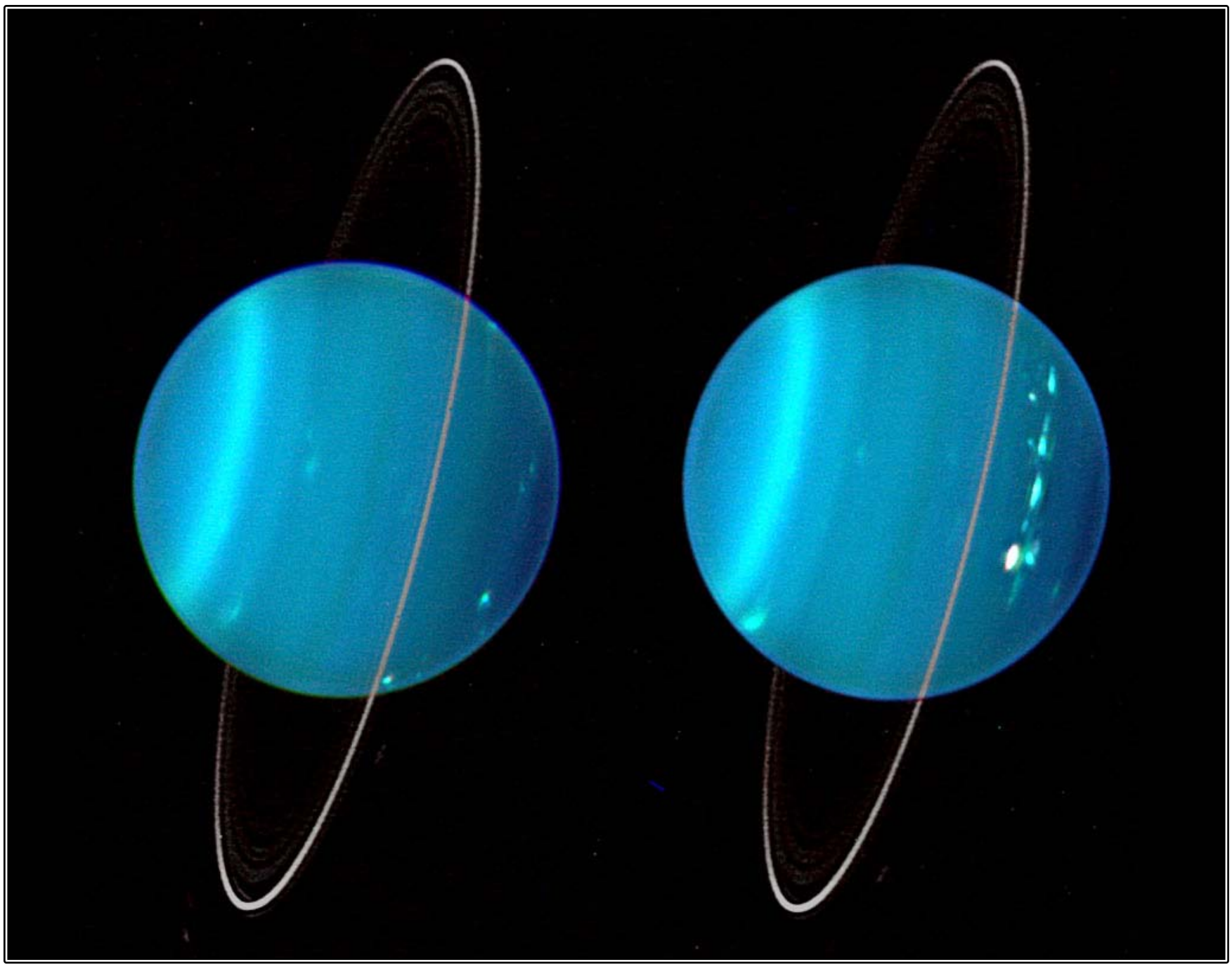
- *Huygens* – a European Space Agency mission, the Huygens lander became the first spacecraft to land on a moon of another planet when it touched down on the surface of Titan, Saturn's largest moon, in 2005.

Current robot explorers:

- *Cassini* – the first spacecraft to orbit Saturn, it provided us with the first detailed information about Saturn and its family of moons and rings.

Distance: 886 million miles (1.4 billion km) from the Sun.

Uranus



Infrared images of the two hemispheres of Uranus were combined to make this picture showing the cloud bands and storms raging on Uranus. Also visible are the planet's rings, showing how Uranus is tilted on its side. Credit: Lawrence Sromovsky, University of Wisconsin-Madison/ W.W. Keck Observatory.

Fun facts:

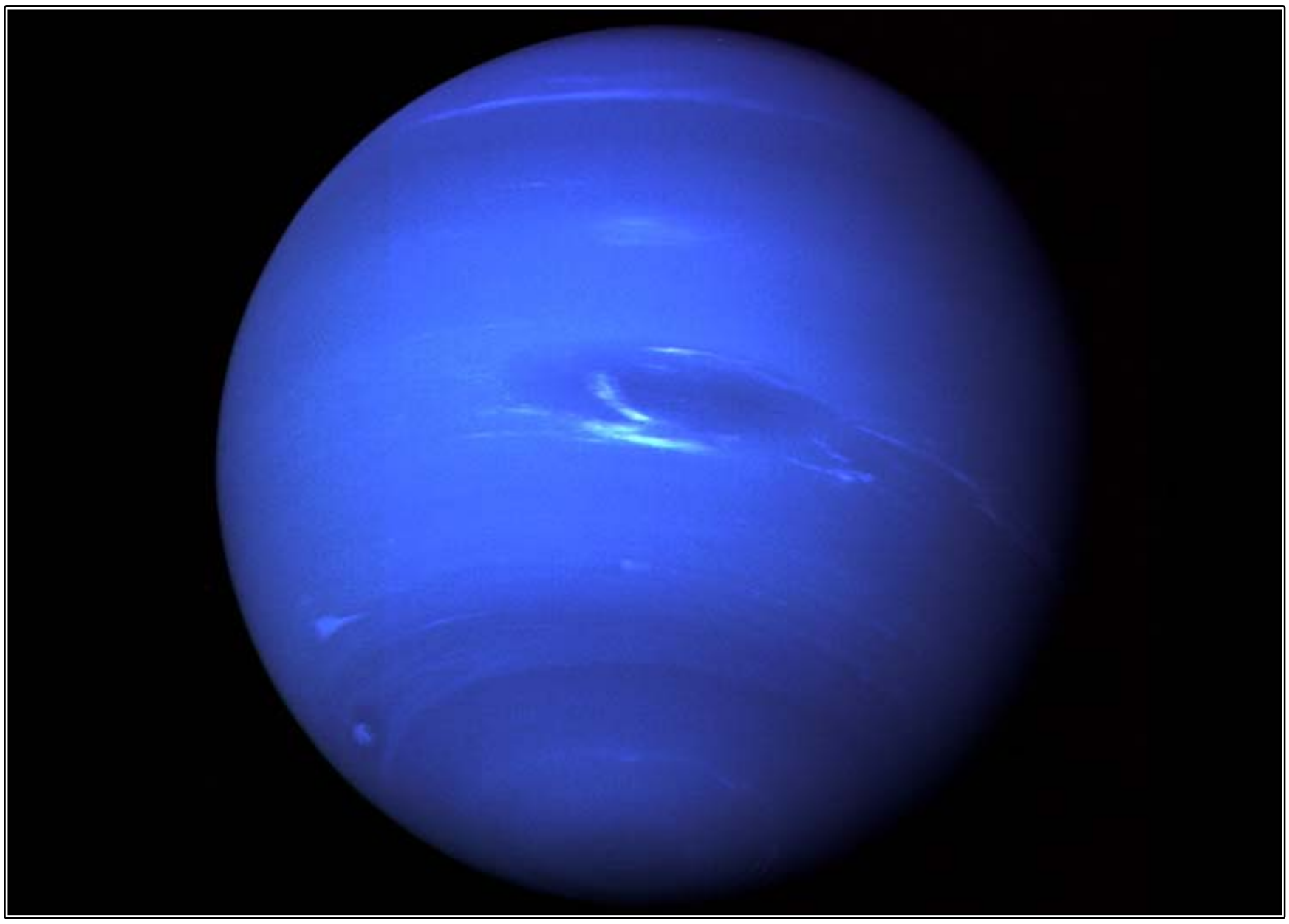
- Long ago, a giant object may have hit Uranus and changed its rotation. This causes Uranus to spin backwards, like Venus. Unlike any of the other planets, Uranus rotates on its side, which means it rolls like a ball, rather than spins like a top.
- Uranus has 13 known rings. The inner rings are narrow and dark and the outer rings are brightly colored.
- Uranus has 27 moons. Uranus' moons are named after characters from the works of William Shakespeare and Alexander Pope.
- Uranus has a blue tint caused by a small amount of methane (CH_4) in its atmosphere, which is mostly made up of hydrogen (H_2) and helium (He).

Past robot explorers:

- *Voyager 2* – the only spacecraft to have flown by Uranus, it discovered evidence of an ocean of boiling water about 480 miles (800 km) below the cloud tops. The spacecraft discovered ten new moons and two new rings.

Distance: 1.8 billion miles (2.9 billion km) from the Sun.

Neptune



Neptune has a large storm called the Great Dark Spot. Scientists named the fast-moving bright feature "Scooter." Credit: NASA.

Fun facts:

- Neptune's atmosphere is blue because of methane (CH_4) and is made up mostly of hydrogen (H_2) and helium (He).
- Neptune has 13 moons. Neptune's moons are named after various sea gods and nymphs in Greek mythology.
- Neptune has six rings.
- Sometimes, during the course of Neptune's orbit, dwarf planet Pluto is actually closer to the sun, and us, than Neptune. This is due to Pluto's unusual elliptical (egg-shaped) orbit.
- One year on Neptune lasts 165 Earth years. One Neptune day lasts 16 hours.

Past robot explorers:

- *Voyager 2* – the only human-made object to have flown by Neptune, it passed less than 3,000 miles (5,000 km) above the planet's cloud tops in the closest approach of its entire tour. It discovered five moons, four rings, and a "Great Dark Spot" that vanished by the time the Hubble Space Telescope imaged Neptune five years later. Neptune's largest moon, Triton, was found to be the coldest known planetary body in the solar system, with a nitrogen ice "volcano" on its surface.

Distance: 2.8 billion miles (4.5 billion km) from the Sun.

Pluto

Pluto has many colors on its surface, which are darkened in this picture to make them easier to see. Scientists are working to understand what caused these different features. Credit: NASA/JHUAPL/SwRI.

Fun facts:

- Pluto has five known moons. Its largest moon, Charon, orbits very close to Pluto.
- Pluto has a thin atmosphere that expands when it comes closer to the sun and collapses as it moves farther away – similar to a comet.
- Pluto is about two-thirds the diameter of Earth's Moon.
- Pluto was considered a planet from 1930, when it was first discovered, until 2006. Scientists discovered many worlds that, like Pluto, orbit far from the Sun. Scientists decided to call Pluto, Ceres, and other similar small worlds “dwarf planets.”
- One day on Pluto takes about 153 hours. Pluto makes a complete orbit around the Sun (one year on Pluto) in about 248 Earth years.

Past robot explorers:

- *New Horizons* – flew through the Pluto system in 2015, becoming the first and only spacecraft to explore Pluto up close. The spacecraft will travel to other distant worlds in the coming years.

Distance: 3.7 billion miles (5.9 billion km) from the Sun.