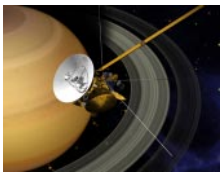
Discovering Saturn, The Real "Lord of the Rings"

Cassini–Huygens at Saturn, July 2004.



LESSON TIME

About 3 hours for the Saturn minibooks; 2 hours for the Saturn poster.

MATERIALS CHECKLIST

Per groups of 4 students:

- *One set of four "Discovering Saturn" minibooks*

Per student:

- *Student handouts 1, 2, 3, and 4: "Pre-Reading/ Pre-Writing Activity Worksheet"; "Note-Taking for Nonfiction Worksheet"; "Descriptive Writing Tip Sheet"; "Peer Conference Guidelines"*
- *Pencil, paper, broad-tip markers, paints, 36 x 48 chart paper*
- *Saturn Discovery Log*

For the teacher:

- *Optional: overhead transparencies of student handouts; a CD or tape of "The Planets" by Gustav Holst*

TO SEE EXAMPLES OF STUDENT WORK, CLICK HERE

LESSON NO. 5

- *Language Arts Focus*
  —*Nonfiction Reading Practice: Saturn Minibooks*
  —*Nonfiction Writing Practice: Descriptive Paragraph*
- *Science Focus — Understanding the Saturnian System by Building 2-D and 3-D Models of Saturn*

OVERVIEW

At this point in our imaginary journey to Saturn with the Cassini–Huygens spacecraft, we have arrived at Saturn! Now students extend and enhance their current understandings about Saturn by reading a series of four Saturn minibooks about the planet, the rings, and the moons. Students take notes as they read for three purposes: first, to collect information that will be used to craft a descriptive paragraph about Saturn; second, to record this information (along with their questions and predictions) in their Saturn Discovery Logs for later comparison with real data collected and transmitted by Cassini; and third, to assist them in writing text for giant-sized Saturn posters. For one extension activity, students build 3-D models of Saturn and its rings.

WHY THIS WORKS

At this point in the unit, students' curiosity about Saturn is piqued. They are eager to learn more about the special features of Saturn — its rings and moons — and the planet itself. While much is known about Saturn, there are still many mysteries. Students are encouraged to ask questions as they read the Saturn minibooks and learn new information. They are given multiple opportunities to reinforce and apply what they have learned by writing, talking, and creating models.

This lesson gives students practice in both reading and writing for authentic purposes. Students pay close attention as they read in order to write descriptively. They write to a specific and authentic audience. Sharing information about the Cassini–Huygens mission with students at their school contributes to building a community of learners.

Objectives

Students will:

1. Read and write for specific, authentic purposes.
2. Practice expository writing by writing a descriptive paragraph about Saturn.
3. Extend and enhance their understanding and knowledge about Saturn by reading, writing, talking, and building models.
4. Create a giant-size Saturn poster.
5. Build a 3-D model of Saturn and its rings (extension activity).

For background on Saturn — http://saturn.jpl.nasa.gov and http://solarsystem.jpl.nasa.gov. To get a feel for how the planets orbit — http://www.fourmilab.ch/cgi-bin/uncgi/Solar

Teacher Preparation

- Print out and photocopy the four "Discovering Saturn: The Real Lord of the Rings" minibooks. Students can take turns reading them. Make enough copies for your students to work in groups of four; for example, if you have 30 students, you will need 8 sets of the booklets.
  The minibooks are:
  Booklet One: "Introducing Saturn"
  Booklet Two: "Saturn — From the Outside In"
  Booklet Three: "Those Amazing Rings!"
  Booklet Four: "Saturn's Moons"
- Print and photocopy (one per student) of student handouts 1, 2, 3, and 4:
  — "Pre-Reading/Pre-Writing Activity Worksheet" (2 pages)
  — "Note-Taking for Nonfiction Worksheet" (2 pages)
  — "Descriptive Writing Tip Sheet"
  — "Peer Conference Guidelines"
- Optional: Make overheads of student handouts rather than individual copies, and have students write in their Saturn Discovery Logs.
- Cut chart paper for students to use for the giant posters (36 by 48 inches). Depending on the age of your students, you may want to trace a large Saturn on the paper and let the students paint or color it.

Extensions:

- For the Connections to Cassini–Huygens Mission extension, prepare an overhead of the teacher reference page "What I Wonder About Saturn."
- If you are planning to do the hands-on extensions, you will need to get materials for the 3-D Scale Model Saturn and Envelopes and Postcards from Saturn activities. It is recommended that you try out these hands-on activities yourself before doing them with the students.

Before You Begin

You may want to discuss color and scale with your students.

1. *Color*. "False color" is sometimes used to help us see details, artificial divisions, or features that we would otherwise miss. For example, in the illustration of Saturn's rings on page 2 of booklet three, "Those Amazing Rings," the artist applied different colors to the various rings to make it easier to distinguish them. In NASA space images, false color is sometimes added during processing to bring out details. Saturn is actually a pale butterscotch color, but adding color to the images brings out atmospheric features and banding. Maps use false colors to identify different cities, states, or countries. Satellite

images of the oceans may use false color to show regions of different temperatures. In images of distant galaxies and nebulas, such as we get from the Hubble Space Telescope, false color is often used to represent wavelengths of light that our eyes can't detect (such as infrared, ultraviolet, or X-ray) or to illustrate the chemicals that predominate in various parts of the object. For more information about false color, visit the following website: *http://chandra.harvard.edu/photo/false_color.html*

2. *Scale*. Illustrations of space missions often show objects that are not to scale — for example, the picture on page 2 of Saturn booklet four, "Saturn's Moons," showing Saturn, the Cassini spacecraft, and part of Titan. (If needed, discuss perspective with your students.) It is clear that the spacecraft is nowhere near as large as it appears to be in the picture. The illustrator uses artistic license so we see the most important objects — Saturn, a moon, and the spacecraft. If the spacecraft were drawn to scale, it would be so tiny that we would not be able to see it.

teacher TIP

• Students will finish reading the minibooks at different rates; those who finish early could do one of the writing extension activities.

What to Do

"Discovering Saturn: The Real Lord of the Rings" Minibooks

Reading and Note-Taking — Suggested time 2–3 hours

1. Give students copies of student handout 1, "Pre-Reading/Pre-Writing Activity Worksheet." Go over the directions with the class and allow time for the students to complete their worksheets.
2. Explain to the students that they will be reading the Saturn minibooks for multiple purposes. First, they will learn new information about Saturn, and second, they will practice note-taking. Finally, they will use the information for two purposes — one, to write a descriptive piece about Saturn, and two, to have this information in a handy place for comparing it with new information we learn about Saturn from the Cassini–Huygens mission.
3. Give students copies of the student handout 2, "Note-Taking for Nonfiction Worksheet." The first minibook students read will be the one they take notes from and write a paragraph about.
4. Read the directions aloud and model how to use the "Note-Taking Sheet for Nonfiction Worksheet." Remind students to just take notes on the first booklet they read.
5. Establish with the students how the minibooks will be shared (for example, "pass to the person on your left.") If students will be reading the books with or to a partner, be sure they are clear about the procedure.
6. Hand out copies of the Saturn minibooks to groups of four students. Read and enjoy!

From Notes to Paragraphs — Suggested time 20–30 minutes

1. Have students read their notes to a partner and share/compare ideas.
2. Review and/or model for students the elements of a descriptive paragraph. Give copies of student handout 3, "Descriptive Writing Tip Sheet," to students and go over it together.
3. Give students time to write their paragraphs.

Sharing — Suggested time 10 minutes

1. Have students read descriptive pieces to a partner. The writer can tell the listener what to listen for, as well as ask for tips. The listener can help the writer by sharing specific places in the writing that are descriptive: "show not tell," examples, details, and figurative language. Students can use student handout 4, Peer Conference Guidelines, for this part of the activity.
2. Invite students to read their paragraphs aloud to the class.

Student pieces can be compiled into a class book, used for individual minibooks, or as text for "Postcards from Saturn" to be shared with a buddy class, pen pals, or family/friends.

Giant Saturn Posters

Posters with Illustrated Text — Suggested time 1–2 hours

1. Put students in groups of four.
2. Give each group a large piece of 36 by 48 inch chart paper.
3. Have students create a giant illustration with text for their posters. They can use tempera paints, collage, or any other media to make their Saturns. Be sure they have broad-tip markers for writing the text. If you feel it is necessary, you can trace the Saturn outline on the chart paper first.
4. Tell students to put new information from their "Note-Taking Sheet for Nonfiction Worksheet" onto their posters.
5. Give the groups some time to present their posters to the class.

Extensions

Connections to the Cassini–Huygens Mission

1. Say to the class: "We've learned many new and interesting things about Saturn from reading the minibooks, and from talking, writing, and working together. There are still many things we want to know more about.
2. Listen while I read what the Cassini scientists wonder about Saturn, and think of some questions of your own.
3. Display the "What I Wonder About Saturn" overhead and read the Cassini scientists' questions aloud.
4. Give students 2 to 3 minutes to "quick write" their own questions.
5. Create a class poster of "Questions We Have."

teacher TIP

• The 3-D model can be done as a center activity. Students can go to a designated area in groups of 4 to 6 to paint their "Saturns."

Hands-on Activity

3-D Scale Model Saturn — Suggested time 2 hours

This outstanding lesson was developed by Dr. Mary Urquhart. If you have time and access to materials, it is highly recommended. The lesson is geared toward 4th–8th graders, but is easily adaptable for younger students. Students build a three-dimensional model of Saturn using a 3-inch-diameter styrofoam ball for the planet and a circle cut from an overhead transparency for the rings. At this scale, a peppercorn represents the moon Titan. Teachers who piloted this lesson suggested painting the styrofoam balls, rather than coloring them with markers, for a more "realistic" look. Students can write about the process of building the model and

discuss the ways the model Saturn is similar to and different from the real planet (additional practice with compare and contrast). If you have limited time and resources, or you feel that it is too complex for your students to do independently, you can do this as a demonstration, or build the model in advance and bring it in to share with your students. The lesson description includes the list of required materials. The URL below will take you to the lesson:
http://lyra.colorado.edu/sbo/mary/Cassini/scale_saturn.html

Writing and Art Activities

Saturn Poetry

Descriptive writing lends itself well to various forms of poetry. Students can write haiku, odes to Saturn, and found poems (to name a few). Use your favorite lessons, with Saturn as the theme. A good resource for ideas on poetry is *Awakening the Heart: Exploring Poetry in Elementary and Middle School*, by Georgia Heard.

Envelopes and Postcards From Saturn

Adapted from *Moon Journals: Writing, Art, and Inquiry Through Focused Nature Study*, Gina Rester-Zodrow and Joni Chancer.
Postcards and letters are a fun alternative form for publishing students' descriptive writing about Saturn. Students will need these materials: pencil, scissors, cardstock (or index cards), colored paper, glue sticks, colored pencils, markers, crayons, and stickers. For samples, provide a real postcard, stamp, and envelope.

How to Make Envelopes

1. Carefully open an envelope along all the seams.
2. Use your flattened envelope as a template for tracing and cutting envelopes from colored paper. Decorate, using available materials, and then carefully reassemble the new envelope. Be careful that the glue stays on the flaps, and does not get into the interior of the envelope.
3. Envelopes can also be made from photocopied pictures of Saturn, recycled wrapping paper, or other decorative papers.
4. Students can design stamps for their envelopes.
5. Put Saturn mail inside envelope, and deliver. Or, you can make a class book of Saturn mail in the style of *The Jolly Postman* books, if desired.

How to Make Postcards

1. Cut cardstock, or use 4 by 6 or 5 by 8 plain index cards.
2. Use a real postcard as a model for deciding where to put text and images.
3. Students can design postage stamps for their postcards.
4. Postcards can be written before Cassini arrives at Saturn, and after (with new descriptive information).
5. Postcards can be sent to a buddy classroom.

Singing Activity

Just for fun, the Cassini Virtual Singers at the Jet Propulsion Laboratory get together occasionally and perform songs they have developed. The singers are scientists, engineers, and others who support the mission. They have a repertoire of about 50 songs, based on familiar melodies but with lyrics about the Cassini mission. Here is a song from the Cassini Virtual Singers:

"The Moon Song" — sung to "Gary, Indiana"
Wordsmithed by Trina Ray; musical arrangement by David Coppedge

Mimas [MY-muss], and Enceladus [n-SELL-uh-duss]
Atlas, and Prometheus [pro-MEE-thee-us]
Oh-please... let us sing 'em once again

Mimas, and Enceladus
Atlas, and Prometheus
Telesto [tell-ESS-toe], Titan, Tethys [TEE-thiss], Rhea [REE-uh] and Pan

If you'd like to have a logical explanation
for the repetition of this lunar system
we can say without a moment of hesitation
We'll sing 'em again, just in case you missed-'EM

Janus [JAY-nus] and Iapetus [eye-AP-eh-tuss].
oh my Epimetheus [epp-ee-MEE-thee-us].
Helene [heh-LEEN], Dione [dy-OH-nee], Pandora, Phoebe [FEE-bee] and Pan

Janus and Iapetus
don't forget Hyperion [hy-PEER-ee-on]
and leaving out Calypso [ka-LIP-so] is a sin

If you'd like to have a logical explanation
For the naming of the moons of Saturn's system
We can say without a moment of hesitation
Old mythology... is what we see

(remember the melody changes here!!)

But Mimas and Enceladus.
Atlas and Prometheus.
Janus and Iapetus
oh my Epimetheus
We'll see 'em all, if we can

Assessment

While children are working, ask yourself the following questions:

1. Are the students able to read the minibooks?
   If you have students for whom English is a second language, you may want to have them partner-read, or you may want to pull a small group and read the books aloud to them.
2. Are the students taking notes as they read?

   If this is the first time your students have done an activity like this, it will be helpful to read one book to the whole class, and do "think aloud" modeling for the students. You can use the Note-Taking Sheet for Nonfiction handout as an overhead, or do it on the board.
3. As the students work on their posters and 3-D models, are they able to identify and name Saturn's special features (rings, the Cassini Division, etc.)?
4. Are they able to identify details about the features that they have learned from their reading?

As you read over the children's work, ask yourself the following questions:

1. Do their descriptive paragraphs indicate an understanding of both science content and writing conventions?
2. Are their paragraphs organized, including a main idea, details, and examples?
3. Are they able to use figurative language to make their descriptions more vivid?

   If you have students who are having difficulty writing, you may want to conference with them individually, teach a mini lesson to a small group, or model descriptive paragraph writing by doing a collaborative piece (again, modeling and thinking aloud) with the whole class.

Standards

National Council of Teachers of English and International Reading Association Standards for the English Language Arts

All students must have opportunities to:

- Participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities.
- Use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).
- Read a wide range of texts to build an understanding of texts and to acquire new information.
- Apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts.

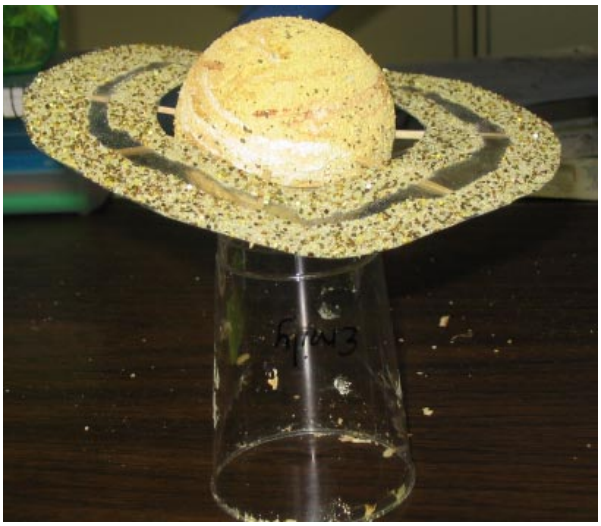
National Science Education Standards

As a result of their activities in grades K–4, all students should develop understanding:

- Of properties of objects and materials (Physical Science).
- Of objects in the sky (Earth and Space Science).
- About science and technology (Science and Technology).
- Of science as a human endeavor (History and Nature of Science).

Examples of Student Work

Giant Saturn poster



3-D model of Saturn

"What I Wonder About Saturn"

by NASA Scientists

The journey to learn more about Saturn is just beginning ! We asked two NASA Cassini-Huygens scientists what they wonder about Saturn. Here is what they said:

Jim Frautnick of Mission Planning wonders:

- I wonder how thick Saturn's rings are.
- I wonder what will happen to the spacecraft as it passes through the rings.
- I wonder what causes storms in Saturn's atmosphere.
- I wonder if we will get some good pictures showing the particles in the rings.
- I wonder what the mission probe will find out about the moon Titan.
- I wonder if there is an ocean on Titan.
- I wonder how fast the winds are on Titan.

Dr. Bonnie Buratti, Investigation Scientist for the Visible and Infrared Mapping Spectrometer (VIMS) instrument wonders:

- I wonder what the rings are made of.
- Saturn has a moon called Iapetus. One side is very bright, almost as bright as fresh snow, and the other side is as dark as soot. I wonder how it got that way.

Pre-Reading/Pre-Writing Activity Worksheet

This reading, thinking, and talking activity will help your brain get ready for the information in the Saturn booklets, and the paragraph you will write after you do your reading.

Because you'll be doing this activity before you read, it's called a "pre-reading activity."

1. Think about what you already know about Saturn. Take 2 minutes to jot down some words, phrases, and sketches in the space below or in your Saturn Discovery Log.

2. Turn to your partner and take turns sharing what you know.

Pre-Reading/Pre-Writing Activity Worksheet
contd.

3. What questions do you have about Saturn? Write them below.

4. You will be using information in the Saturn booklets, plus what you know from other activities and research you've done, to write a descriptive paragraph about Saturn. You will be writing your paragraph to share with your buddy.

   Think: In what ways can you use the information you've written on this worksheet to help your buddy understand, and picture in her or his mind, information about Saturn?

Note-Taking for Nonfiction Worksheet

1. Preview the Saturn booklet you will be reading. Look at the title, bold-face headings, and illustrations. Think/write about what you already know, questions you have, and predict what you will learn. You can write in your Saturn Discovery Log. You can write more than one response for each question or statement!

What I already know: _____

I think I will learn: _____

I predict: _____

Questions I have right now:

I wonder _____

I wonder _____

I wonder _____

2. Read the booklet. Jot down ideas that are important for the type of writing you are going to do: details if you are writing a description, important big ideas if you are writing a summary, etc. Remember, for taking notes don't write more than 5 words for any one idea!

_____

_____

_____

_____

_____

Note-Taking for Nonfiction Worksheet contd.

3. Read through your notes, and scan the booklet again. Choose ideas for the chart below.

What's Important (Themes, Main Ideas, BIG Ideas)	What's Interesting (Amazing, cool, fun, weird, surprising, but NOT the main idea)

Descriptive Writing Tip Sheet

Tips when you are reading descriptive writing

- The purpose of descriptive writing is to help readers feel as though they are seeing, hearing, tasting, smelling, or feeling whatever the author is describing.
- Descriptive writing can be used for many different reasons. It can help persuade the reader of something (such as help the reader love polar bears as much as the author loves them). It can be used in an analysis so the reader understands the problem better. For example, if you want the reader to support more funding to clean up oil spills, it may help if they can really picture what the oil spill looks like and how the birds look all covered in oil. It can be used in compare and contrast writing so you can get a clear picture of the two things being compared.

Tips when you are writing descriptive writing

(Adapted from readwritethink.org)

- Describe from memory — Picture the object in your mind. Take yourself to a specific location. For example, the location of your "Walk of Wild Size," or Saturn's beautiful rings. If you are describing an object, imagine that you are close enough to touch it. Can you feel it? Look at it closely. What do you notice? Write every detail about the object that you can remember.
- Sketch — Draw a picture of your object. Don't worry about not being an artist. This sketch is just for you to help you fully explore the details of the object. Sketching the object also gives you a creative outlet for when you are struggling with putting pen to paper.

Good descriptive writing helps the reader really feel like he or she is there.

Here is an example of poor descriptive writing:
This page has some things on it.

Here is an example of good descriptive writing:
This page has letters on it that are written using the alphabet of the English language. The letters are organized into words. The words are organized into sentences. There are some headings on the page that tell the reader what the sentences are about. The page is written in black and white.

Peer Conference Guidelines

Writer

1. Choose a partner.
2. Tell the partner what kind of help is needed.
3. Read the piece out loud and listen to it.
4. Consider the partner's response.
5. What will you do next?

Partner

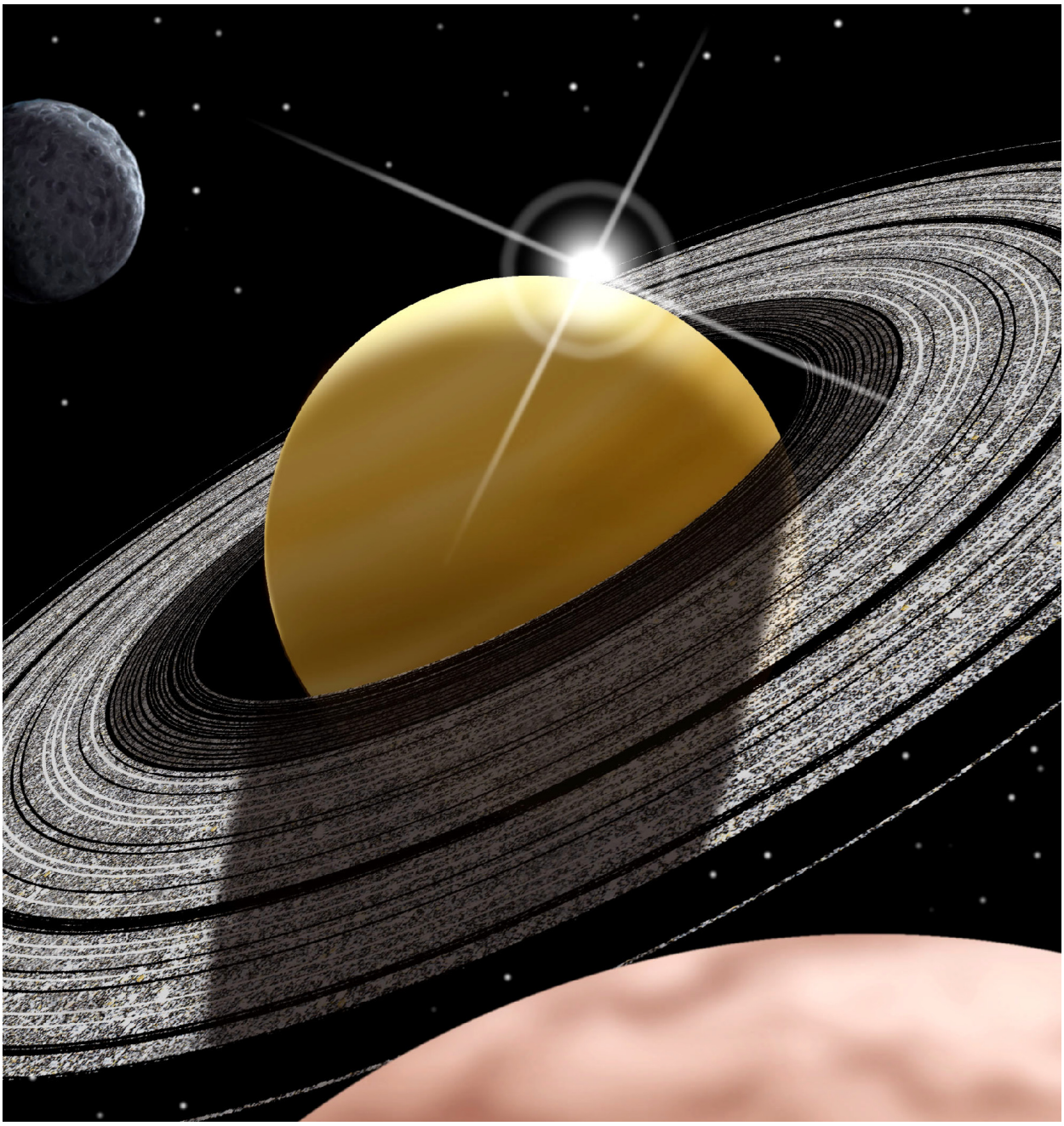
1. Find out what kind of help the writer needs.
2. Listen carefully.
3. Start by telling the writer what works ("three plusses" – compliments or positive statements).
4. Make a suggestion ("and a wish").

General Rules

1. Keep your conference short (4 to 5 minutes).
2. Use conference areas.
3. Only one conference per writing period.
4. No back-to-back conferences.
5. Use soft voices.

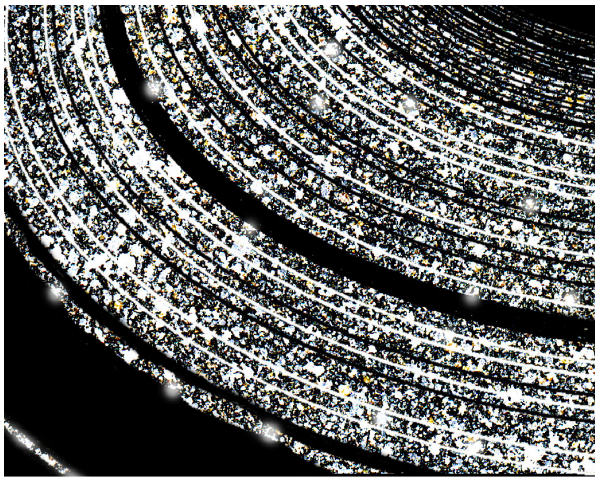
Introducing Saturn

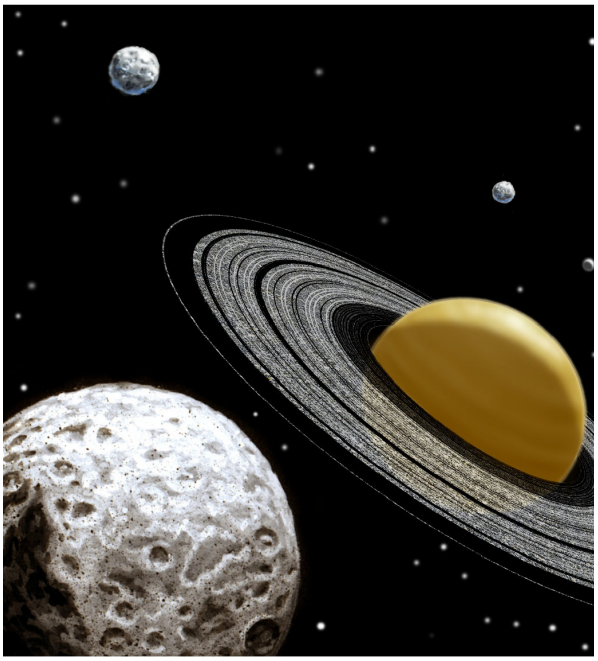
Questions, Answers, and Cool Things to Think About



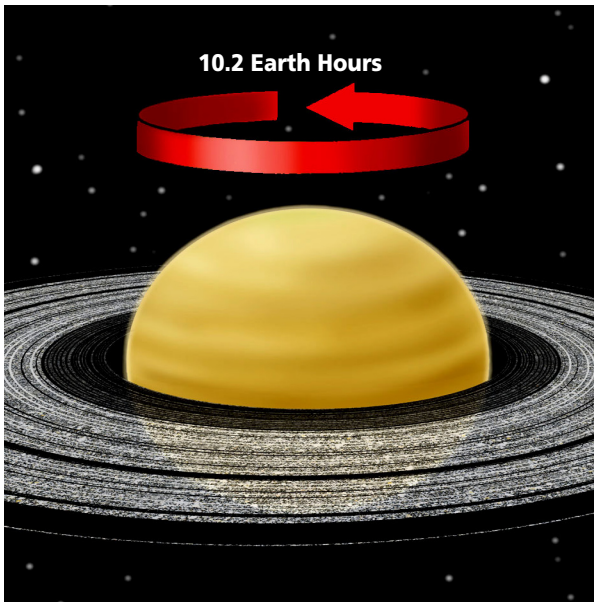
Discovering Saturn: The Real Lord of the Rings

Mysterious rings, strange and wonderful moons, and bands of gold, brown, and white, in which storm clouds swirl. This is the sixth planet from the Sun, Saturn! Saturn has been called "The Jewel of the Solar System." Look at the pictures on this page. What other nicknames would you give Saturn? Scientists believe that Saturn formed more than four billion years ago from the same giant cloud of gas and dust, whirling around the very young Sun, that formed Earth and the other planets of our solar system. But Saturn is much larger than Earth. Its mass is 95.18 times Earth's mass. In other words, it would take over 95 Earths to equal the mass of Saturn. If you could weigh the planets on a giant scale, you would need slightly more than 95 Earths to equal the weight of Saturn! Saturn's diameter is about 9.5 Earths across. At that ratio, if Saturn were as big as a baseball, Earth would be about half the size of a regular M&M candy.





Saturn spins on its axis (rotates) just as our planet Earth spins on its axis. However, its period of rotation, or the time it takes Saturn to spin around one time, is only 10.2 Earth hours. That means that a day on Saturn is just a little more than 10 hours long. So, if you lived on Saturn, you would only have to be in school for a couple hours each day! Because Saturn spins so fast, and its interior is gas, not rock, Saturn is noticeably flattened, top and bottom. Saturn is 10 percent fatter in the middle than at the poles.

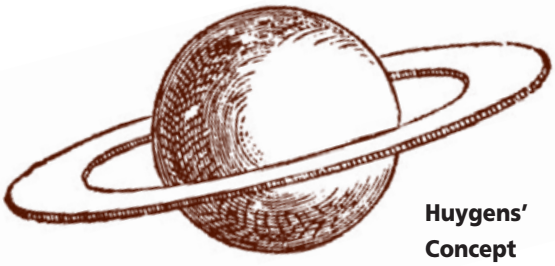


Length of a Saturn Day

Saturn is much farther from the Sun than is Earth. In fact, it gets only about 1/90 the amount of sunlight as does Earth. It takes Saturn almost 29-1/2 years to revolve once around the Sun. Can you figure out how old you are in Saturn years? Like the inner planets and Jupiter, Saturn is clearly visible to the naked eye in the night sky, so people have known about it for many thousands of years. The ancient Romans named the planet after their god of agriculture. It wasn't until 1610, however, that anyone saw Saturn's rings. That's when Galileo looked at the planet through one of the world's first telescopes. But his telescope wasn't powerful enough to show the rings clearly, and Galileo thought he was looking at some kind of triple planet.

Galileo

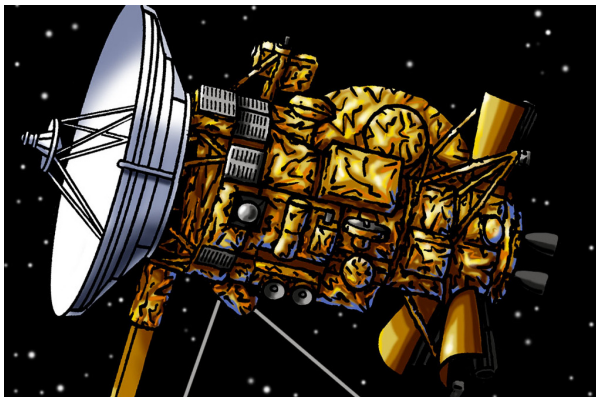
Later, in 1655, a Dutch astronomer named Christiaan Huygens looked at Saturn through a more powerful tele-



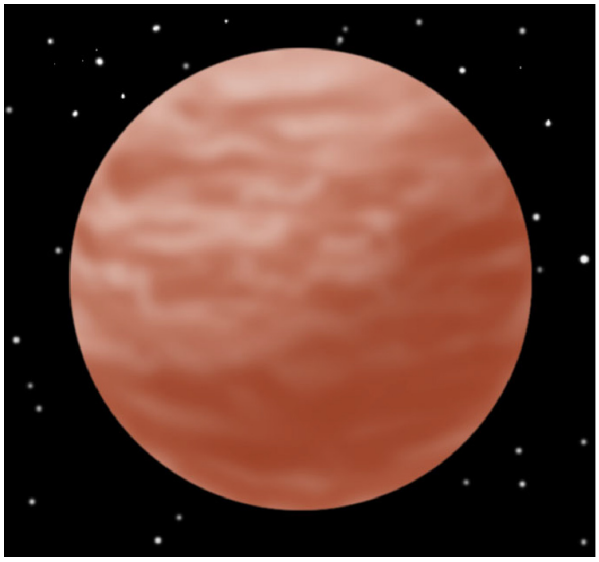
Huygens' Concept of Saturn

scope, and figured out that the planet is surrounded by a giant flat ring.

Although people have been observing and studying Saturn for thousands of years, first with just their eyes, and then with telescopes and robotic spacecraft, things got really exciting in July 2004. That is when the Cassini-Huygens spacecraft arrived at Saturn. Cassini-Huygens is really two spacecraft. The Huygens probe (named after the Dutch astronomer we mentioned earlier) rode along with Cassini until it went into orbit around Saturn. Then Huygens flew off to Saturn's largest moon, Titan. We've never been able to see Titan's surface, because it's hidden under a thick, smoggy atmosphere. But Huygens parachuted down through the atmosphere for 2-1/2 hours and spent more than 60 minutes on Titan's surface before it stopped working, sending us pictures and new information about Titan.



Cassini–Huygens Spacecraft



Titan

Meanwhile, the Cassini spacecraft will continue to orbit Saturn and send us information about its rings, its moons, and the planet itself until the year 2008! What grade will you be in then?

National Aeronautics and Space Administration

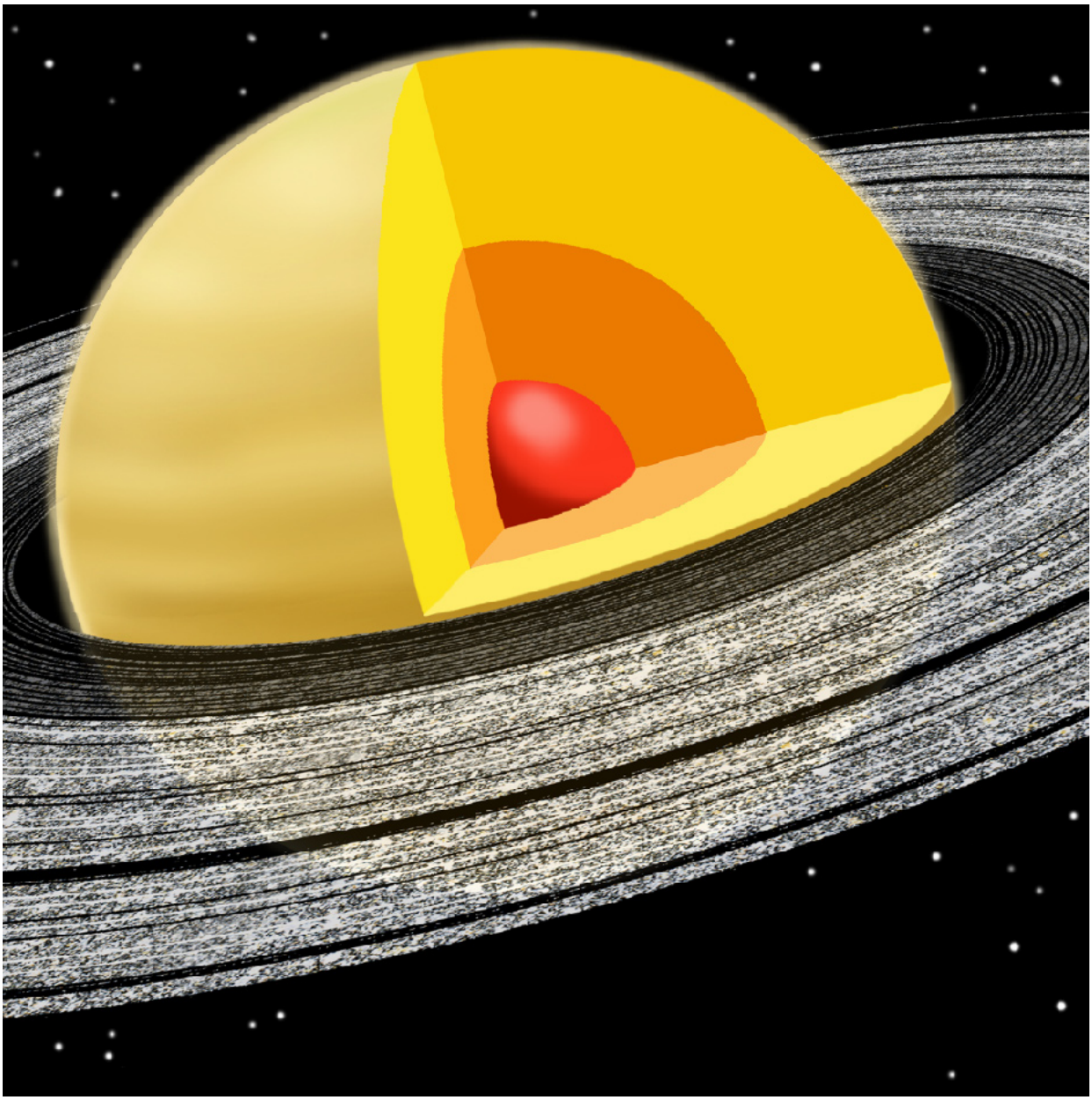
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL 400-1315a 7/07

www.nasa.gov

Saturn — From the Outside In

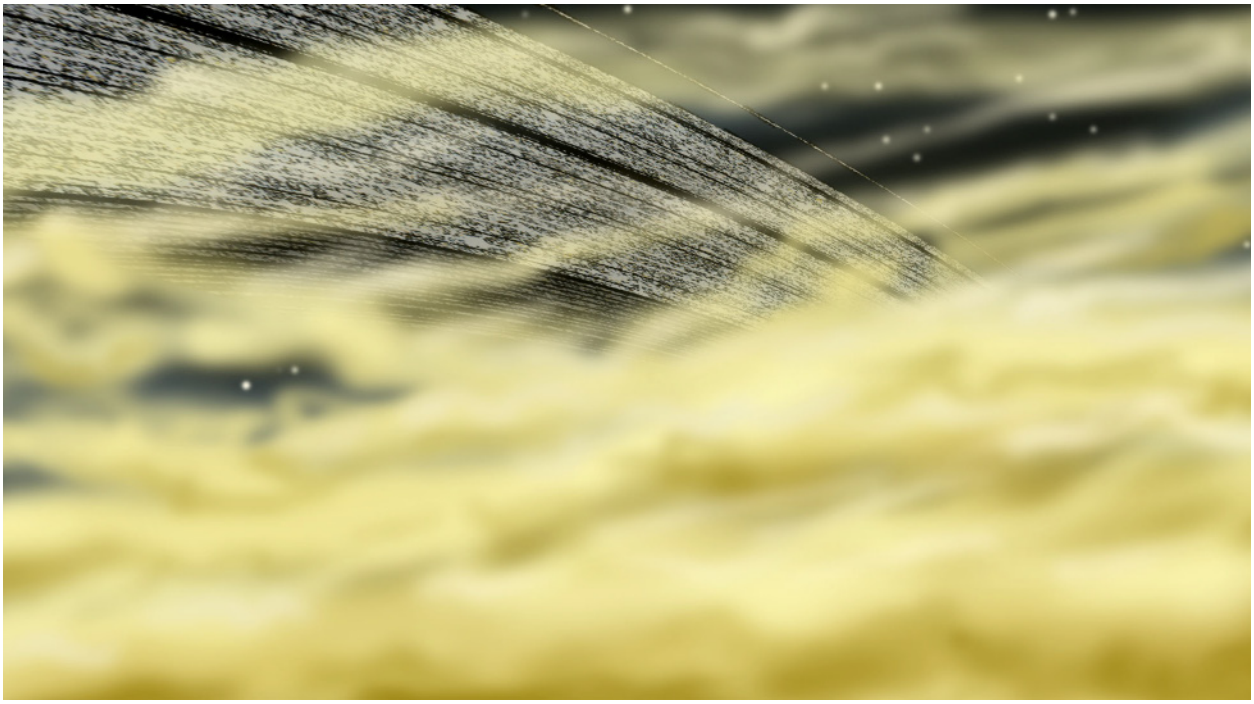
Questions, Answers, and Cool Things to Think About



Discovering Saturn: The Real Lord of the Rings

Although no one has ever traveled from Saturn's atmosphere to its core, scientists do have an understanding of what's there, based on their knowledge of natural forces, chemistry, and mathematical models. If you were able to go deep into Saturn, here's what you might find along your journey.

First, you would enter Saturn's upper atmosphere, which has super-fast winds. In fact, winds near Saturn's equator (the fat middle) can reach speeds of 1,100 miles per hour. That is almost four times as fast as the fastest hurricane winds on Earth! These winds get their energy from heat rising from Saturn's interior. As gases in Saturn's interior warm up, they rise until they reach a level where the temperature is cold enough to freeze them into particles of solid ice. Icy ammonia forms the outermost layer of clouds, which look yellow because ammonia reflects the sunlight. Other chemicals, trapped in the ammonia ice particles, add shades of brown and other colors to the clouds. Methane and water freeze at higher temperatures, so they turn to ice farther down, below the ammonia clouds. Hydrogen and helium rise even higher than the ammonia without freezing at all. They remain gases above the cloud tops.

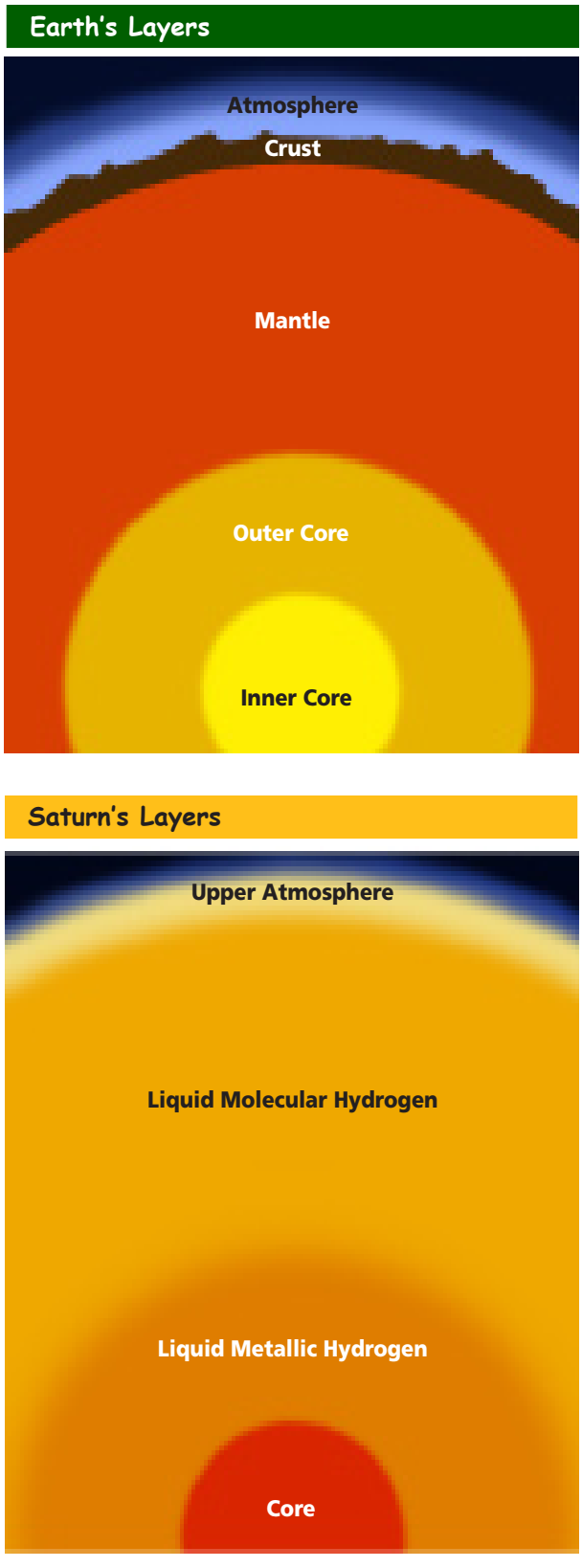


Fierce winds blow clouds of icy ammonia across Saturn's upper atmosphere.

Warm gases are continually rising in Saturn's atmosphere, while icy particles are continually falling back down to the lower depths, where they warm up, turn to gas and rise again. This cycle is called "convection" (kon-VEK-shun). You can see the same kind of thing happen if you watch a big pot of soup boiling on your stove!

From far away, Saturn may look like a gigantic ringed version of the rocky planets in the inner solar system. However, it is really quite different. Unlike planet Earth, where there is a sudden change from the gases in the atmosphere to the solid crust (land) or liquid (oceans), the layers within Saturn and the other giant planets change from one form to another gradually.

Saturn is made up mainly of hydrogen and helium, in both gas and liquid forms. You couldn't stand on Saturn, because there's no solid surface to stand on. If you tried to "land" on Saturn, you'd sink thousands of miles to depths where the heat and pressure are so high that not even the sturdiest submarine could survive!

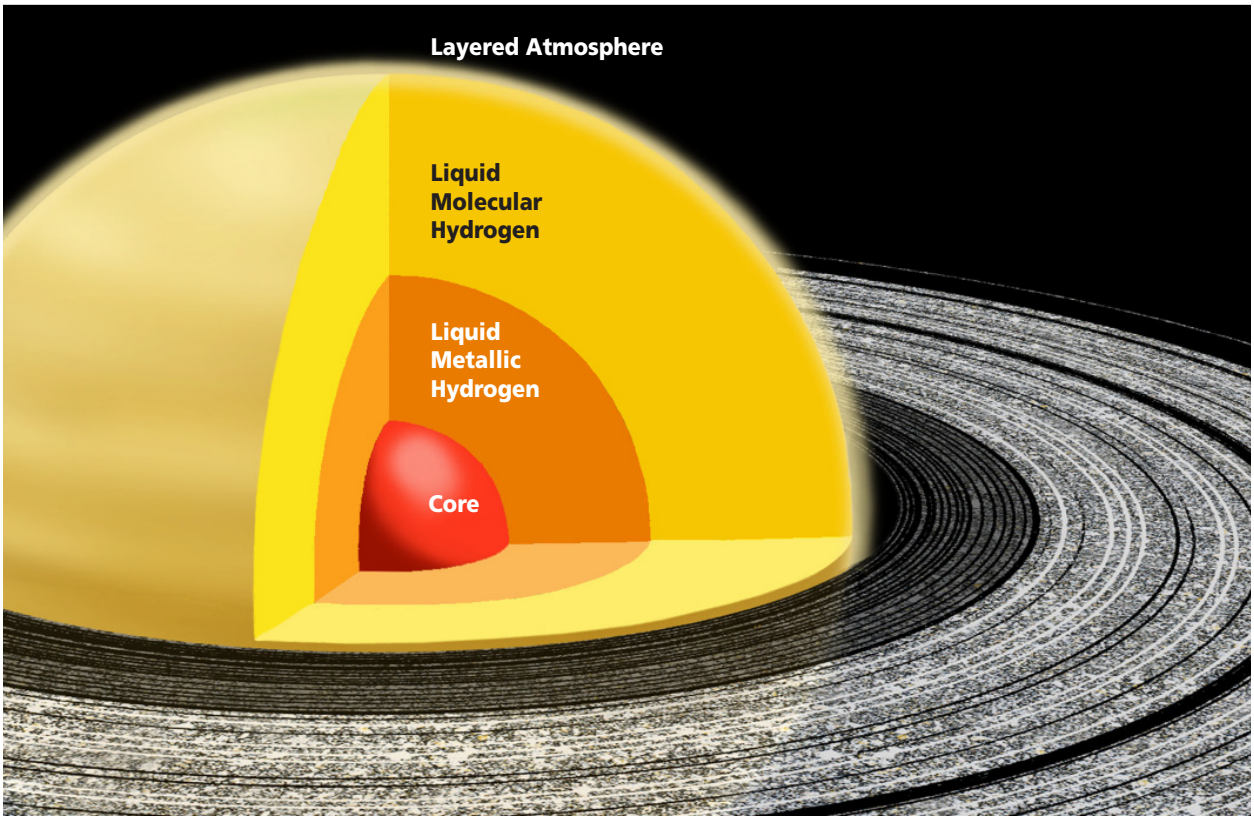


Comparing Earth's Layers to Saturn's Layers

The liquid sections of Saturn form the largest portions of the planet, and are very deep. The first liquid layer inside Saturn, immediately under the atmosphere, is the liquid hydrogen layer. Under the liquid hydrogen layer is a liquid metallic hydrogen layer.

You may be wondering how a gas like hydrogen can also be a liquid. The answer is that most substances can be solid, liquid, or gas, depending on their temperature and pressure. For example, water is liquid at room temperature, but freezes into a solid when it's very cold and boils into water vapor (a gas) when it's very hot. Also, liquid water can boil into vapor at a lower temperature if you carry it up to a very high mountain, where the pressure in the atmosphere is less than it is at sea level. Bring the water vapor back down to sea level, where the pressure in the atmosphere is higher, and it turns back into a liquid.

Deep within Saturn, the pressure is so enormous that it turns the hydrogen gas into a liquid, even though the tem-



Inside Saturn

perature is also very high. Still deeper, where the pressure is even greater, the liquid hydrogen acts like a metal and can conduct electricity.

Finally, at Saturn's center is a molten rocky metallic core. Saturn's interior is hot! At the core, the temperature is at least 15,000 degrees Fahrenheit. That's hotter than the surface of the Sun!

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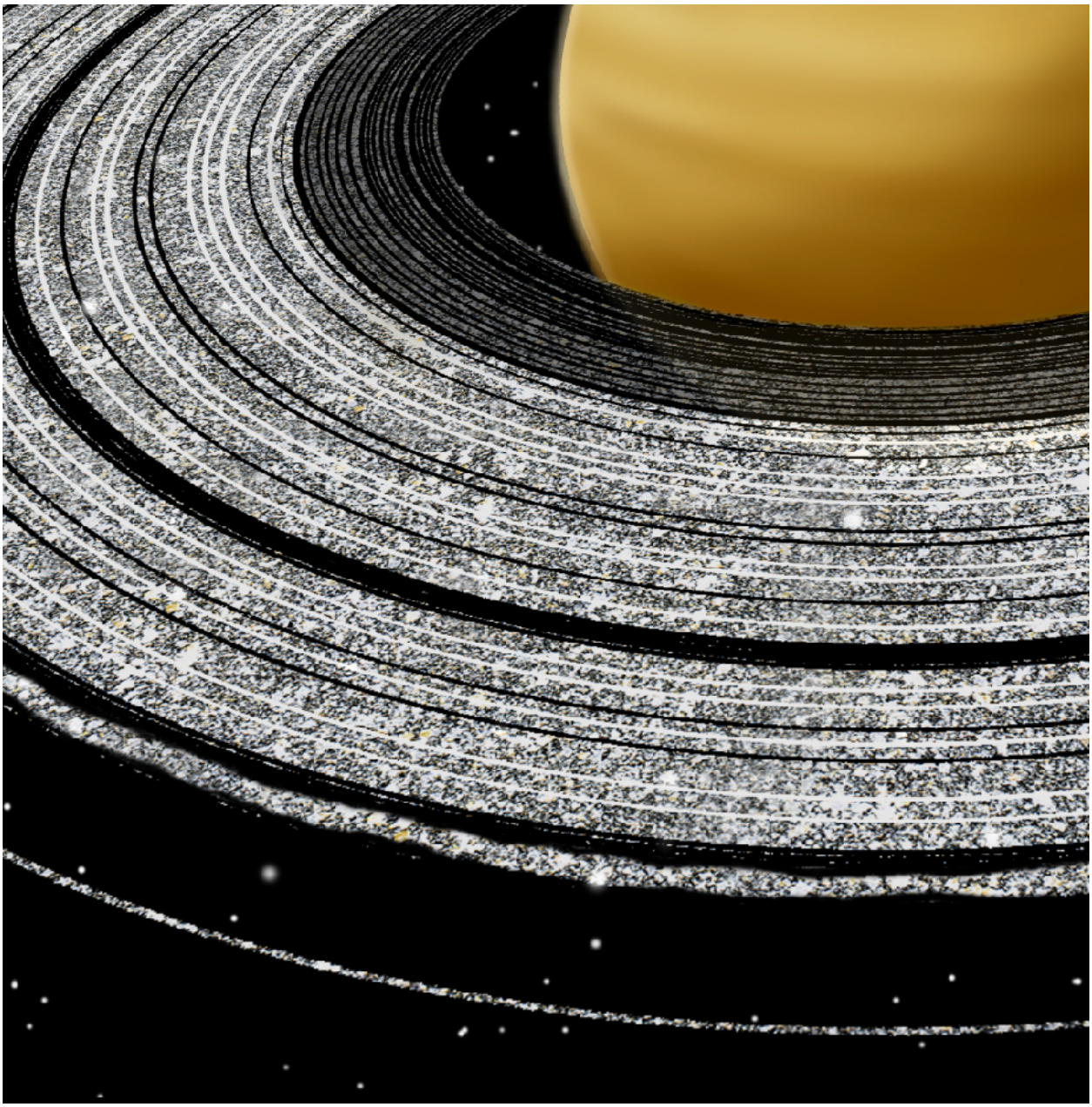
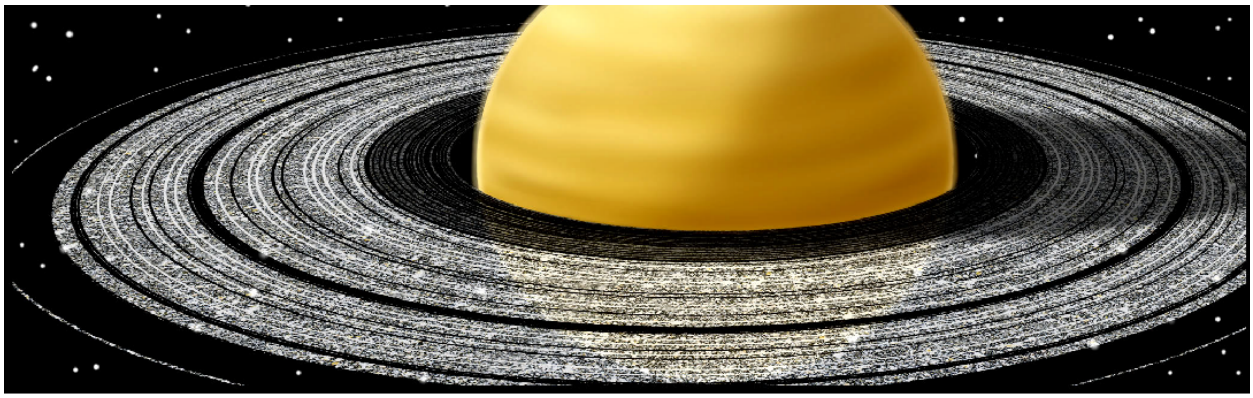
Those Amazing Rings!

Questions, Answers, and Cool Things to Think About



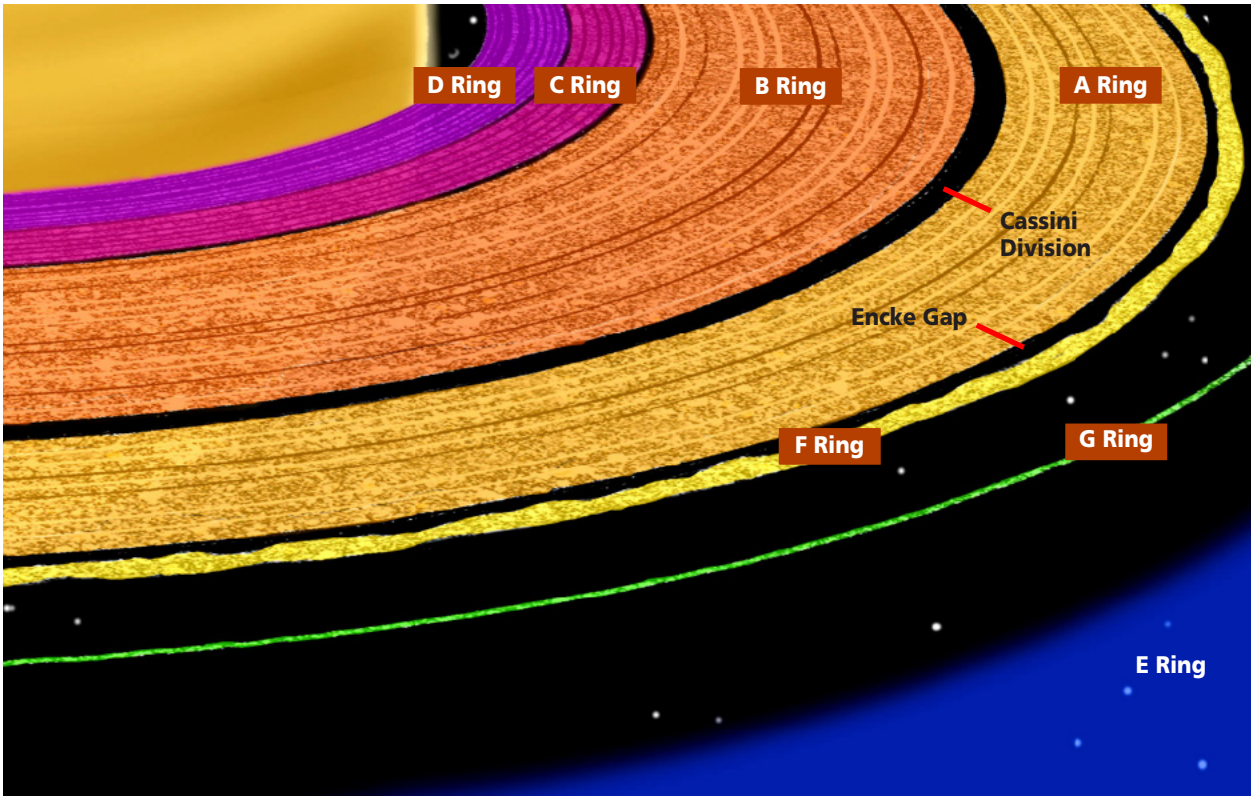
Discovering Saturn: The Real Lord of the Rings



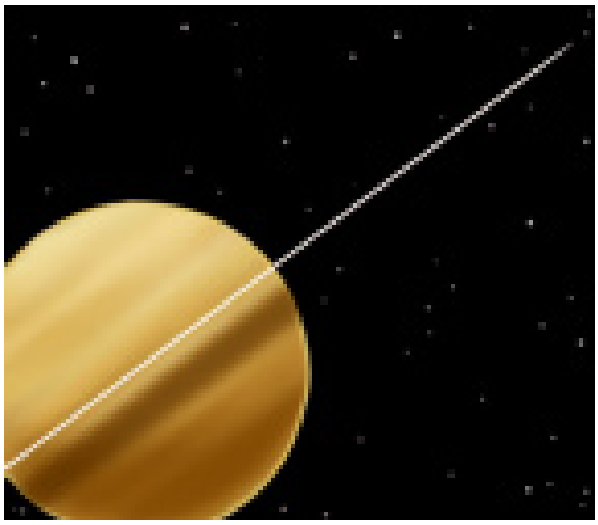
While all the gas giant planets have rings, Saturn's rings are the brightest and most spectacular, although we need a good telescope to see them from Earth. What other adjectives or describing words come to mind when you look at the rings?

(The colors shown below are not real.)

The rings are named in order of their discovery, so even though the A ring is not the closest ring to Saturn, it is called "A" because it was discovered first. From the planet outward, they are known as the D, C, B, A, F, G, and E rings. Can you think of a better way to name the rings?



The rings stretch all around Saturn and are about 170,000 miles in diameter. That is almost the distance from Earth to the Moon! While the rings stretch for hundreds of thousands of miles to circle Saturn, they are less than a kilometer (about half a mile) thick. In fact, scientists have found that in some places they are as little as 10 meters (30 feet) thick.

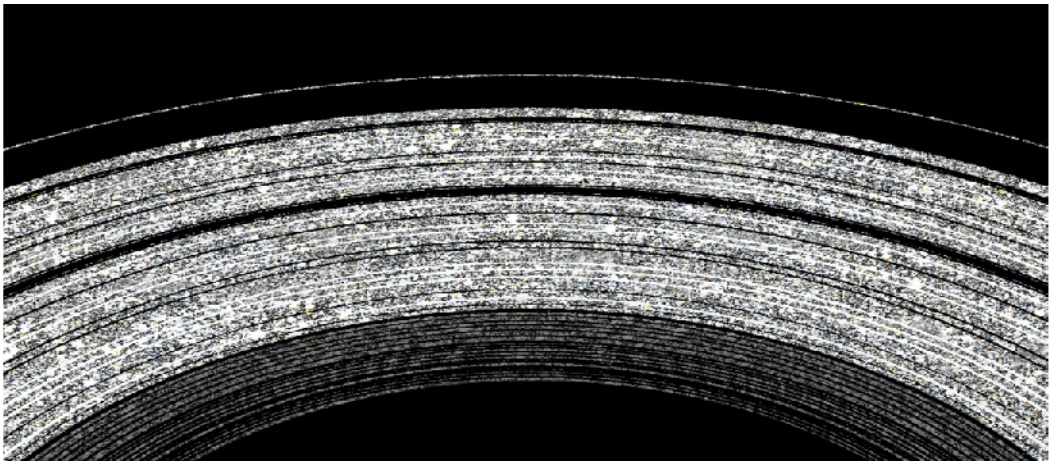


It is amazing that Saturn's rings can be hundreds of thousands of miles across and yet less than a soccer field in thickness. If you were to use a piece of paper to make a scale model of Saturn's A, B, and C rings, and have the thickness of the paper represent the thickness of the rings, you would need to cut out a circle with a diameter greater than 10,000 feet, or about two miles, across. The rings are really thin!

Long ago, when Jean-Dominique Cassini and Christiaan Huygens were alive, people thought the rings were solid bands. But Saturn's rings only look like solid bands when seen from far away.

Cassini

Huygens



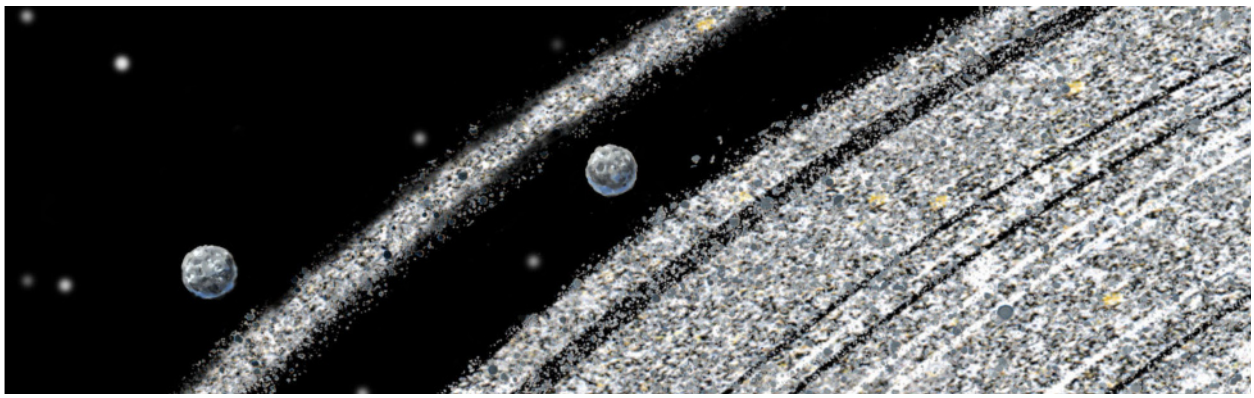
Kids: Look at this drawing from across the room and see if the rings look solid to you.

The A, B, and C rings are really made up of chunks of water ice and ice-covered rock, ranging in size from a grain of sand to as big as a house! Particles in the D and E rings are even smaller — about the size of particles in smoke. We don't know yet how big the particles are in the F ring.

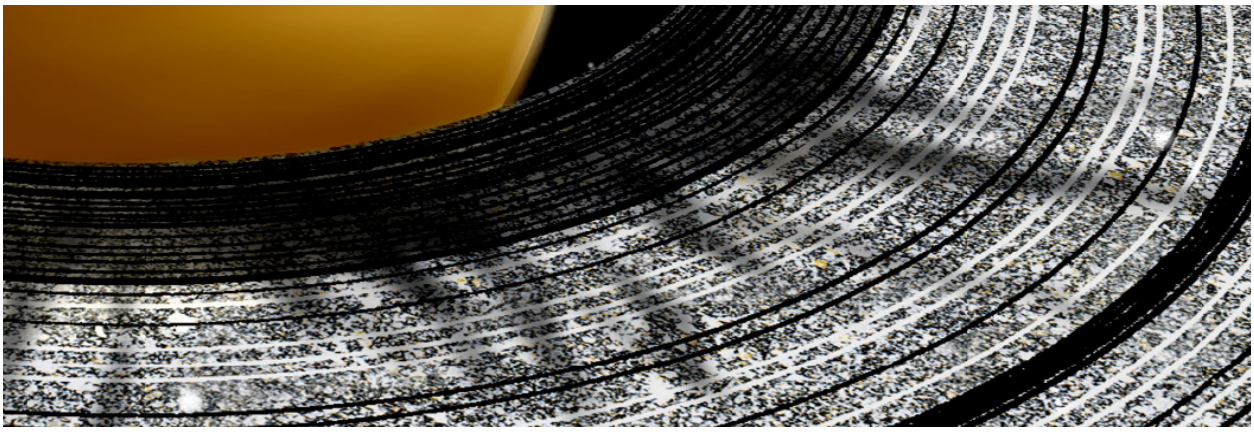
Where do you think these particles came from? Many scientists think they came from former moons that crashed into each other and smashed into pieces!

You might expect that all the pieces would eventually float away from each other and the rings would break up. But some of Saturn's moons act like shepherds herding sheep. Their gravity keeps the icy particles from straying out of the rings. In fact, they're called "shepherd moons."

Shepherd moons are less effective at holding the smallest particles in place, however. Many of these particles gradually fall into Saturn. But they are replaced by new particles that come from the ongoing collisions of large rocks and moons, so the rings are always in the process of being rebuilt.



Shepherd Moons



Spokes

Saturn's rings have gaps between them, though only a few of these gaps were known before space probes visited the planet. The largest of these gaps, located between the A ring and the B ring, is called the Cassini Division, after its discoverer, Jean-Dominique Cassini. It is about 4,800 kilometers wide (about the distance across the United States), although this varies quite a bit around the planet. There is another division between the A ring and the F ring called the Encke Gap. (See diagram on page 2.) The gaps are produced by the gravitational pull of one or more of Saturn's many moons on the particles in the rings.

There are other characteristics about the rings that puzzle scientists. The F ring almost seems to be braided in places, and there are features that look like spokes that stretch across the rings. What do you think these might be? Scientists are hoping that the Cassini spacecraft will help them to understand Saturn's amazing rings better.

Closeup of the Braided F Ring

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Saturn's Moons

Questions, Answers, and Cool Things to Think About

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Next time you look up at the Moon in the night sky, imagine what it would be like to live on a world that had 60 moons! That's how many we've found so far orbiting Saturn. There might be even more that we haven't discovered yet.

Most of Saturn's moons are much smaller than Earth's Moon. But they are strange and fascinating in many ways. Some of them help to keep Saturn's famous rings together. The rings are

made up of millions of icy stones and specks of dust, and gravity from some of the moons keeps the material from floating away from the rings, much like a shepherd keeps sheep from wandering away from the flock. In fact, those moons are called "shepherd moons."

No one knew that Saturn had any moons until 1655, when a Dutch astronomer named Christiaan Huygens pointed a telescope at the giant planet and saw its largest moon, Titan, for the first time. During the centuries since then, as people built more powerful telescopes and sent robot explorers into space, we discovered more and more moons around Saturn. We've found 60 so far, and it's possible that the Cassini spacecraft will discover even more as it orbits the planet from 2004 to 2008.

One moon, called Enceladus (in-CELL-uh-dus), is one of the shiniest objects in the solar system. It's about as wide as Arizona, and it's covered in ice that

reflects sunlight like freshly fallen snow. That makes it extremely cold — about 330 degrees below zero on the Fahrenheit scale! Some scientists think that the icy particles that make up Saturn's E ring came from volcanoes or ice geysers on this moon.

Another moon, Mimas (MY-muss), has a giant crater that is one-third as wide as the moon itself. In the center of the crater is a mountain as tall as some of the biggest mountains on Earth.

Two other moons, Epimetheus (ep-uh-ME-thee-us) and Janus (JAY-nuss), trade orbits with each other every few years, taking turns being closer to the planet.

Iapetus (eye-A-pe-tus) may be the strangest of Saturn's moons. It looks like a big ball that's chocolate on one side and vanilla on the other side!

Some scientists think a moon called Phoebe (fee-bee) may have started out far beyond Pluto, and wandered billions of miles toward the Sun until it was captured by Saturn's gravity. Titan is by far Saturn's biggest moon. It's the second largest moon in the whole solar system. (The largest one, Ganymede, is in orbit around Jupiter.) Titan is bigger than the planet Mercury!

We haven't had a good look at Titan's surface yet, because it is hidden beneath a thick, deep-red haze. But

Mimas

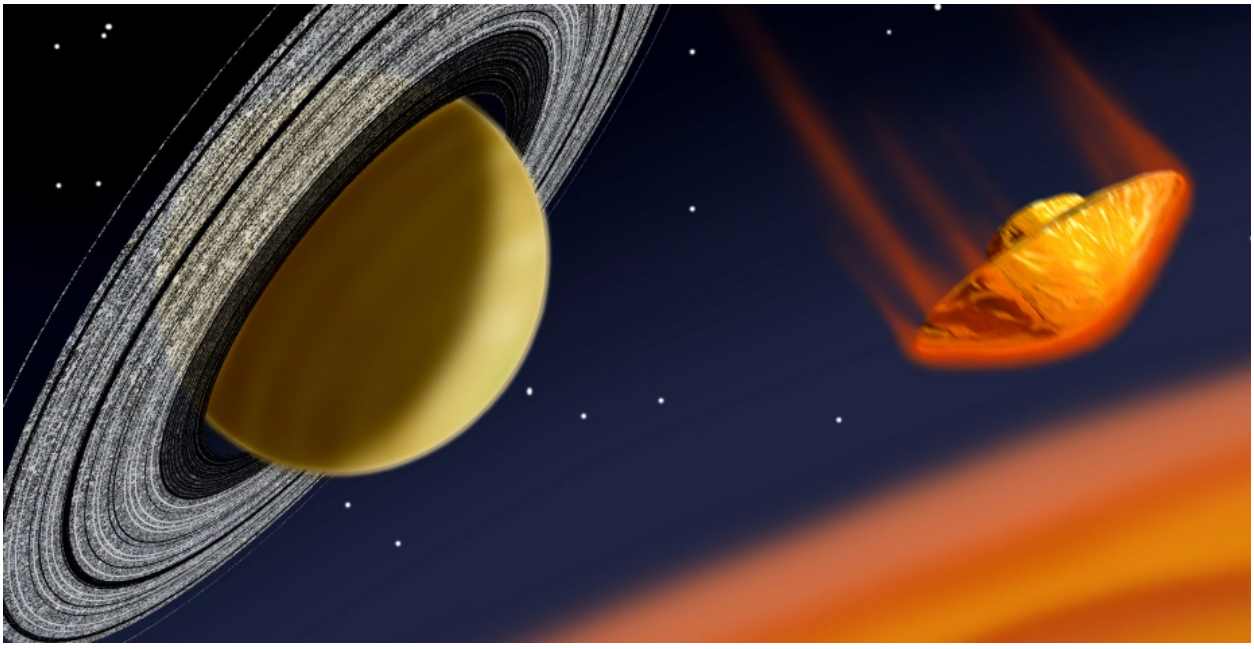
Iapetus

scientists on Earth used the world's most powerful radar system to bounce microwaves off the giant moon — which was about 800 million miles away at the time — and the radar showed that there might be huge lakes or oceans on Titan. But they aren't filled with water. Instead, they are thought to be filled with a liquid that's kind of like alcohol!

The Cassini spacecraft carried something that may help us learn much more about Titan. It's a machine called the Huygens probe, named after the astronomer who discovered Titan.

In January, 2005, the Huygens probe flew to Titan and dropped down through its atmosphere on a parachute, taking pictures and gathering information as it fell to the surface. It used radio to send the pictures and information to Cassini, and Cassini sent them to us here on Earth.

Which of Saturn's moons would you most like to visit? Why?



Before its parachutes open, Huygens begins to fall through Titan's atmosphere.

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