Activity 3
Discovering Saturn: The Real "Lord of the Rings"

Overview

- We have arrived at Saturn in our imaginary journey with the Cassini–Huygens spacecraft! By now, it is intended that students' curiosity about Saturn is piqued and they are eager to learn more about the special features of Saturn — its rings and moons — and the planet itself.

In this activity, your youth:

- Take a firmer grasp on their role as scientists and engineers as they are introduced to the value of research into past discoveries.
- Research 4 mini-books about Saturn, pull out interesting information to share, and look for answers to a matching game they will play.
- Share their findings and work in teams to win the game.
- Make posters to share the most important findings from the books, and record their new knowledge on the "Notice/Know/Wonder" charts they created in an earlier activity.
- Reinforce new knowledge by observing, measuring, and drawing scale models of Saturn and its moon Titan, compared to Earth and its Moon.

Time/number of sessions	Activity Type	Space Needed
Four 40-minute sessions	Reading, journaling, group discussion and sharing, art/drawing and gaming	Room with tables and chairs

Activity Goals

Youth will:

- Begin to visualize themselves working as scientists and engineers, as they learn the importance of claims supported by evidence.
- Read and share for specific, authentic purposes.
- Extend and enhance their understanding and knowledge about Saturn and communicate it by summarizing, journaling, sharing, and drawing models.
- Demonstrate their knowledge with materials based on scientific claims that have been supported by evidence.

Where's the Science and Engineering?

- Before scientists for the Cassini–Huygens mission proposed to go to Saturn, they first researched to see what questions their colleagues had already asked and answered.
- Once the scientists felt they had gathered all the information they could, they began to add their own questions to form the purpose of the Cassini–Huygens mission.
- As the mission proceeds, scientists carefully analyze the data from the spacecraft and make claims supported by evidence they found. They share these discoveries so that other scientists and the public can learn from them. They more we learn, the more new questions we come up with!
- The ability to research, discuss and present in a clear and engaging way is an important skill for all those on a solar system mission team.

National Science Education Standards

5–8

Earth and Space Science:

- Earth in the Solar System

Equity/Leveling the Playing Field

- Making posters of Saturn requires lots of different skills. Some students will be more artistic, some focused on accuracy and science content, some on neatness or the presentation. Stress that this is a team endeavor and that everyone's talents, interests, and skills are required to make the best poster.
- Point out to the students that the teams from NASA who worked on (and continue to work on) the Cassini–Huygens mission consist of many people with a variety of talents and skills.
- Remind students that everyone on the team should participate because everyone's idea is important.
- See the "Internet Resource List" for links to the Spanish version of the mini-books.

Getting Ready

For Sessions 1 and 2

- Make copies of the *Saturn/Cassini Match Game Question Cards* in one color, and use a different color for the *Saturn/Cassini Match Game Answer Cards*.
- Lay out copies of the match game for each team to view (don't pre-cut them — students will cut during Session 2).

For Session 4

- Hang up the "Notice/Know/Wonder" charts (from Activity 1 — "What Do I See When I Picture Saturn?") around the room

Leader Tips

- Find some prize or privilege that a team can have for winning the match game. The winning team's poster can be saved and used as part of the culminating and assessment event in Activity 8 — "Celebrating Saturn and Cassini."

- 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.

- If the majority of your students are reading below the level of the mini-books, you may prefer instead to do Activity 4 — "Saturn's Fascinating Features" — they can still gain information on Saturn and its moons, as well as practice listening and writing brief sentences.

- Try providing for each student fruit of the appropriate size for Saturn, Titan, Earth, and Earth's Moon — turning an edible model into a snack after the students have completed their measurements and drawing.

Materials

From Your Supply Closet

Session	For Students
All	*Saturn Discovery Logs*
2	For each student team of 4: • Poster size chart paper (for match game results) • Glue sticks, or clear tape in dispensers • Scissors (for each team member) • One marker pen
3	• Pencils, paper, broad-tip markers, tempura paints, paint brushes, one piece of 36" x 48" chart paper per team
4	For size-comparison scale model (requires a trip to the grocery store for the fruit option): • 3-inch Styrofoam™ ball, rubber band ball, or fresh orange (Saturn) • Built-in pencil eraser, or peppercorn (Titan) • Eraser pencil top (separate larger eraser that fits on top of a pencil), or small blueberry (Earth) • Short strip of paper rolled into a ball the size of a rice grain, or rice grain (Earth's Moon) • Rulers (metric or English units) • Broad-tip markers • "Notice/Know/Wonder" charts from Activity 1 — "What Do I See When I Picture Saturn?"

From a Photocopier/Printer

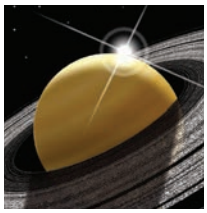
Session	For Leader	For Students
1		For each student team of 4: • Copy of the mini-book "Introducing Saturn" • Copy of the mini-book "Saturn — From the Outside In" • Copy of the mini-book "Those Amazing Rings!" • Copy of the mini-book "Saturn's Moons" • Copy of *Saturn/Cassini Match Game Question Cards*
2	• *Saturn/Cassini Match Game Answer Key*	For each student team of 4: • Copy of *Saturn/Cassini Match Game Question Cards* • Copy of *Saturn/Cassini Match Game Answer Cards* (on different color paper)
3	• The two sample Cassini–Huygens NASA educational poster art: *Saturn: Jewel of the Solar System* *Titan: Behind the Veil*	

Discovering Saturn: The Real "Lord of the Rings"

Student Activity

Session 1 • Reading and Group Sharing

1. Prepare your students for their scientific "reading investigation" with the following conversation guide:
   - When scientists are about to start an investigation with their own questions, they often look up what other scientists have already discovered. Reviewing what is already known often causes scientists to come up with even more questions. As the Cassini–Huygens scientists have been investigating Saturn, they have learned many new things — and they continue to want to learn more as they uncover more details.
   - In an earlier activity, you have already begun to think and act as scientists in this way by observing ("What I Notice" chart) and questioning ("What I Wonder" chart). However, noticing and observing something is only a step towards "knowing" something. Knowing in the science community is a matter of something that can be tested and then "claimed" because it is supported by evidence. When you stood before a picture, you could "claim" something about the picture, based on what you noticed. But until you can test that claim, or research a reliable source to find that it is true, you have no evidence that your claim is true. There is an important difference between "claims" and claims supported by "evidence."
   - In this session, you will continue as "scientists" to investigate what has been learned so far about Saturn. Each of you will become a "science expert" in one area of Saturn, by working with one of the four mini-books in the series "Saturn, the Real Lord of the Rings." What you will see in the mini-books are examples of things that scientists noticed or wondered about — and then tested so they could make claims supported by evidence.
   - Scientists often prepare presentations to share what they have learned with other scientists. You are going to need to work together to share information about Saturn. We will form teams, and each member of a team will be responsible for sharing what they learn with the rest of the team.
2. Have students "count-off" to form teams of 4. Have each team work at a separate table.
3. Have the students retrieve their *Saturn Discovery Logs*. Tell them they will be taking notes in these logs. Tell them they will later share those notes with each other, and in the next session, use them to play a game.
4. Hand out 4 different mini-books to each team and assign students to each book. (Note: If students' reading level does not match the mini-books, then you as the leader can read aloud to the whole group, asking each student to "take a specialty" and take notes on their choice of "specialty book" from the four books.)
5. Hand out an uncut copy of the *Saturn/Cassini Match Game Question Cards* for each team.



Activity 3

6. Tell them that they should write down a few words to describe anything they read that interests them, that they think is important or worth knowing about Saturn, and look for the answers to the questions on the *Saturn/Cassini Match Game Question Cards*, which they will use in the next session. Suggest some ideas for what might be "most important" about Saturn, such as "Saturn is very big," "Saturn is far away and very cold," "Saturn is beautiful," "Saturn has the most complicated rings of all the planets," and some questions from the *Saturn/Cassini Match Game Question Cards*.
7. Allow about 20 minutes for students to read their mini-books and take notes.
8. Explain to the students that, to help them report what they learned to the other students in their team, they should identify and write down the five or so most important or interesting facts about Saturn from their notes.
9. Have each student present the main points about Saturn from their mini-books with the rest of their team.

Session 2 • The Saturn/Cassini Match Game

In this session, students are going to use the notes they took in their *Saturn Discovery Logs* to help their team win the Saturn/Cassini Match Game, by being the first team to match all questions with the correct answer.

1. Return the *Saturn Discovery Logs* to the students.
2. Give each team a large piece of chart paper, a marker pen, and glue sticks or clear tape in a dispenser.
3. Ask the teams draw lines to divide their chart paper into four equal sections, and label each section as follows: Saturn, Saturn's Rings, Saturn's Layers, Saturn's Moons.
4. Pass out the *Question Cards*, *Answer Cards*, and scissors for each team, and have students cut out the playing cards.
5. Have students shuffle all cards (both questions and answers) into one stack in the middle of the table.
6. Explain to the students the rules for the game and post them on the board as you explain them, using the conversation guide below:
   - At the game start, your team will take all the cards and lay them out individually on the table, face up.
   - When I say "Go!", use the notes you took in your *Saturn Discovery Log*, and work together as fast as you can to match as many answers to their correct question as you can.
   - Glue (or tape) the matched pairs side by side on your piece of chart paper, placing them under the section that best matches them (Saturn, Saturn's Rings, Saturn's Layers, Saturn's Moons).
   - When you believe you have all questions and answers correctly matched and placed in the right section of your chart paper, call out "Done." When every team is done, we'll check the matching pairs.
7. Set the teams to working on the game. If students are having difficulty finishing the game, pass out the sets of mini-books to refresh their memories.
8. Number the teams in order as they finish.
9. When all teams have finished their game chart, post all charts on the wall, and check the matches using the *Saturn/Cassini Match Game Answer Key*. The earliest team to finish with the correct answers wins.

Session 3 • A Giant Poster of Saturn

1. Scientists and engineers are responsible for sharing their discoveries with the rest of the scientific community in a way that engages them. Remind students that they have

been learning different ways of communicating their science discoveries: journaling, drawings, making models, etc. Now, they will continue as scientists and engineers to engage their "science community" with the information they have just learned in the mini-books by making a poster.

2. Explain to the students that in this session they will be using the information they gathered in the last session to create a giant poster about Saturn and its rings, layers, and moons.
3. Divide students into new teams, grouped together by the mini-book for which they were experts. If there are students who missed the earlier sessions, assign them to the smaller teams and encourage the team to share what they've learned. If your teams are too large for everyone to participate in designing drawing on the poster, make extra teams and assign them one of the books. Hand each team the mini-book that matches their poster theme. Show the group a sample of NASA poster art.
4. Give them instructions using the following conversation guide:
   - You will create a poster like the sample poster art, but the poster your team makes will reflect the theme of your particular mini-book.
   - You remember that we talked about the difference between claims and evidence. When we notice something, we can make a claim, but we need the evidence to say that we "know" it. Now that we have read the mini-books on Saturn from scientists at NASA, you can design your posters with claims that have been tested and have "evidence" from discoveries of the Cassini–Huygens mission. Put information you learned from the mini-books on your poster.
   - As you work on your poster, think about what you originally "noticed" and what you now "know" from Cassini–Huygens scientists' discoveries (claims supported by evidence).
   - Since answers to science questions often raise new questions, each team should add to their poster one new question you have about your Saturn theme.
5. Give each team a large piece of chart paper. They can use tempera paints, collage, or any other media to make their Saturn posters. Be sure they have broad-tip markers for writing the text.
6. As they finish, hang the posters.

Session 4 • Taking Saturn to Scale

1. Show the students a 3-inch-diameter Styrofoam™ or rubber-band ball, or fresh orange, and tell them it represents Saturn. The outer edges of Saturn's most visible rings span about twice the diameter of Saturn.
2. Ask them how big they think Titan would be in a scale model. At this scale, a peppercorn (or built-in pencil eraser) represents the moon Titan. Show the students this model Titan.
3. Ask the students how big they think our Moon is compared to the Earth. (Earth's Moon is ¼ the diameter of Earth.) Ask them to suggest materials to represent that relationship. To be on the same scale as a 3-inch Saturn, Earth would be the size of a large green pea (or small blueberry) and Earth's Moon about the size of a rice grain. See if the students' suggested materials are about those sizes. If not, were they too big or too small?
4. Capture this model as a drawing. Ask the students to create in their *Saturn Discovery Logs* a scale drawing of Saturn, its rings, and Titan by measuring the diameters of the model pieces and transferring the measurements to their paper.
5. Ask students to label as much of the drawing as possible.

Questions for the Youth (Informal Assessment)

Ask the students, and chart their responses in the "Know" column on the appropriate "Notice/Know/Wonder" chart:

- Now that you have read the mini-books that contain scientists' knowledge of Saturn, what can we add to the "Know" column, that is a claim supported by evidence? What can we now move from the "Wonder" column into the "Know" column?

Sharing the Findings (Informal Assessment)

- Hang the teams' Saturn posters around the room. Give the teams some time to present their posters to the group.
- Ask the students for new questions they have about Saturn and its moons and chart their responses.

Leader Reflection/Assessment

While students are working, ask yourself the following questions:

1. Are the students able to read the mini-books? If not, work with them on the vocabulary through the glossary.
2. Are the students taking notes as they read?
3. As the students work on their posters, are they able to identify pieces of information that can stand as claims supported by evidence from their research of the mini-books?
4. Are they able to identify details about the features that they have learned from their reading?
5. Do you see them recognizing that they are beginning to work as scientists or engineers would?

Glossary

- **Ammonia** — A pungent, colorless gas compounded of nitrogen and hydrogen
- **Conduct** — To act as a medium for conveying or transmitting
- **Core** — The central part of a celestial body (as Earth or the Sun) usually having different physical properties from the surrounding parts
- **Gravitational** — Having the force of attraction between physical bodies proportional to their masses
- **Helium** — The next heavier element than hydrogen; a colorless, odorless, tasteless, inert gas
- **Hydrogen** — The simplest and lightest element, found in abundance in the Sun and planetary atmospheres
- **Mass** — The measure of the amount of material
- **Metallic** — Having properties of or behaving like a metal
- **Methane** — A colorless, odorless compound of carbon and hydrogen
- **Microwaves** — A short wave (wavelength from 1 meter to 1 millimeter) of electromagnetic energy (the light our eyes see is a shorter waveform)
- **Moon** — Any natural planetary satellite; the Earth's natural satellite, our Moon, orbits the Earth at a mean distance of 238,857 miles (384,393 kilometers). Some planets, including Saturn, have multiple moons.
- **System** — A combination of things or parts that forms an organized set. Earth is part of the solar system; Saturn and its moons form the Saturnian system.
- **Transmit** — To communicate information by signal, wire, radio, microwave, or television waves. Cassini transmits information to Earth.

Information for Families

Parents can start their own Exploration Journal with their child. It can be a simple "scrapbook journal" with pictures and newspaper articles, their ideas and questions as a jumping-off point for a shared interest in learning more about space.

For Saturn-related games, live streaming videos, and just plain fun, parents can visit:
spaceplace.nasa.gov/search/?q=saturn
with their children. For the Spanish version, see:
spaceplace.nasa.gov/sp/search/?q=saturno

NASA Resources

Careers at NASA

Dr. Amanda Hendrix is the Deputy Project Scientist for the Cassini mission at NASA's Jet Propulsion Laboratory, and studies the icy moons of Jupiter and Saturn. Ask students to write a job description for Amanda Hendrix. What kinds of skills and education does she need? Does she need imagination? Curiosity? What characteristics are important to be a scientist?

Read her blog about working at JPL at:
blogs.jpl.nasa.gov/author/hendrix

Role Model Resource

Amanda Hendrix helps to interpret the wealth of data from the Cassini mission to Saturn and Galileo mission to Jupiter to understand the surface composition through a variety of ways. Read more about Amanda Hendrix at:
science.jpl.nasa.gov/people/Hendrix.

Resources

The Spanish language version of the mini-books are available at:

- "Presentando a Saturno"
saturn.jpl.nasa.gov/files/Minibook_1-Spanish.pdf
- "Saturno: Desde afuera hacia adentro"
saturn.jpl.nasa.gov/files/Minibook_2-Spanish.pdf
- "Esos asombrosos anillos!"
saturn.jpl.nasa.gov/files/Minibook_3-Spanish.pdf
- Las Lunas de Saturno"
saturn.jpl.nasa.gov/files/Minibook_4-Spanish.pdf

The complete version of the poster "Saturn: Jewel of the Solar System" can be found at:
solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=163

The complete version of the poster "Titan: Behind the Veil" can be found at:
solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=762

For more background on Saturn, visit —
saturn.jpl.nasa.gov and solarsystem.nasa.gov/saturn

Learn more about Saturn's moons and get the latest count at JPL's Cassini mission website:
saturn.jpl.nasa.gov/science/moons

Listen to the Sounds of Cassini for actual sounds recorded by the Cassini–Huygens spacecraft:
saturn.jpl.nasa.gov/news/cassinifeatures/feature20060424/

Explore other NASA missions in Spanish and English: www.nasa.gov/educacion/nasaytu

Taking Science to the Next Step

Connections to the Cassini–Huygens mission—

- Give students 2 to 3 minutes to write new questions they have about Saturn and the Cassini mission in their *Saturn Discovery Logs*.
- Create a whole group poster/chart, "What we know about Saturn."

Use the units of engineering — work with the students to convert the measurements in the mini-books into metric units, more commonly used by engineers. Here is an easy was to convert from miles to kilometers: 1 mile = 1.609 kilometers; from feet to meters: 1 foot = 0.3048 meters; from Fahrenheit scale temperature (F) to Celsius scale temperature
C = (F – 32)*5/9

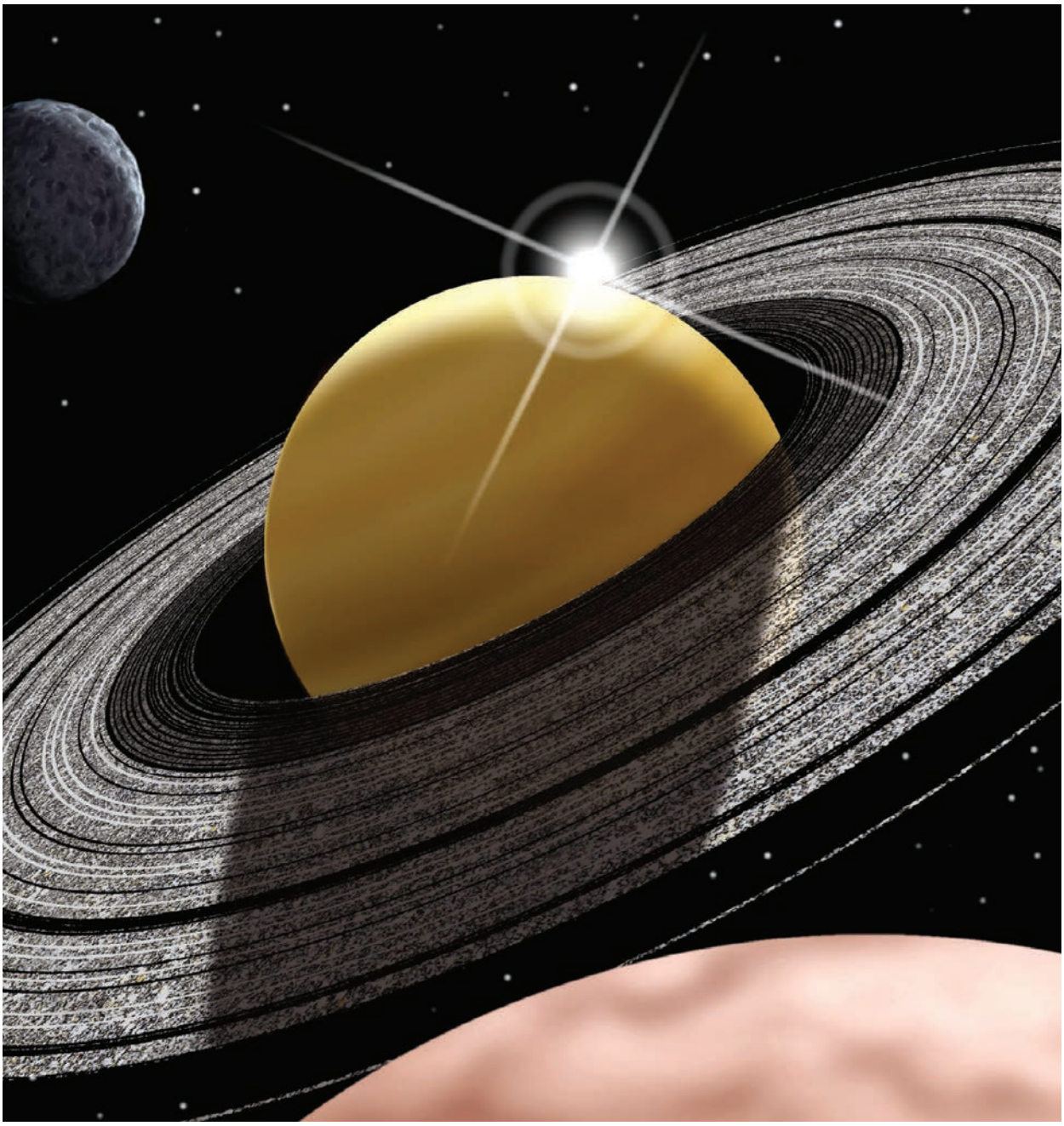
Literacy

Write a poem about Saturn, the Jewel of the Solar System. Students can write haiku, odes to Saturn, a "rap" about Saturn, or nonsense rhymes. Ask students to read their poems aloud.

Ask students to work in small teams to write a short story as a team about Saturn that includes 5 Saturn facts. Instructions for a suggested structure are: "Write a short story of four paragraphs with five sentences per paragraph. The first paragraph has your ideas (from entries in your Saturn Discovery Log about "I Wonder…" about Saturn. The second and third paragraphs have a total of 5 Saturn facts. For the last paragraph, think about how your ideas have changed from "I wonder…" to "I know…" since learning facts about Saturn."

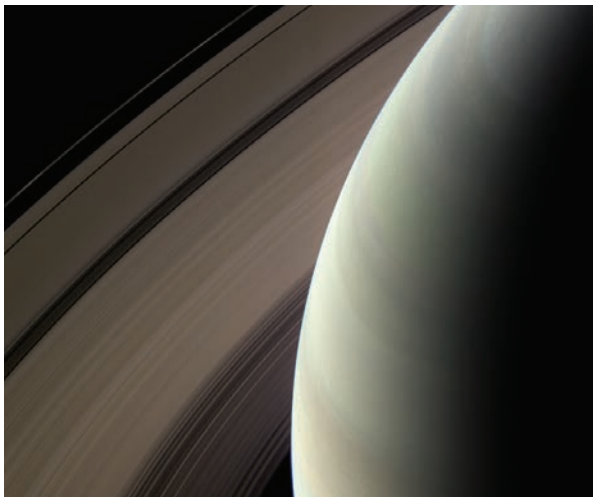
Introducing Saturn

Questions, Answers, and Cool Things to Think About



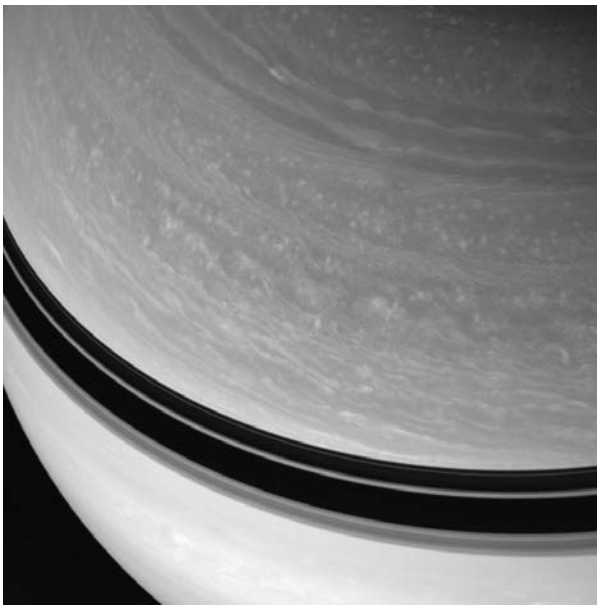
Discovering Saturn: The Real Lord of the Rings

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 95.16 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 at the equator 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.



Natural-color image of rings and Saturn

Montage of natural-color Cassini images of Saturn and moons

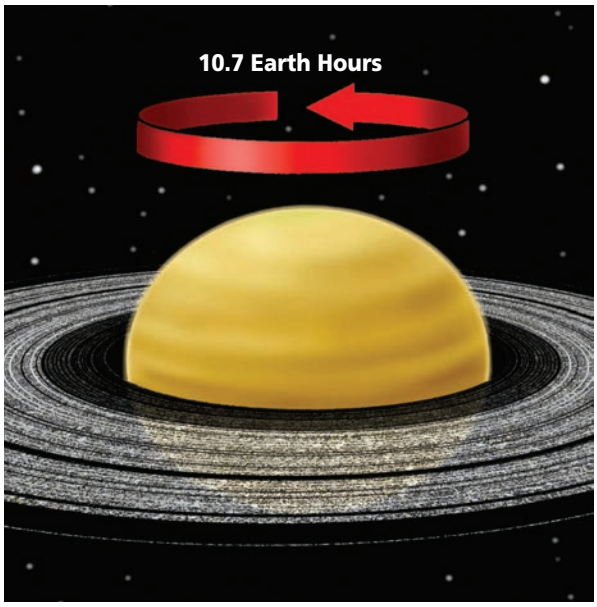


Black-and-white image of Saturn's upper clouds

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 10.7 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 most of 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.

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

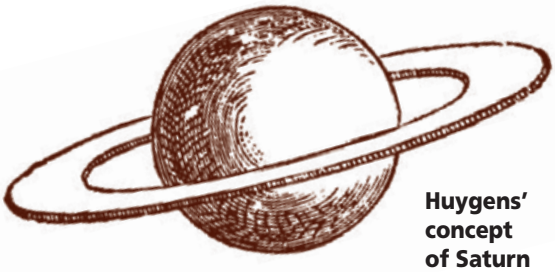
Galileo



Length of a Saturn day

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.

Later, in 1655, a Dutch astronomer named Christiaan Huygens (HOY-gens) looked at Saturn through a more powerful telescope, and figured out that the

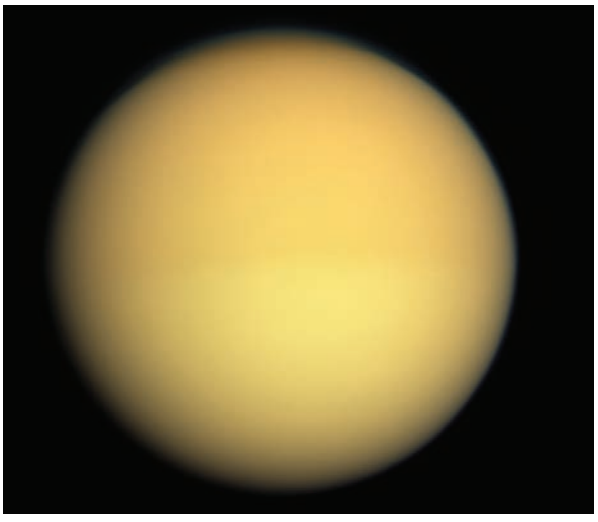


Huygens' concept of Saturn

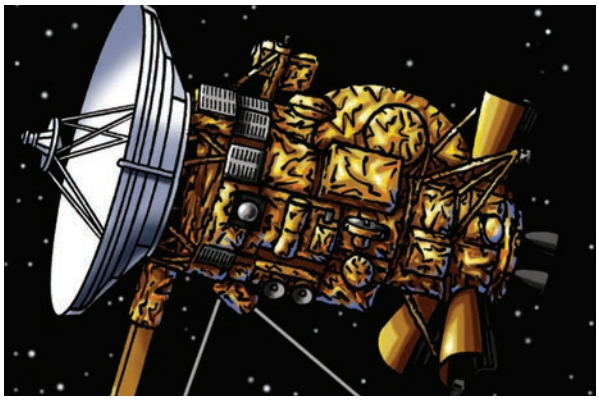
planet is surrounded by a giant flat ring.

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 (cuh-SEEN-ee) 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 90 minutes on Titan's surface before it stopped working, sending us pictures and new information about Titan.

Image by Cassini



Titan



Cassini–Huygens spacecraft

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 2017! What grade will you be in then?

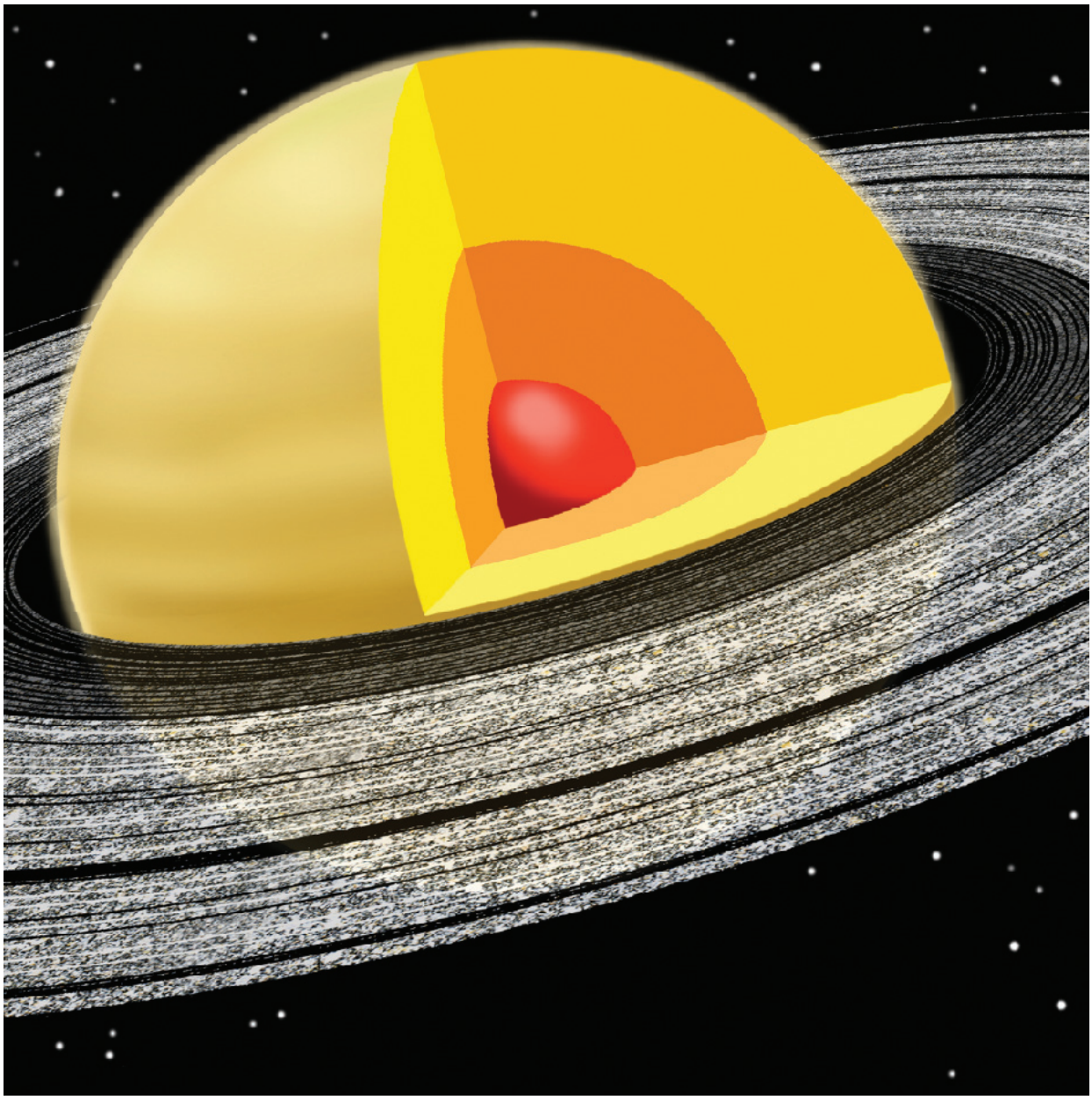
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Saturn — From the Outside In

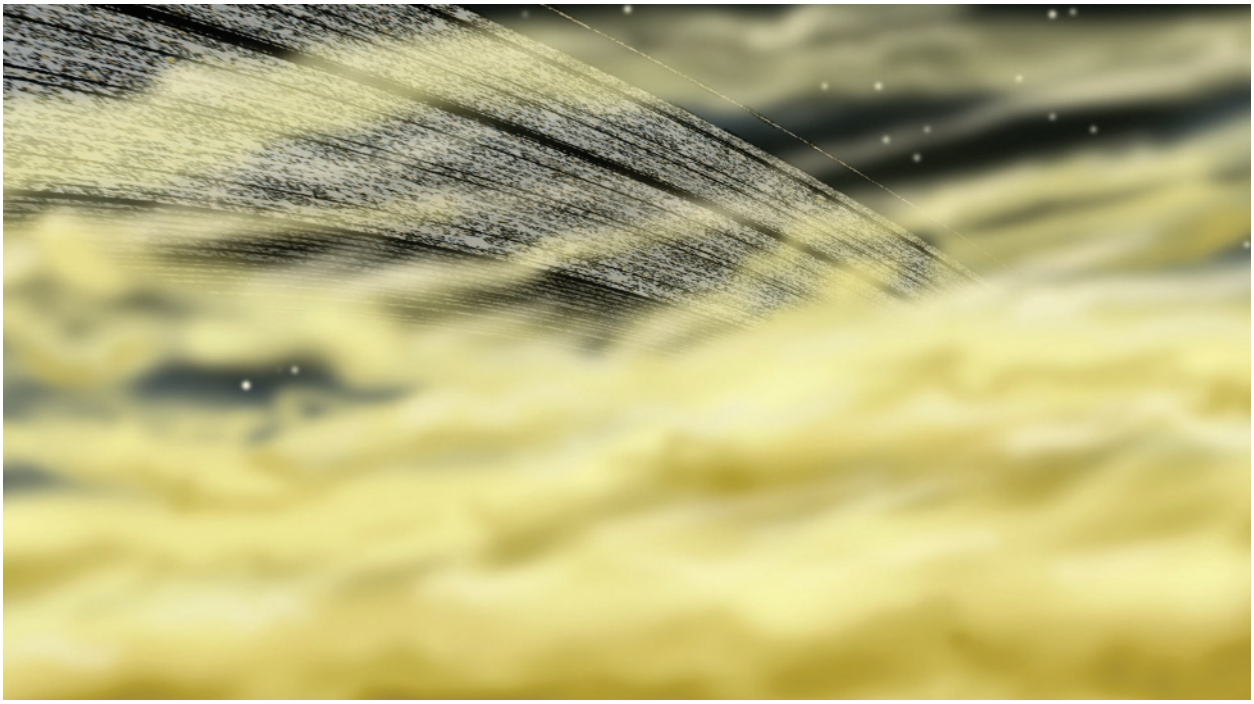
Questions, Answers, and Cool Things to Think About



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.

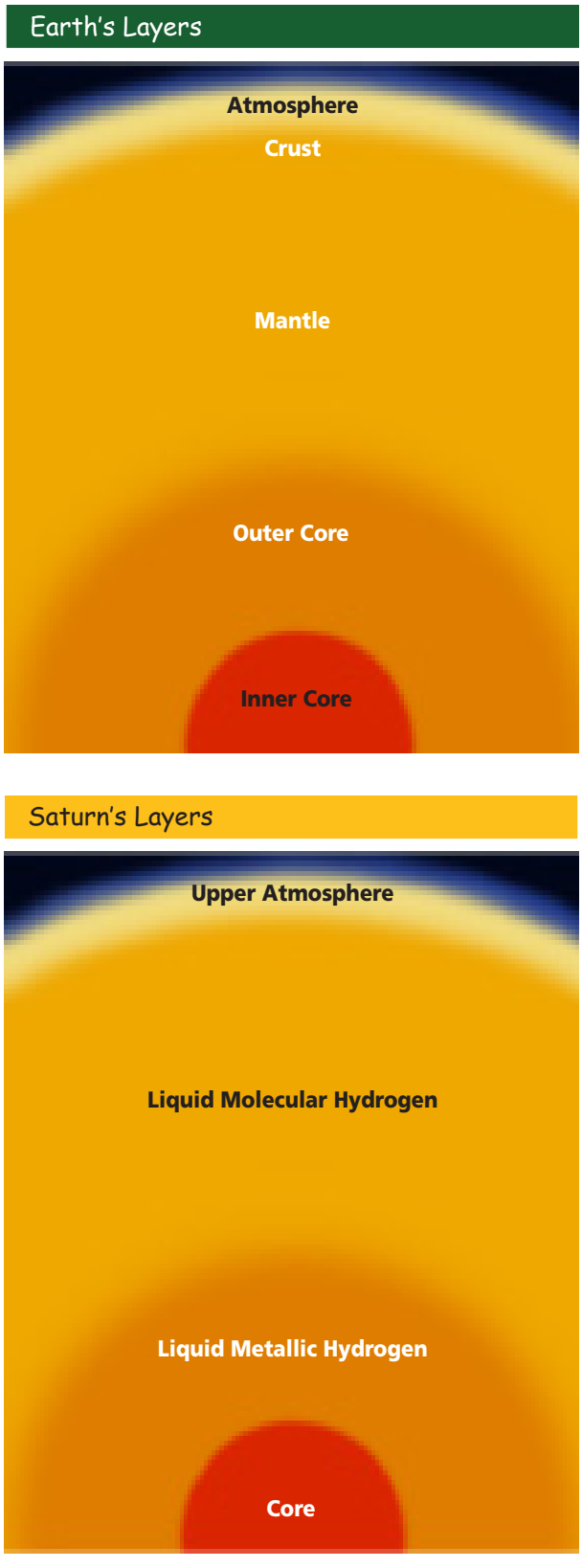


Fierce winds blow clouds of icy ammonia across Saturn's upper atmosphere.

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!

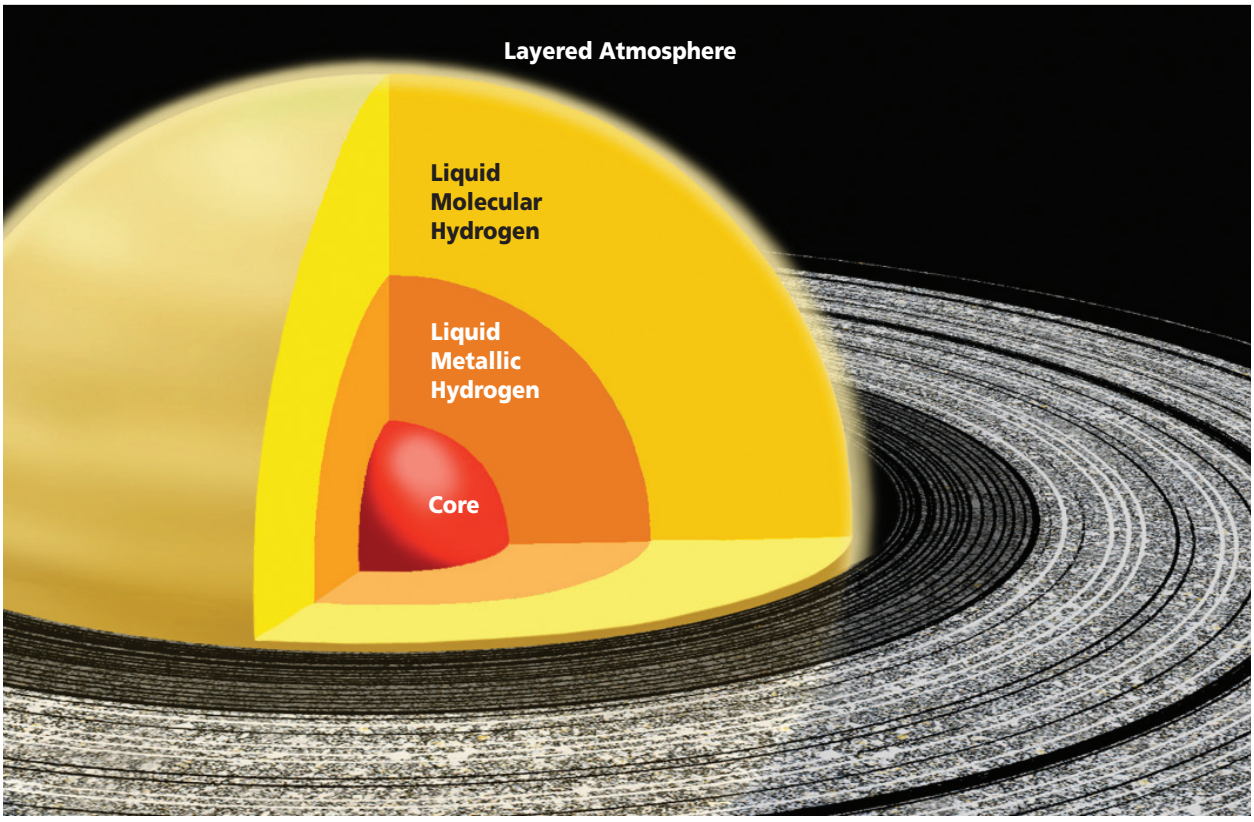


Comparing Earth's Layers to Saturn's Layers

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



Inside Saturn

temperature 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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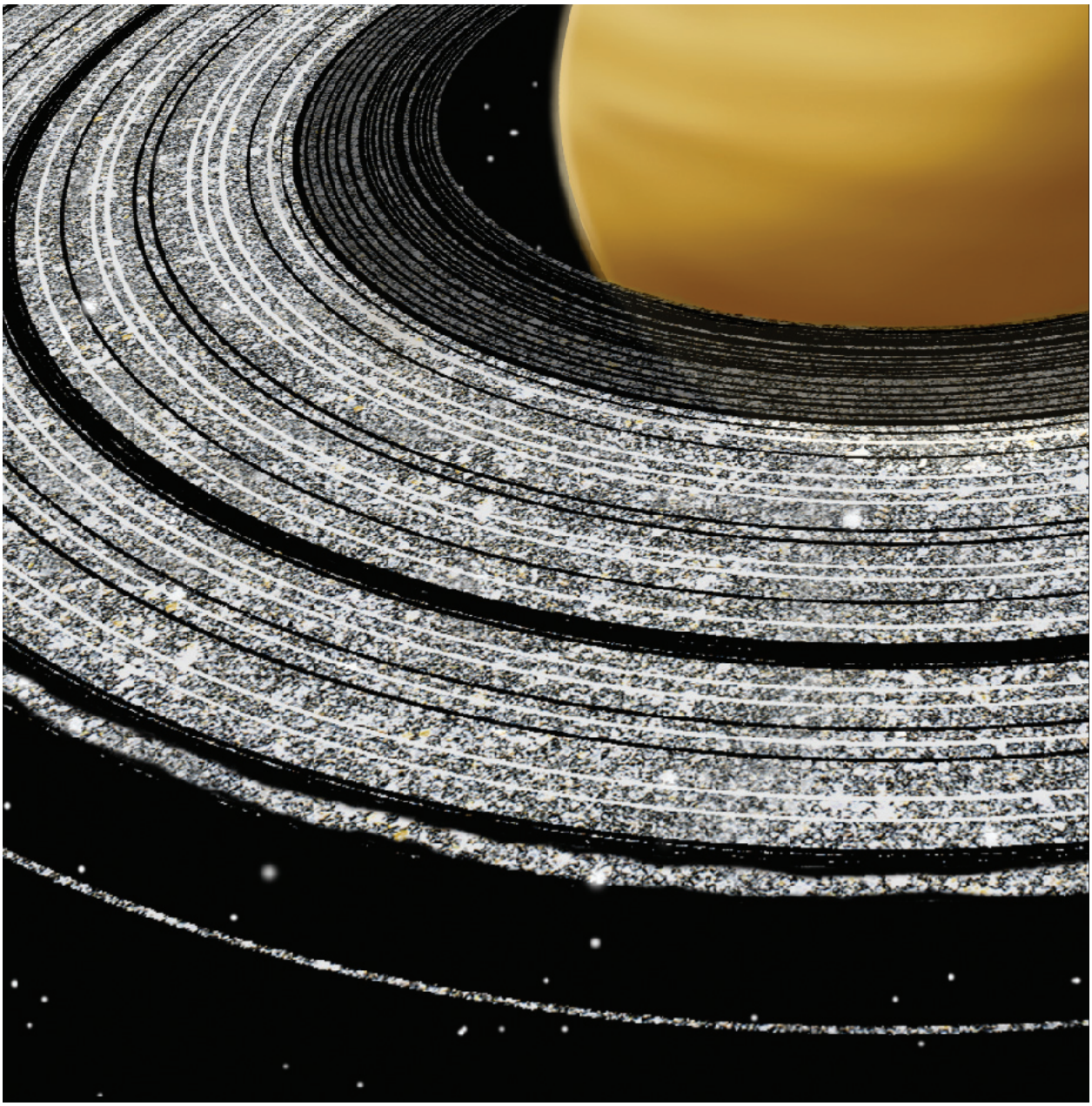
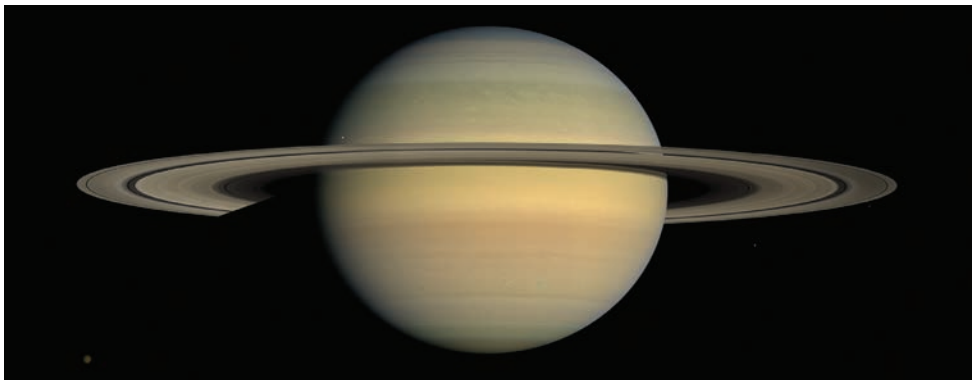
Those Amazing Rings!

Questions, Answers, and Cool Things to Think About



Discovering Saturn: The Real Lord of the Rings

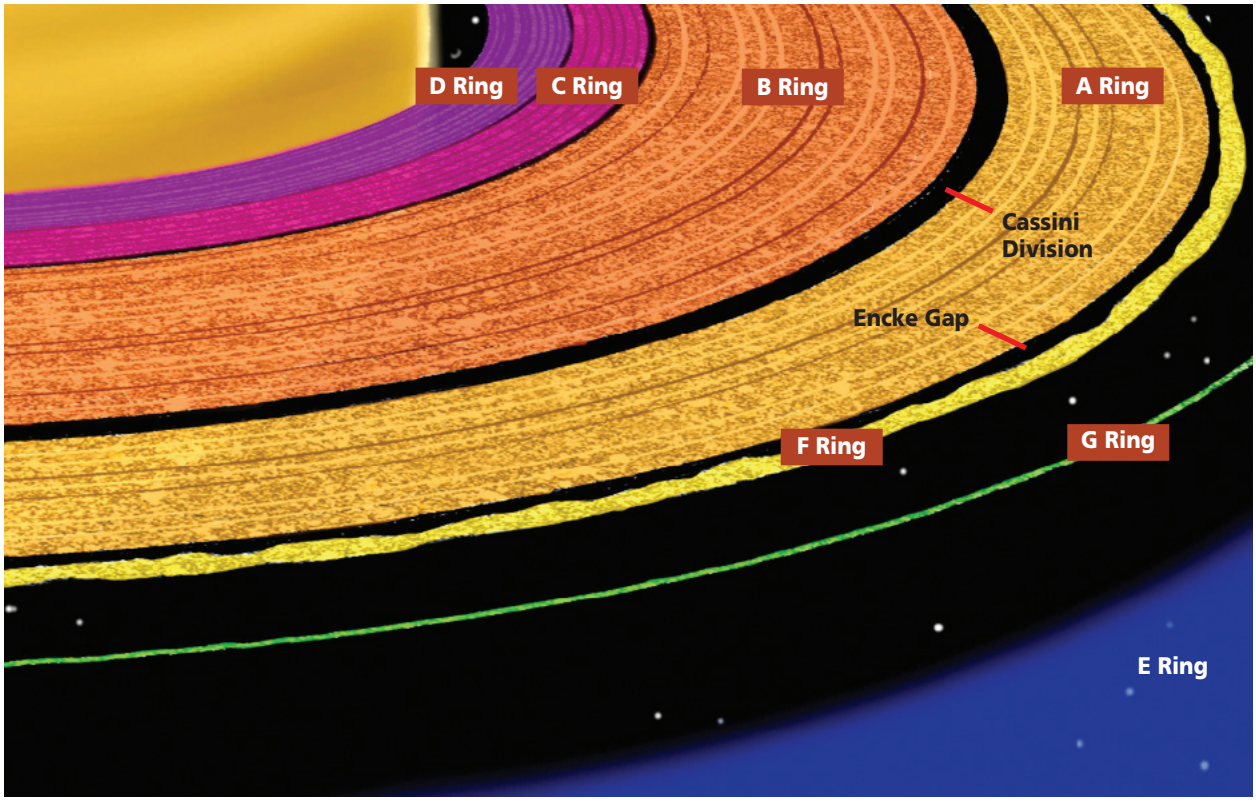


Cassini image of Saturn casting a shadow on its rings

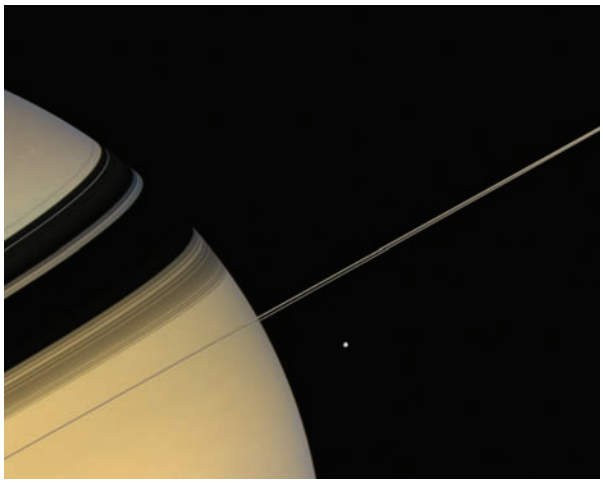
While all the gas giant planets have rings, Saturn's rings are the brightest and most spectacular, although we need a good telescope to see them from Earth. What other adjectives or describing words come to mind when you look at the rings?

The 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 colors shown below are not real.)



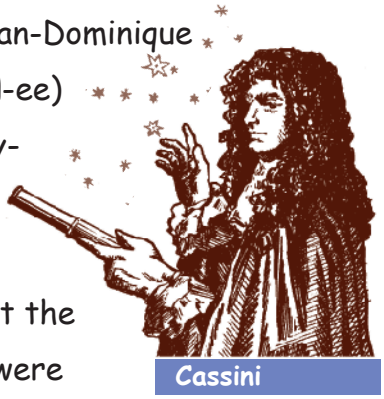
The rings stretch all around Saturn and are about 170,000 miles in diameter. That is almost the distance from Earth to the Moon! While the rings stretch for hundreds of thousands of miles to circle Saturn, they are less than a kilometer (about half a mile) thick. In fact, scientists have found that in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



Cassini image of Saturn with rings edge-on, casting a shadow on the cloud-tops

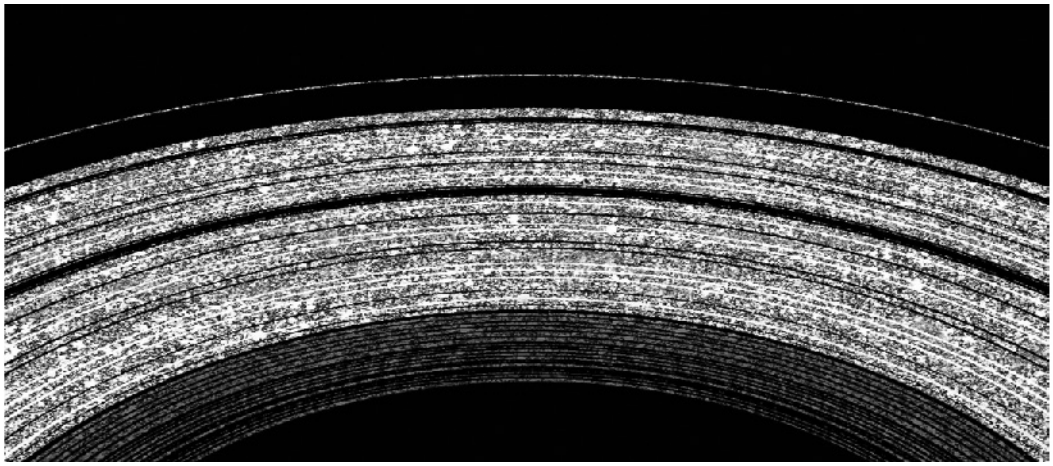
It is amazing that Saturn's rings can be hundreds of thousands of miles across and yet less than a soccer field in thickness. If you were to use a piece of paper to make a scale model of Saturn's A, B, and C rings, and have the thickness of the paper represent the thickness of the rings, you would need 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 (cuh-SEEN-ee) and Christiaan Huygens (HOY gens) 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."

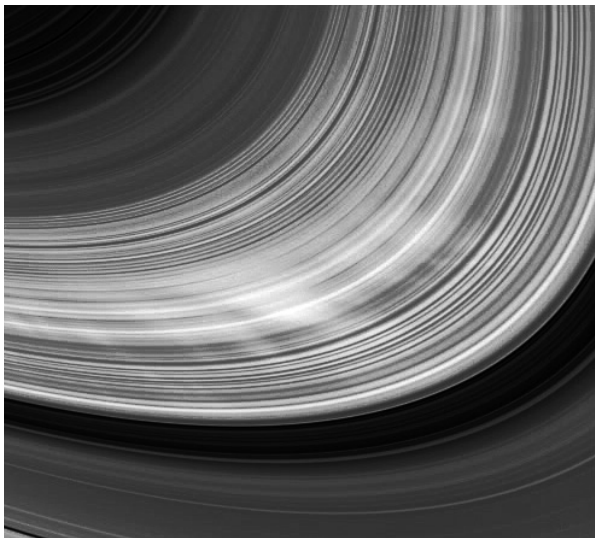
Shepherd moons are less effective at holding the smallest particles in place, however. Many of these particles gradually fall into Saturn. But they are replaced by new particles that come from the ongoing collisions of large rocks and moons, so the rings are always in the process of being rebuilt.

Cassini image of shepherd moon Prometheus "tending" to the F ring

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 (cuh-SEEN-ee) Division, after its discoverer, Jean-Dominique Cassini. It is about 4,200 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 (EN-kee) Gap. The gaps are produced by the gravitational pull of one or more of Saturn's many moons on the particles in the rings.

Closeup of the braided F ring

Image by Cassini



Spokes

There are other characteristics about the rings that puzzle scientists. The F ring almost seems to be braided in places. 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.

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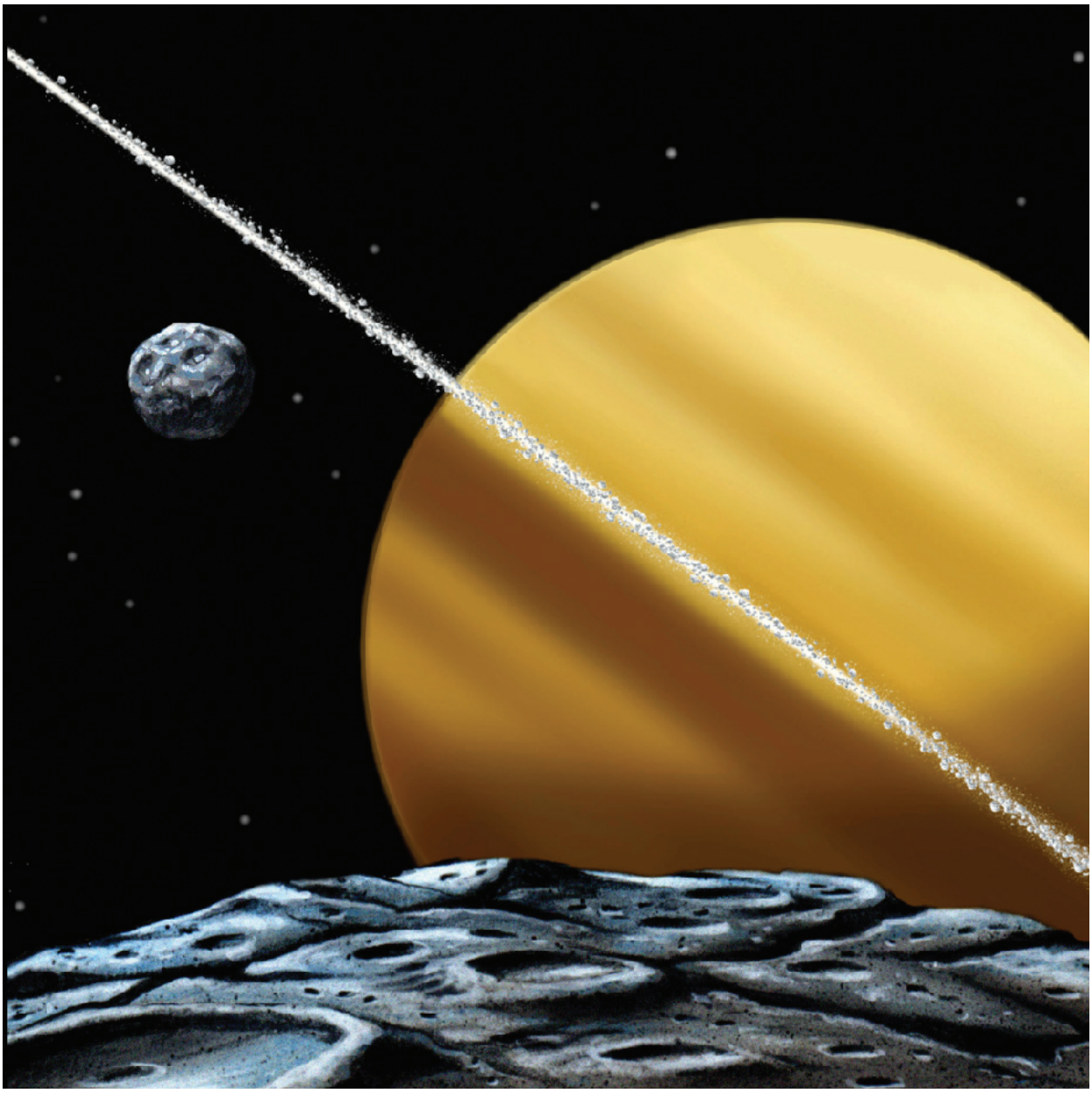
Saturn's Moons

Questions, Answers, and Cool Things to Think About



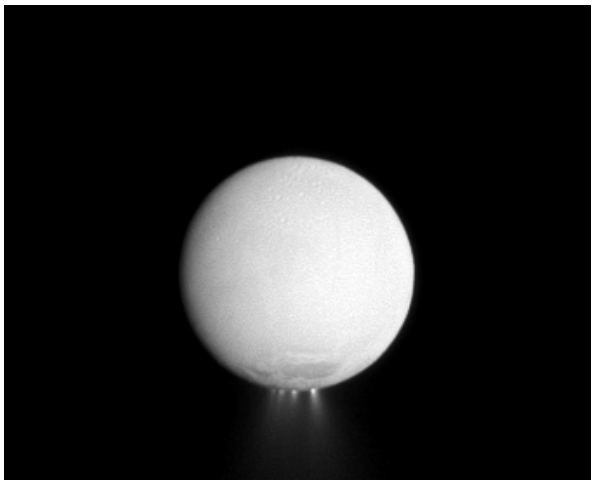
Discovering Saturn: The Real Lord of the Rings

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

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 more than 60 so far, and it's possible that the Cassini spacecraft will discover even more as it orbits the planet until 2017.

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."

One moon, called Enceladus (en-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 —



Cassini image of Enceladus's ice geysers

about 330 degrees below zero on the Fahrenheit scale! 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.

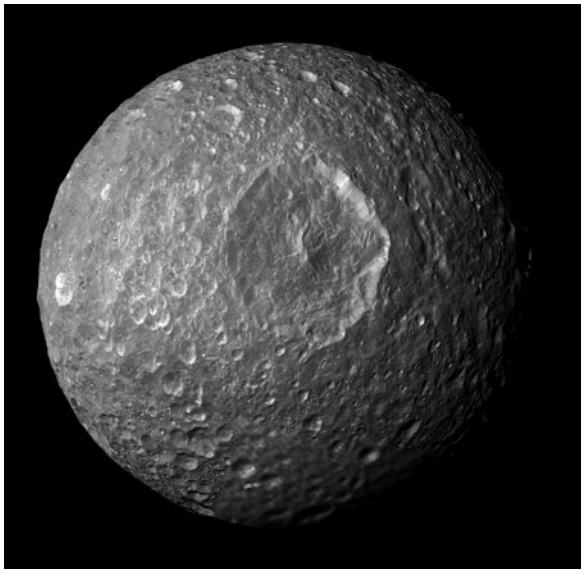
Iapetus (eye-A-pe-tus) may be the strangest of Saturn's moons. It looks like a big ball that's chocolate on one side and vanilla on the other side!

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!

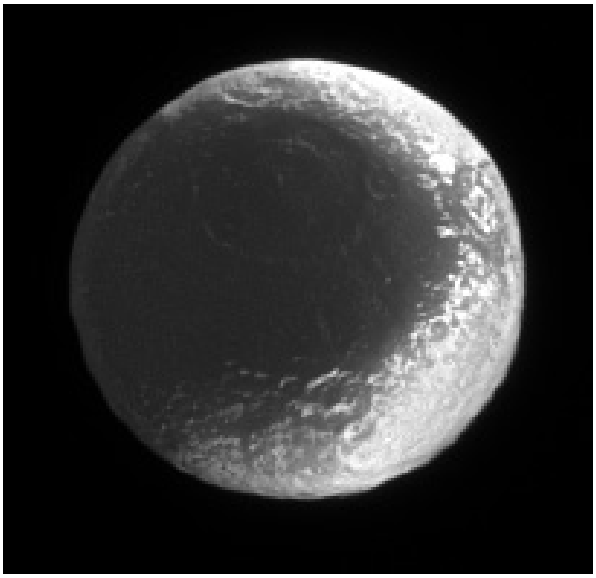
Titan's surface is hidden beneath a thick, deep-orange haze. But radar can "see" through the haze, and scientists on Earth using a powerful radar system to bounce microwaves off the giant moon found what they thought might be huge lakes or oceans on Titan. But there was no clear evidence yet.

The Huygens probe, named after the astronomer who discovered Titan, was carried by the Cassini spacecraft to Saturn. The probe parachuted to Titan through the murky skies, sending back the first images from the surface. The probe's landing site looked as though it had been eroded by a flowing liquid.

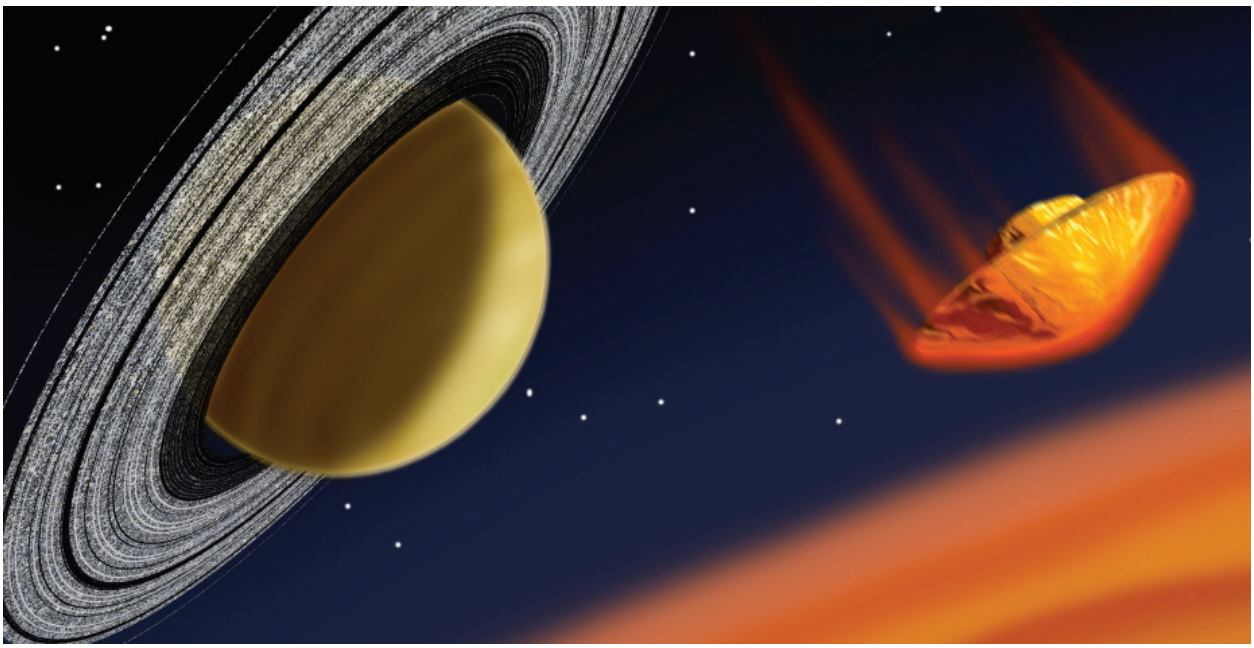
Images by Cassini



Mimas



Iapetus

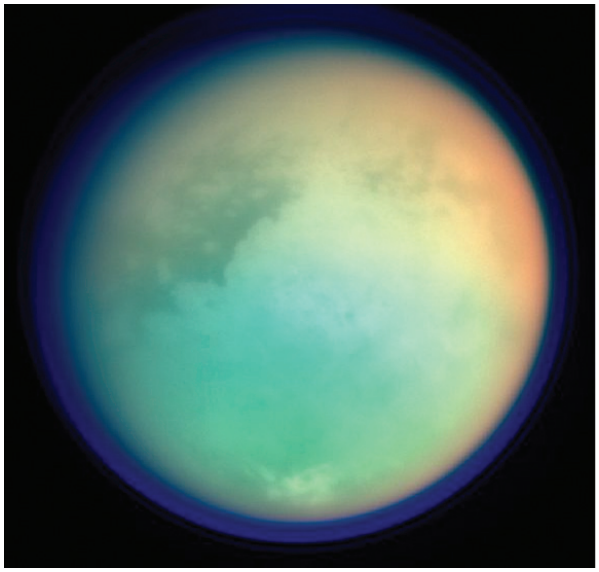


Before its parachutes opened, Huygens began to fall through Titan's atmosphere.

Then, in 2007, Cassini mission scientists announced the Cassini's imaging radar system had discovered more than 75 lakes on Titan. These lakes are filled with liquid methane instead of water. Titan is so cold that water there is frozen as hard as rock!

We now know that Titan has an active atmosphere and complex, Earth-like processes. Titan resembles a very cold version of Earth as our planet was several billion years ago.

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



Cassini image of Titan's cloud layers, shown in "false colors"

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Activity 3 Materials

Saturn/Cassini Match Game — Question Cards (1 of 2)

How many "Earths" would make up my diameter?

How many Earth hours long is my day?

My middle layer is made of what?

How many Earth years long is my year?

Which space-craft visited me with a probe?

My layers have gas and ice particles made of what?

Where did my name come from?

My outermost planet layer is called what?

The layer next to my core is made of what?

Activity 3 Materials

Saturn/Cassini Match Game — Question Cards (2 of 2)

How many moons does Saturn have?

Which moon is a very cold version of early Earth?

Why don't some of my rings drift or fall apart?

My rings were named in what order?

Which moon has a crater that is one-third its total size?

Which moon is vanilla-colored on one side and chocolate-colored on the other?

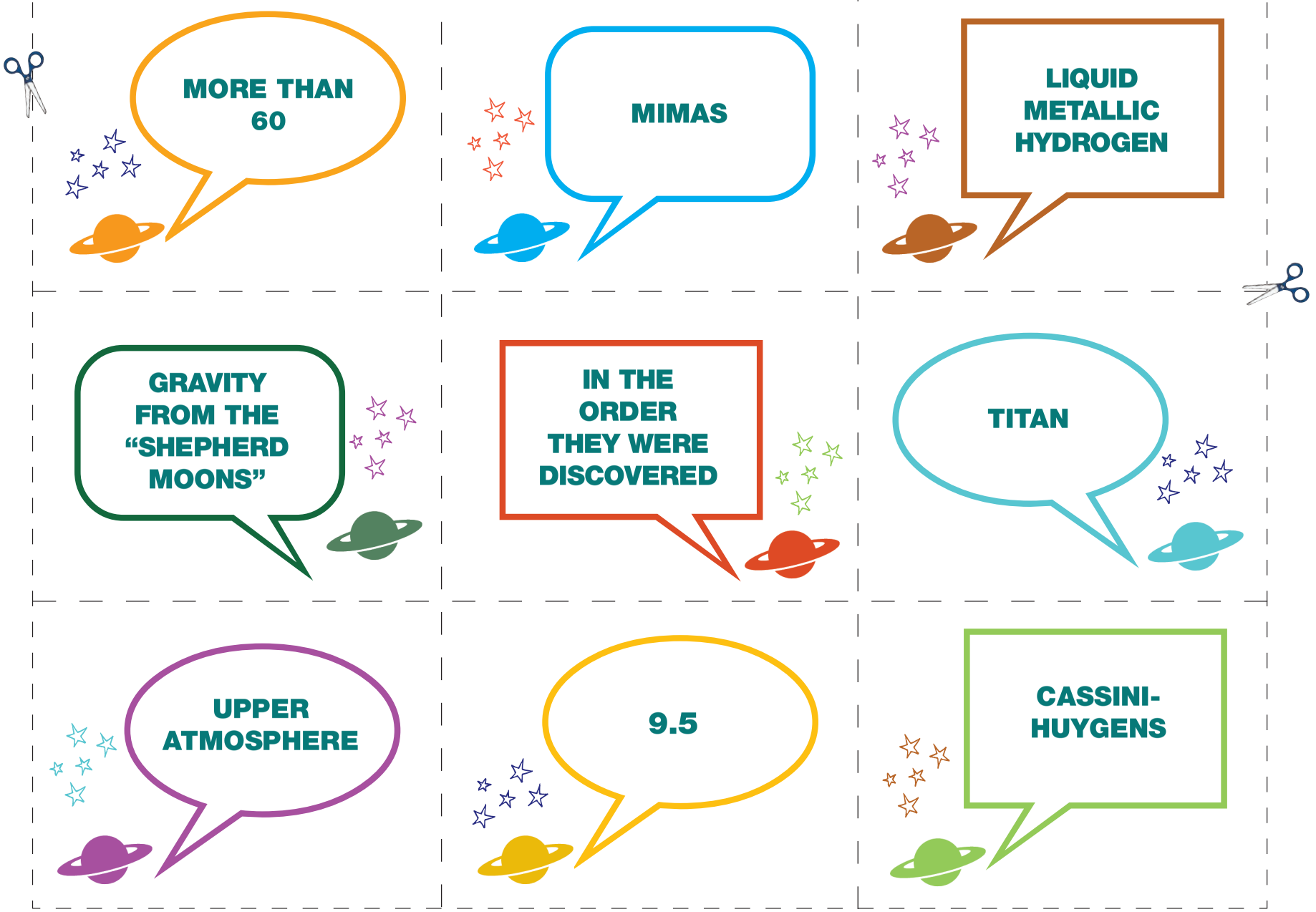
The areas between my rings are called what?

What do Janus and Epimetheus do every few years?

What are my rings made of?

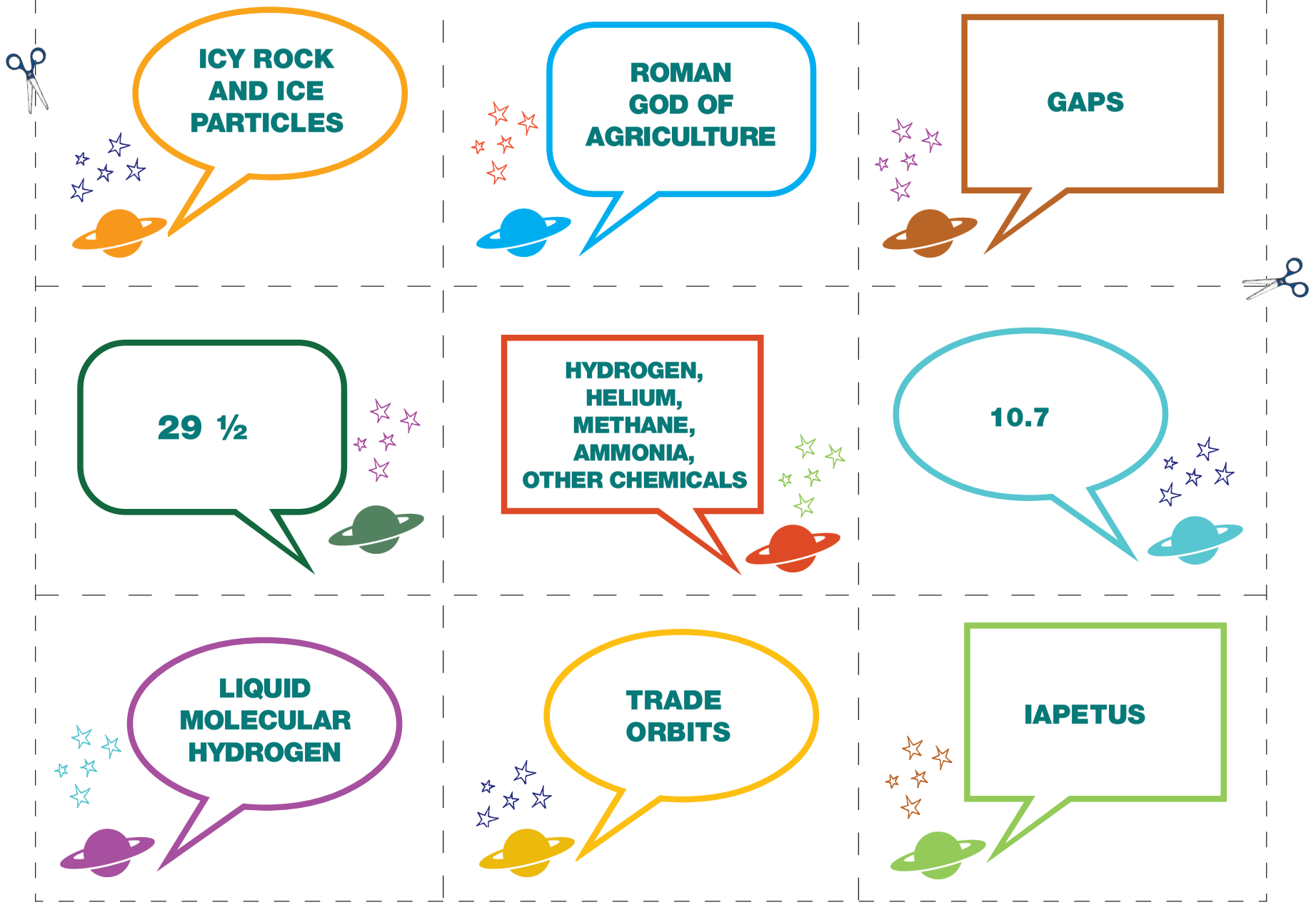
Activity 3 Materials

Saturn/Cassini Match Game — Answer Cards (1 of 2)

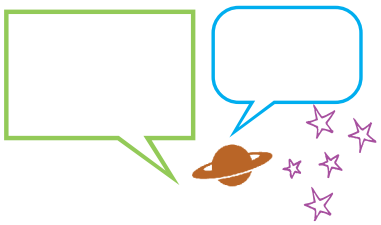


Activity 3 Materials

Saturn/Cassini Match Game — Answer Cards (2 of 2)



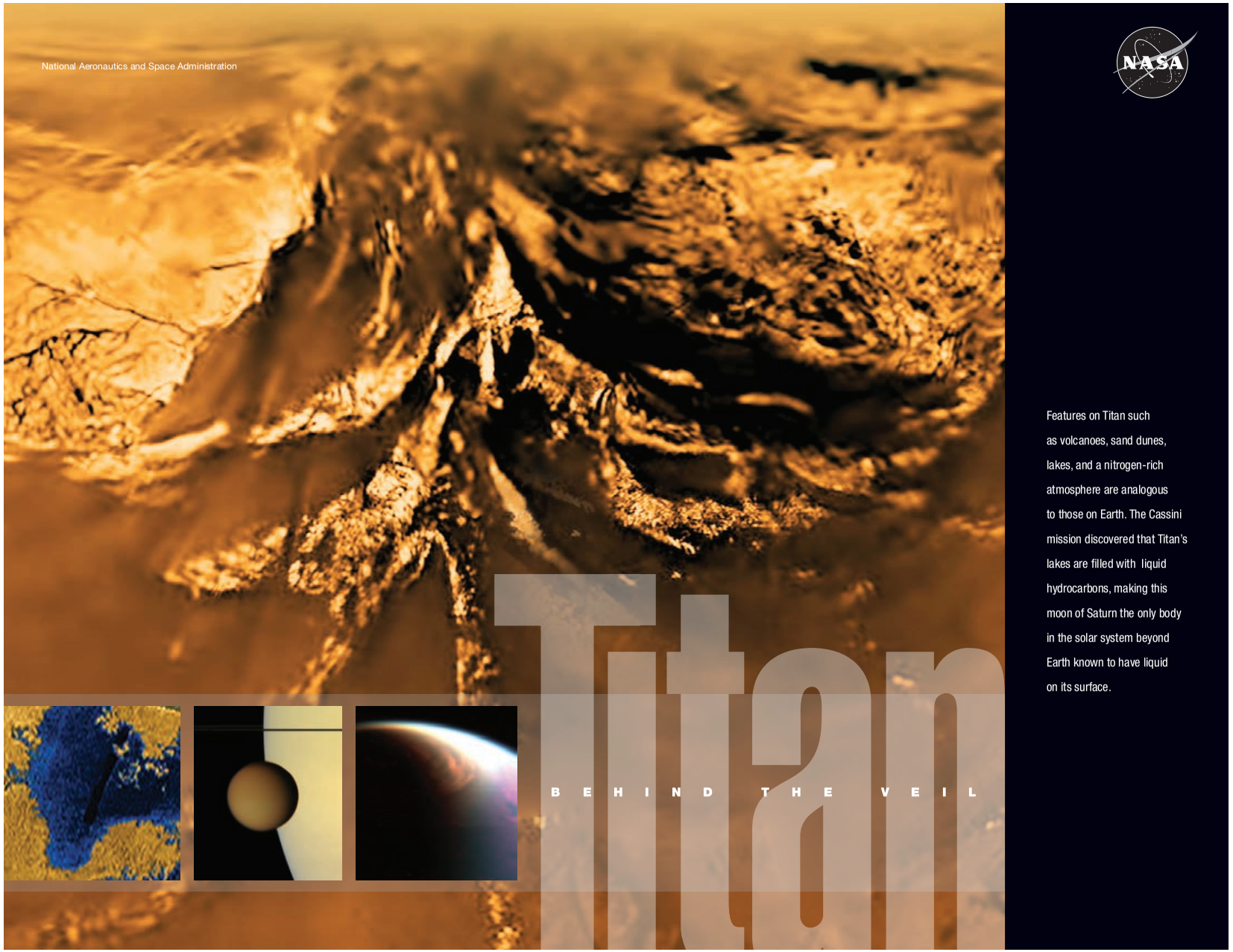
Saturn/Cassini Match Game — Answer Key



How many "Earths" would make up my diameter?	9.5
How many Earth hours long is my day?	10.7
How many Earth years long is my year?	29 ½
Where did my name come from?	ROMAN GOD OF AGRICULTURE
Which spacecraft visited me with a probe?	CASSINI-HUYGENS (cuh-SEEN-ee HOY-gens)
My layers have gas and ice particles made of what?	HYDROGEN, HELIUM, METHANE, AMMONIA, OTHER CHEMICALS
My outermost planet layer is called what?	UPPER ATMOSPHERE
My middle layer is made of what?	LIQUID MOLECULAR HYDROGEN
The layer next to my core is made of what?	LIQUID METALLIC HYDROGEN
My rings were named in what order?	IN THE ORDER THEY WERE DISCOVERED
What are my rings made of?	ICY ROCK AND ICE PARTICLES
art?	GRAVITY FROM THE "SHEPHERD MOONS"
The areas between my rings are called what?	GAPS
How many moons does Saturn have?	MORE THAN 60
Which moon has a crater that is one-third its total size?	MIMAS
What do Janus (JAY-ness) and Epimetheus (ep-uh-ME-thee-us) do every few years?	TRADE ORBITS
Which moon is vanilla-colored on one side and chocolate-colored on the other?	IAPETUS (eye-A-pe-tus)
Which moon is a very cold version of early Earth?	TITAN

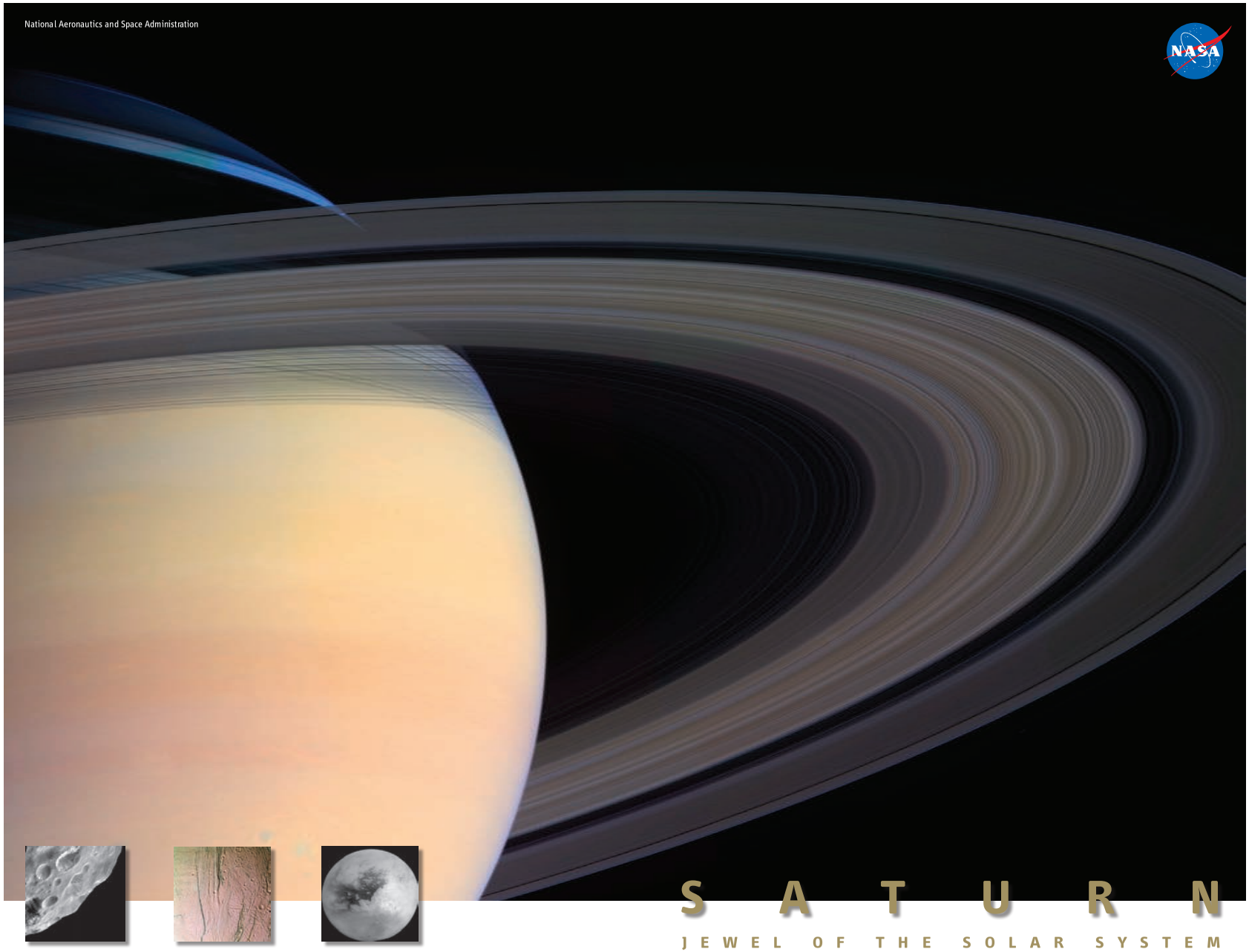
Activity 3 Materials

Poster Art



Activity 3 Materials

Poster Art



Activity 4
Saturn's Fascinating Features

Overview

During this activity, your youth:

- Are introduced to several of Saturn's exciting features that are of particular interest to scientists and that capture the imagination of all!
- Develop their listening and writing skills.
- Make and Take: Their own multi-layer 3-d book of Saturn, with diagrams showing its various layers, ring system, and many moons.

Time/number of sessions	Activity Type	Space Needed
Two 40-minute sessions	Journaling and art	Classroom or cafeteria, space with tables and chairs

Activity Goals

Youth will:

- Learn to write with scientific accuracy to characterize Saturn and its features.

Where's the Science and Engineering?

- Saturn is often referred to as the "jewel of the solar system." Its striking rings and numerous icy moons set it apart from the other planets.
- Planets have distinct features that interest scientists and motivate our ongoing planetary exploration. For example:
  — Cassini–Huygens mission scientists are exploring Saturn's atmosphere to learn more about its temperature, cloud properties, structure, and rotation.
  — The configuration of Saturn's rings, their sizes, and the distribution of material within them are also being studied by scientists.
  — The icy satellites that orbit Saturn are under investigation as scientists explore satellites embedded in the rings and their composition.
- Most of Saturn's moons orbit along the plane of the rings, but Phoebe does not. It orbits outside the ring plane and also orbits in opposition to the rest of the moons! The youth will notice this "disorder" and comment on it.

National Science Education Standards

K–4

Physical Science

- Properties of objects and materials

Earth and Space Science

- Objects in the sky
- Changes in environments

5–8

Physical Science

- Changes of properties in matter

Earth and Space Science

- Structure of the Earth system