GETTING TO KNOW SATURN

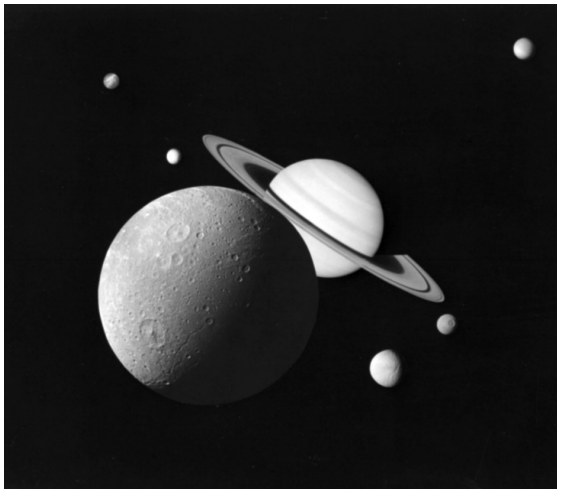
LESSON 1

3 hrs

The Saturn System

Students learn the concept of a system and apply it to learning about the Saturn system. They work with a ready-made scale diagram of the Saturn system, including the planet, rings, and moons.

The lesson prepares students to complete a Venn diagram that compares and contrasts the Saturn and Earth–Moon systems in terms of the systems' components and interactions.



Composite of Voyager images of Saturn and some of the moons.

MEETS NATIONAL SCIENCE EDUCATION STANDARDS:

Unifying Concepts and Processes
- *Systems, order, and organization*

Earth and Space Science
- *Earth in the Solar System*

PREREQUISITE SKILLS

Working in groups
Drawing and interpreting system diagrams
Measuring in millimeters
Computation (multiplication and division)
Completing a Venn diagram

BACKGROUND INFORMATION

Background for Lesson Discussion, page 2
Questions, page 7
Answers in *Appendix 1,* page 225
1–21: Saturn
22–34: Rings
35–50: Moons
51–55: Observing Saturn in the Sky

EQUIPMENT, MATERIALS, AND TOOLS

For the teacher

Photocopier (for transparencies & copies)
Overhead projector
Chalkboard, whiteboard, or easel with paper; chalk or markers
Color image or video of Saturn (optional)
Basketball (optional)

For each group of 3 to 4 students

Chart paper (18" x 22"); color markers
Notebook paper; pencils; clear adhesive tape; scissors; ruler with millimeter divisions
Meter stick (optional)

Materials to reproduce

Figures 1–8 are provided at the end of this lesson.

FIGURE	TRANSPARENCY	COPIES
1	1	1 per group
2	1	optional
3		1 per group
4		1 per group
5		1 per group
6		1 per group
7		optional
8		1 per student

LESSON 1

Background for Lesson Discussion

Comparing the Saturn system to Earth's system

(See Procedures & Activities, Part II, Step 3)

- The Saturn system is farther from the Sun.
- The planet in the Saturn system is bigger.
- Saturn is a different color (butterscotch yellow).
- Saturn is made mostly of gas instead of rock.
- The Saturn system has rings.
- The Saturn system has more than one moon.
- The Saturn and Earth systems are both subsystems of the Solar System.
- Both systems receive and reflect sunlight.
- Both systems have at least one moon.
- In both systems, gravity acts to keep the moon(s) orbiting around the planet.
- In both systems, there are tidal forces between the planet and moon(s).

Examples of interactions in the Saturn system

(See Procedures & Activities, Part II, Step 10)

The basic parts of the Saturn system are the planet, rings, and moons. The relationships and interactions among them are defined predominantly by gravity. The moons and ring particles of the Saturn system orbit Saturn just like the planets and asteroids of the Solar System orbit the Sun. Fundamental properties of a system arise from the interaction of its parts, not from the properties of the individual parts.

- Moon–ring interaction include:
  - — Prometheus and Pandora "shepherding" the F ring
  - — Pan "clearing" the Encke Gap at the outer edge of the A ring
  - — Enceladus possibly having ice geyers that create the E ring
- Moon–moon interactions include Epimetheus and Janus swapping orbits.
- Moon–planet interactions include tidal forces between the moons and the planet.

(Note: This can be discussed further if students have learned something previously about tidal forces between Earth and the Moon. See the Glossary.*)*

Examples of inputs and outputs in the Saturn system

(See Procedures & Activities, Part II, Step 10)

Sunlight is both an input to and an output of the Saturn system. As an input, the Sun heats the system, but because Saturn is so far away from the Sun, it is very cold compared with Earth. As an output, reflected sunlight is seen when we observe Saturn and its rings and moons. In the same way, we see the reflected light of the Moon from Earth.

It is possible that Saturn's gravity captures asteroids, comets, and meteorites from time to time. These events are considered inputs to the system. The moon farthest from Saturn (Phoebe) may be a captured asteroid. Comets that passed near Saturn may have collided with and broken up a moon, and played a role in the formation of Saturn's rings.

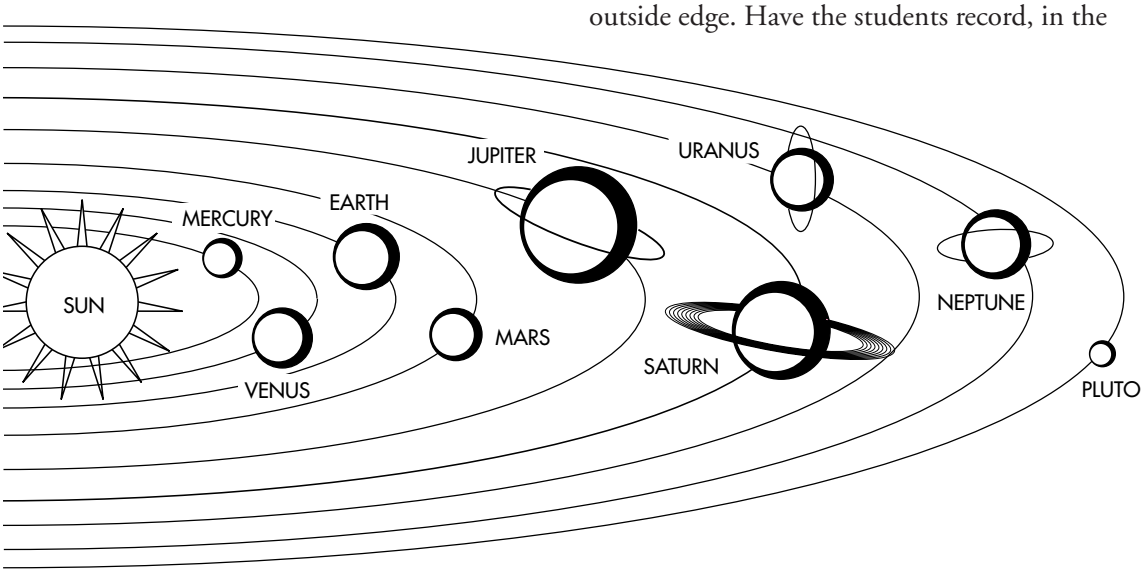
Radio waves are another output of the Saturn system. The mechanisms behind some of Saturn's emission of "light" in the radio-wave portion of the electromagnetic spectrum are unknown.

LESSON 1

Lesson Plan

Part I: What Is a System?

1 Tell the students that diagrams are simple drawings that can show the basic organization of a system. Demonstrate how to make diagrams by drawing the Solar System, including the Sun and planets with their labels, and the planets' orbital paths. For completion, title the diagram (of course, it is not to scale).



The Solar System (not to scale).

2 Ask students this question: How have you heard the word "system" used? List their responses on the chalkboard. Possible student responses include: Solar System, school system, computer system, stereo system, digestive system, and so on.

According to the National Science Education Standards, a system is an organized group of related objects or components that form a whole. For example, systems can consist of organisms, machines, fundamental particles, galaxies, ideas, numbers, transportation, and education. Systems have boundaries, components, flow (input and output), and interactions.

3 Have the students select and diagram on notebook paper a system other than the Solar System.

4 Have students form groups with those who have drawn different system diagrams. Limit group size to four students.

5 Give each group a sheet of chart paper, and have them attach their diagrams around the outside edge. Have the students record, in the center of the paper, all the similarities they can find in their system diagrams. Guide students to consider questions such as — What do all the diagrams have in common? (For example: titles, labels, or objects.) What do all the systems have in common? (For example: parts, interconnections and interactions among parts, boundaries, inputs, outputs, organizing principles, or forces.)

6 Have each group share their diagrams with the whole class. Discuss with students their understanding of systems. Guide them to recognize the various aspects of a system and the pervasive nature of "systems" in our world, in the Solar System, and in the Universe.

Part II: Making Connections to Saturn

1 Have the students focus on the planet Saturn in the Solar System diagram you drew for them. Note that Saturn is the sixth planet from the Sun and that it has rings (as do all of the giant planets in the outer Solar System which are composed primarily of gases). Remind them that the Solar System diagram is not to scale, that Saturn is really much larger than Earth, and that Saturn is approximately 10 times farther from the Sun than is Earth. Inform the students that NASA has a spacecraft called Cassini that will study Saturn (it was launched in 1997 and will arrive at Saturn in 2004).

2 Display the transparency of the *Voyager Image of Saturn* (Figure 1) to introduce the look of Saturn and its rings. Tell students that Saturn is a large ball of gas and does not have a solid surface like Earth's. Ask students to guess what size Earth would be if placed next to Saturn in this image (they will work out the answer during a later activity).

Note: If you have a color image or video of Saturn, it can be used to further motivate students' interest in Saturn. If you have access to the World Wide Web, the Cassini website is an excellent source of Saturn images (http://www.jpl.nasa.gov/cassini/). There are also other exceptional websites — please see *Appendix 5, Resources*.

3 Ask students to consider how Saturn's system is different from or the same as Earth's system. For example: How are the parts of the two systems different or the same? How might the interactions between the parts be different or the same? How are the inputs and outputs different or the same? (See information in *Background for Lesson Discussion*.)

4 Display the *Saturn Ring System* (Figure 2) transparency. Discuss students' observations of the ring illustration. For example: How many rings are there? Do the rings appear in alphabetical order from Saturn outward? How wide are the rings relative to the planet and to the Earth–Moon system?

5 Explain that the next part of the lesson will involve looking at a close-up of a smaller section of the rings, and show students the four pages of the *Saturn System Diagram* (Figure 4). Detailed instructions for assembling the diagram are shown in Figure 3. Tell students that the scaled Saturn on the diagram is about the size of a basketball. Show them how to tape together the *Saturn System Diagram:*

- Line up the center lines of each section (labeled A, B,C, and D).
- Use the arc of the G ring to estimate the connection between Sections A and B.
- Tape A and B together.
- Line up C and D to B and tape together.

Note: Older or more advanced students can achieve a more accurate depiction of scaled distances to the moons outside the A ring by following the directions in *How to Assemble the Saturn System Diagram*. (For lower grade levels, this degree of care in assembly is likely to take too much time away from the main concept of the lesson.)

6 Put students in an even number of small groups of 3 or 4. Give each group a copy of the 4-page *Saturn System Diagram* and a paper copy of the *Voyager Image of Saturn* (Figure 1). Have students carefully tape together their diagrams.

7 Ask the students to look at their assembled *Saturn System Diagram* and review it briefly. Ask them to share their immediate observations — for example, the number of rings, gaps, or divisions; location of moons; size of Earth relative to Saturn and Titan; special notes about various elements of the system, etc. *Optional: Pass a basketball around to each group so that students can compare its size to Saturn in their diagram.*

8 Distribute a copy of the *Saturn System Scavenger Hunt* (Figure 5) pages to each group. Point out that it is important for students to read all the information for each question to learn more about the Saturn system. Explain that each section of the scavenger hunt includes questions for the students to answer by using the *Saturn System Diagram.* Some sections include space for students to generate additional questions that can be answered by using the diagram. Advise students that their classmates will be asked to answer the questions they create using the diagram.

9 After students have completed the *Saturn System Scavenger Hunt*, have them trade scavenger hunts with another group. Each group will then try to find answers to the questions created by their partner group.

10 Review and discuss the scavenger hunt. (See the *Saturn System Scavenger Hunt Answer Key* [Figure 6] at the end of this lesson.) Guide students to see how the Saturn system is an example of a system. What are the parts of a system? How do they relate and interact with each other? What are the inputs and outputs of the system? (See information in *Background for Lesson Discussion*.) Figure 7, the *Saturn System Table*, can be provided to students for additional information in working with the *Saturn System Diagram* (see *Additional Exercises*).

Part III: Assessment

1 Give each student a copy of the *Earth/Saturn Systems Venn Diagram* (Figure 8). Ask students to think about how the two systems are alike and how they are different in terms of their definition of a system. Explain the three different areas on the Venn diagram — the region where the circles intersect should contain aspects that both systems have in common, and the regions that do not overlap should contain aspects that are unique to each system.

2 Have students record system aspects in the appropriate areas on the Venn diagram. Ask students to record at least three system aspects in each area.

3 Have students write a paragraph or two on the back of their Venn diagram sheets that explains how the Saturn system is a system. Tell them that their explanations should include specific examples to illustrate various properties of the system.

Assessment Criteria

1. The student should identify differences and similarities between the two systems and write them in the correct areas of the Venn diagram. Some included items might be:

EARTH SYSTEM
- *Inner part of Solar System*
- *One moon*
- *Inhabited by humans and other life forms*
- *Moon has been visited by humans*
- *Earth and Moon made mostly of rock*
- *Planet does not have rings*

SATURN SYSTEM
- *Outer part of Solar System*
- *Many moons*
- *Uninhabited*
- *Planet is a ball of gas instead of rock*
- *Planet has rings*

BOTH EARTH AND SATURN SYSTEMS
- *Have parts that interact*
- *Are subsystems of the Solar System*
- *Orbit the Sun*
- *Have at least one moon*
- *Have been explored by spacecraft*
- *Are held together by the force of gravity*

2. In the student's paragraph, the Saturn system is explained as a system composed of several elements, including a planet, rings, and moons. There should be two to three examples of how the system's components interact with or relate to each other, and at least one example of an input and output to the system. (See information in Background for Lesson Discussion.*)*

Part IV: Questions for Reflection

- How would the night sky be different if you lived in the Saturn system instead of the Earth–Moon system?
- What are the similarities and differences between the Saturn system and the Solar System?
- What are the similarities and differences between the Saturn system and the system you diagrammed at the beginning of the lesson?

Part V: Lesson Extensions

1. Ask students to do additional measurements and computations of distances on the *Saturn System Diagram*. See the *Saturn System* table for measurements and scale factors.

2. Ask the students to make a 3-D scale model of Saturn and its main rings using a 3-inch-diameter styrofoam ball and other basic materials. You can download classroom-tested directions for making the model at this website — http://lyra.colorado.edu/sbo/mary/Cassini/scale_saturn.html

LESSON 1

Questions

These questions and their answers can be used to provide background for teachers or to explore prior knowledge and facilitate discussions with students. The answers are found in Appendix 1*, starting on page 225.*

Saturn

1. When did we discover Saturn?
2. How did Saturn get its name?
3. Where is Saturn located?
4. How old is Saturn?
5. How big is Saturn?
6. If Saturn is so much more massive than Earth, why is it said that Saturn could float in water?
7. What is Saturn made of?
8. Could we breathe Saturn's atmosphere?
9. Pictures of Saturn show that it sort of flattens out near the poles and is wider at the equator. Why is that?
10. Why is Saturn so much larger and more massive than Earth?
11. Since Saturn does not have a solid surface, would I sink to the middle of the planet if I tried to walk there?
12. What's gravity like on Saturn? Would I weigh the same on Saturn as on Earth?
13. What is the temperature on Saturn?
14. Does Saturn have winds and storms?
15. Since Saturn and Jupiter are both made up of mostly hydrogen and helium, why isn't Saturn the same color as Jupiter?
16. Is there life on Saturn?
17. Does Saturn have a magnetic field like Earth's?
18. How long is a day on Saturn?
19. How long is a month on Saturn?
20. How long is a year on Saturn?
21. Does Saturn have seasons like Earth?

Rings

22. How did we first find out about Saturn's rings?
23. What are the rings of Saturn made of ? Are they solid?
24. How many rings are there?
25. Do the rings move?
26. In the opening sequence of the TV show *Star Trek: Voyager*, a ship passes through the rings of Saturn from bottom to top. Do the rings contain more empty space or more solid particles?
27. How big are the rings?
28. How much stuff is in the rings?

29. Do ring particles collide?

30. Why does Saturn have rings? How were the rings made?

31. How old are the rings? Has Saturn always had rings? Will it always have rings?

32. Are there other planets with rings?

33. Why doesn't Earth have rings?

34. If Earth had rings like Saturn's, what would they look like from the ground?

Moons

35. How many moons does Saturn have?

36. Who discovered all these moons?

37. How did the moons get their names?

38. Are Saturn's moons like Earth's Moon?

39. Why does Saturn have so many moons, but Earth has only one?

40. Are Saturn's moons in the rings? Do the moons collide with the ring particles?

41. What is the difference between a moon and a ring particle?

42. What's gravity like on Saturn's moons? Could we walk there?

43. Are there volcanoes on any of Saturn's moons?

44. How cold are Saturn's moons?

45. Do any of Saturn's moons have an atmosphere? Could we breathe it?

46. Is there water on Titan?

47. Is there life on Titan?

48. What is the weather like on Titan?

49. Cassini carries a probe that is going to Titan, not Saturn or any other moons? Why Titan?

50. Will there be a mission that takes humans to Titan in the near future?

Observing Saturn in the Sky

51. Can I see Saturn in the sky at night?

52. Can I see Saturn's rings from Earth?

53. What do I do if I want to see Saturn's rings, but I don't have a powerful enough telescope?

54. If I were on Saturn or Titan, could I see Earth and its Moon? Would I need a telescope?

55. If I were standing on Titan, how would Saturn look?

LESSON 1

Materials

Figure 1 **Voyager Image of Saturn**

Figure 2 **Saturn Ring System**

Figure 3 **How to Assemble the Saturn System Diagram**

Figure 4 **Saturn System Diagram (4 pages)**

Figure 5 **Saturn System Scavenger Hunt (4 pages)**

Figure 6 **Saturn System Scavenger Hunt Answer Key**

Figure 7 **Saturn System Table — Optional**

Figure 8 **Earth/Saturn Systems Venn Diagram**

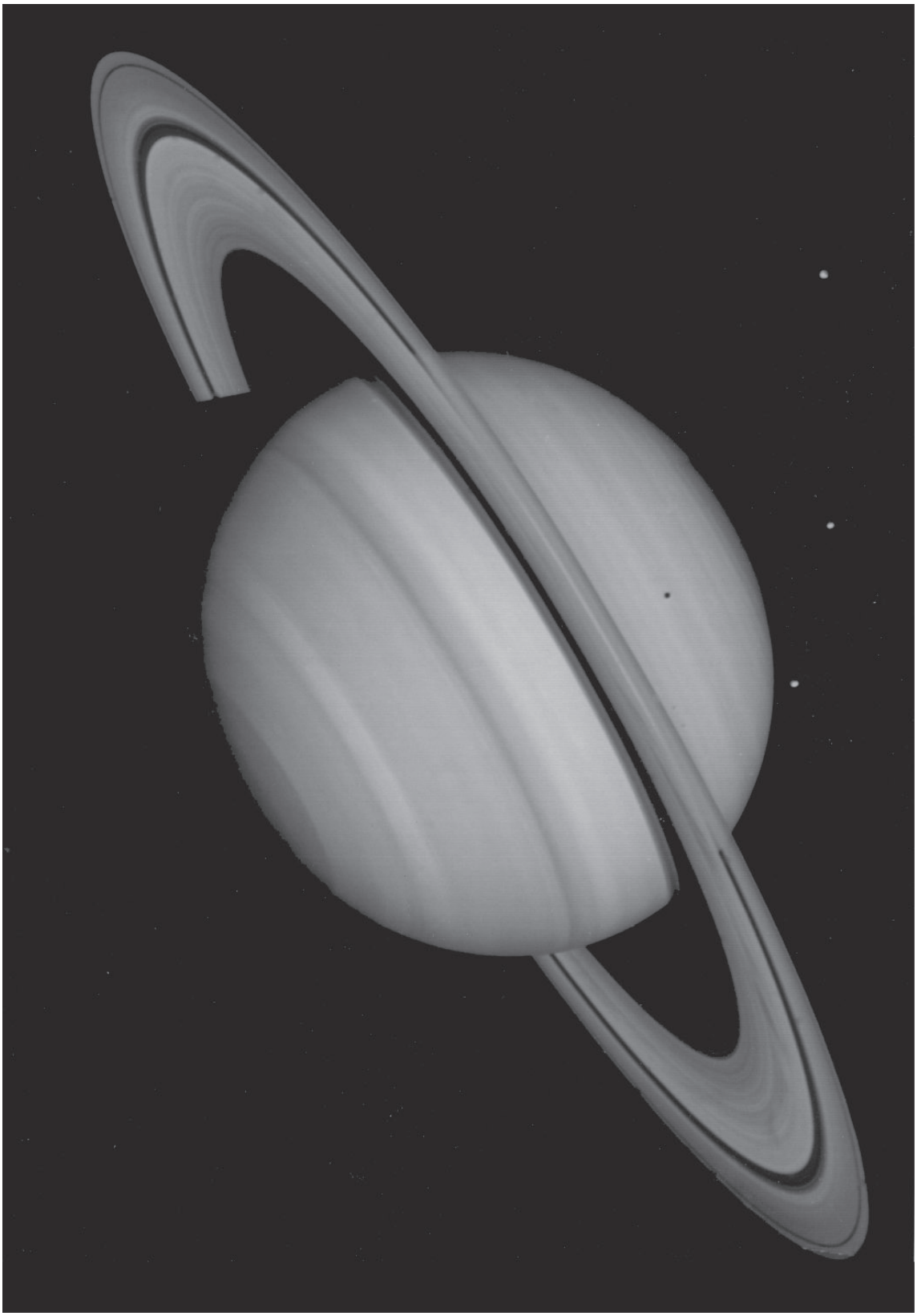
LESSON 1

Figure 1

It appears that three moons are scattered about Saturn, but in reality, all of Saturn's known moons except the two outermost ones orbit in the same plane as do Saturn's rings. In images, a moon may appear outside Saturn's ring plane because of the moon's position in its orbit and the angle from which the Saturn system is being viewed. The small dark shadow on the surface of Saturn is that of a fourth moon, which does not appear in the image.

A similar image of Saturn may be found at <http://www.jpl.nasa.gov/cassini/ Images/astro/23887.html>.

Voyager Image of Saturn



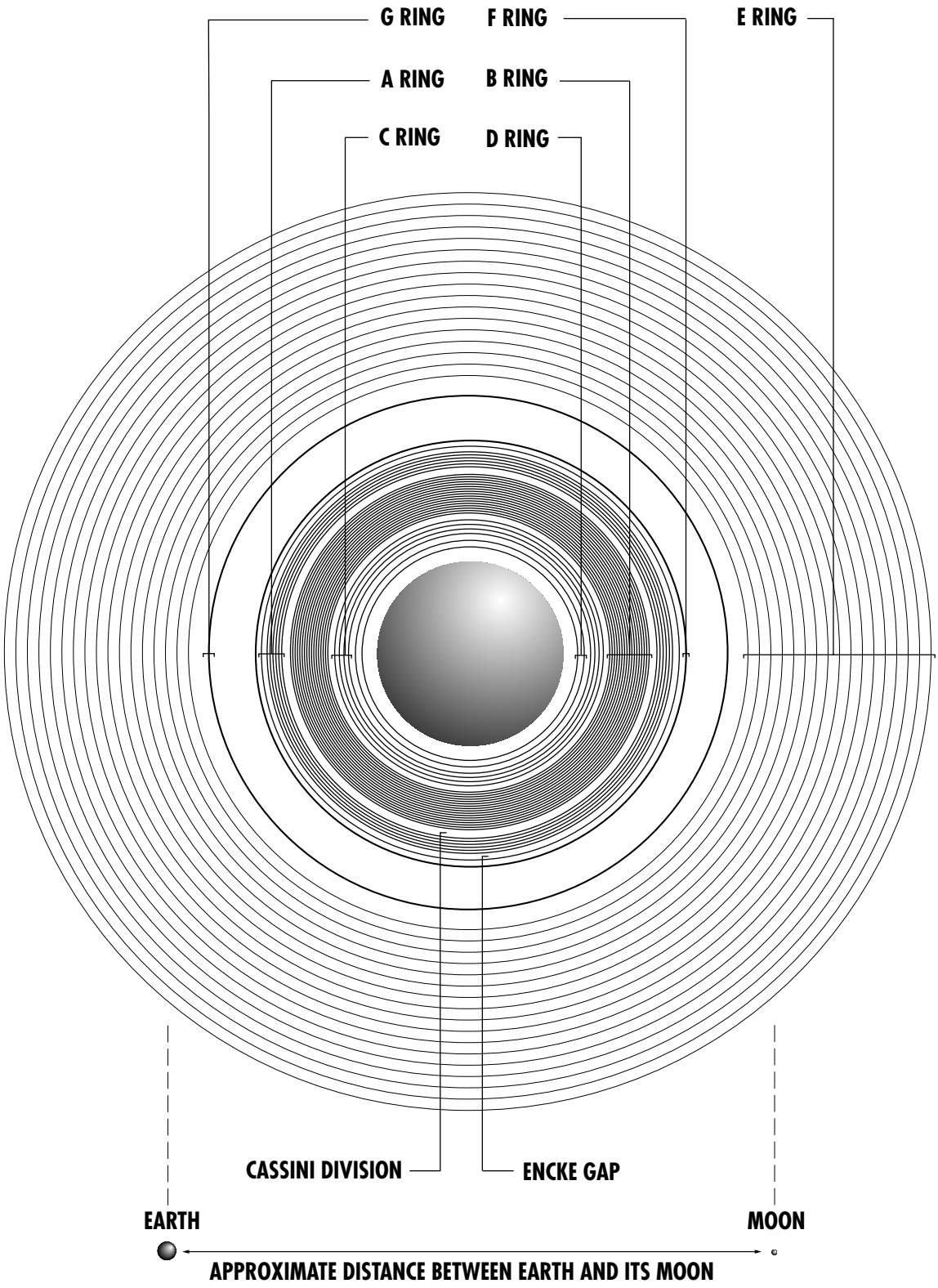
TOP

Figure 2

Note: Saturn's rings consist of individual particles. The relative density of particles is represented by the spacing of the circles within each ring.

Colored markers can enchance the visual distinction between rings.

Saturn Ring System (shown to scale)

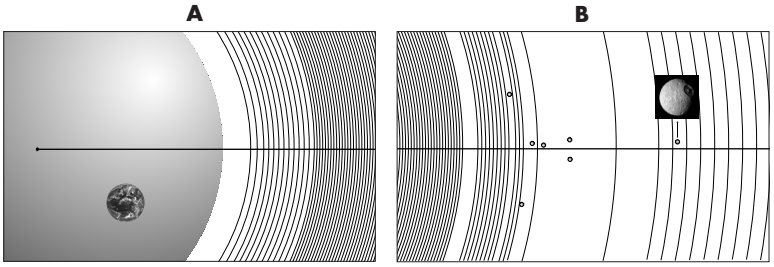


Saturn's rings are not located in alphabetical order outward from the planet because they were named in order of their discovery. From inner to outer, the rings are — D, C, B, A, F, G, E.

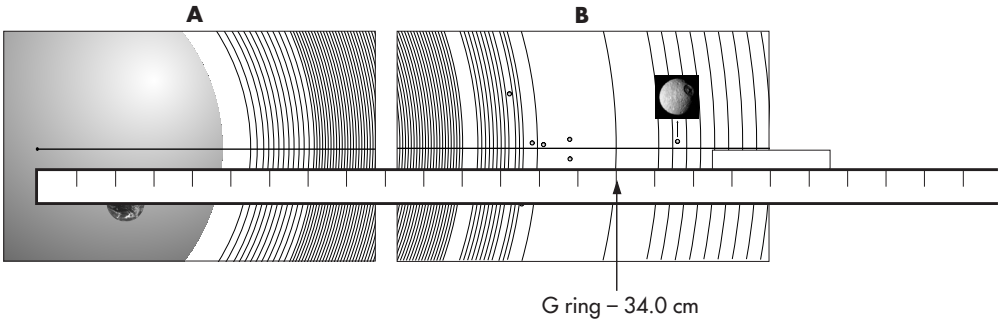
Figure 3

How to Assemble the Saturn System Diagram

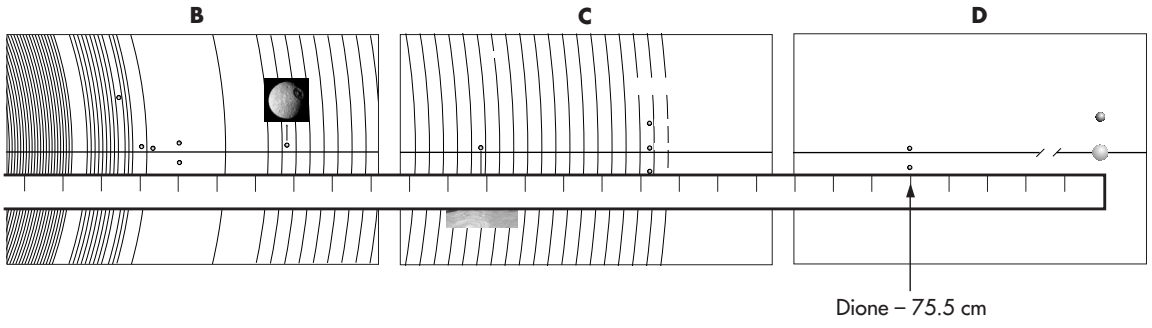
1. Be sure you have all 4 sections (A, B, C, and D) of the *Saturn System Diagram*. Place Section B to the right of Section A so they are lined up along the center line, as illustrated below.



2. Place the meter stick over the two sections so that the end "0" mark of the meter stick lines up with the center of Saturn located near the left edge of Section A. Now align your meter stick with the black line running from left to right across the center of each section of the diagram. Adjust the position of Section B to the left or right as needed so that the G ring crosses the center line at 34 cm on the meter stick. When you are certain that it is in position, tape the two sections together. (When the pages are correctly positioned, the horizontal edges may or may not overlap.) Tape them together so that the center lines are continuous, aligned, and straight. Don't tape the meter stick to the sections!



3. Place Section C to the right of Section B; then place D next to C. Adjust Section D to the left or right so that the moon Dione is located at 75.5 cm on the meter stick. When you have Dione in position, tape Sections B, C, and D together. As before, the edges may or may not align. You have now assembled your *Saturn System Diagram* and you are ready to begin your scavenger hunt!

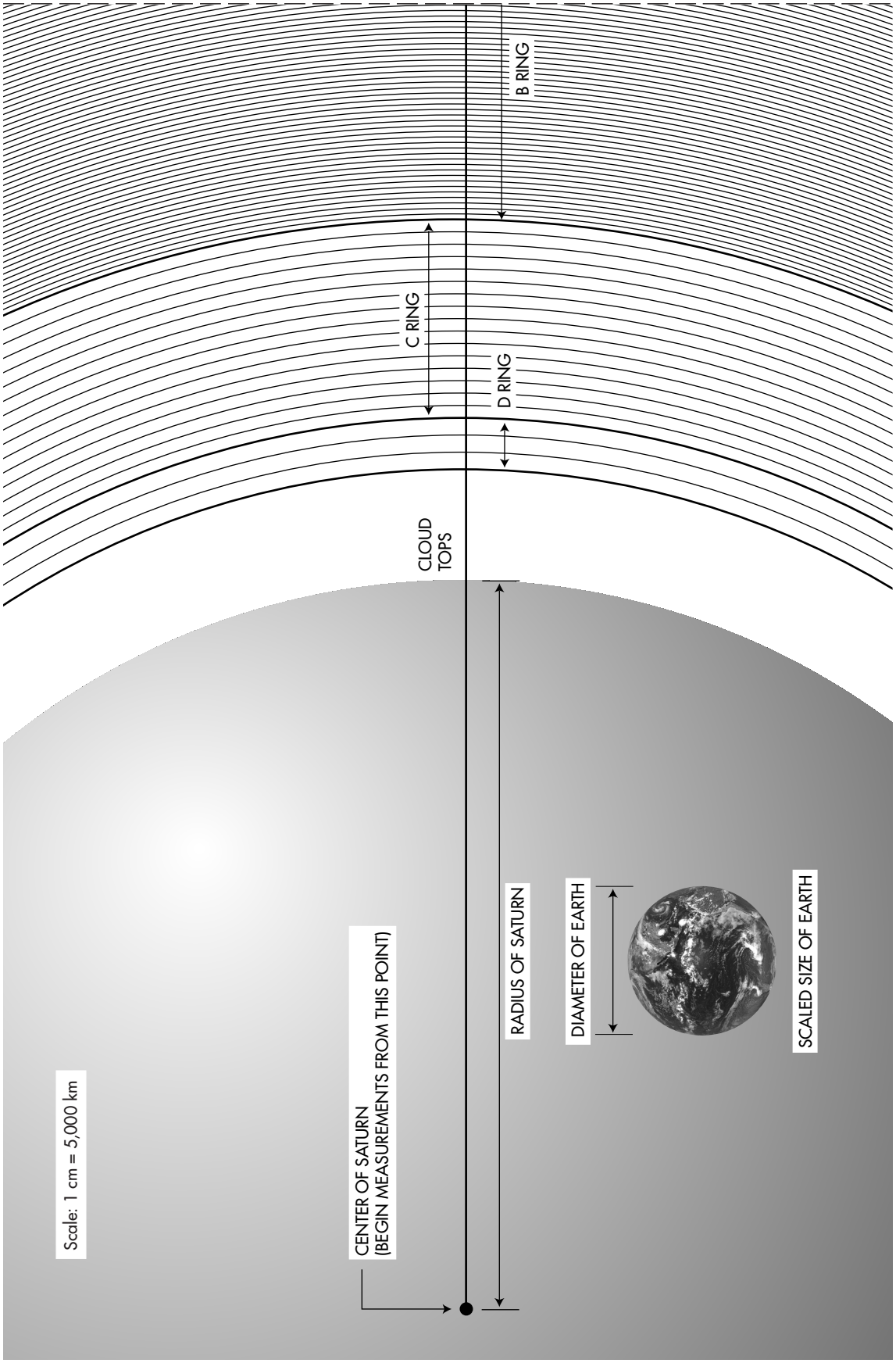


Saturn System Diagram (A) (1 of 4)

Figure 4

Scale: 1 cm = 5,000 km. The radius of Saturn corresponds to the radius of a basketball in this scale diagram.

Note: Saturn's rings consist of individual particles. The relative density of particles is represented by the spacing of the circles within each ring.

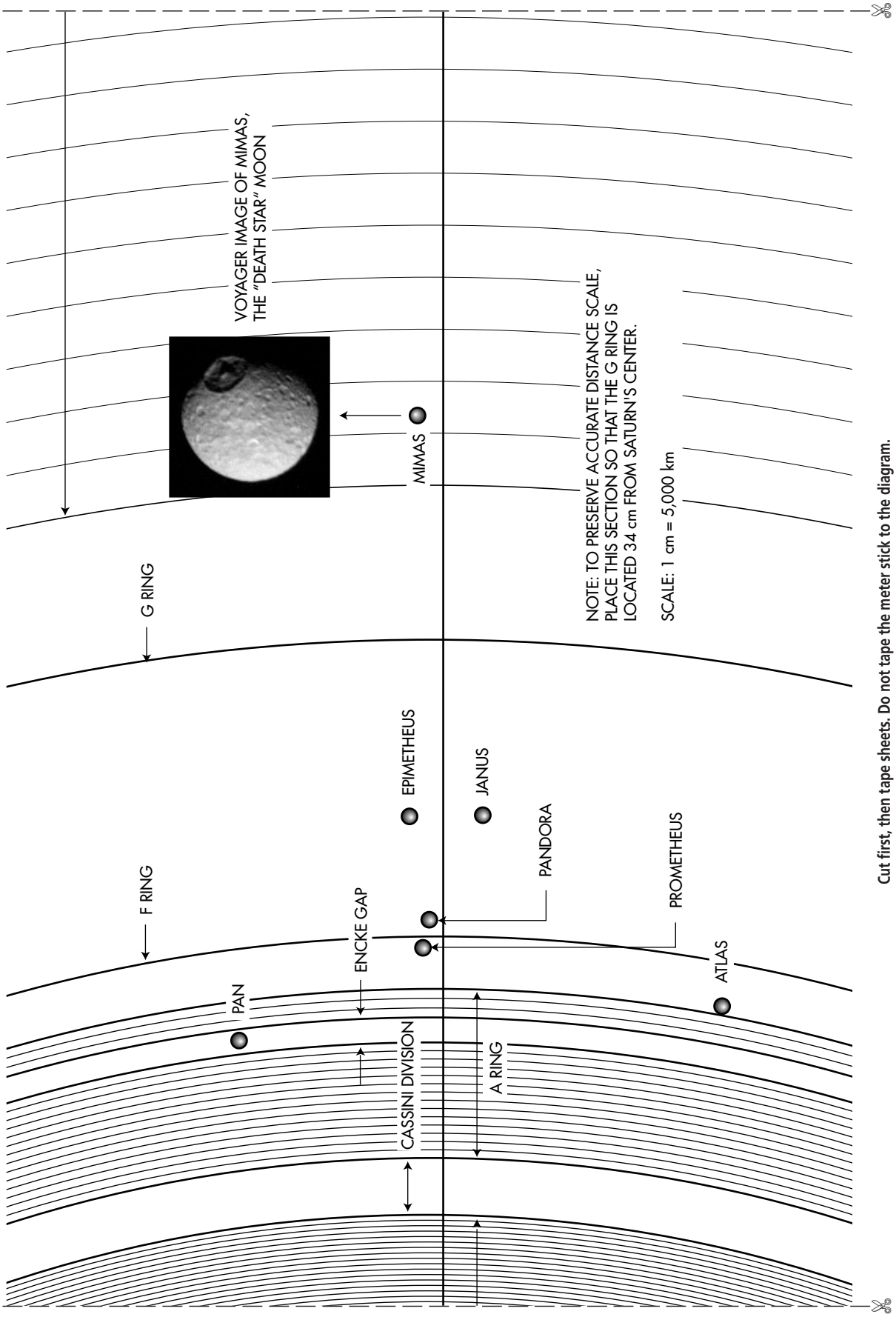


Cut first, then tape sheets. Do not tape the meter stick to the diagram.

Saturn System Diagram (B) (2 of 4)

Figure 4

Note: Saturn's rings consist of individual particles. The relative density of particles is represented by the spacing of the circles within each ring.

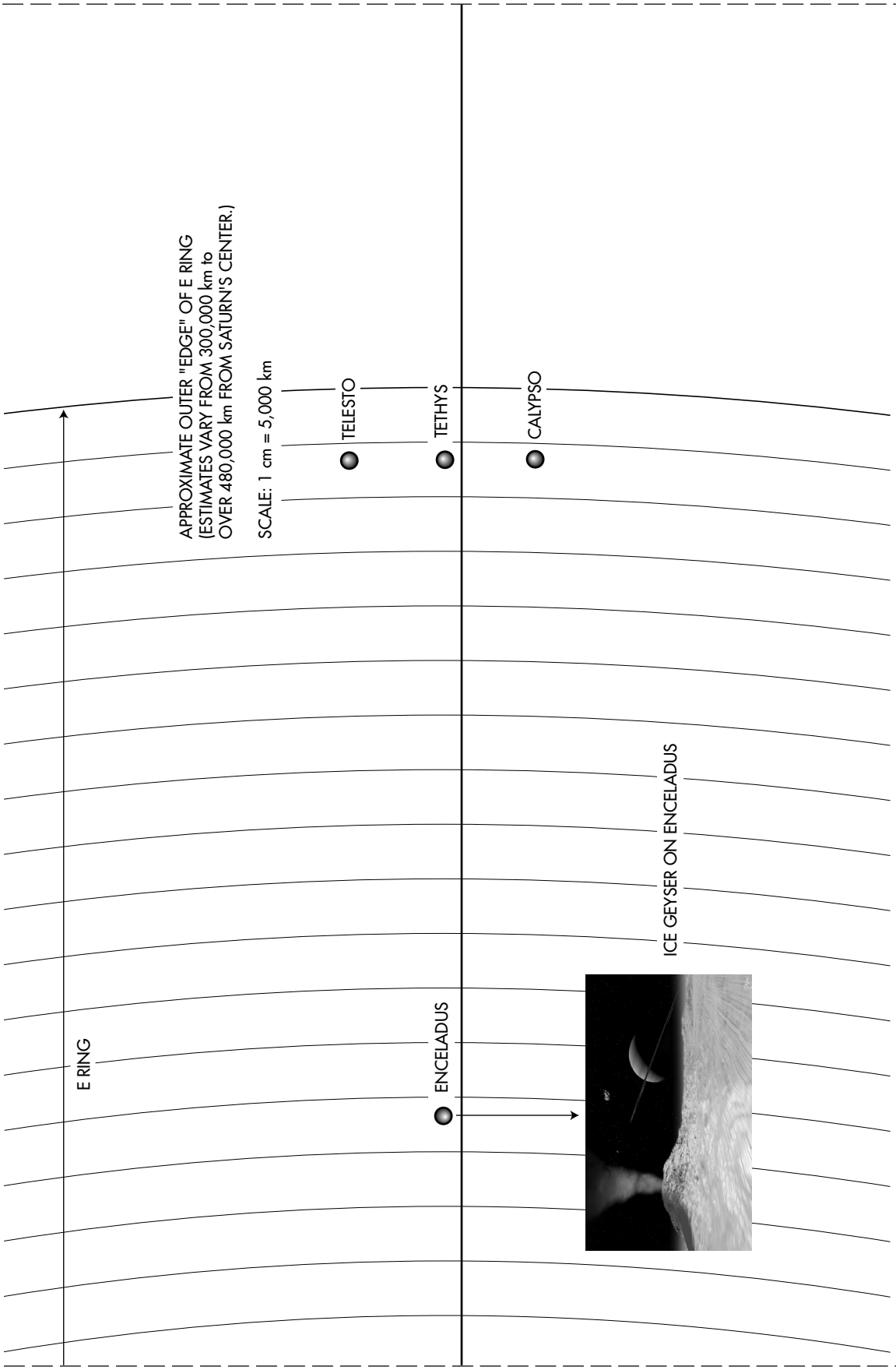


Cut first, then tape sheets. Do not tape the meter stick to the diagram.

Figure 4

Note: Saturn's rings consist of individual particles. The relative density of particles is represented by the spacing of the circles within each ring.

Saturn System Diagram (C) (3 of 4)



Cut first, then tape sheets. Do not tape the meter stick to the diagram.

Saturn System Diagram (D) (4 of 4)

Figure 4

Note: Saturn's rings consist of individual particles. The relative density of particles is represented by the spacing of the circles within each ring.

Cut first, then tape sheets. Do not tape the meter stick to the diagram.

LESSON 1

Figure 5

Saturn System Scavenger Hunt (1 of 4)

Student group members: Use the information in the assembled *Saturn System Diagram* scale model to find answers to the following questions. In Sections A and B below, use the space provided to create two or three of your own questions. You must be able to answer the questions using the diagram. *Your classmates will be asked to answer the questions you create.*

Section A: Rings and Gaps

1. Saturn's rings are not solid, but are composed of many chunks of ice and rock that range in size from a grain of sand to a house. The names of the rings in the order they appear from the cloud tops of Saturn outward toward the moon Titan are:

_____ _____ _____ _____ _____ _____ _____.

2. Jean-Dominique Cassini is the person who discovered a division (gap) in Saturn's rings in 1659. The _____ and _____ rings are on either side of the Cassini Division.

3. The narrowest rings by far are the _____ ring and the _____ ring.

4. Compare the projected *Voyager Image of Saturn* and the *Saturn System Diagram* (and/or the *Saturn Ring System* illustration) and explain which of Saturn's rings you think we are seeing in the Voyager image.

5. Student questions about the rings and gaps:

Saturn System Scavenger Hunt (2 of 4)

Section B: Moons

1. There are _____ (a number) moons orbiting Saturn at distances closer to the planet than the G ring.

2. There are _____ (a number) moons orbiting Saturn at distances farther from the planet than the G ring. (HINT: Don't forget to count the moons that are farther away than Titan. All of Saturn's moons, except the two most distant ones, orbit Saturn in the same plane as the rings.

3. The farthest moon from Saturn is actually orbiting very slowly in the opposite direction from all the other moons and ring particles. It may be an asteroid captured by Saturn's gravity. The Cassini spacecraft will investigate this possibility. This moon is called _____.

4. Student questions about the moons:

Section C: Relationships and Interactions

1. _____ is the force that holds the moons and the ring particles in orbit around Saturn.

2. The widest ring of Saturn has a moon called Enceladus orbiting where the ring is densest. Enceladus may have ice volcanoes that supply the _____ ring with small ice particles. Cassini will observe Enceladus to see if the science instruments on board can detect any ice volcanoes.

Figure 5

Saturn System Scavenger Hunt (3 of 4)

3. The _____ ring has a gap near its outer edge caused by the tiny moon named Pan. Cassini may discover other moons like Pan that orbit within the A and B rings.

4. The narrow _____ ring is held together ("shepherded") by the gravity of the moons Prometheus and Pandora, which orbit on either side of the ring.

5. The tiny moons Janus and Epimetheus are between the _____ ring and the _____ ring. The gravitational forces between these small, odd-shaped moons cause them to trade orbits with one another.

Section D: Compare the Size of Earth with the Size of Saturn

For the following, make measurements to the nearest millimeter wherever possible.

1. Measure the scaled diameter of the Earth on the *Saturn System Diagram*:

_____ cm

Use your measurement to compute the diameter of Earth:

_____ cm	×	5,000 km/cm	=	_____ km
(scaled diameter)		*(scale factor)*		*(actual diameter)*

2. Measure the scaled radius of Saturn on the *Saturn System Diagram*:

_____ cm

Use your measurement to compute the actual radius of Saturn:

_____ cm	×	5,000 km/cm	=	_____ km
(scaled radius)		*(scale factor)*		*(actual radius)*

Figure 5

Saturn System Scavenger Hunt (4 of 4)

3. What is the actual diameter of Saturn?

Actual diameter of Saturn = 2 × (radius of Saturn) = _____ km

4. Compare the diameter of Saturn with the diameter of Earth by forming the ratio of Saturn's diameter to Earth's diameter:

$$\frac{\text{Saturn diameter}}{\text{Earth diameter}} = \frac{\qquad}{\qquad} = \qquad$$

Therefore, Saturn's diameter is _____ times bigger than Earth's diameter.

Note: Use the problem set above as a model to construct a problem that compares the size of Titan (the largest moon in the Saturn system) with the size of Earth's Moon.

Saturn System Scavenger Hunt Answer Key

Section A: Rings and Gaps

1. D, C, B, A, F, G, and E

2. A and B

3. F and G

4. Not all the rings are visible in the Voyager image of Saturn. The F, G, and E rings, and most of the D and C rings, are too faint to be seen. Considering the sizes of the observable features in the Voyager image and their distances from the Saturn cloud tops, we are seeing the bright B and A rings with the Cassini Division in between. It is possible we are seeing a bit of the C ring, but it is difficult to tell because there is no gap between the B ring and the C ring.

5. Possible student question about rings and gaps: The brightest and densest ring is the _____ ring. (Answer — B ring)

Section B: Moons

1. Six moons — Pan; Atlas; Prometheus and Pandora; Epimetheus and Janus.

2. Twelve moons — Mimas; Enceladus; Tethys, Telesto, and Calypso; Dione and Helene; Titan; Rhea; Hyperion; Iapetus; Phoebe.

3. Phoebe.

4. Possible student question about the moons: The largest moon in the Saturn system is _____. (Answer — Titan)

Section C: Relationships and Interactions

1. Gravity

2. E ring

3. A ring

4. F ring

5. F ring and G ring

Section D: Compare the Size of Earth with the Size of Saturn (Optional)

1. Scaled diameter of Earth = 2.5 cm; 2.5 cm × 5,000 km/cm = 12,500 km (actually, 12,800 km)

2. Scaled radius of Saturn = 12.0 cm; 12.0 cm × 5,000 km/cm = 60,000 km (actually, 60,300 km)

3. Actual diameter of Saturn = 120,000 km (diameter = 2 × radius — actually, 120,600 km)

4. Ratio of Saturn's diameter to Earth's diameter = 9.6 (in reality, the ratio is about 9.4)

Figure 7

Saturn System Table

Moon/Ring	Distance from Saturn's Center (cm)	Scale Factor (km/cm)	Approximate Distance from Saturn's Center (km)
D Ring (inner edge)	13.4	× 5,000	67,000
C Ring (inner edge) D Ring (outer edge)	14.9	× 5,000	74,500
B Ring (inner edge) C Ring (outer edge)	18.4	× 5,000	92,000
B Ring (outer edge) Cassini Division (inner edge)	23.5	× 5,000	117,500
A Ring (inner edge) Cassini Division (outer edge)	24.4	× 5,000	122,000
Encke Gap and Pan	26.7	× 5,000	133,500
A Ring (outer edge)	27.4	× 5,000	137,000
Atlas	27.5	× 5,000	137,500
Prometheus	27.9	× 5,000	139,500
F Ring	28.0	× 5,000	140,000
Pandora	28.3	× 5,000	141,500
Epimetheus and Janus	30.3	× 5,000	151,500
G Ring	34.0	× 5,000	170,000
E Ring (approx. inner edge)	36.2	× 5,000	181,000
Mimas	37.1	× 5,000	185,500
Enceladus	47.6	× 5,000	238,000
Tethys, Telesto, and Calypso	58.9	× 5,000	294,500
Dione and Helene	75.5	× 5,000	377,500
E Ring (approx. outer edge)	96.6	× 5,000	483,000
Rhea	105.0	× 5,000	525,000
Titan	244.0	× 5,000	1,220,000

Optional: Students can measure the shaded items using the Saturn System Diagram.

LESSON 1

Figure 8

Earth/Saturn Systems Venn Diagram