Sorting the Solar System

Activity C4

Grade Level: 3–12

Source: This activity was written for this new edition of the *Universe at Your Fingertips*, by Alice Gift Enevoldsen (Pacific Science Center) and Anna Hurst Schmitt (Astronomical Society of the Pacific). It is presented here for the first time.

What's This Activity About?

Branches of science often begin by organizing things into categories — whether it is birds, bones, particles, or planets. Choosing the right categories can be essential to making progress. On the other hand, science in our schools is often taught as if the categories in any branch of science were ordained by supernatural authorities rather than created by the human mind. This activity helps students come up with their own categories for the members of our solar system.

What Will Students Do?

Through a card sorting activity, students explore some of the different objects in the solar system and create their own categories for organizing them. They then have a discussion about how they chose their categories and what categories scientists currently assign to each object.

Tips and Suggestions

- The hardest part of this activity for the teacher (and for knowledgeable students) is not to be prejudiced by existing categories, but to keep an open mind. Give students frequent permission to make their own categories and not the ones they may have read about in books or seen on TV or the web.
- Printing out and laminating a sufficient number of card sets the first time can be costly or time consuming. You may want to get parents who have good printers at home to help you with this.

What Will Students Learn?

Concepts

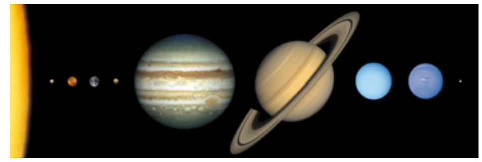
- Planets in the solar system
- Planets versus dwarf planets
- Asteroids and comets

Inquiry Skills

- Classifying
- Describing
- Organizing
- Explaining
- Comparing

Big Ideas

- Diversity and unity
- Systems



Sorting the Solar System

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Type of Activity:	Card sorting, discussion
Set up Time:	20 minutes first time; 5 minutes after that
Time to Do:	30 minutes to 1 hour
Age:	3rd–8th grade, can be adapted for high school and adults

Through this card sorting activity, students explore some of the different objects in the Solar System and create their own categories for organizing them. They then have a discussion about how they chose their categories and what categories scientists currently assign to each object.

Materials

- For each group of 3–4 students you will need one set of 44 color Solar System Cards (see section 6 on *The Universe at Your Fingertips* disk to print your own.)
- Paper and pencils for recording categories and criteria

Background Information

The Solar System (from Sol, meaning Sun in Latin) includes all the objects that share the Sun's "neighborhood." There are six types of objects represented on the cards: star, planet, dwarf planet, moon, comet, and asteroid. These categories are defined below under "Suggestions for Wrapping Up the Activity".

The list of which category each object on the cards fits in, as well as some additional information about each object, is provided beginning on page 6. This is for the teacher's use — do not distribute this list to students before they complete this activity, since we want students to invent their own categories.

You can consult the resources at the end of this lesson plan for more information about the classification of solar system objects.

Setting Up the Activity

The first time you do this activity, you will need to print out a set of Solar System Cards. Print the cards in color (if possible) and double-sided so that the corresponding card fronts and backs line up. There are four cards per sheet, so you can use a paper cutter to cut the cards down the middle along the length and along the width. Or you can just print each master sheet separately, and then glue the front and back of each card to an index card of piece of cardboard. There is also a page of blank cards so that you can add your own favorite objects or new images as more discoveries are made. (See the guide to where to find good planetary images at the end.)

Suggestions for Introducing the Activity

Ask students if they can tell you what the Solar System is. Note that many students do not understand the differences between the Solar System, the Milky Way Galaxy (and other galaxies), and the Universe. You might ask a trick question: How many stars are in the Solar System? You may receive answers of "Millions!" or "Billions!" but the answer is in fact just one: our Sun is the only star in the Solar System. Explain that the Solar System consists of the Sun and all of the objects that orbit it.

Tell the students that they will be looking at images and learning information about many different objects in the Solar System and that their job will be to organize the pictures into groups that are similar in some way. Do not mention the categories astronomers use before starting the activity unless the students mention them themselves. Students often think there is one "right" classification system, so they should not start out the activity with any kind of bias about what system might be "right".

Doing the Activity

Distribute a set of 44 Solar System Cards to each group of 3–4 students. Together, students should first sort their cards into a number of groups using whatever criteria they choose, and then list the criteria they used to create the categories. They can use the image on the front of the card and the information on the back. The idea behind the criteria is that, if they were given a new object, they should easily be able to place it into one of the categories.

Emphasize that students must be able to identify and explain the criteria for each category — "because it is" or "because I learned it that way" are tempting to use, but not enough. If students need a place to start, you could suggest they consider appearance, size, distance from the Sun, composition, or some combination of these. Encourage students to invent their own categories, rather than using names they have already heard about. For example, they might create a "lumpy potato-like" category, rather than "asteroids". Students probably know that Jupiter and Mars are both planets, but challenge them to consider the information on the cards before putting them together in a single category. If students ask how many categories they should have, let them know it is up to them, based on the criteria they choose to sort the objects.

If students ask why they are not getting more guidelines, you might point out that you want them to act like scientists. When scientists discover something new — a new kind of astronomical object or a new species of insect, they can't "look up the right category" or ask a teacher. They must come up with a classification and then see if other scientists agree with their choice.

Students may ask why some of the images are fuzzy or pixilated. Explain that some of the objects are relatively small and very far away, so it is difficult to take a clear picture of them. With those objects, as with the others, the students should use the other information on the back of the cards in addition to the images to help them create categories.

Circulate among the groups as they work on their classifications. As they finish a group, ask them about the reasoning they used to create that category. Encourage them to try out a variety of different classification systems. Remember, students may think there is a single "right" answer and may be reluctant to try different systems once they have settled on one.

After they have finished sorting, you can facilitate a discussion with students about their categories and how they chose them. Ask a few groups to share their categories and write a few on the board. What criteria did they use? Were there other criteria they could have used? Were there any objects that didn't quite fit into any category? Are there categories that have only one object? Is that a problem or is it acceptable? Choose a few cards and ask a group in which of their categories the objects belong. Remember to emphasize that there is no single "right" answer. Some objects you might use to challenge students are: Dactyl, Eris, and Shoemaker-Levy 9.

Suggestions for Wrapping Up the Activity

Once students have finished sharing and discussing their own categories, you can lead a discussion of how scientists currently classify these objects. Explain that in many sciences there are collections of objects that get sorted and classified: birds, plants, bacteria, rocks, etc. Scientists come up with lists of questions or criteria to help determine which group an object will ultimately belong to. As new objects are discovered, these questions can help decide if they are like other things that we already know or if they are different.

Sometimes new discoveries make us think about our definitions in new ways, so that sometimes revisions need to be made. The discovery of Eris (early on referred to as the "tenth planet") forced astronomers to give a fresh look at their definition of a planet and make revisions. As they discover ever more planets around other stars, some of them different from the kinds of planets we know in the Solar System, they may have to revise the definition again.

The current categories (as of 2010) for the objects in the Solar System are as follows. These categories are defined by the International Astronomical Union (IAU), which is an international body of astronomers from many countries.

Star — A star is a giant ball of gas that gives off energy (light) due to thermonuclear reactions. Our Sun is the only star in the Solar System, but is one of about 200 billion stars in the Milky Way Galaxy.

Planet — A planet is a celestial body that
(a) is in orbit around the Sun,
(b) has enough mass to be nearly spherical in shape, and
(c) has cleared out the neighborhood around its orbit

of objects like itself.

Dwarf Planet — A "dwarf planet" is a celestial body that

(a) is in orbit around the Sun,
(b) has enough mass to be nearly spherical in shape,
(c) has not cleared the neighborhood around its orbit (that is, it shares its orbital neighborhood with other objects like it)

Moon / Satellite — A satellite (moon) is an object that orbits another object that orbits the Sun, such as a planet, dwarf planet or asteroid.

Comet — A comet is a small body that orbits the Sun, usually with a highly elliptical orbit, and that exhibits a coma (atmosphere) and tail when it approaches the Sun. For such a coma to form, the comet must be made, at least in part, of ice. Comets belong to a bigger category known as "Small Solar System Bodies," a term introduced by the IAU in 2006.

Asteroid — An asteroid is a small body that orbits the Sun, often, but not necessarily, within the Asteroid Belt, a region of the Solar System between the orbits of Mars and Jupiter. Asteroids are composed mostly of rock and metal and thus would not show a significant coma. Asteroids also belong to the category "Small Solar System Bodies" and have also been referred to as minor planets.

If time permits, you may want to define these categories and have students try to sort some of the cards again into these categories, in small groups or together as a class. Are there any that don't fit these categories? Could any of the definitions be improved? Could any of these categories be further refined (e.g. planets could be divided into terrestrial planets and giants)? Emphasize that scientists frequently update their categories for classifying these objects as they learn more about the objects or discover new objects. At one time, there were 13 objects in our Solar System that were classified as planets, but as scientists discovered new objects, they changed definitions and categorized them differently.

As an extension, you could ask students to brainstorm what other areas of science involve setting up categories.

Resources for Teachers

The IAU Introductory Page on Naming Astronomical Objects: http://www.iau.org/public/naming/

The IAU Introductory Page on what happened with Pluto and the definitions of planet and dwarf planet: http://www.iau.org/public/pluto/

NASA/JPL Solar System Exploration Pages: http://solarsystem.nasa.gov/index.cfm

The Planetary Society Solar System Pages: http://www.planetary.org/explore/topics/groups/our_solar_system/

"Teaching What a Planet Is: A Roundtable on the Educational Implications of the New Definition of a Planet", edited by A. Fraknoi, Astronomy Education Review: http://dx.doi.org/10.3847/AER2006028

"Hubble Observations of Ceres and Pluto: A Closer Look at the 'Ugly Ducklings' of the Solar System" by Max Mutchler in the *Universe in the Classroom* Newsletter: http://www.astrosociety.org/education/publications/tnl/70/pluto.html

The Pluto Files on PBS's NOVA http://video.pbs.org/video/1425502261

The ~~Nine~~ 8 Planets Solar System Tour http://nineplanets.org

Where to Find Planetary Images

Planetary Photojournal: http://photojournal.jpl.nasa.gov/index.html (This site features thousands of images from planetary exploration, with captions of varied length. You can search images by world, feature name, date, or catalog number, and download images in a number of popular formats.)

Astronomy Picture of the Day: http://antwrp.gsfc.nasa.gov/apod/lib/aptree.html (Two space scientists scour the internet and select one exciting astronomy image to feature each day. Their archives range widely, from traditional astronomical objects to space history, and have also been organized by subject.)

Views of the Solar System: http://www.solarviews.com/eng/homepage.htm

Mars Express: http://www.esa.int/SPECIALS/Mars_Express

Moon Mission Images from the National Space Science Data Center: http://nssdc.gsfc.nasa.gov/imgcat/html/group_page/EM.html

Sorting the Solar System Cards: Key to Images

Note to the teacher — Do not distribute this list to students, as it would strengthen the misconception that there is one single correct, immutable classification scheme. This list is provided for your information to help you facilitate discussions during the activity. It includes the name of each object, its current scientific classification (as of 2010), and some information about the object.

Amalthea, satellite of Jupiter Amalthea is a moon of Jupiter's consisting mainly of ice. It is the largest of Jupiter's tiny inner satellites and has a somewhat redder surface than other such satellites. Both the Voyager and Galileo missions returned information about Amalthea.

Annefrank, asteroid The Asteroid Belt is a region between the orbits of Mars and Jupiter. Annefrank is one of the over one million asteroids estimated to reside in that belt. It was named after Anne Frank, the young German-Belgian girl whose diary is one of the most personal records of the horrors of the Holocaust. Asteroid Annefrank was used during a flyby to test the techniques of the Stardust space probe.

Ariel, satellite of Uranus Ariel is the second of Uranus' five larger moons. It is a tidally-locked satellite of Uranus, meaning that the same side always faces the planet. The Voyager 2 probe was the only mission that explored Ariel.

Callisto, satellite of Jupiter Callisto is Jupiter's second largest moon and the third largest moon in the Solar System (larger are Saturn's Titan and Jupiter's Ganymede). Callisto has about the same diameter as the planet Mercury. It is the furthest from Jupiter of the planet's four largest moons. Excellent images and information about Callisto were sent back by the Voyager and Galileo missions.

Ceres, dwarf planet The largest member of the Asteroid Belt, Ceres is now classified as a dwarf planet. Ceres' round shape suggests that its interior is layered like those of terrestrial planets, such as Earth. Ceres may have a rocky inner core, an icy mantle, and a thin, dusty outer crust. The Dawn mission should tell us more about Ceres, when it arrives there in 2015.

Dactyl, satellite of asteroid Ida Dactyl was the first satellite of an asteroid to be clearly observed. It was discovered in 1993 when the Galileo spacecraft visited Ida on its way to Jupiter. Today, we know some 200 asteroids and small objects to have moons, so Dactyl is not unique.

Deimos, satellite of Mars This is one of Mars' two small moons (the other is Phobos), which were probably asteroids that were trapped by Mars' gravity. Its surface is cratered, although it is much smoother than the surface of Phobos. Viking 2 and the Mars Reconnaissance Orbiter have returned detailed images of Deimos.

Dysnomia, satellite of dwarf planet Eris Dysnomia is the only known satellite of Eris. It is probably not massive enough to be spherical in shape.

Earth, planet Earth is one of the four terrestrial (rocky) planets of the inner solar system (along with Mercury, Venus, and Mars). It has a thick atmosphere and is the only planet currently known to have life.

Enceladus, satellite of Saturn Liquid water lies beneath the icy surface of Enceladus and can be seen escaping in plumes venting from its south polar region. The surface has different regions that can be cratered, smooth, or ridged. Voyager 2 was the first spacecraft to observe the surface in detail, but since then, the Cassini mission has sent back stunning images of Enceledus from its three flybys of the moon.

Eris, dwarf planet Eris was first called the "tenth planet," but is now considered the largest known dwarf planet. Its discovery in 2003 is part of what sparked the latest debate over the definition of a planet, since it is about the size of Pluto and orbits beyond Pluto's orbit in a region known as the Kuiper Belt. Since no spacecraft has visited it, the only pictures we have of this distant world (which takes 557 years to orbit the Sun) must be taken from Earth.

Eros, asteroid Eros is one of a family of objects called Near Earth Asteroids. Its path around the Sun actually crosses the orbit of Mars and comes further inward. In February 2000, it was visited by the robotic spacecraft NEAR-Shoemaker, which sent back dramatic close-up images before descending to the asteroid's surface.

Europa, satellite of Jupiter Jupiter's fourth largest moon, Europa, has the smoothest icy surface of any moon we have photographed. The Galileo orbiter sent back hundreds of close-up images of the moon, showing features that strongly indicate the presence of liquid water under the surface of Europa.

Ganymede, satellite of Jupiter Ganymede is the largest satellite in the Solar System and one of the four discovered by Galileo Galilei in 1610. It has been explored by both the Voyager and Galileo spacecraft missions. There are intriguing hints from the Galileo mission data that Ganymede, like Europa, may have a liquid water layer under its surface. It likely has a liquid core with iron in it, and is the only know satellite to have a magnetic field.

Gaspra, asteroid Gaspra is located close to the inner edge of the asteroid belt. It was the first asteroid to be approached closely by a human spacecraft, when the Galileo spacecraft flew by the asteroid in 1991 on its way to Jupiter. The name comes from a vacation resort on the Black Sea (back on Earth.)

Hale-Bopp, comet The nucleus of a comet is like a dirty snowball. Most comets come from a very cold region in the far reaches of our Solar System, called the Oort Cloud, and spend most of their time far from the Sun. When they do come close to the Sun, some of the ice in the nucleus vaporizes, producing the bright cloud (or *coma)* that we see around the comet, and the tail that we can see from Earth. The tail of a comet can reach millions of miles in length! Comet Hale-Bopp (discovered independently by Alan Hale and Thomas Bopp) was visible to the naked eye from Earth in 1996 and 1997 and was very bright and widely observed.

Halley, comet Some comets are captured by the gravity of the giant planets into orbits that bring them inward to the Sun much more frequently. Comet Halley is the most famous of these "periodic comets," having been observed from Earth every 76 years for over 2000 years. The Giotto spacecraft produced this historic image. Its mission was to approach Halley and send back the first images of a comet's nucleus

Hartley 2, comet This comet, which orbits the Sun every 6.5 years, was discovered by astronomer Malcolm Hartley in 1986. The image was taken in 2010 by NASA's EPOXI mission, which flew by within almost 400 miles of the surface of the comet. There are two obvious regions of jet activity associated with rough terrain, where ice is being vaporized by the energy of the Sun. The smooth surface in the middle is lower than the rest of the comet.

Iapetus, satellite of Saturn Iapetus is Saturn's third largest moon. It has dramatic two-tone coloration, with the leading hemisphere looking darker than the trailing hemisphere. The moon, as revealed by the Cassini mission, also has a large ridge around its equator.

Ida, asteroid Ida is a member of the asteroid belt. It was discovered in 1884 by Austrian astronomer Johann Palisa. It takes 4.8 years to orbit the Sun. This image was taken by the Giotto spacecraft on its way to Jupiter.

Io, satellite of Jupiter Io is the innermost of Jupiter's large Galilean moons (the moon's discovered by Galileo in 1610). Squeezed by the combined gravity of Jupiter and the giant moons beyond it, Io is "seething" and hot inside and has become the most volcanically active world we know. It has been explored by both the Voyager and the Galileo space probes.

Itokawa, asteroid Itokawa is an asteroid with an orbit that crosses the orbits of Earth and Mars, named after Japan's "Dr. Rocket," Hideo Itokawa. The Japanese space probe Hayabusa visited Itokawa in 2005 to take images, gather data, and eventually collect samples of the asteroid.

Jupiter, planet Jupiter is the largest planet in the Solar System. It is one of the four "gas giants" (like Saturn), meaning that it is made mostly of liquid and gas. Jupiter has no solid outside surface on which you could walk. There are many storms in the clouds of its upper atmosphere, including the famous Great Red Spot. Eleven Earths could fit side by side across the equator of Jupiter. Both the Voyager and the Galileo missions have explored Jupiter and its system of rings and moons. Part of the Galileo spacecraft was actually sent *into* Jupiter.

Mars, planet Along with Mercury, Venus, and Earth, Mars is one of the terrestrial (rocky) planets in the inner solar system. It has a thin atmosphere today, but there is good evidence that billions of years ago it had a thicker blanket of air and flowing water on its surface. Mars has the largest volcanoes in the solar system and an enormous rift valley called Valles

Marineris. Many different landers and orbiters have explored Mars, including the two Mars Exploration Rovers, the European Mars Express orbiter mission, the Mars Global Surveyor orbiter, the Viking and Phoenix landers, etc.

Mercury, planet Mercury is the smallest planet in the Solar System, and the planet closest to the Sun. Together with Venus, Earth, and Mars, it is one of the terrestrial (rocky) planets in the inner solar system. Mercury has a large core of metal, especially iron surrounded by a rocky layer. Its surface resembles the Moon in that it's highly cratered. The Mariner 10 and MESSENGER missions have both studied and photographed Mercury.

Mimas, satellite of Saturn Mimas is the smallest of the major moons orbiting Saturn. It has a highly cratered surface, and is made mostly of ice, with a smaller amount of rocky material. It is marked by a large crater on its surface, called Herschel, which is the remains of a giant impact long ago that almost shattered this satellite. Mimas was explored by the Voyager and Cassini missions.

Miranda, satellite of Uranus This image is a mosaic of photographs collected by the Voyager 2 spacecraft. Miranda's intriguing surface consists of several types of terrain. One is an old, heavily cratered, rolling terrain with relatively uniform *albedo,* or reflectivity. But we also see younger, complex terrain, characterized by sets of bright and dark bands, scarps (cliffs) and ridges.

Moon, satellite of Earth The Moon is the Earth's only natural satellite. It is made of rock, covered in craters, and has no atmosphere. It's the fifth largest moon in the solar system, and is about ¼ the diameter of planet Earth. It is quite unusual for a moon to be so large compared to the planet it orbits. The Moon is the only place other than Earth that human beings have landed and walked around (during the later Apollo missions). Rocks from the Moon have been brought back both by astronauts and by robotic missions.

Neptune, planet Like Jupiter, Saturn, and Uranus, Neptune is a giant planet, and it is the most remote from the Sun of all the giant planets, taking 165 years to orbit the Sun. The planet is made mostly of gas and liquid, and has a vast ocean of water, methane, and ammonia beneath its gaseous atmosphere. Scientists call it an "ice giant", but the word ice doesn't mean that the lower layers are solid, but rather that they are hot, fluid solid ices, more like the mantle of the Earth than like ice in your soda. Only the Voyager 2 spacecraft has ever visited distant Neptune.

Phobos, satellite of Mars This is one of Mars' two small moons (the other is Deimos), which were probably asteroids that were trapped by Mars' gravity. Phobos is highly non-spherical and covered in craters, including the very large Stickney crater with a diameter of 9 km (about one third the diameter of Phobos itself). Viking 1, the Mars Global Surveyor, Mars Express, and the Mars Reconnaissance Orbiter have returned detailed images of Phobos.

Phoebe, satellite of Saturn Phoebe is Saturn's outermost moon that still has a significant size. It is almost spherical, but highly cratered and quite dark. It is made of a combination of ice and rock and may have been captured by Saturn sometime after the planet and inner moons formed. It was the first target of the Cassini mission when it arrived at Saturn in 2004.

Pluto, dwarf planet Pluto, smaller than the Earth's Moon and with a highly eccentric (not circular) and tilted orbit, is classified as a dwarf planet. It is also one of the largest Kuiper Belt Objects (KBOs). The Kuiper Belt is a disk-shaped region beyond the orbit of Neptune. Over a thousand KBOs have been discovered so far and Pluto bears the distinction of being the first of these ever found. Pluto has an extremely thin atmosphere that tends to freeze out when the dwarf planet is on the part of its 248-year orbit that takes it farthest from the Sun. No spacecraft has yet explored Pluto, but the New Horizons probe is expected to get there around 2015.

Prometheus, satellite of Saturn This small moon is extremely elongated and has several ridges and impact craters. The Cassini Mission produced these images of Prometheus.

Saturn, planet Saturn is also a gas and liquid giant (like Jupiter). It is made of such light materials, that on average it is less dense than water. If you had a bathtub big enough, Saturn would float! It is known for its magnificent ring system, though the other giant planets have rings as well. Although the Pioneers and Voyagers flew by, it is the Cassini mission that has sent the most stunning images of Saturn and its moons back to Earth.

Sedna, dwarf planet candidate Sedna is a trans-Neptunian object that has not yet been classified as a dwarf planet. It orbits the Sun at a distance about three times as far as Neptune's orbit. This great distance makes it difficult to determine its size and shape, so it is not currently possible to know whether it fits all the criteria of a dwarf planet. We must observe objects like Sedna with telescopes on Earth.

Shoemaker-Levy 9, comet Coming too close to Jupiter broke Shoemaker-Levy 9 apart into many icy pieces (some larger than a kilometer), which then collided with Jupiter in 1994. This was the first time scientists ever observed the collision of solar system objects beyond Earth. The Hubble Space Telescope and many telescopes on the ground were able to observe the impact features in Jupiter's atmosphere.

Sun, star Our Sun is the only star in the Solar System. The planets and other solar system objects orbit the Sun. The Sun is a stable, relatively long-lived star. It has been shining for roughly 5 billion years and will continue in its stable stage for at least that much longer.

Tempel 1, comet This comet orbits the Sun every 5 ½ years and was discovered by Wilhelm Tempel in 1867. The Deep Impact spacecraft produced this image about 5 minutes before part of the craft smashed into the comet's surface. Since impacts produce a lot of the craters and features we see on other worlds, astronomers wanted to make their own impact with a comet and look at the results.

Tethys, satellite of Saturn Tethys is one of the icy medium-sized moons of Saturn, similar to Dione and Rhea. It is composed almost entirely of water-ice and is one of the most reflective objects in the Solar System. Its surface is covered in craters and cracks. The Voyager and Cassini missions have sent back information about Tethys.

Titan, satellite of Saturn Titan is Saturn's largest moon and the second largest moon in the solar system. Its diameter is 5,150 km (3,200 miles), the size of the United States! It is the only moon in the solar system with a thick atmosphere. Unfortunately, the atmosphere is quite smoggy, so it is hard to look through it with visible light. The Cassini spacecraft carried infra-red and radar instruments for penetrating the smog. It is so cold on Titan that water is frozen as hard as rock, but Cassini found lakes of ethane and methane on the surface of the moon. A small probe called Huygens, launched from Cassini, soft-landed on Titan and sent back the first images and data from the surface of a moon in the outer solar system.

Triton, satellite of Neptune Triton is Neptune's largest moon and is, in some ways, a twin of Pluto. Triton is covered in ice and may have a very thin atmosphere. The Voyager 2 spacecraft got some good images of this mysterious moon.

Uranus, planet Uranus was the first planet we discovered with a telescope (planets inward of it could be seen with the unaided eye and had been known since humans first looked at the sky). Like Jupiter and Saturn, Uranus is a giant planet. It is made mostly of gas and liquid, and has a vast ocean of water, methane, and ammonia beneath its gaseous atmosphere. Scientists call it an "ice giant", but the word ice doesn't mean that the lower layers are solid, but rather that they are hot, fluid solid ices, more like the mantle of the Earth than like ice in your soda. Only the Voyager 2 spacecraft has ever visited Uranus. It is a planet that is tipped over — in the sense that its axis of rotation is in the plane of its orbit. In plain language, Uranus is orbiting "on its side."

Venus, planet Venus, like Mercury, Earth, and Mars, is one of the terrestrial (rocky) planets in the inner solar system. It has a very thick and cloudy atmosphere, which acts like a giant "greenhouse." It allows sunlight to filter through, but keeps the heat from escaping, raising the surface temperature on Venus higher than that of a pizza oven. A number of spacecraft have orbited Venus or descended to its surface to tell us what it's like there, especially the Venera series of landers from the former Soviet Union.

Wild 2, comet This comet was discovered by Swiss astronomer Paul Wild in 1978 and takes 6.4 years to orbit the Sun. The Stardust mission spacecraft produced this image of Wild (pronounce "Vilt") 2, while passing close in order to collect samples of the interstellar dust from the comet.

AMALTHEA

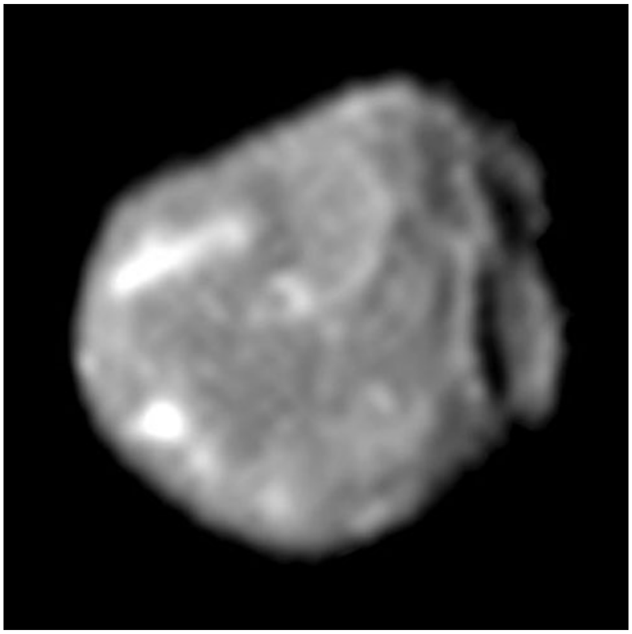

Image Source: Galileo
NASA/Cornell

ANNEFRANK

Image Source: Stardust
NASA/JPL

ARIEL

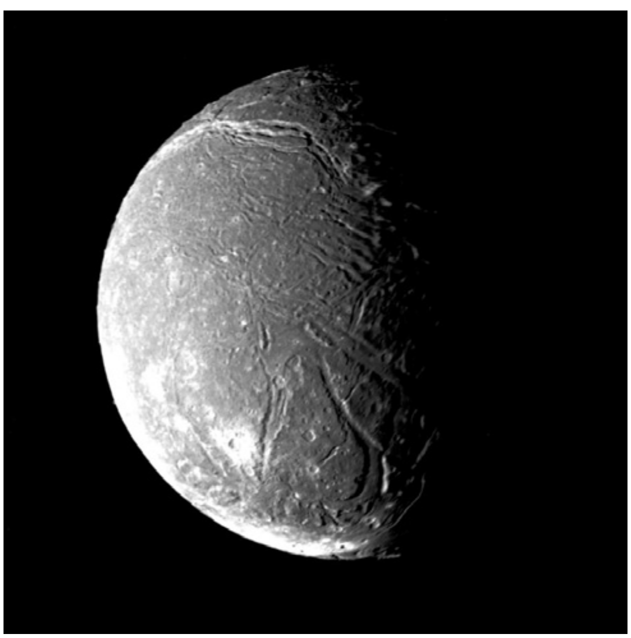

Image Source: Voyager 2
NASA/JPL

HARTLEY 2

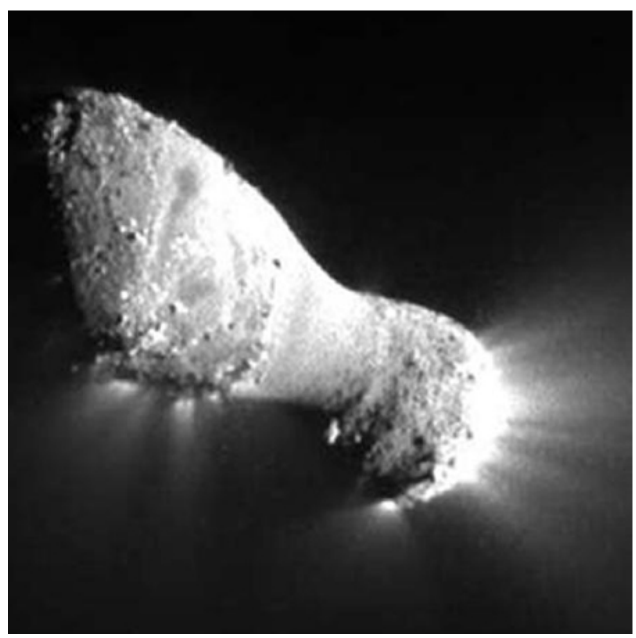

Image Source: EPOXI
NASA/JPL

ANNEFRANK

Size:
Tiny
5 km

Distance to Sun:
327,000,000 km

Made of:
Rock

Orbits around:
Sun

AMALTHEA

Size:
Tiny
270 km

Distance to Sun:
778,000,000 km

Made of:
Ice

Orbits around:
Jupiter

HARTLEY 2

Size:
Tiny
2 km

Distance to Sun:
160,000,000 km
to 880,000,000 km

Made of:
Ice, Rock

Orbits around:
Sun

ARIEL

Size:
Small
1,160 km

Distance to Sun:
2,900,000,000 km

Made of:
Rock, Ice

Orbits around:
Uranus

CALLISTO

Image Source: Galileo
NASA/DLR

CERES

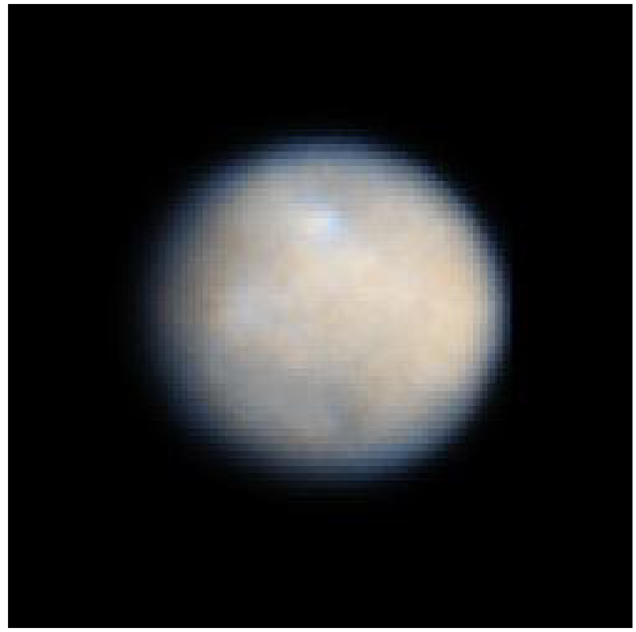

Image Source: Hubble
NASA/ESA

DEIMOS

Image Source: Mars Reconnaissance Orbiter
NASA

DACTYL

Image Source: Galileo
NASA/USGS

CERES

Size:
Small
950 km

Distance to Sun:
446,000,000 km

Made of:
Rock, Ice

Orbits around:
Sun

CALLISTO

Size:
Medium
4,800 km

Distance to Sun:
778,000,000 km

Made of:
Rock, Ice

Orbits around:
Jupiter

DACTYL

Size:
Tiny
1.5 km

Distance to Sun:
428,000,000 km

Made of:
Rock, Ice(?)

Orbits around:
Ida

DEIMOS

Size:
Tiny
12 km

Distance to Sun:
227,940,000 km

Made of:
Rock

Orbits around:
Mars

DYSNOMIA

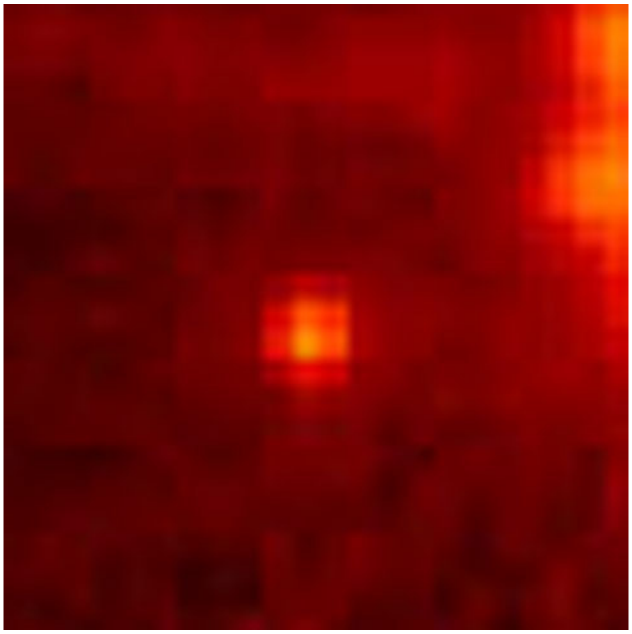

Image Source: Hubble
NASA/ESA/M. Brown

EARTH

Image Source: Apollo 17
NASA

ERIS

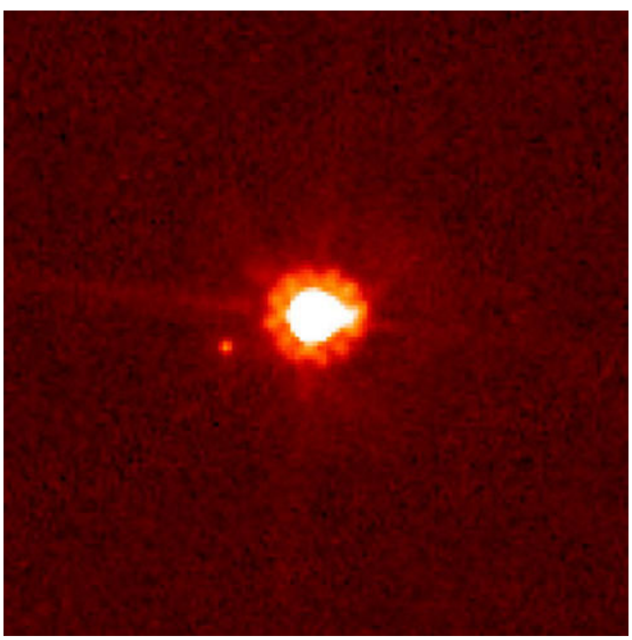

Image Source: Hubble
NASA/ESA/M. Brown

EROS

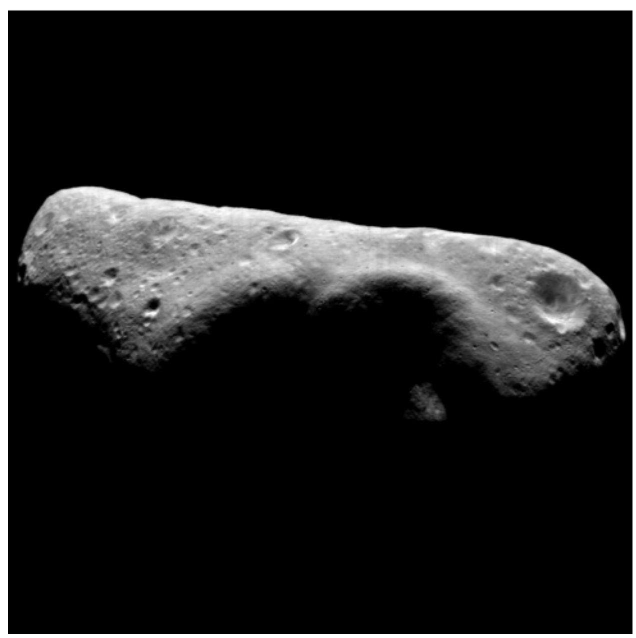

Image Source: NEAR
NASA/Johns Hopkins

EARTH

Size:
Medium
12,760 km

Distance to Sun:
149,598,000 km

Made of:
Rock, Metal

Orbits around:
Sun

DYSNOMIA

Size:
Tiny
100 km

Distance to Sun:
5,700,000,000 km
to 14,500,000,000 km

Made of:
Rock, Ice

Orbits around:
Eris

EROS

Size:
Tiny
34 km

Distance to Sun:
180,000,000 km

Made of:
Rock

Orbits around:
Sun

ERIS

Size:
Medium
2,400 km

Distance to Sun:
5,700,000,000 km
to 14,500,000,000 km

Made of:
Rock, Ice

Orbits around:
Sun

EUROPA

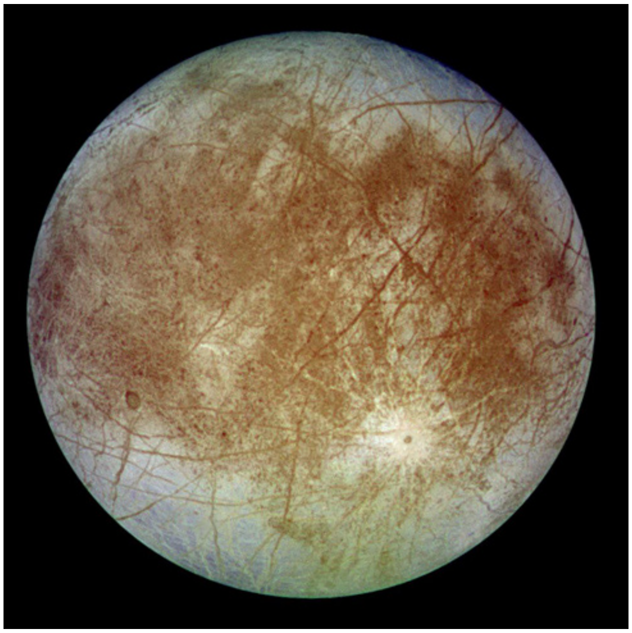

Image Source: Galileo
NASA/DLR

GANYMEDE

Image Source: Voyager 1
NASA/JPL

GASPRA

Image Source: Galileo
NASA/USGS

HALE-BOPP

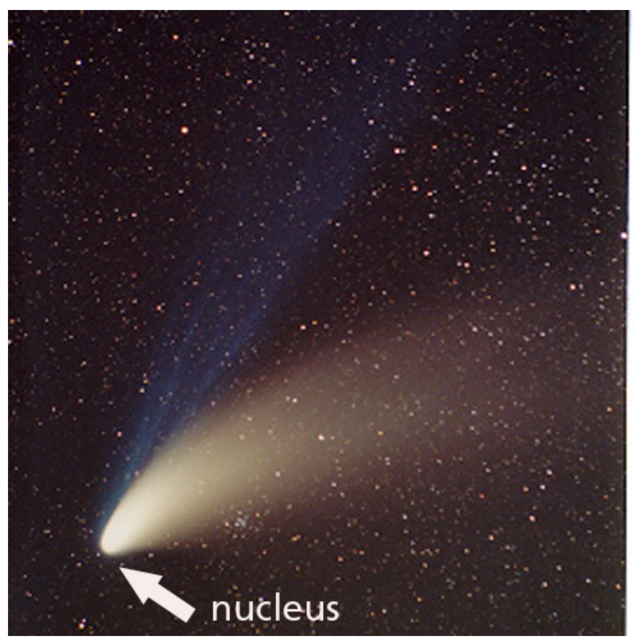

Image Source: Ground-based
GSFC/Kevin Hartnett

GANYMEDE

Size:
Medium
5,260 km

Distance to Sun:
778,000,000 km

Made of:
Rock, Metal, Ice

Orbits around:
Jupiter

EUROPA

Size:
Medium
3,140 km

Distance to Sun:
778,000,000 km

Made of:
Rock, Ice

Orbits around:
Jupiter

HALE-BOPP

Size (of nucleus):
Tiny
60 km

Distance to Sun:
136,000,000 km
to 55,500,000,000 km

Made of:
Ice, Rock

Orbits around:
Sun

GASPRA

Size:
Tiny
18 km

Distance to Sun:
330,000,000 km

Made of:
Rock

Orbits around:
Sun

HALLEY

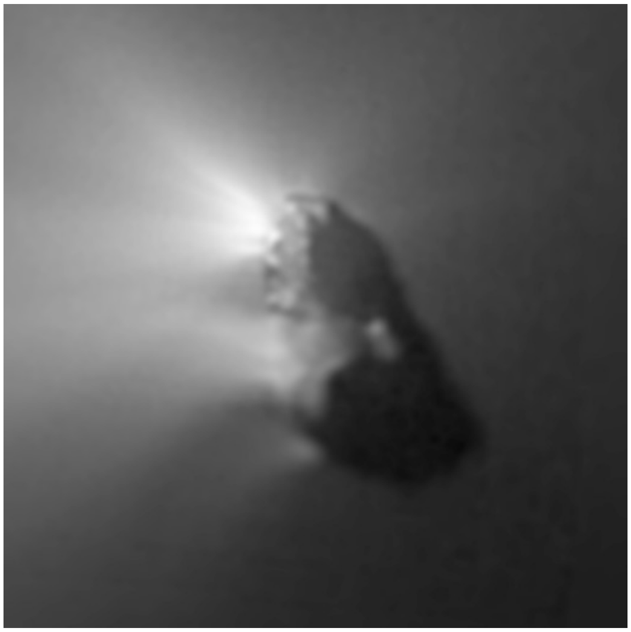

Image Source: Giotto
MPAE/ESA

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ENCELADUS

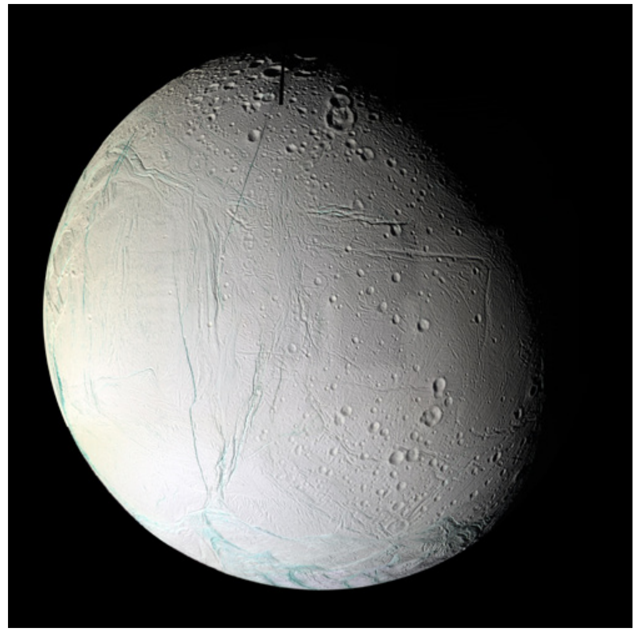

Image Source: Cassini-Huygens
NASA

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IAPETUS

Image Source: Cassini
NASA/Cassini

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IDA

Image Source: Galileo
NASA/USGS

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ENCELADUS

Size:
Tiny
252 km

Distance to Sun:
1,429,000,000 km

Made of:
Ice, Metal, Rock

Orbits around:
Saturn

HALLEY

Size:
Tiny
11 km

Distance to Sun:
88,000,000 km
to 5,200,000,000 km

Made of:
Ice, Rock

Orbits around:
Sun

IDA

Size:
Tiny
53 km

Distance to Sun:
428,000,000 km

Made of:
Rock

Orbits around:
Sun

IAPETUS

Size:
Small
1,470 km

Distance to Sun:
1,429,000,000 km

Made of:
Rock, Ice

Orbits around:
Saturn

IO

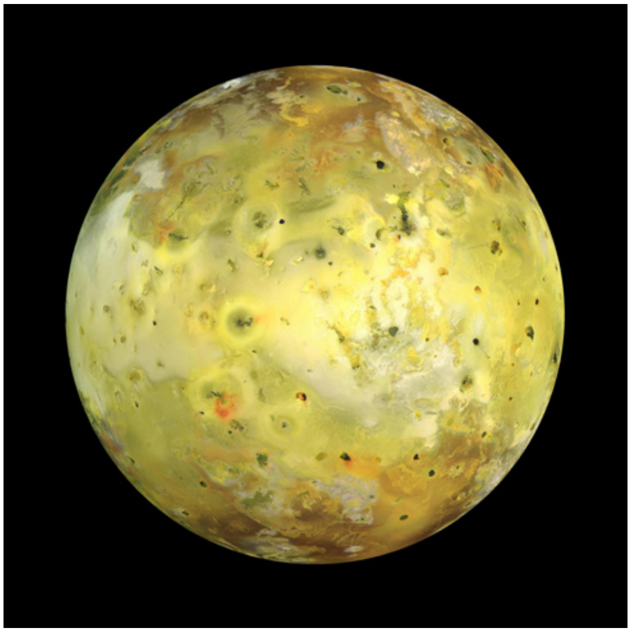

Image Source: Galileo
NASA/U of Arizona

JUPITER

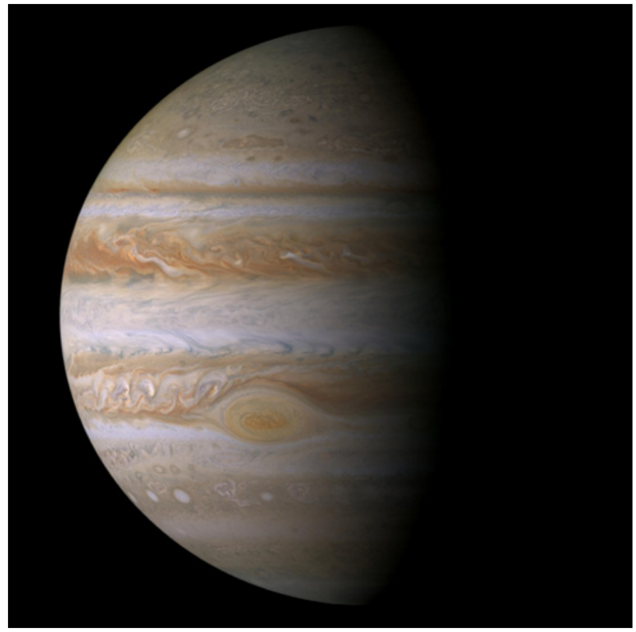

Image Source: Cassini
NASA/CICLOPS

MARS

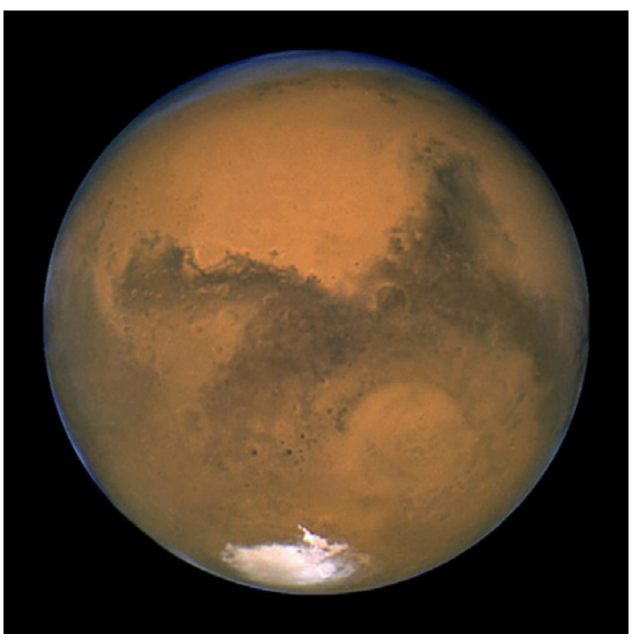

Image Source: Hubble
NASA

ITOKAWA

Image Source: ISAS
JAXA

JUPITER

Size:
Large
143,000 km

Distance to Sun:
778,000,000 km

Made of:
Liquid Hydrogen, Gas

Orbits around:
Sun

IO

Size:
Medium
3,630 km

Distance to Sun:
778,000,000 km

Made of:
Rock, Metal

Orbits around:
Jupiter

ITOKAWA

Size:
Tiny
0.53 km

Distance to Sun:
142,000,000 km
to 239,000,000 km

Made of:
Rock

Orbits around:
Sun

MARS

Size:
Medium
6,794 km

Distance to Sun:
227,940,000 km

Made of:
Rock, Metal

Orbits around:
Sun

MERCURY

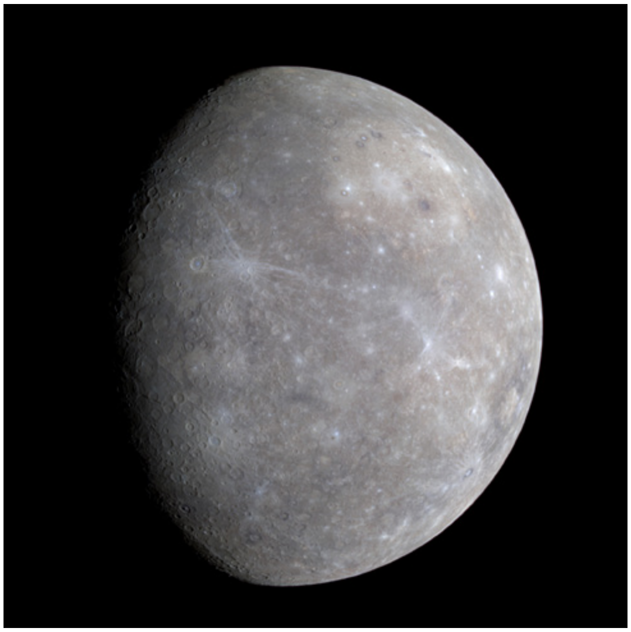

Image Source: MESSENGER
NASA/Johns Hopkins

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MIMAS

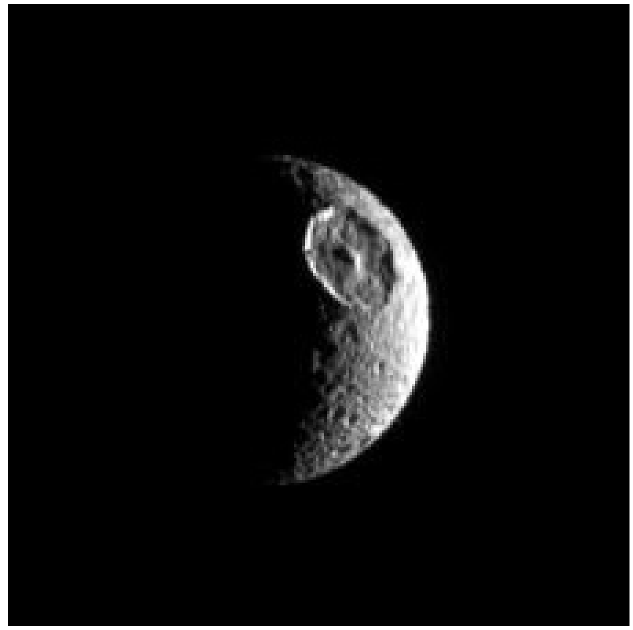

Image Source: Cassini
NASA/Cassini

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MOON

Image Source: Galileo
NASA/USGS

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NEPTUNE

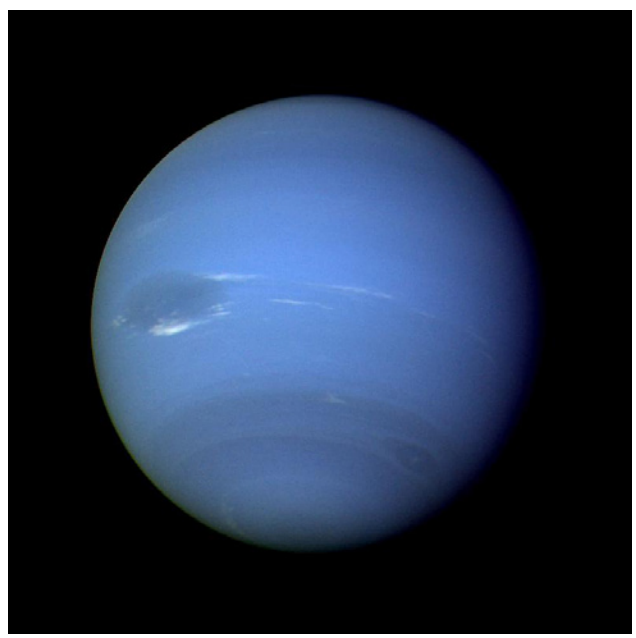

Image Source: Voyager
NASA/JPL

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MIMAS

Size:
Tiny
392 km

Distance to Sun:
1,429,000,000 km

Made of:
Rock

Orbits around:
Saturn

MERCURY

Size:
Medium
4,880 km

Distance to Sun:
57,910,000 km

Made of:
Rock, Metal

Orbits around:
Sun

NEPTUNE

Size:
Large
49,530 km

Distance to Sun:
4,504,000,000 km

Made of:
Liquid Ice, Gas

Orbits around:
Sun

MOON

Size:
Medium
3,475 km

Distance to Sun:
149,598,000 km

Made of:
Rock, Metal

Orbits around:
Earth

PHOBOS

Image Source:MRO
NASA/Johns Hopkins

PHOEBE

Image Source: Cassini
NASA/CICLOPS

PLUTO

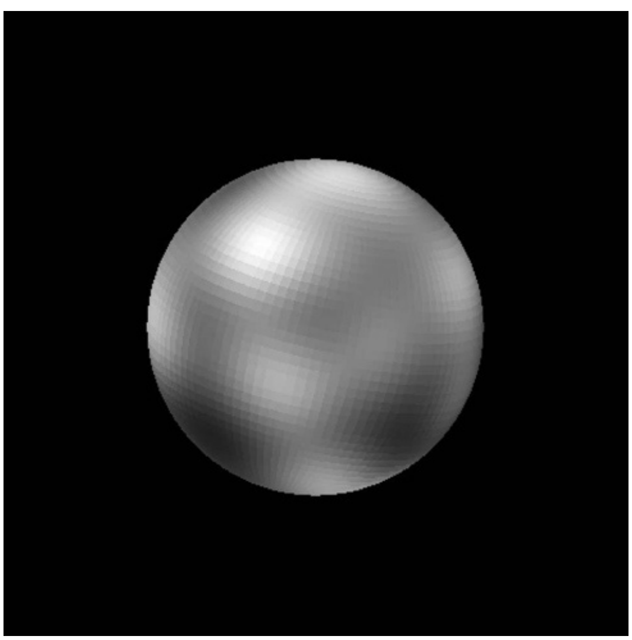

Image Source: Hubble
NASA/Lowell

MIRANDA

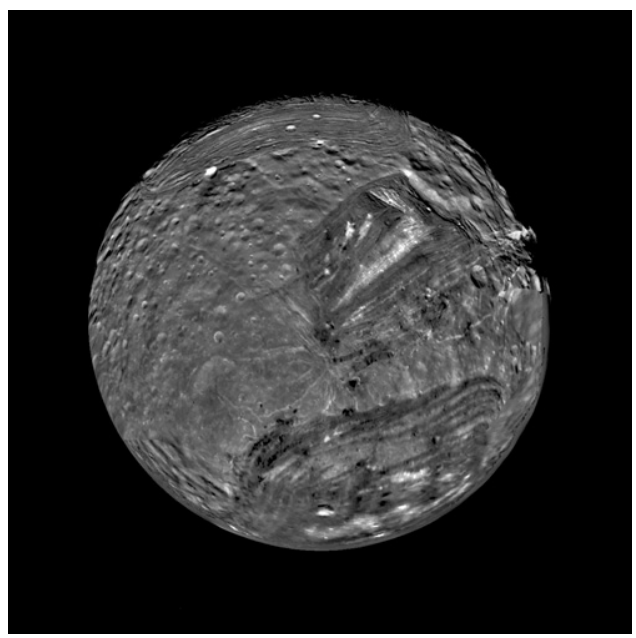

Image Source: Voyager
NASA

PHOEBE

Size:
Tiny
220 km

Distance to Sun:
1,429,000,000 km

Made of:
Rock

Orbits around:
Saturn

PHOBOS

Size:
Tiny
27 km

Distance to Sun:
227,940,000 km

Made of:
Rock, Ice

Orbits around:
Mars

MIRANDA

Size:
Small
480 km

Distance to Sun:
2,900,000,000 km

Made of:
Ice, Rock

Orbits around:
Uranus

PLUTO

Size:
Medium
2,274 km

Distance to Sun:
5,914,000,000 km

Made of:
Rock, Ice

Orbits around:
Sun

SATURN

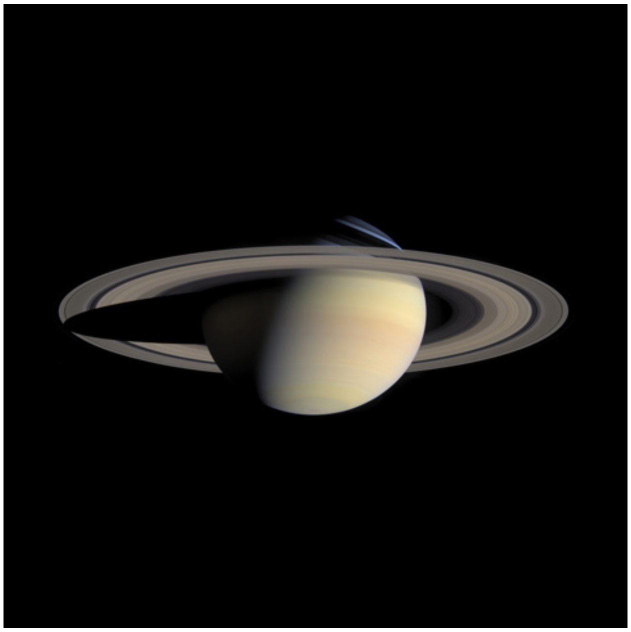

Image Source: Cassini
NASA/CICLOPS/SSI

SEDNA

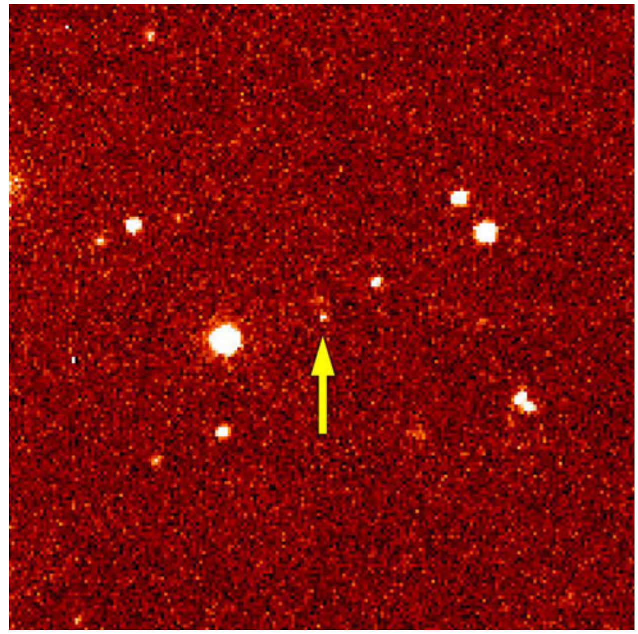

Image Source: Ground-based
NASA/Caltech

SHOEMAKER-LEVY 9

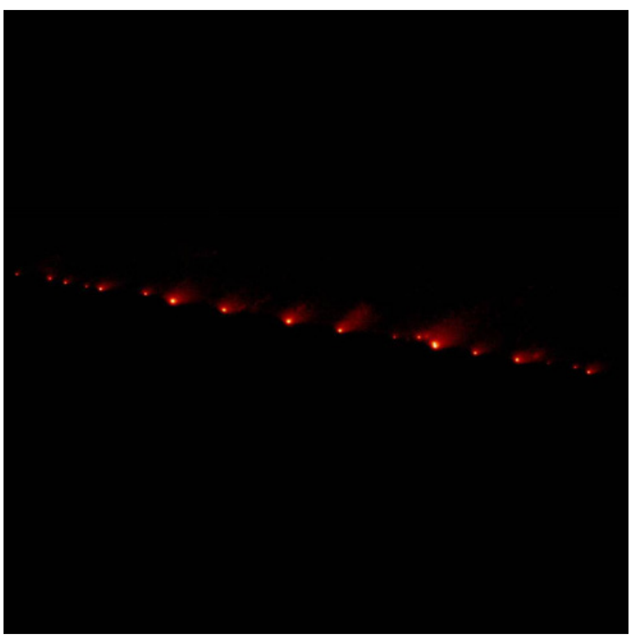

Image Source: Hubble
NASA/STSCI

SUN

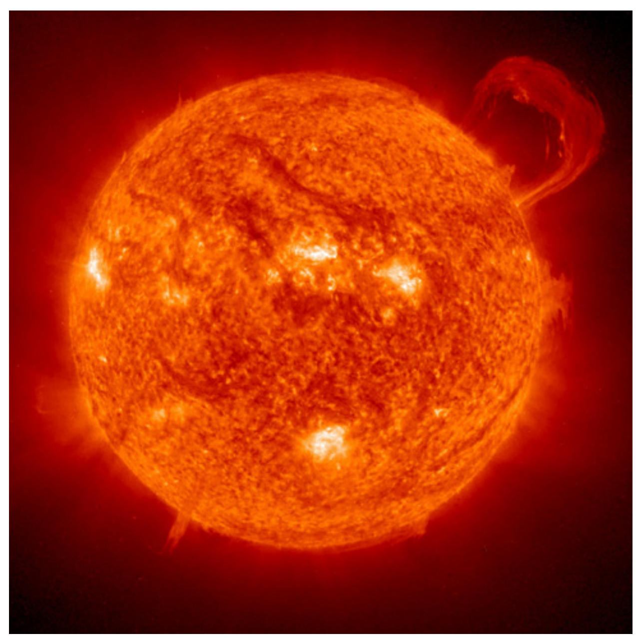

Image Source: SOHO
NASA/ESA

SEDNA

Size:
Medium
1,600 km

Distance to Sun:
11,400,000,000 km
to 139,000,000,000 km

Made of:
Rock, Ice

Orbits around:
Sun

SATURN

Size:
Large
120,500 km

Distance to Sun:
1,429,000,000 km

Made of:
Liquid Hydrogen, Gas

Orbits around:
Sun

SUN

Size:
Huge
1,390,000 km

Distance to Sun:
0 km

Made of:
Gas/Plasma

Orbits around:
Galactic Center

SHOEMAKER-LEVY 9

Size:
Tiny
2 km

Distance to Sun:
778,000,000 km

Made of:
Ice

Orbited around:
Sun, Jupiter

TEMPEL 1

Image Source: Deep Impact
NASA/U. of Maryland

TETHYS

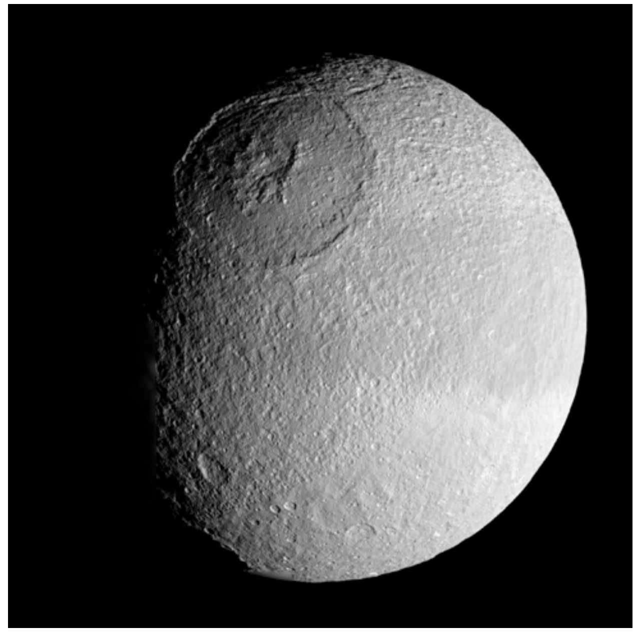

Image Source: Cassini
NASA/Cassini

TITAN

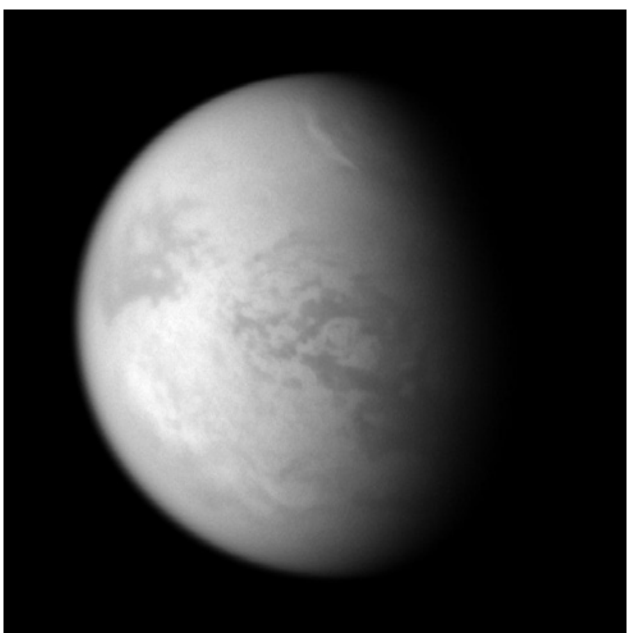

Image Source: Cassini
NASA/Cassini

TRITON

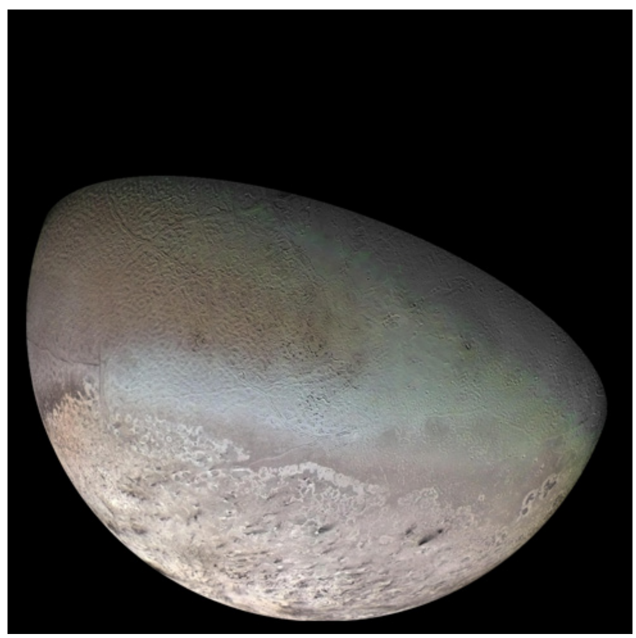

Image Source: Voyager 2
NASA/JPL

TETHYS

Size:
Small
1,070 km

Distance to Sun:
1,429,000,000 km

Made of:
Ice, Rock

Orbits around:
Saturn

TEMPEL 1

Size:
Tiny
6 km

Distance to Sun:
224,000,000 km
to 793,000,000 km

Made of:
Ice, Rock

Orbits around:
Sun

TRITON

Size:
Medium
2,700 km

Distance to Sun:
4,504,000,000 km

Made of:
Rock, Ice

Orbits around:
Neptune

TITAN

Size:
Medium
5,150 km

Distance to Sun:
1,429,000,000 km

Made of:
Rock, Ice

Orbits around:
Saturn

URANUS

Image Source: Voyager 2
NASA/JPL

VENUS

Image Source: Magellan
NASA/JPL

PROMETHEUS

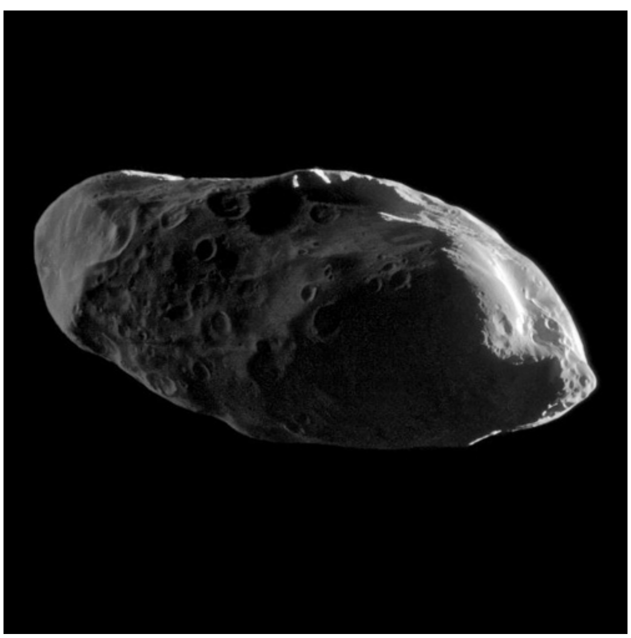

Image Source: Cassini-Huygens
NASA

WILD 2

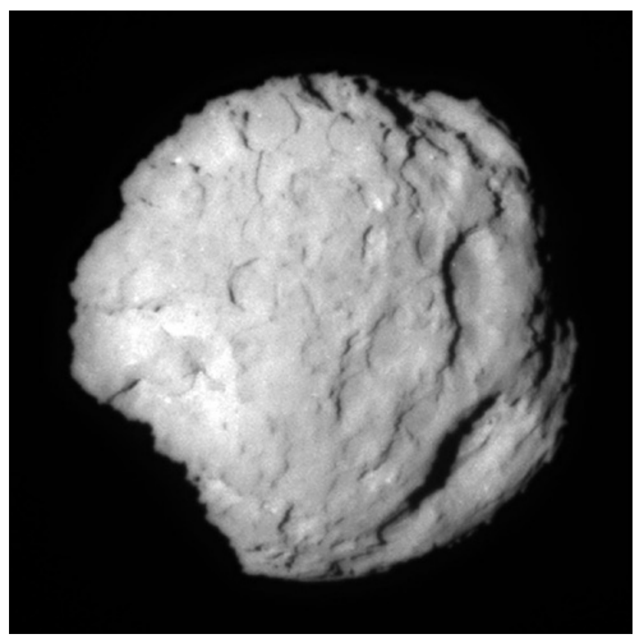

Image Source: Stardust
NASA/Caltech

VENUS

Size:
Medium
12,103 km

Distance to Sun:
108,200,000 km

Made of:
Rock, Metal

Orbits around:
Sun

URANUS

Size:
Large
51,100 km

Distance to Sun:
2,900,000,000 km

Made of:
Liquid Ice, Gas

Orbits around:
Sun

WILD 2

Size:
Tiny
4 km

Distance to Sun:
238,000,000 km
to 793,000,000 km

Made of:
Ice, Rock

Orbits around:
Sun

PROMETHEUS

Size:
Tiny
86 km

Distance to Sun:
1,429,000,000 km

Made of:
Ice

Orbits around:
Saturn

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Size:

Distance to Sun:

Made of:

Orbits around:

Size:

Distance to Sun:

Made of:

Orbits around:

Size:

Distance to Sun:

Made of:

Orbits around:

Size:

Distance to Sun:

Made of:

Orbits around: