

# Sorting the Solar System

## *What's this activity about?*

### **Big Questions:**

- What types of objects are in our Solar System?
- Why do the definitions of the objects change?

### **Big Activities:**

- Using images of Solar System objects, start discussions of the characteristics of asteroids, comets, planets, and moons.
- Practice scientific thinking by sorting objects into categories according to their common qualities.

### **Participants:**

**From the club:** A minimum of one person.

With larger groups, up to four presenters can participate.

**Visitors:** This activity is appropriate for families, the general public, and school groups ages 10 and up. With small groups, one set of cards can be used. Four sets are included for use in classrooms or larger groups.

Also, a large set of objects is included in this manual. You may print them yourself, but it is recommended that you do this at a print shop. Printing them requires a lot of ink.

### **Duration:**

Ten minutes, up to a half hour, depending on the depth of questions and conversation.

### **Topics Covered:**

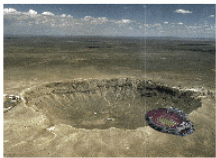
- Review of the diversity of objects in our Solar System
- How scientists use common characteristics to classify the world around us





## Barringer Crater

- This crater is located in Arizona, USA
- It was created 50,000 years ago by a chunk of **METAL** from space
- It measures about **1.2 km** in diameter



Size of crater compared to a stadium

## Ceres

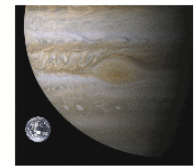
- Ceres is the largest object between the orbits of Mars and Jupiter
- It is made mostly of **ROCK** and **ICE**
- Ceres is about **950 km** in diameter



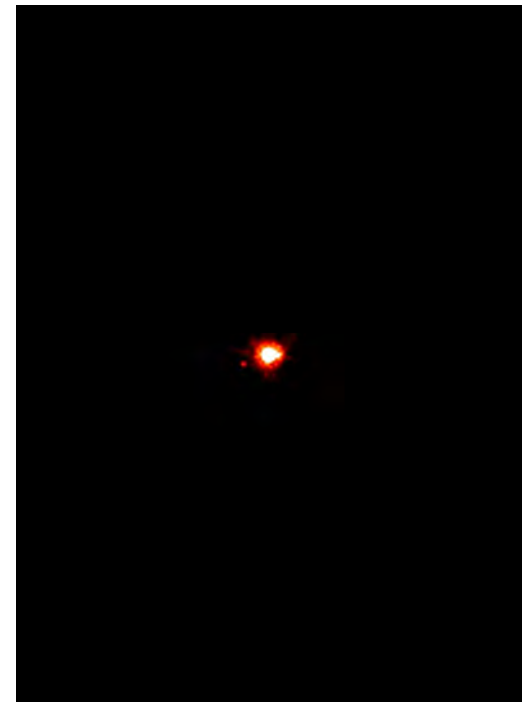
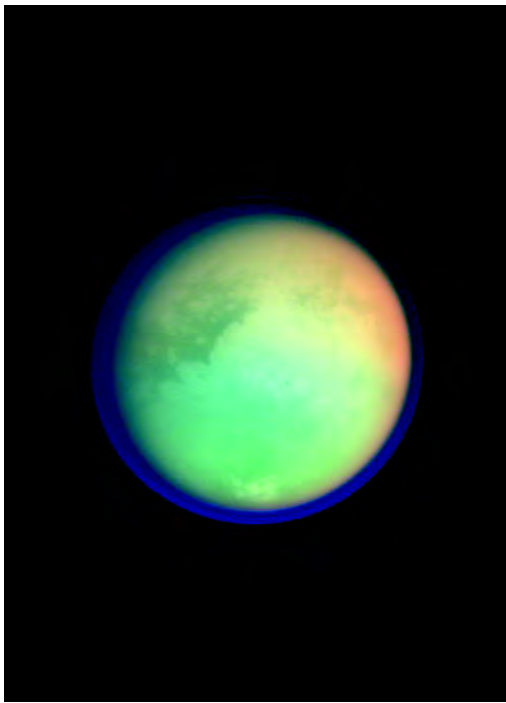
Ceres (bottom left) compared to the Earth and Moon

## Earth

- It orbits the Sun between Venus and Mars
- Earth is made of **ROCK**, a **METAL** core and both solid and liquid **ICE** (water, that is) on its surface
- Its diameter is **12,650 km**

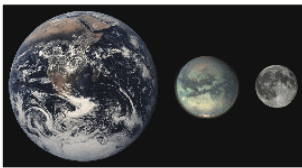


Size of Earth compared to Jupiter



## Titan

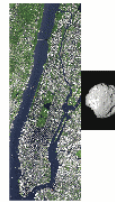
- Titan orbits Saturn
- It is made of **ROCK** and **ICE** and has a thick atmosphere
- It is **5,150 km** in diameter, between the size of the Earth and Moon



Size of Titan (center) compared to the Earth and Moon

## Wild 2

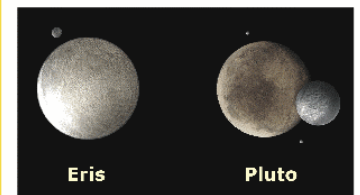
- Wild 2 orbits the Sun between Mars and Jupiter, though its orbit used to be much more distant
- It is made of **ICE** and **DUST**
- It is about **4 km** across



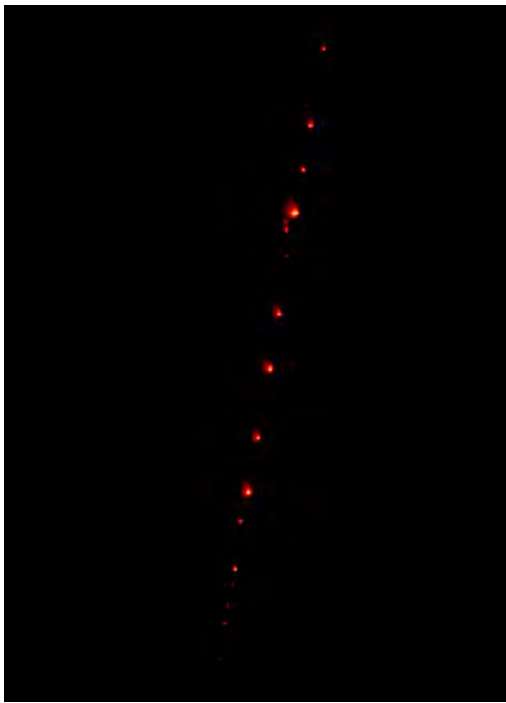
Size of Wild 2 compared to Manhattan

## Eris

- The orbit of Eris is very distant, mostly beyond Pluto's orbit.
- It is made of **ICE** and **ROCK**
- The diameter of Eris is about **2,600 km**

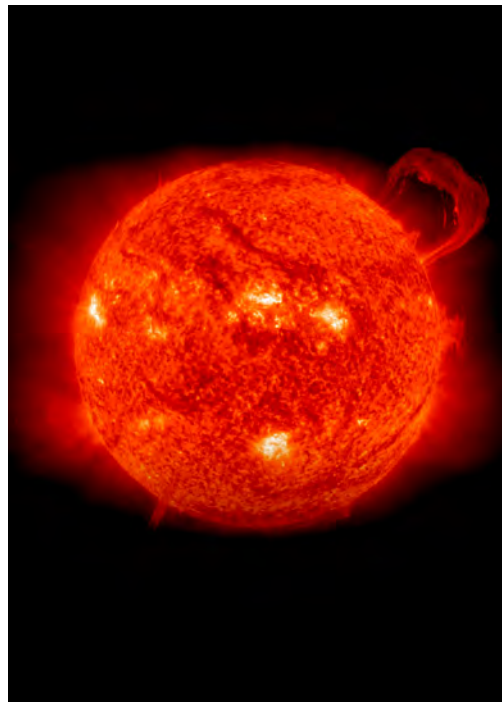
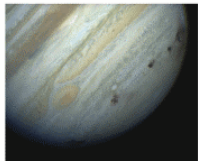


Size of Eris compared to Pluto



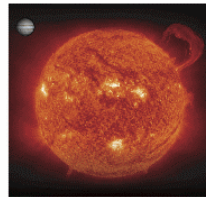
## Shoemaker-Levy 9

- Its orbit originally took it beyond Pluto. After it was captured by Jupiter's gravity, it was torn apart and eventually smashed into Jupiter.
- Made of **ICE** and **ROCK**
- Largest pieces were **1km** and left huge marks on Jupiter

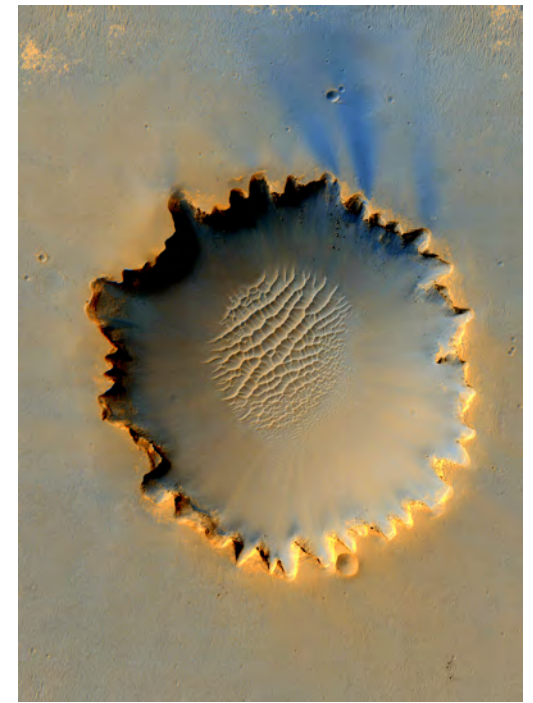


## Sun

- The Sun is located in the center of our Solar System
- It is made mostly of hydrogen and helium **GAS**
- The Sun is **1.4 million km** in diameter



Size of Sun compared to Jupiter



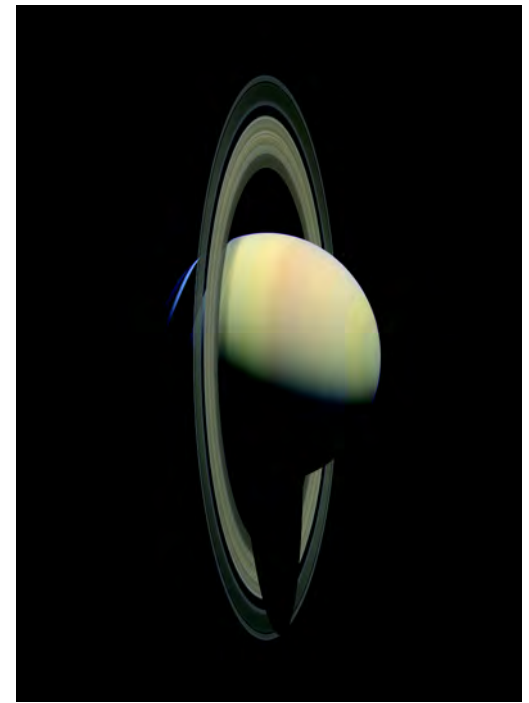
## Victoria Crater

- This crater is one of the smaller craters on Mars
- The rim's jagged edges are due to erosion caused by **ROCK** and **DUST**
- It is **750 meters** across



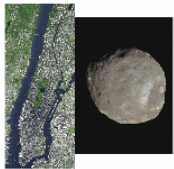
Size of crater compared to a stadium





## Phobos

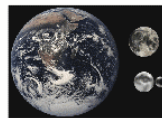
- Phobos closely orbits Mars and will eventually collide with it
- It is mostly made of **ROCK** but may have **ICE** inside
- Phobos is about **11 km** across



Size of Phobos compared to Manhattan

## Pluto & Charon

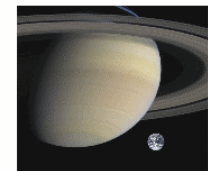
- Pluto and Charon orbit each other, together are mostly outside Neptune's orbit
- These round objects are made of **ICE** and **ROCK**
- Pluto is about **2,300 km** across



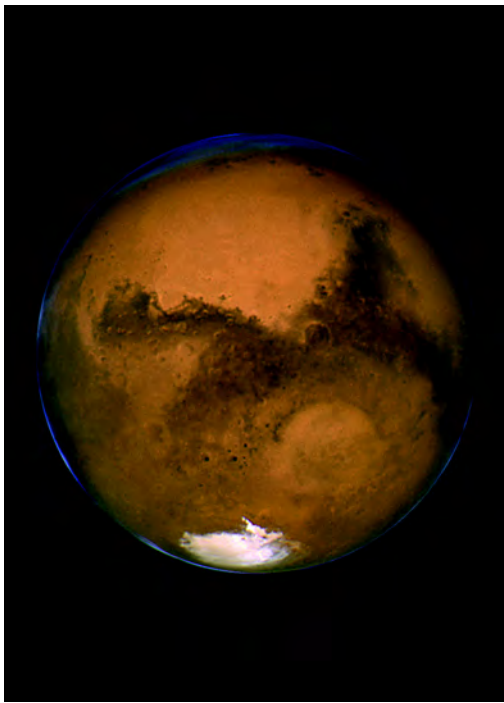
Size of Pluto & Charon compared to Earth and Moon

## Saturn

- Saturn orbits the Sun between Jupiter and Uranus
- Saturn is mostly made of **GAS**
- The main body is **120,000 km** across

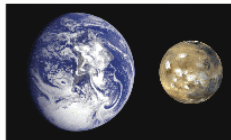


Size of Saturn compared to Earth



## Mars

- The orbit of Mars is between Earth and the Asteroid Belt
- Mars is made of **ROCK** with a **METAL** core and some solid **ICE** on its surface
- It is **6,800 km** in diameter, about half as wide as the Earth



Size of Mars compared to Earth

## Meteor

- Meteors occur in Earth's atmosphere, about 75km above the surface
- We see the glowing pieces of **ROCK**
- The pieces of rock are mostly less than **1cm**, or the size of a coin



Size of rock compared to a coin

## Meteorite

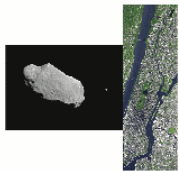
- Meteorites are pieces of asteroids that land on other worlds
- They are made of **METAL** and **ROCK**
- Almost all meteorites on Earth are smaller than **1 meter**





## Ida and Dactyl

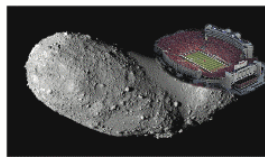
- Together they orbit the Sun between the orbits of Mars and Jupiter. Dactyl (the smaller object) orbits Ida.
- They are mixtures of **ROCK** and **METAL**
- Ida is about **15 km** across



Size of Ida compared to Manhattan

## Itokawa

- Itokawa's orbit crosses the orbits of Earth and Mars but is not a threat to either
- It is made of a loose pile of boulders made of **ROCK** and **METAL**
- Its longest side is **535 meters**



Size of Itokawa compared to a stadium

## Jupiter

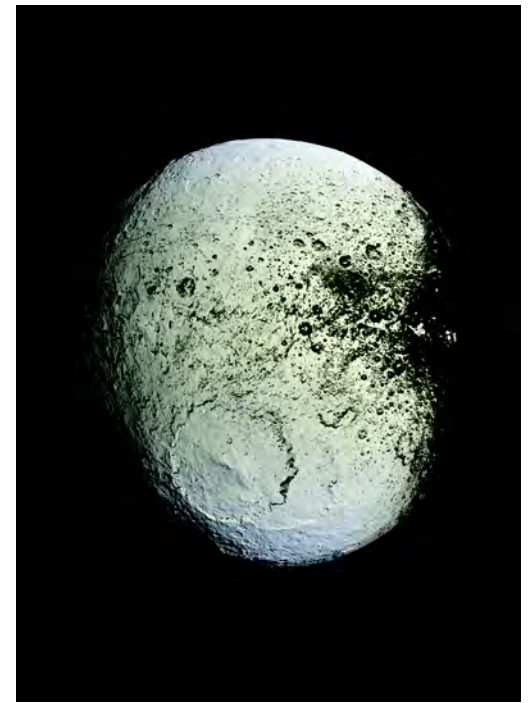
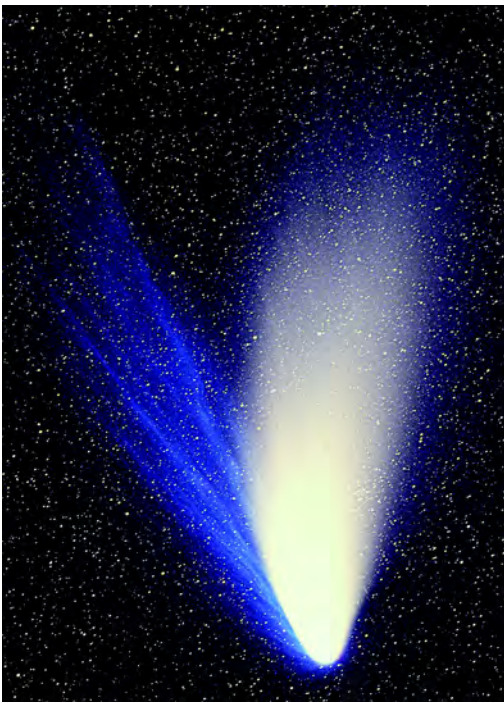
- Jupiter orbits the Sun between the Asteroid Belt and Saturn
- It is made of **GAS**
- Its diameter is about

**143,000 km**



Size of Jupiter's Red Spot compared to Earth





## Hale-Bopp

- Hale-Bopp orbits between Earth's orbit and the distant Solar System — far beyond the orbit of Pluto
- Hale-Bopp is made of **ICE** and **DUST**
- The tail shown here extends more than **1 million km**



## Hoba

- This object landed on Earth 80,000 years ago in what is now the country of Namibia
- Hoba is made of **METAL**
- It measures about **3 meters** across



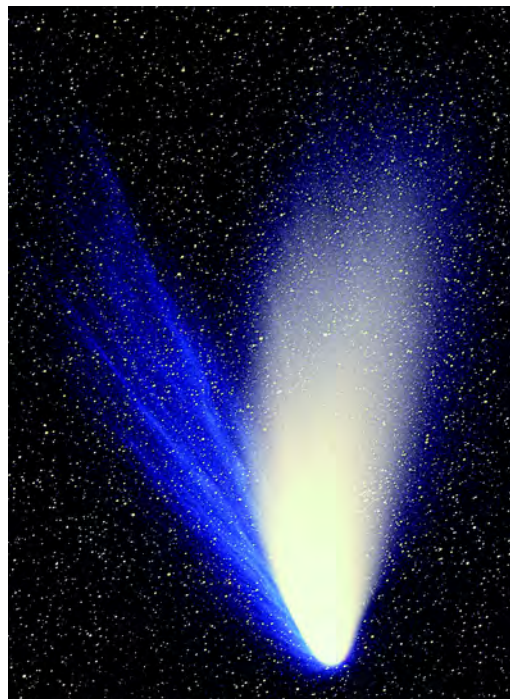
## Iapetus

- Iapetus orbits Saturn
- This walnut-shaped object is made of **ICE** with some **ROCK**
- It is **1,500 km** across, or about half as wide as the Earth's Moon



Size of Iapetus compared to Moon





## Earth's Moon

- The Moon orbits Earth
- It is made of **ROCK** with a small **METAL** core
- The Moon is **3,500 km** in diameter or about  $\frac{1}{4}$  the width of Earth



Size of Moon compared to Earth

## Gaspra

- This object orbits the Sun between Mars and Jupiter
- It is made of a mixture of **ROCK** and **METAL**
- It is **18 km** on the longest side



Size of Gaspra compared to Manhattan

## Hale-Bopp

- Hale-Bopp orbits between Earth's orbit and the distant Solar System — far beyond the orbit of Pluto
- Hale-Bopp is made of **ICE** and **DUST**
- The tail shown here extends more than **1 million km**



## Key to Sorting the Solar System Cards

| Object                  | Description  | Size (km) | Picture Credits                                    |
|-------------------------|--|-----------|--|
| <b>Barringer Crater</b> | Also known as Meteor Crater, it is located in Arizona, USA. Created by the impact of a meteorite about 50,000 years ago, this crater was formed before humans inhabited the Americas.  | 1.2       | B.P. Snowder                                       |
| <b>Ceres</b>            | Ceres is the largest object in the Asteroid Belt. The International Astronomical Union classifies Ceres as a Dwarf Planet. It is the target of the Dawn spacecraft in 2015.  | 950       | NASA, ESA, J. Parker (SwRI) et al.                 |
| <b>Earth</b>            | Earth is the third planet from the Sun and is the fifth largest planet in the Solar System. About 71% of Earth's surface is water, the remainder consists of land.   | 12,650    | Taken from Apollo 17 in 1972, credit NASA          |
| <b>Earth's moon</b>     | The moon is the fifth largest satellite in the Solar System. It is the only celestial body on which humans have landed. Although it appears bright in the sky, it is actually as dark as coal.   | 3,500     | NASA/JPL/USGS                                      |
| <b>Eris</b>             | Eris is a Dwarf Planet with a moon called Dysnomia. It is more massive than Pluto and orbits the Sun three times farther. It was discovered in 2005 and caused a stir after initially being described as the 10th planet.  | 2,600     | NASA/ESA/M. Brown                                  |
| <b>Eros</b>             | Eros was the first near-Earth asteroid discovered. It is also one of the largest. The probe NEAR Shoemaker landed on this asteroid in 2001. Eros orbits between Earth and Jupiter, crossing Mars's orbit.  | 34        | NASA/JPL/JHUAPL                                    |
| <b>Gaspra</b>           | Gaspra is an asteroid that orbits the inner edge of the main Asteroid Belt. The Galileo spacecraft flew by Gaspra on its way to Jupiter.   | 18        | NASA/JPL/USGS                                      |
| <b>Hale-Bopp</b>        | Hale-Bopp was one of the brightest and most widely viewed comets of the 20th century. It came into the inner Solar System in 1997 and has an orbital period of over 4,000 years.   | 1,000,000 | E. Kolmhofer, H. Raab; Johannes-Kepler-Observatory |
| <b>Hoba</b>             | The Hoba meteorite is the largest known meteorite on Earth. It landed here about 80,000 years ago in what is now Namibia. Hoba weighs over 60 tons and is the most massive piece of naturally-occurring iron on Earth's surface.                                   | 0.003     | Patrick Giraud                                     |
| <b>Iapetus</b>          | Iapetus is the third largest moon of Saturn. It has an equatorial ridge that makes it look a bit like a walnut, as well as a light and a dark side. Astronomers think that the dark side is covered with a thin layer of residue from the icy surface sublimating. | 1,500     | NASA/JPL/Space Science Institute                   |
| <b>Ida and Dactyl</b>   | Ida is a main belt asteroid and the first asteroid found to have a moon, Dactyl. It was imaged by the Galileo spacecraft on its way to Jupiter.  | 15        | NASA/JPL   |
| <b>Itokawa</b>          | Asteroid Itokawa crosses the orbits of both Mars and Earth. It is a rubble pile of rocks. In 2005, the Hayabusa probe landed on Itokawa to collect samples.  | 0.5       | ISAS, JAXA   |
| <b>Jupiter</b>          | Jupiter is the largest planet in the Solar System, more massive than all the other planets combined. This gas giant has been explored by many spacecraft, notably the Galileo orbiter. It has four large moons and dozens of smaller moons.                        | 70,000    | NASA/JPL/University of Arizona                     |

## Key to Sorting the Solar System Cards

| Object                  | Description   | Size (km) | Picture Credits   |
|-------------------------|---|-----------|---|
| <b>Mars</b>             | Mars is the fourth planet from the Sun. Iron oxide gives it a reddish appearance. It has polar ice caps and a very thin atmosphere. Two tiny moons might be captured asteroids.   | 6,800     | NASA  |
| <b>Meteor</b>           | Small pieces of asteroids or comets collide with Earth's atmosphere to create meteors. The compressed air in front of the rock heats up, causing it to glow and leave a trail of ionized gas.   | 0.00001   | Chuck Hunt  |
| <b>Meteorite</b>        | Most meteorites are pieces of the Asteroid Belt that land on Earth's surface. Over 90% of meteorites are considered stony meteorites. About 5% are iron meteorites. Both types contain a significant amount of iron.  | 0.001     | Dr. Svend Buhl<br>www.meteorite-recon.com                         |
| <b>Phobos</b>           | Phobos is the largest moon of Mars, but still quite small. It is likely a captured asteroid and will break up and crash into Mars in the next 40 million years.   | 11        | NASA/JPL-<br>Caltech/University of<br>Arizona                     |
| <b>Pluto and Charon</b> | Pluto is the 2nd largest dwarf planet in the Solar System (after Eris). It has a large moon Charon and two smaller moons, Nix and Hydra. Pluto and Charon are sometimes treated as a binary system since their center of gravity is between the two.                                  | 2,300     | ESA/ESO/NASA  |
| <b>Saturn</b>           | Saturn is the second largest planet in the Solar System. It is made of gas and has very thin icy rings. It also has dozens of moons. The Cassini-Huygens spacecraft has been orbiting Saturn since 2004.  | 120,000   | NASA/JPL/Space Science<br>Institute                               |
| <b>Shoemaker-Levy 9</b> | Comet Shoemaker-Levy 9 provided the first direct observation of the collision of extraterrestrial solar system objects. It broke into many fragments, called the "String of Pearls," and impacted Jupiter in 1994.  | 1         | NASA/HST  |
| <b>Sun</b>              | The Sun is the star at the center of our Solar System, about 150 million km from Earth. It contains 99.9% of all the mass in our Solar System. It travels once around the Milky Way Galaxy in about 250 million years.  | 1,400,000 | ESA/NASA/SOHO   |
| <b>Titan</b>            | Titan is the largest moon of Saturn, comprising 96% of the mass of all Saturn's moons combined. It is a cold world with a thick nitrogen atmosphere and liquid methane lakes on its surface. The Huygens probe landed on its surface in 2005 and took pictures of icy conditions.     | 5,150     | NASA/JPL/Space<br>Science Institute<br>NASA/JPL-                  |
| <b>Victoria Crater</b>  | This impact crater near the equator of Mars was visited by the Mars Exploration Rover <i>Opportunity</i> . The scalloped edges of the crater are caused by erosion. Although Mars has very little atmosphere, it does have dust storms.   | 0.75      | Caltech/University of<br>Arizona/Cornell/Ohio<br>State University |
| <b>Wild 2</b>           | Comet Wild 2 is officially named 81P/Wild. It once orbited beyond Jupiter but got too close to the giant planet in 1974 and was tugged into a smaller orbit between Jupiter and Mars. The Stardust sample return mission took pictures and captured some of the comet's coma in 2004. | 4         | NASA/JPL-Caltech  |

## ***Helpful Hints***

### **Common *misconceptions* addressed by these resources:**

- The Solar System contains more than one star
- The planets are the only things in our Solar System
- Science is a rigid set of facts to be memorized

### **Other Games:**

#### **Sort It:**

With a group of 20+, give each person a card and ask them to sort themselves by size, distance from the Sun, common materials, alphabetically, or shape. There may be more than one way to sort. All reasonable attempts should be accepted.

With smaller groups, each person (or group of up to 3 people) gets their own deck to answer the same questions. The first group to sort them correctly wins. Allow each group to finish and hold their hand up when they're done. Once they raise their hand, they can't change their order. If the first group has anything out of order, go to the second, and so forth.

#### **20 Questions:**

Have the presenter pick an object but don't tell the visitors. Let the visitors take turns asking yes/no questions until they guess the object. The person who guesses correctly gets to pick the next object. Give time during games and between rounds for visitors to look at the backs of the cards.

## ***Background Information***

This activity was adapted from a classroom activity originally developed by Anna Hurst Schmitt for the Teacher's Newsletter Universe in the Classroom:  
<http://www.astrosociety.org/education/publications/tnl/70/pluto.html> - 10

For a history of the definition of a planet, see these websites:  
<http://www2.ess.ucla.edu/~jlm/epo/planet/planet.html>

<http://www.astrosociety.org/education/publications/tnl/70/pluto.html>

<http://www6.cet.edu/dawn/multimedia/makeplanet.asp>



## ***Detailed Activity Description***

### **Sorting Our Solar System**

**Misconception Tip:**

Many people don't understand the difference between Solar System, Galaxy and Universe. Here is a chance to talk at length about the smallest of these scales.

**Presentation Tips:**


These cards can be used to illustrate many points. The activity described here is one example, but you may find others that work in different situations. You can also find other ideas in the "Helpful Hints" section.

Using more than one deck and breaking visitors into small groups can be interesting because they see that there are different ways to categorize the same objects.

If you would like to use more than one set of cards, it is recommended that you print them on various color card stock. The individual sets get easily combined into a single pile if they are all one color.

**Before you get started:**

Remove the Ceres card from the deck and put in your pocket. You will bring this out later.

| Leader's Role  | Participants' Role (Anticipated)   |
|--|--|
| <p><u>To say:</u><br/>What kinds of things do we find in our Solar System?</p> <p>Ahh! How many stars are there in our Solar System?</p> <p>There is actually only one star in our Solar System. The term "Solar System" refers just to our own star, the Sun and everything orbiting it.<br/>That includes planets, like you said. What else is in the Solar System that's not here on Earth?</p> <p><u>To do:</u><br/>Bring out all of the Solar System Cards, except for Ceres.</p> <p><u>To say:</u><br/>Great! Take a look at this. I've got pictures here that represent a sample of the different kinds of objects found in our Solar System. Now, you can't tell how big each object is just from the picture. Some pictures are taken close up and others from far away. You'll want to check the backs of the cards to see how big each object is. What else does the back of the card tell us?</p> <p>To do:<br/>Pick up one of the cards (in the following example, we are using Gaspra)</p> <p><u>To say:</u><br/>Scientists sort things by their physical characteristics. What are some characteristics of this object? Can you describe what it looks like?</p>  | <p>Planets, stars, people, airplanes</p> <p>Billions and billions</p> <p>Comets, moons, asteroids</p> <p>Where it is, what it's made of, how big it is</p> <p>It's lumpy. And brown, and has craters</p> |

| Leader's Role  | Participants' Role<br>(Anticipated)  |
|--|--|
| <p><u>To say:</u><br/>Great! We also know from the information on the back that it's as big as a city and that it orbits the Sun between Mars and Jupiter. These are characteristics too.</p> <p>Now it's your turn to be the scientist. Work together to sort these objects into some categories using their characteristics. Get creative! You get to choose the categories.</p>   | <p>Participants sort the cards into various groups.</p>  |
| <p><b>Presentation Tip:</b><br/>If you are working with a large group, give each person a card and have them sort themselves into categories. This can be very fun and collaborative!</p>  |  |
| <p><u>To say:</u><br/>There are no limits to the number of categories you can have. But think about the characteristics that objects in each of your categories have.</p> <p>Tell me about the categories you picked.</p> <p>Did any of the objects fit into more than one category? Tell me why you decided on the category you put them in.</p> <p>Okay, now where would this object fit?</p> <p><u>To do:</u><br/>Hand the group the Ceres card.</p> <p><u>To say:</u><br/>What characteristics does it share with that group? Could it fit in more than one group?</p> <p>(Extension) Could you refine your category definitions so that nothing fits in more than one category?</p> | <p>Describe groups</p> <p>Usually they do</p> <p>Put it in one of the categories</p> <p>Sometimes the groups are flexible enough</p> |

| Leader's Role   | Participants' Role<br>(Anticipated) |
|---|-------------------------------------|
| <p><i>To say:</i></p> <p>This is great! You are being real scientists. This is exactly what biologists, chemists, geologists, and astronomers do. And as new bacteria or birds or fossils are found, they use their knowledge of what has already been discovered to help them think about this new object.</p> <p>That's exactly what happened when Eris was discovered. Eris is another Pluto-sized object that's also orbiting way out past Neptune. And many more objects are being found out there all the time.</p> <p>Sometimes new discoveries even cause the definitions to change! The definition of a planet changed in 2006 and a whole new category was created: dwarf planet. That category includes both Ceres and Pluto.</p> <p>(If before an observing evening) Can you see any of these categories in the sky right now?</p> <p>Actually, do you see that bright star-like light over there? Well, it's not a star at all. That's Jupiter! Which category does that fit onto?</p> | <p>Sun or Moon or none</p>          |

## ***Materials***

### **What materials from the ToolKit do I need?**

In the activity bag:

At least one set of Solar System Cards (4 sets included in 2 decks)

### **What must I supply?**

- Table or flat surface for organizing the cards, unless you have a big group that can hold one card each



## Where do I get additional materials?

You can order additional sets, while supplies last, from the Night Sky Network. For more information, send an email to: [nightskyinfo@astrosociety.org](mailto:nightskyinfo@astrosociety.org)

To make additional copies of the cards, just print the following five pages in color, *one-sided* on card stock (or other thick paper).

Cut each page into 3 strips so that the image and description stay together.



Fold each strip in half to make two-sided cards. You can paste them with glue or tape around the edges.

For large groups where each person will hold a single card, you may want to print the large size cards. In that case, simply fold them in half and glue them together, as shown.



This activity can be done with any set of images in any size. The Hubble Site and the NASA Image archive have a wealth of pictures of Solar System objects.

- <http://hubblesite.org/newscenter/>
- <http://www.nasa.gov/multimedia/imagegallery/>

***Where could I use this activity?***

| ACTIVITY                 | Star Party | Pre-Star Party – Outdoors | Pre-Star Party – Indoors | Girl Scouts / Youth Group Meeting | Classroom |     |      | Club Mtg | Gen Public Presentation (Seated) | Gen Public Presentation (Interactive) |
|--------------------------|------------|---------------------------|--------------------------|-----------------------------------|-----------|-----|------|----------|----------------------------------|---------------------------------------|
|                          |            |                           |                          |                                   | K-4       | 5-8 | 9-12 |          |                                  |                                       |
| Sorting the Solar System |            | ✓                         | ✓                        | ✓                                 |           | ✓   | ✓    | ✓        | ✓                                | ✓                                     |

***What do I need to do before I use this activity?***

| What materials from the ToolKit are needed for this activity?  | What do I need to supply to run this activity that is not included in the kit? | Preparation and Set Up  |
|--|--|---|
| At least one set of Sorting the Solar System Cards. Four sets are included for use with larger groups. | A table or flat surface is preferred.  | Remove the Ceres card from the deck(s). These will be used later. |