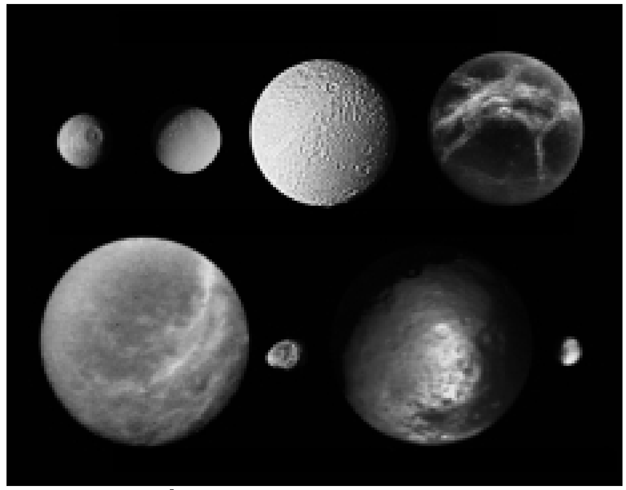
LESSON A2

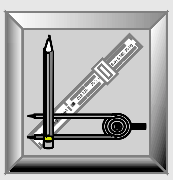
Saturn's Moons



Saturn's eight icy moons. Courtesy, NASA/JPL

Science Content Standards:
UNIFYING CONCEPTS AND PROCESSES
-Systems, order and organization
SCIENCE AS INQUIRY
-Abilities necessary to do scientific inquiry
EARTH AND SPACE SCIENCE
-Earth in the Solar System

Description:
Students use the data provided on a set of 18 *Saturn Moon Cards* to compare Saturn's moons to Earth's moon, and to explore moon properties and physical relationships within a planet-moon system. For example, the farther the moon is from the center of the planet, the slower its orbital speed, and the longer its orbital period. The lesson enables students to complete their own Moon Card for a "mystery moon" of Saturn whose size, mass, and distance from the center of Saturn are specified.



MATERIALS AND TOOLS

For the teacher:
Overhead projector
Earth Moon Chart* (T)

For each student group of 2-3:
Set of 18 Saturn Moon Cards*
2 to 3 paper clips
Paper

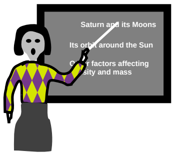
For each student:
Earth's Moon Chart *
Mystery Moon Card*

*Master is included T = Transparency

Prerequisite Skills:
Working in groups
Reading in the context area of science
Basic familiarity with concepts of mass, surface gravity, orbital period, and orbital speed (see next page)
Interpreting scientific notation
Using Venn diagrams
Sorting and ordering data

Estimated Time for Lesson:
3 hours (may vary with grade level)

Background Information:
Background for Lesson Discussion (see next page)
Question & Answer Section
1 - 21: The Planet Saturn
35 - 50: The Moons



Background for Lesson Discussion

Students may ask about the quantities listed on the Saturn Moon Cards:

Radius/Size: To determine the actual size of a moon or a planet, scientists make images of it and use the resolution or “scale” of the image (e.g. 1 picture element or “pixel” = 10 km). So, for example, if a round moon covers 6 pixels in the image, then the moon’s diameter would be: 6 pixels x 10 km/pixel = 60 km. Some moons have irregular shapes and so there may be more than one size dimension. If a moon is round, then one size (radius) is sufficient.

Distance from the center of Saturn: To determine the distance of a moon from the center of Saturn, astronomers make images of the moon and Saturn together and use the scale of the image, just as for determining size above.

Orbital Speed: Orbital speed is the speed of an object in orbit around another object. To determine orbital speed of a moon around Saturn, astronomers can take pictures of the moon over a period of time, and *measure* how far it moves in its orbit around Saturn during that time. This information can be used to compute a speed (Speed = Distance/Time). If you already know the moon’s distance from the center of Saturn, then you can use mathematical equations (Newton’s Laws) to *calculate* orbital speed. Orbital speed is the same for all objects orbiting at the same distance from the center of Saturn.

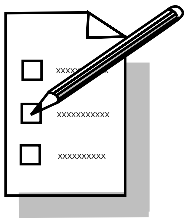
Orbital Period: The orbital period of a moon is the time it takes the object to go once around in its orbit of a planet. It can be observed directly or calculated using the moon’s distance from the center of Saturn (Kepler’s Laws -- see Glossary).

Mass: Mass is a measure of the amount of “stuff” an object is made up of. The most direct way to measure the mass of a moon only works for the larger moons. It involves a spacecraft flying very close to the moon to see how the moon’s gravity influences the speed of the spacecraft. From this, a mass can be calculated (using Newton’s Laws). This method does not work for the smaller moons because they do not have a strong enough gravity to have a measurable effect on the spacecraft’s speed. Thus, the masses of the smaller moons are largely unknown.

Surface Gravity: Surface gravity is a measure of the acceleration of gravity at the surface of the planet or moon. For Earth, this is about 9.8 meters/sec^2. For Earth’s moon it is 0.17 times this value or about 1.7 meters/sec^2. To calculate surface gravity you must know the moon’s size and mass. Surface Gravity = GM/R^2, where R is the radius of the moon, M is the mass of the moon, and G is the universal gravitational constant. Because the masses of the smaller moons are unknown, their surface gravities are also unknown.

Procedure:

Part I: What do we know about Earth's moon?



1. Display a transparency of the Earth's Moon Chart. Cover up the half of the transparency that displays moon data, and display only the lined half of the transparency on the overhead.

2. Ask students the following questions: What do you know about Earth's moon? Why do we call it a moon? What have we done to explore the moon? What moon mysteries do we still want to solve? Record their responses on the lined half of the transparency.

3. Give each student a copy of the Earth's Moon Chart. Allow students time to record the moon data that were collected on the transparency. Share the other half of the transparency and briefly review the provided Moon data. Review the meaning of the terminology used on the chart, including terms such as "orbital period" and "surface gravity". [See Background for Lesson Discussion on previous page.]

Part II: Making Connections to Saturn

1. Tell students that the focus of the lesson is to take a closer look at one of the elements of the Saturn system — the moons. Tell them that Saturn has more moons than any other planet in the Solar System. Draw a line down the center of the blackboard. At the top of the first column, write "What We Know." Ask students what they already know about Saturn's moons. Record their responses in the first column.

2. At the top of the second column, write "Questions We Have." Ask students what they want to learn about Saturn's moons. What questions do they have? Record their questions in the second column.

A set of Moon Cards for each student group must be made prior to the next portion of the lesson. To make one set, copy the 9 pages of Moon Cards and cut them in half. The Moon Cards begin on the page after the Earth's Moon Chart.

You may also want to use the completed Venn Diagram from Lesson A1 to introduce similarities and differences between the Saturn system and the Earth-Moon system.

You may want to use Greek mythology to introduce the names of Saturn's moons. See Connections Section of this Guide or other resources such as children's literature or videos.

3. Arrange students in groups of two or three. Give each group the set of 18 Moon Cards. Review the meaning of each of the properties listed on the cards [see Background for Lesson Discussion]. The bold terms on the cards are defined in the Glossary.

4. Instruct groups to explore the cards and to select the Saturn moon they consider most like Earth's moon. Remind them to use the information on Earth's moon from the beginning of the lesson for comparison. Guide students to consider properties other than surface features and physical appearance, such as distance from the center of the planet, orbital speed and period, radius, mass, and surface gravity. (Each group needs a fairly large space to work — the floor is an option!)

5. Once each group finds the moon they consider most like Earth’s moon, ask the students to create a Moon Comparison Chart using a piece of notebook paper. They should use paper clips to attach their chosen Saturn moon card to the left half of the page, and use the right half to fill in corresponding properties for Earth’s moon. One member of the group should record the group’s explanation of how they determined the two moons are alike.

6. Have student groups share their Moon Comparison Charts and explain how they determined that the two moons are alike. (Their moon choices will vary.)

According to the National Science Education Standards, “Abilities necessary to do scientific inquiry” include designing and conducting a scientific investigation (i.e., students should be able to formulate questions, design and execute experiments, interpret data, synthesize evidence into explanations, propose alternative explanations for observations, and critique explanations and procedures.)

7. Gather the class in an open area and tell students that the next part of the lesson is to use the Moon Cards to look for relationships between the various properties of Saturn’s moons. Model how to arrange the cards according to a property listed on the Moon Card. For example, ask students to order the cards from least to greatest “Distance from the Center of Saturn.” Check to be sure each group has done this properly.

8. Explain that relationships can be determined by looking at the other data provided on the cards when the cards are ordered or sorted in a particular way. For example, ask them to examine the ordered cards to try to determine what happens to the orbital period as a moon’s distance from the center of Saturn increases?

9. Guide students to see that as the distance from the center of Saturn increases, the orbital period also increases. In other words, the farther the moon is from Saturn, the longer the moon takes to orbit the planet Saturn.

10. Record the observed relationship on the blackboard. “As the distance from the center of Saturn increases, the orbital period increases.” Tell students that there are many other relationships to be discovered from the data on the Moon Cards.

11. Point to the other properties listed on the cards to model how to look for a pattern of increasing or decreasing data. Explain that this is one way to look for relationships. As one set of data increases, does another increase or decrease? How does it change?

12. List the following on the blackboard:
   a. Mass - Size
   b. Size - Shape
   c. Date of Discovery - Size
   d. Distance from center of Saturn - Orbital Speed
   e. Distance from center of Saturn - Mass
   f. Orbital Speed - Mass
   g. Size -Orbital Speed

13. Tell students that they need to arrange the Moon Cards in different ways to test for the relationships between the pairs of properties listed on the board. Have them record their conclusions about the relationships on a separate sheet of paper. Inform students that a clear relationship may not exist between some of the pairs of properties.

14. Once all groups have recorded their discoveries, ask every group to report out their results on the first relationship. Record responses. Discuss and resolve any discrepancies in group responses for this relationship. Repeat for each relationship. See the table on the following page for a sample of correct answers (Relationships in the Saturn System: a Sample of Correct Responses).

Part III: The Assessment

1. Tell students that other moons may exist in the Saturn system. Tell them that the next part of the lesson is hypothetical and that they will be creating a Mystery Moon Card. They will model their card after the Saturn Moon Cards.

2. Record the following information about the mystery moon on the blackboard: 1) The mystery moon is located in the Saturn system. 2) The mystery moon’s distance from the center of Saturn is the same as the distance between the Earth and its moon. 3) The radius, mass and surface gravity of the mystery moon are the same as Earth’s moon.

3. Give each student a copy of the Mystery Moon Card. Tell students they should use the Saturn Moon Cards, the Earth’s Moon Chart, and what they have learned about discovering relationships in the Saturn system to estimate the unknown data on the Mystery Moon Card. A helpful hint is to suggest that students order the cards and include Earth’s Moon Chart in their ordering of the Moon Cards. Each student should prepare his or her own unique Mystery Moon Card.

4. Allow time for students to work with the Moon Cards and the Earth’s Moon Chart. Have students complete their Mystery Moon Card by giving their moon a unique name, drawing their mystery moon, naming themselves as discoverer, estimating when the moon would have been discovered by real astronomers, estimating an orbital period and orbital speed, and writing a paragraph about the moon’s features.

Relationships in the Saturn System: A Sample of Correct Responses	
Compared Properties	**Relationship**
a. Mass-Size	As the radius/size of the moon increases, the mass of the moon also increases. This does not mean, however, that larger things are generally more massive. Compare a beach ball and a cannon ball. Which is larger? Which is more massive?
b. Size-Shape	As the moons increase in size, the shape becomes spherical. The smaller moons tend to have more irregular shapes.
c. Date of Discovery - Size	As the size of the moon decreases, the date of discovery is more recent. Bigger moons were discovered before smaller moons. Ask students why they think this is? Better technology?
d. Distance from center of Saturn - Orbital Speed	As the distance from the center of Saturn increases, the orbital speed decreases. Moons farther away from Saturn move around more slowly. This is a consequence of Newton's Law of Gravity.
e. Distance from center of Saturn - Mass	There is no simple physical relationship between a moon's distance from the center of Saturn and its mass.
f. Orbital Speed - Mass	There is no relationship between the orbital speed of the moons and the mass of the moons. In fact, orbital speed is not at all dependent on mass.
g. Size-Orbital Speed	There is no physical relationship between the size of the moons and the orbital speed of the moons.

Assessment Criteria

The drawing of the mystery moon is spherical in shape. [Earth's moon is similar in size to the moons of Saturn that are spherical in shape.]

The Mystery Moon Card data falls within the ranges noted below:

Date of Discovery: Between 1655 (Titan) and 1672 (Rhea)
[The size of Earth's moon (1738 km) is between the size of Titan (2575 km) and Rhea (764 km). Using the relationship between the size and the date of discovery, students can infer that the mystery moon would have been discovered between 1655 and 1672.]

Distance from the center of Saturn: 384,000 km [same as Earth-Moon distance]

Orbital Period: Between 2.74 days (Dione) and 4.52 days (Rhea)
[The distance of 384,000 km falls between the orbits of Dione (377,400 km) and Rhea (527,040 km). Since the orbital period increases with distance from the center of the planet, the orbital period of the mystery moon should fall between the orbital period of Dione (2.74 days) and Rhea (4.52 days).]

Orbital Speed: Between 8.49 km/sec (Rhea) and 10.03 km/sec (Dione)
[Since orbital speed decreases as distance from the center of the planet increases, the orbital speed of the mystery moon should fall between the orbital speed of Rhea (8.49 km/sec) and Dione (10.03 km/sec).]

Radius: 1738 km [Same as Earth's Moon]

Mass: 735×10^{20} kg [Same as Earth's Moon]

Surface Gravity: 0.17 of Earth's [Same as Earth's Moon]

There is a paragraph that describes the surface features of a mystery moon.

Part IV: Questions for Reflection

Would the relationships between physical properties (e.g. between orbital speed of a moon and distance from the center of the planet it orbits) be the same for Jupiter and its many moons?

If you were to send a probe to one of Saturn's moons, which one would it be? Why? What would you hope to discover?

Earth's Moon Chart

Distance from Earth:

384,000 km (238,080 mi)

Period of Orbit:

655.68 hours (27.32 days)

Orbital Speed:

1.02 km/sec (0.63 mi/sec)

Radius:

1,738 km (1,078 mi)

Mass:

735×10^{20} kg

Surface Gravity:

0.17 of Earth's

Other Features:

Rocky, cratered, mountainous.

One side always faces Earth.

Prominent flat, dark areas known as maria on Earth-facing side -- probably lava flows from past volcanic activity.

Humans first landed there in 1969.

PAN

Negative image courtesy of NASA/Voyager

DATA ON PAN

Discovered by Mark Showalter, 1991

Distance from center of Saturn
133,580 km (83,000 mi)

Orbital Period
0.575 days (13.80 hours)

Orbital Speed
16.86 km/sec (10.45 mi/sec)

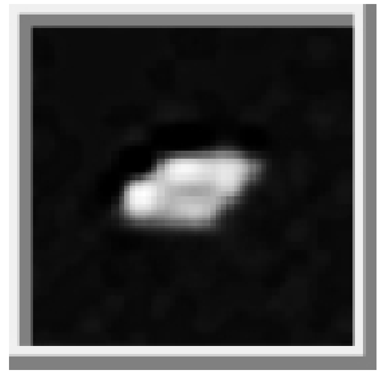
Radius
10 km (6 mi)

Mass
Unknown

Surface Gravity
Unknown

One of the tiniest moons in the Saturn system, Pan orbits in the narrow Encke Gap near the outer edge of the A Ring and clears out ring particles to form the gap. If Pan disappeared, so would the Encke Gap. Voyager made images of Pan during the **flybys** of 1980-81, but it was not detected until ten years later when astronomer Mark Showalter carefully hunted through the Voyager images to see if he could find a moon. **Cassini might answer...** Are there more undiscovered moons like Pan, clearing areas like the Encke Gap in the main rings?

ATLAS



Courtesy of NASA/Voyager

DATA ON ATLAS

Discovered by Rich Terrile and others, Voyager 1, 1980

Distance from center of Saturn
137,670 km (85,540 mi)

Orbital Period
0.602 days (14.45 hours)

Orbital Speed
16.61 km/sec (10.3 mi/sec)

Radius
19 x 17 x 14 km
average = 17 km (10 mi)

Mass
Unknown

Surface Gravity
Unknown

Atlas [AT-less] is the second innermost of Saturn's known moons. Astronomers believe it may be maintaining the sharp outer edge of the A Ring. **Cassini might answer...** How could a moon like Atlas keep the outer edge of the A Ring so sharp?

PROMETHEUS

Courtesy of NASA/Voyager

DATA ON PROMETHEUS

Discovered by Stewart Collins and others,
Voyager 1, 1980

Distance from center of Saturn
139,350 km (86,590 mi)

Orbital Period
0.613 days (14.71 hours)

Orbital Speed
16.50 km/sec (10.23 mi/sec)

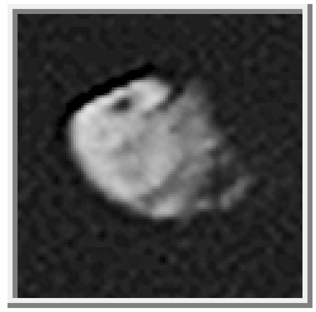
Radius
74 x 50 x 34 km
average = 53km (33 mi)

Mass
Unknown

Surface Gravity
Unknown

Moving outward from Saturn, Prometheus [pro-MEE-thee-uss] is the third moon. Together with Pandora (the fourth moon) it acts as a shepherd moon for the F Ring. This means the moons' gravity nudges the F Ring particles into a thinner ring, much like shepherds keep their flocks of sheep together. Prometheus is extremely elongated, even more so than an egg. **Cassini might answer...** What could have caused Prometheus' odd shape? How do Prometheus and Pandora shepherd the F Ring? Are there other moons playing shepherding roles?

PANDORA



Courtesy of NASA/Voyager

DATA ON PANDORA

Discovered by Stewart Collins and others,
Voyager 1, 1980

Distance from center of Saturn
141,700 km (88,050 mi)

Orbital Period
0.629 days (15.08 hours)

Orbital Speed
16.37 km/sec (10.15 mi/sec)

Radius
55 x 44 x 31 km
average = 43 km (27 mi)

Mass
Unknown

Surface Gravity
Unknown

Moving outward from Saturn, Pandora [pan-DOR-uh] is the fourth moon. Together with Prometheus (the third moon) it acts as a shepherd moon for the F Ring. This means the moons' gravity nudges the F Ring particles into a thinner ring, much like shepherds keep their flocks of sheep together. **Cassini might answer...** How do Prometheus and Pandora shepherd the F Ring? Are there other moons playing shepherding roles?

EPIMETHEUS

Courtesy of NASA/Voyager

DATA ON EPIMETHEUS

Discovered by John Fountain and Steve Larson, 1966

Distance from center of Saturn
151,420 km (94,090 mi)

Orbital Period
0.694 days (16.66 hours)

Orbital Speed
15.83 km/sec (9.81 mi/sec)

Radius
69 x 55 x 55 km
average = 60 km (37 mi)

Mass
Unknown

Surface Gravity
Unknown

The moon Epimetheus [epp-ee-MEE-thee-uss] actually shares its orbit with its neighbor, Janus. Both moons are in circular orbits around Saturn, with one of them slightly inward of the other. As the inner moon passes the outer one, they swap orbits! The new inner moon — which used to be the outer one — then begins to pull away from its companion, and the whole process begins again. In the image, note the shadow of one of Saturn’s rings! **Cassini might answer...** Are there other moons which swap orbits like these two moons?

JANUS

Courtesy of NASA/Voyager

DATA ON JANUS

Discovered by Audouin Dollfus, 1966

Distance from center of Saturn
151,470 km (94,120 mi)

Orbital Period
0.695 days (16.67 hours)

Orbital Speed
15.83 km/sec (9.81 mi/sec)

Radius
95 x 95 x 77 km
average = 89 km (55 mi)

Mass
Unknown

Surface Gravity
Unknown

The moon Janus [JANE-uss] actually shares its orbit with its neighbor, Epimetheus. Both moons are in a circular orbit around Saturn, with one of them slightly inward of the other. As the inner moon passes the outer one, they swap orbits! The new inner moon — which used to be the outer one — then begins to pull away from its companion, and the whole process begins again. **Cassini might answer...** Are there other moons which swap orbits like these two moons?

MIMAS

Courtesy of NASA/Voyager

DATA ON MIMAS

Discovered by William Herschel, 1789

Distance from center of Saturn
185,520 km (115,280 mi)

Orbital Period
0.94 days (22.62 hours)

Orbital Speed
14.30 km/sec (8.87 mi/sec)

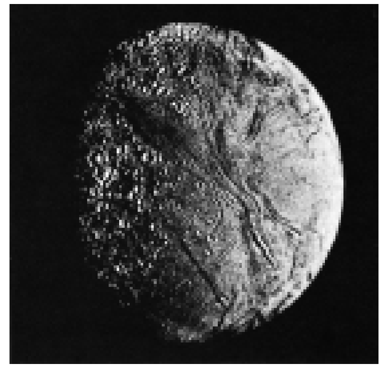
Radius
196 km (122 mi)

Mass
0.4 x 10^{20} kg

Surface Gravity
0.007 of Earth's

Mimas [MY-muss], the so-called "Death Star" moon, may have been hit and nearly shattered by a large asteroid or another moon. The massive crater caused by the impact is 130 kilometers (80 miles) in diameter, and in the center of the crater is a mountain more than 10 kilometers (6 miles) high — almost a mile higher than Mt. Everest! Astronomers think that even though Mimas does not orbit in the Cassini Division, its gravity is responsible for making this division (between the brightest A and B rings) clear of ring material. **Cassini might answer...** How does the gravity of Mimas clear out the Cassini Division?

ENCELADUS



Courtesy of NASA/Voyager

DATA ON ENCELADUS

Discovered by William Herschel, 1789

Distance from center of Saturn
238,020 km (147,900 mi)

Orbital Period
1.37 days (32.88 hours)

Orbital Speed
12.63 km/sec (7.83 mi/sec)

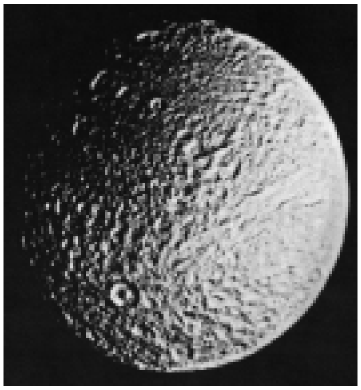
Radius
249 km (155 mi)

Mass
0.84 x 10^{20} kg

Surface Gravity
0.008 of Earth's

Much of the bright surface on Enceladus [N-sell-uh-duss] consists of water ice. The surface is smooth and has only a few impact craters, suggesting that events such as earthquakes or volcanic eruptions may have erased many older craters. It may even be possible that the gravitational tug of **tidal forces** from Saturn have caused the surface of Enceladus to warm and melt, occasionally triggering geysers of ice and water to erupt from the surface! **Cassini might answer...** Are ice geysers from this moon spewing material that becomes the tiny ice particles of the E Ring?

TETHYS



Courtesy of NASA/Voyager

DATA ON TETHYS

Discovered by Jean-Dominique Cassini, 1684

Distance from center of Saturn
294,660 km (183,090 mi)

Orbital Period
1.89 days (45.32 hours)

Orbital Speed
11.35 km/sec (7.04 mi/sec)

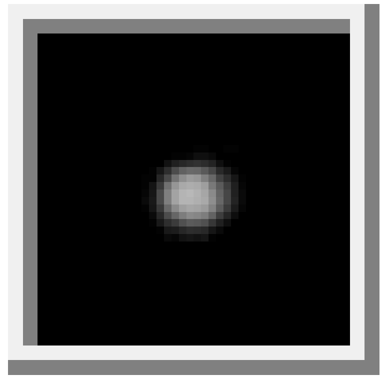
Radius
530 km (329 mi)

Mass
7.55×10^{20} kg

Surface Gravity
0.15 of Earth's

Tethys [TEE-thiss] is full of impact craters, including a large crater over 400 kilometers (250 miles) across — nearly half the diameter of the moon itself. On the opposite side, a giant crack extends over 3/4 of the way around the moon! This enormous canyon on Tethys is many times longer and deeper than the Grand Canyon on Earth. **Cassini might answer...** What more can we learn about the giant crack, named Ithaca Chasma, on this moon? What more can we learn about the giant crater, named Odysseus, on the opposite side? Are they linked?

TELESTO



Courtesy of NASA/Voyager

DATA ON TELESTO

Discovered by Brad Smith, Steve Larson, and Harold Reitsema, 1980

Distance from center of Saturn
294,660 km (183,090 mi)

Orbital Period
1.89 days (45.32 hours)

Orbital Speed
11.35 km/sec (7.04 mi/sec)

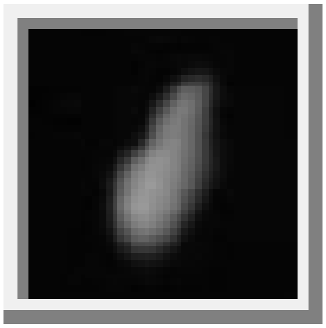
Radius
15 x 12.5 x 7.5 km
average = 12 km (7 mi)

Mass
Unknown

Surface Gravity
Unknown

The orbit of this moon has a special relationship to that of the large moon Tethys. Tethys orbits at the same distance from Saturn as Telesto [tel-LESS-toe] and Calypso as they travel around Saturn. Tethys always remains 60° ahead of Tethys, while Calypso is always 60° behind. Can you draw a labeled diagram to show this? **Cassini might answer...** How did the moons get into this type of orbit with each other?

CALYPSO



Courtesy of NASA/Voyager

DATA ON CALYPSO

Discovered by Dan Pascu and others, 1980

Distance from center of Saturn
294,660 km (183,090 mi)

Orbital Period
1.89 days (45.32 hours)

Orbital Speed
11.35 km/sec (7.04 mi/sec)

Radius
15 x 8 x 8 km
average = 10 km (6 mi)

Mass
Unknown

Surface Gravity
Unknown

The orbit of this moon has a special relationship to that of the large moon Tethys. Tethys orbits at the same distance from Saturn as Calypso [kuh-LIP-soh] and Telesto as they travel around Saturn. Calypso always remains 60° ahead of Tethys, while Telesto is always 60° behind. Can you draw a labeled diagram to show this? **Cassini might answer...** How did the moons get into this type of orbit with each other?

DIONE

Courtesy of NASA/Voyager

DATA ON DIONE

Discovered by Jean-Dominique Cassini, 1684

Distance from center of Saturn
377,400 km (234,500 mi)

Orbital Period
2.74 days (65.7 hours)

Orbital Speed
10.03 km/sec (6.22 mi/sec)

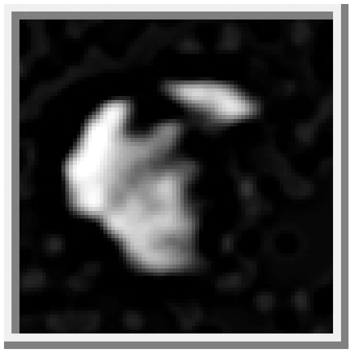
Radius
560 km (347 mi)

Mass
10.5×10^{20} kg

Surface Gravity
0.023 of Earth's

Dione [DI-oh-nee] appears to be covered with water ice and many impact craters. Floods may have filled many of the craters. Bright streaks cover one side of this moon. Dione also appears to control the intensity of **radio waves** generated by Saturn's **magnetic field**. **Cassini might answer...** Are the floods the result of recent ice flows? Why might Dione be affecting Saturn's radio emissions? Does Dione have a magnetic field of its own?

HELENE



Courtesy of NASA/Voyager

DATA ON HELENE

Discovered by Pierre Laques and Jean Lecacheux, 1980

Distance from center of Saturn
378,400 km (234,600 mi)

Orbital Period
2.74 days (65.69 hours)

Orbital Speed
10.02 km/sec (6.21 mi/sec)

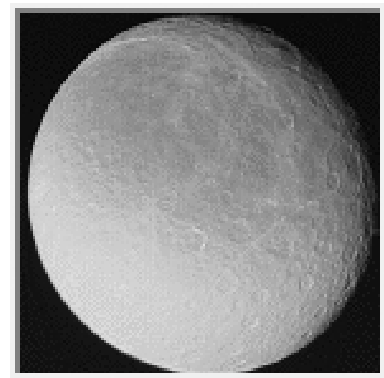
Radius
17.5 x 16 km
average = 17 km (11 mi)

Mass
Unknown

Surface Gravity
Unknown

Helene [huh-LEE-nee] is a small moon orbiting at the exact same distance from Saturn as the large moon Dione. Saturn seems to have a long history of "adopting" moons. Most of the smaller moons like Helene are not round, but instead have strange or irregular shapes. **Cassini might answer...** Why do so many of Saturn's moons share orbits?

RHEA



Courtesy of NASA/Voyager

DATA ON RHEA

Discovered by Jean-Dominique Cassini, 1672

Distance from center of Saturn
527,040 km (327,490 mi)

Orbital Period
4.52 days (108.4 hours)

Orbital Speed
8.49 km/sec (5.26 mi/sec)

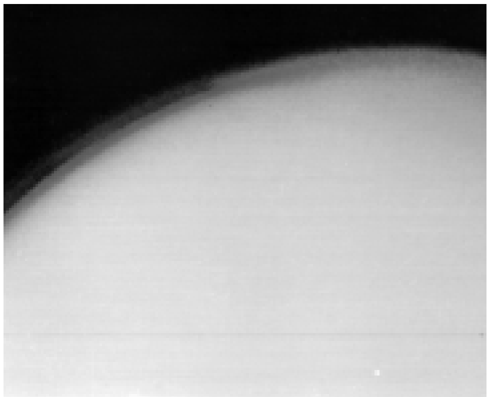
Radius
764 km (474 mi)

Mass
24.9×10^{20} kg

Surface Gravity
0.026 of Earth's

Rhea [REE-uh] is Saturn's second largest moon. Like Dione and Tethys, astronomers think it is composed of rock covered by water ice. It has more impact craters than any other moon orbiting Saturn. In the Voyager pictures, we also see wispy, light-colored streaks on one side of the moon. **Cassini might answer...** Why does Rhea have so many craters compared to the other moons? Does it have any connection with geologic activity such as earthquakes or erupting volcanoes? Could the wispy streaks be water released from the interior and frozen on the surface in the distant past? Why are the streaks only on one side?

TITAN



Courtesy of NASA/Voyager

DATA ON TITAN

Discovered by Christiaan Huygens, 1655

Distance from center of Saturn
1,221,830 km (759,210 mi)

Orbital Period
15.95 days (382.7 hours)

Orbital Speed
5.57 km./sec (3.45 mi/sec)

Radius
2,575 km (1,597 mi)

Mass
1350×10^{20} kg

Surface Gravity
0.137 of Earth's

Titan [TI-ten], Saturn's largest moon, is one of the few bodies in the Solar System besides Earth with a dense **atmosphere.** Like Earth, its atmosphere is made mostly of nitrogen. Scientists believe Titan's atmosphere may be similar to that of the early Earth, before life began. Titan's atmosphere is extremely cold and so hazy that very little sunlight reaches the surface. Titan's temperatures hover around -180 °C (-292 °F). The Cassini mission's Huygens Probe will descend through Titan's atmosphere, taking the first pictures ever of Titan's landscape. **Cassini might answer...** Will Titan have mountains of icy rock? What color will Titan's surface be?

HYPERION

Courtesy of NASA/Voyager

DATA ON HYPERION

Discovered by William Bond, George Bond, and William Lassell, 1848

Distance from center of Saturn
1,481,100 km (920,300 mi)

Orbital Period
21.28 days (510.6 hours)

Orbital Speed
5.06 km/sec (3.14 mi/sec)

Radius
180 x 140 x 113 km
average = 144 km (90 mi)

Mass
Unknown

Surface Gravity
Unknown

Little Hyperion [high-PEER-ee-on] is especially interesting. It orbits just beyond Saturn's giant moon, Titan. Why is Hyperion shaped like a dented hamburger? Could it be a fragment of a large moon that was split apart by collision with an asteroid or a chunk of moon? It tumbles unpredictably in its orbit, causing its north pole to point in different directions. Sometimes it spins slowly, and sometimes quickly! **Cassini might answer...** Could the gravitational tug of Titan be causing Hyperion's wild tumbling?

IAPETUS

Courtesy of NASA/Voyager

DATA ON IAPETUS

Discovered by Jean-Dominique Cassini, 1671

Distance from center of Saturn
3,561,300 km (2,212,900 mi)

Orbital Period
79.3 days (1,904 hours)

Orbital Speed
3.26 km/sec (2.02 mi/sec)

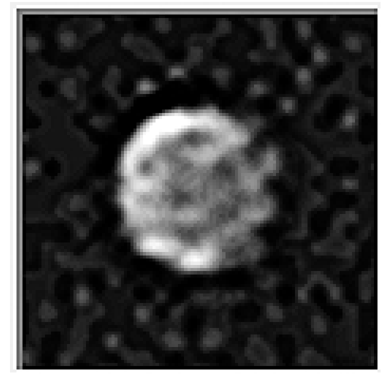
Radius
718 km (445 mi)

Mass
18.8×10^{20} kg

Surface Gravity
0.02 of Earth's

Iapetus [eye-APP-eh-tuss] is a strange moon that appears bright white on one side and dark, almost black, on the other. The bright area may be water ice, while the dark area — called Cassini Regio — is a mystery! **Cassini might answer...** Why is Iapetus' surface half bright and half dark? Could it come from dark material bubbling out from volcanoes? Or might it come from dust in space being swept up by the moon, like a dirty cosmic broom?

PHOEBE



Courtesy of NASA/Voyager

DATA ON PHOEBE

Discovered by William Pickering, 1898

Distance from center of Saturn
12,952,000 km (8,048,000 mi)

Orbital Period
550.5 days (13,212 hours)

Orbital Speed
1.71 km/sec (1.06 mi/sec)
(reversed)

Radius
115 x 110 x 105 km
average = 110 km (68 mi)

Mass
Unknown

Surface Gravity

Little Phoebe [FEE-bee] is the farthest moon from Saturn yet discovered. Unlike the other moons of Saturn, Phoebe and neighboring moon Iapetus both have orbits that are significantly tilted. This means these moons pass above then below the plane of Saturn's rings during their journey around Saturn. Phoebe is a strange, dark little moon that orbits Saturn in the direction opposite that of all of Saturn's other moons! It is uncertain why Phoebe is so "backwards." **Cassini might answer...** Is Phoebe a captured **asteroid**? Why is it orbiting backwards compared to the rest of the moons? Will it still be there far in the future?

Mystery Moon Card

Name of Moon: __________________________

Drawing of my Mystery Moon

Discovered by: ____

DATA ON MY MYSTERY MOON

Distance from center of Saturn: ________________________

Orbital Period: ___________________________________

Orbital Speed: ___________________________________

Radius: ____

Mass: ____

Surface Gravity: _________________________________

Description of my Mystery Moon: ___________________________________

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