National Aeronautics and Space Administration

Grades 4-5

Jewel of the Solar System

Afterschool Program Activity Guide

From Out-of-School to Outer Space Series

Jet Propulsion Laboratory
California Institute of Technology

Educational Product	
Educators	Grades 4–5

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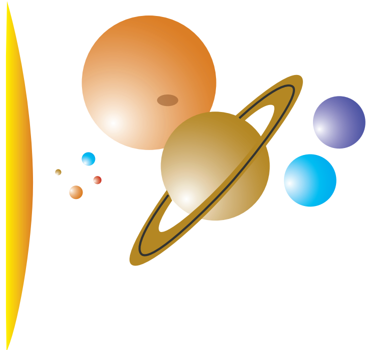
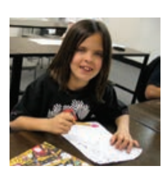


Jewel of the Solar System

Program Unit Overview

Storyline	Activity	Activity Type	Sessions/ Length	Science	Make & Take	Skills & Fun for the Kids
What do I already know?	**1. What Do I See When I Picture Saturn?**	Journaling, art, team observation	2 @ 40 min each	Observing, wondering and forming conclusions like a scientist. Learning about claims and evidence.	Make & Take: Decorated Saturn Discovery Log	Make observations fun. Learn Saturn vocabulary
Size and distance in the solar system	**2. Where Are We in the Solar System?**	Kinesthetic walk, art	1 @ 30 min 2 @ 40 min	Solar system scale (size and distance)	Make: Solar system scale model poster	Take a walk in a solar system model to experience its vast size
What do Saturn and its moons look like?	**3. Discovering Saturn: The Real "Lord of the Rings"**	Reading, journaling, group discussion, game, art	4 @ 40 min each	Observing Saturn's appearance and that of its moons	Make: Saturn poster	Play a game and make a team poster of new knowledge
Saturn from the outside in	**4. Saturn's Fascinating Features**	Journaling, art	2 @ 40 min each	The internal and surface properties of Saturn and its rings	Make & Take: Multi-layered 3-d book on Saturn	Decorate and compose their own 3-D book of Saturn facts
Engineering: Designing and building a spacecraft	**5. My Spacecraft to Saturn**	Hands-on model engineering	4 @ 40 min sessions	Think like engineers to design and build a spacecraft	Make: Design team drawing, spacecraft model	Brainstorm, plan, build and present
Saturn's moon Titan through the eyes of a spacecraft	**6. All About Titan and the Huygens Probe**	Art, creative writing	2 @ 40 min sessions	Learn about Titan. Learn about the probe's path to Titan (orbit insertion and drop).	Make & Take: Drawing and personalized story as a spacecraft	Imagine themselves as a spacecraft and write a fictional story with facts
Engineering: Tackling the challenges of space	**7. Drop Zone! Design and Test a Probe**	Hands-on model engineering	4 @ 40 min sessions	Work with the challenges of designing a parachute and probe to safely land	Make: Team build of a parachute and probe	Use creativity and problem solving skills to design and drop a parachuted spacecraft
A visual representation of our understanding of Saturn	**8. Celebrating Saturn and Cassini**	Art, communication, presentation	1 or more @ 40 min sessions, plus event	Use science and engineering skills of integration and presentation of knowledge	Make: Create a display, event, or skit to present Saturn	Use imagination and creativity to present Saturn to their community

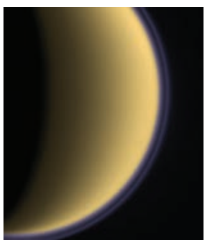


Jewel of the Solar System

Kids love space, and their favorite planet is often the magnificent ringed "Jewel of our Solar System" — Saturn!

Saturn is the sixth planet from our Sun and the second largest planet in our solar system (after Jupiter). Pressures and temperatures inside Saturn are so extreme that they cannot be duplicated here on Earth, and wind speeds can reach over 1,100 miles per hour. Saturn's largest moon, Titan, holds secrets that include oceans of hydrocarbons and sunken mountain ranges. Not hospitable places — and yet, from earliest times, people have appreciated Saturn for its beauty and uniqueness. Saturn's striking ring system is not duplicated anywhere in our planetary neighborhood.



Take your afterschool youth on a journey of science and engineering to Saturn through literacy and creative arts with this "Jewel of the Solar System" **afterschool program unit for grades 4–5.** Designed for leaders with no science background, this unit explores how far Saturn is from the Sun and from Earth, and Saturn's size and location in the solar system. It allows the students to understand the unique structure of the magnificent rings, and it teaches about Titan. The unit also exposes the students to engineering challenges much like those NASA engineers face in designing a robotic spacecraft and mission.

Beyond the science and engineering, "Jewel of the Solar System" contains several activities to **help students make literacy and creative arts connections, and explore types of careers available at NASA and in the fields of science, technology, engineering, and mathematics** (STEM). It introduces students to scientists currently working at NASA and those whose contributions have moved space exploration forward in the past. Because it is literacy-rich, this program unit can serve as a first bridge to science activities for leaders and youth more familiar and comfortable with literacy.

"Jewel of the Solar System," adapted specifically for afterschool use from a NASA literacy unit for the classroom, provides:

- Step-by-step instructions for **8 hands-on activities, divided into 22 distinct 40-minute sessions — a total of 15 hours of programming.**
- A connection to active robotic space exploration — the Cassini–Huygens mission to Saturn.
- A materials list selected from off-the-shelf items from a typical afterschool site that are also "culturally accessible."
- A connection to the classroom day through the NRC National Science Education Standards.
- Youth-centered learning — the leader guides the students to wonder, question, and discover on their own.
- Several activity styles to appeal to a variety of learners — journaling, art, reading, kinesthetic, and engineering design and model construction — with ideas for further exploration.
- Experience for students to understand and use the processes of science and engineering, and develop their "habits of mind."

- Development of teamwork and communication skills.
- Conversation guides to aid the leader in conveying essential science and engineering concepts.
- Questions and journaling activities that can provide an assessment of student and leader experience.
- A culminating and assessment event for youth to share their experience with other students, their parents, and their community.

This program unit was pilot- and field-tested in several afterschool programs in New York City and Los Angeles, and staff made specific recommendations about what should be included to make the unit the most "user-friendly." **Everything you need to know to do an activity is condensed into a 3- to 5-page format, followed by the materials to be photocopied.**

"Check It Out!" page

- Time/Number of Sessions, Activity Type, Space Needed
- Activity Goals
- Background: Where's the Science and Engineering?
- National Science Education Standards
- Equity/Leveling the Playing Field
- Materials List, Getting Ready
- Leader Tips — suggestions based on actual experiences

"Do It!" page(s)

- Student Activity — step-by-step instructions for each session
- Questions for the Youth (Informal Assessment)
- Sharing the Findings (Informal Assessment)
- Leader Reflection and Assessment
- Glossary

"Take it Further!" page

- Information for Families
- NASA Resources, Careers at NASA, Role Model Resource
- Taking the Science to the Next Step
- Literacy

The Cassini–Huygens robotic mission is a partnership between NASA, the European Space Agency, and the Italian Space Agency to study Saturn, its rings, and its moons. The vehicles for this extraordinary mission are the Cassini Orbiter, named for Jean-Dominique Cassini, and the Huygens Probe, named for Christiaan Huygens. The Cassini mission brought these space vehicles on an interplanetary path of exploration. When the Huygens Probe landed on Titan on January 14, 2005, it was the first landing of a human-made object in the outer solar system. The Cassini Orbiter is the first human-made satellite to orbit Saturn.

Nothing inspires like NASA! The Cassini Orbiter continues to send back information and pictures from Saturn. **The Cassini Status countdown clock tells when the Cassini spacecraft will next pass by Saturn or Titan or another moon — visit it at saturn.jpl.nasa.gov.** The website houses also the latest pictures, videos, and news from this other world and its moons. You can also download 30-minute video podcasts of Ring World 2, the story of the Cassini–Huygens mission, in both English and Spanish, for interesting background information for you and your students — saturn.jpl.nasa.gov/video/videodetails/?videoID=114

Be sure, as you use this unit, to share the spirit of exploration, the wealth of information, and the excitement of discovery of Cassini's journey at Saturn!

As you begin the "Jewel of the Solar System" program unit, you can copy the letter on the next page to send home with students to help their families to support the children's curiosity.

Dear Family,

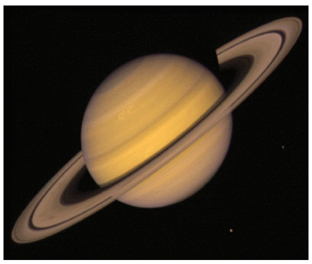
In the next few weeks, your child will be exploring Saturn and its moon Titan, and the Cassini robotic spacecraft. We will create *Saturn Discovery Logs*, discuss careers at NASA, learn about some scientists, journal, draw, and create models, and share the cool stuff we learn and do with you and others.

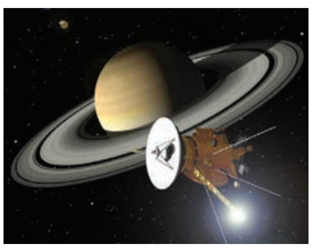
Your child has begun a lifelong journey of learning more about the mysteries of space and challenges of space travel. There are many ways to continue the learning:

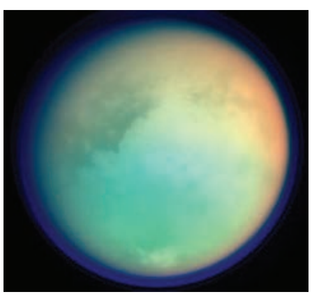
- Visit a museum or planetarium.
- Visit a library. Borrow a book or video about science.
- Watch NASA TV (available on cable or www.nasa.gov/ntv). NASA TV has live coverage of the International Space Station, Mars rovers, and pictures from space (just to name a few things!).
- Go to the NASA solar system website (solarsystem.nasa.gov) and NASA's website (www.nasa.gov) and kid page (www.nasa.gov/audience/for kids/kidsclub/flash/index.html) for information, activities, and videos;.
- Ask your child about their day — what did they learn?
- Have fun with science. What questions does your child have? You don't need to know the answer — you can find out together.

Remember! Don't forget to encourage curiosity!

Sincerely,







Top: A butterscotch-colored Saturn and rings. (Cassini image)

Middle: The Cassini spacecraft at Saturn. (artist's concept)

Bottom: Saturn's largest moon, Titan. (Cassini image)

A Note to Site Coordinators

This guide provides resources to assist in preparing, observing, and assessing the activities.

- The "Materials Summary" lists what you'll need for the entire unit from a photocopier or printer, and from your closet stocked with standard supplies. (Leaders may require a storage bin for keeping student projects between sessions and for collecting household recyclables for building spacecraft models.)

- The "Internet Resource List" provides the addresses to allow leaders' and students' access to supporting materials (pictures, podcasts, games, etc.).

- The "Check It Out!" page for each activity describes the particular space and materials needed, what the students will gain from the activity, and tips for its implementation. Use this page along with the "Informal Assessments" and "Leader Reflection and Assessment" (from the "Do It!" pages) for your discussions with the leaders and observations of them doing the activities.

- Each student creates and updates his or her own *Saturn Discovery Log* through which progress can be assessed as each activity is completed.

- Plan ahead for the final culminating and assessment activity, "Celebrating Saturn and Cassini," which will require space for displays and an audience, along with an invitation.

- Like an exhibition, students draw from the products they have created and the skills and knowledge they have gained to communicate their findings and discoveries about Saturn and the Cassini mission.

Activity Materials Summary

		From Your Supply Closet		From a Photocopier/Printer (Find originals in Activities)	
		For the Leader	**For Students**	**For the Leader**	**For Students**
1.	**What Do I See When I Picture Saturn?**	Sample article from newspaper or magazine with both illustration and text Chart paper/whiteboard/chalkboard and markers/chalk 7 pieces of chart paper	Crayons/markers, colored pencils, writing pencils, construction paper, writing paper	7 Leader Reference *Saturn/Cassini–Huygens images*	
2.	**Where Are We in the Solar System?**	Chart paper, markers, tape Scissors, tongue depressors or Popsicle™ sticks, glue, thin cardboard or manila folder Yardstick, yellow highlighter, metric measuring tape or meter ruler, butcher paper or 4 poster boards	Marking pens, string, scissors	Sun, Earth, and Saturn image page Instruction Sheet for *Take a Walk on the Wild Size*	Instruction Sheet for *Take a Walk on the Wild Size* to take home
3.	**Discovering Saturn: The Real "Lord of the Rings"**		Chart paper, markers, pencils, scissors, glue sticks, clear tape, rulers, pencil eraser top Office supplies (3-inch Styrofoam™ ball, rubber band ball) or fruit selection (fresh orange, blueberry, peppercorn, rice grain) to model planet and moon sizes.	*Saturn/Cassini Match Game Answer Key* NASA educational poster art *Saturn: Jewel of the Solar System* and *Titan: Behind the Veil*	4-page mini-book, selected from: "Introducing Saturn" "Saturn — From the Outside In" "Those Amazing Rings" "Saturn's Moons" *Saturn/Cassini Match Game Question & Answer Pages*
4.	**Saturn's Fascinating Features**		Crayons, scissors, silver glitter glue, stapler, black construction paper	Color images of Saturn *The Ringed World of Saturn* Leader Instruction Sheet	*The Layers of Saturn* 3-d book pages
5.	**My Spacecraft to Saturn**		Pencils, writing paper For Spacecraft Model • Clean recyclable items (empty cereal/ pasta boxes, paper towel tubes, plastic bottles, etc.) • Pipe cleaners, tape, string, paper, aluminum foil	*Designing a Spacecraft Script*	*Design Questions* student handout
6.	**All About Titan and the Huygens Probe**	Chart paper/whiteboard/ chalkboard and markers/ chalk	Tape or glue, pencils, drawing paper	*Memoirs of a Spacecraft — The Huygens Probe Encounters Titan* Read-Aloud Passage	
7.	**Drop Zone! Design and Test a Probe**	Long-arm stapler, chart paper, whiteboard/chalkboard, markers/chalk. Clay to make small ball, stopwatch or wrist-watch with timer, sidewalk chalk or hula hoop	Pencils, drawing paper For Parachutes & Probes Tissue paper or paper napkins, Hand-held hole punch, tape or hole reinforcements, kite string or packing string Metal washers or large paperclips, garbage bags or other plastic bag, rubber bands Paper cups/plates, clean pint-size milk containers, paper cylinders (paper towel roll), pipe cleaners, straws, Popsicle™ sticks, tissue paper, corks, stapler	Leader Reference *Huygens Probe Components*	4-page *Parachuting Probe Package*
8.	**Celebrating Saturn and Cassini**		Crayons, markers, colored pencils, writing pencils, poster boards Students' *Saturn Discovery Logs*	Photos from previous activities	*Cassini Extras* student handout

Activity Materials Summary (contd)

1. **What Do I See When I Picture Saturn?**

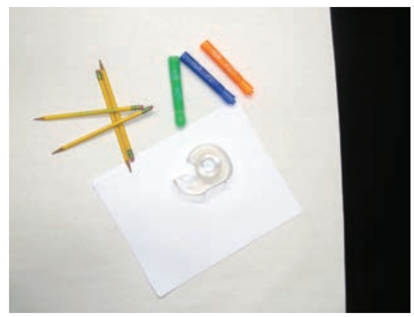
2. **Where Are We in the Solar System?**

3. **Discovering Saturn: The Real "Lord of the Rings"**

4. **Saturn's Fascinating Features**

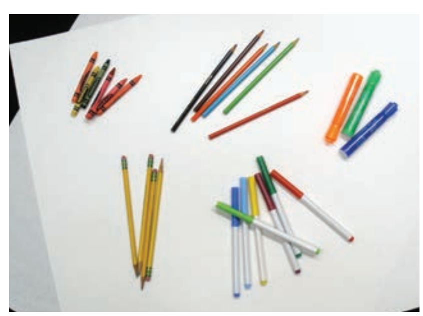
5. **My Spacecraft to Saturn**

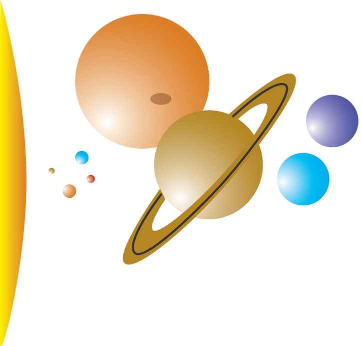
6. **All About Titan and the Huygens Probe**



7. **Drop Zone! Design and Test a Probe**

8. **Celebrating Saturn and Cassini**





Activity 1
What Do I See When I Picture Saturn?

Overview

During this activity, your youth:

- Create science journals called *Saturn Discovery Logs*, to chronicle their journey of discovery about Saturn and the Cassini–Huygens mission.
- Draw and share what they picture when they hear "Saturn," and add labels and captions to their drawings.
- Closely observe pictures of Saturn, the Cassini spacecraft, and the Huygens Probe and write about what they notice. In teams, they also discuss and record what they wonder about. Practicing skills of careful observation, team discussion, and development of questions prepares students to develop "habits of mind" of scientists or engineers. Their writing forms the basis for "claims" and "evidence" as projects and presentations are formulated.
- Make and Take — their own decorated *Saturn Discovery Log*.

Time/number of sessions	Activity Type	Space Needed
Two 40-minute sessions (longer when there are extended questions)	Art and journaling	Room with tables and chairs

Activity Goals

Youth will:

- Practice organizing and presenting their thinking in illustrations with text format.
- Learn to observe carefully and record observations and questions.
- Begin to understand the need to support claims with evidence from reliable sources.

Where's the Science and Engineering?

- Saturn is the sixth planet from the Sun and is often called the "jewel of the solar system" because of its beautiful rings. It is the second largest planet in our solar system. Saturn is named for the Roman god of agriculture.
- The spacecraft Cassini–Huygens (pronunciation: cuh SEEN ee / HOY gens) was launched from Earth in 1997 and arrived at Saturn in July 2004. Cassini is exploring the mysteries of Saturn and its rings, while the Huygens Probe landed on Saturn's largest moon, Titan, in January 2005. The Cassini spacecraft continues to orbit Saturn and send back data until 2017. Explore more information about Saturn or the Cassini mission at NASA's Saturn website: saturn.jpl.nasa.gov.
- Science is a way of thinking and doing things, called inquiry. Identifying questions forms the basis for inquiry throughout this program unit.

National Science Education Standards

Science as Inquiry

- An appreciation of how we know what we know in science.

Understanding the Nature of Science

- The dispositions to use the skills, abilities, and attitudes associated with science.

The Standards state that "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science." In this activity guide, students will read actively to find answers to their questions. Unanswered questions spark a lifelong curiosity to learn more about space, and follow discoveries as they are made.

Equity/Leveling the Playing Field

- This program unit has as much idea sharing and writing as hands-on activities. Students will be asked to publicly share what they know, so it is important to create an environment where everyone's idea is important and valued.
- Remember that writing may slow the process for some students. Be sure to allow enough time for everyone to contribute to the team.

Getting Ready

For Session 1

- Write the following *Saturn Discovery Log* prompt on the chalkboard or chart paper: "Draw everything that you picture when you hear the word Saturn. Add labels to your drawing."
- Find a newspaper or magazine article that has an illustration with text to use as an example to show the children.

For Session 2

- Print and cut out the Leader Reference *Saturn/Cassini–Huygens images*:
  Image 1 — Saturn (image by the Cassini spacecraft)
  Image 2 — The Saturn system (Collage of natural-color Cassini images of Saturn and moons. The moons shown are, starting at upper left and proceeding clockwise, Dione, Titan, Enceladus (directly in front of Titan), Rhea (partially in front of Titan), and Helene.)
  Image 3 — Cassini spacecraft approaching Saturn (artist's concept)
  Image 4 — Cassini launch
  Image 5 — Drawing of Cassini's path to Saturn, showing "swing–bys" that use the gravity and motion of planets to alter spacecraft path and speed
  Image 6 — Time sequence of the Huygens Probe as it descends to Titan's surface (artist's concept)
  Image 7 — Drawing of Saturn ring particles
- Create seven charts by attaching the images to the tops of sheets of chart paper. Drawing with a large marker, divide each sheet of chart paper into three columns under the image and label as follows — "What I Notice," "What I Know," and "What I Wonder."
- Place charts and images in seven locations around the room. Decide what signal you will use to have the students rotate to new images, and how you will make sure the rotation goes smoothly.

Leader Tips

- A fun way to introduce this activity is to show the students the live Cassini Status countdown clock that tells when the Cassini spacecraft will next pass by Saturn or Titan or another moon. See "Taking Science to the Next Step" for this activity.
- The format for the *Saturn Discovery Log* is a suggestion. Any folder or science notebook can hold students' writing and worksheets in an organized way.
- The images in this lesson provide breathtaking pictures of Saturn and its moons from the Cassini–Huygens mission. This lesson promotes two types of scientific skills — observing and wondering.
- Select one image to observe for a few moments yourself, and jot down your own thoughts on a separate piece of paper — both for what you notice and for what you wonder about. Model the learning process by participating in this activity with your own questions and writing to emulate the science process of inquiry. Your questions spark their curiosity!
- If students "know" something, ask how they know it, to support the idea of the importance of evidence to support claims. A "Word Wall" — a systematically organized collection of words displayed in the classroom — featuring "Claims" and "Evidence" might be helpful.
  - Encourage students to take risks in questioning.
  - Help students develop observational skills by encouraging them to notice the fine details.
- Keep the images and charts the students complete for them to later add more of "What I Know" in Activity 3 — "Discovering Saturn: The Real Lord of the Rings."

Materials

From Your Supply Closet

Session 1

For Leader

- Sample article(s) from the science section of a major newspaper or magazine with both illustration and text (with excellent illustrations and text to explain new discoveries)
- Chart paper/whiteboard/ chalkboard and markers/chalk
- Seven pieces of chart paper

For Students

- For *Saturn Discovery Log* : 12 x 18 inch construction paper (1 sheet for each student) and 8-1/2 x11 inch white paper (6 sheets for each student)
- Crayons/markers
- Construction paper
- Colored pencils
- Pencils

From a Photocopier/Printer

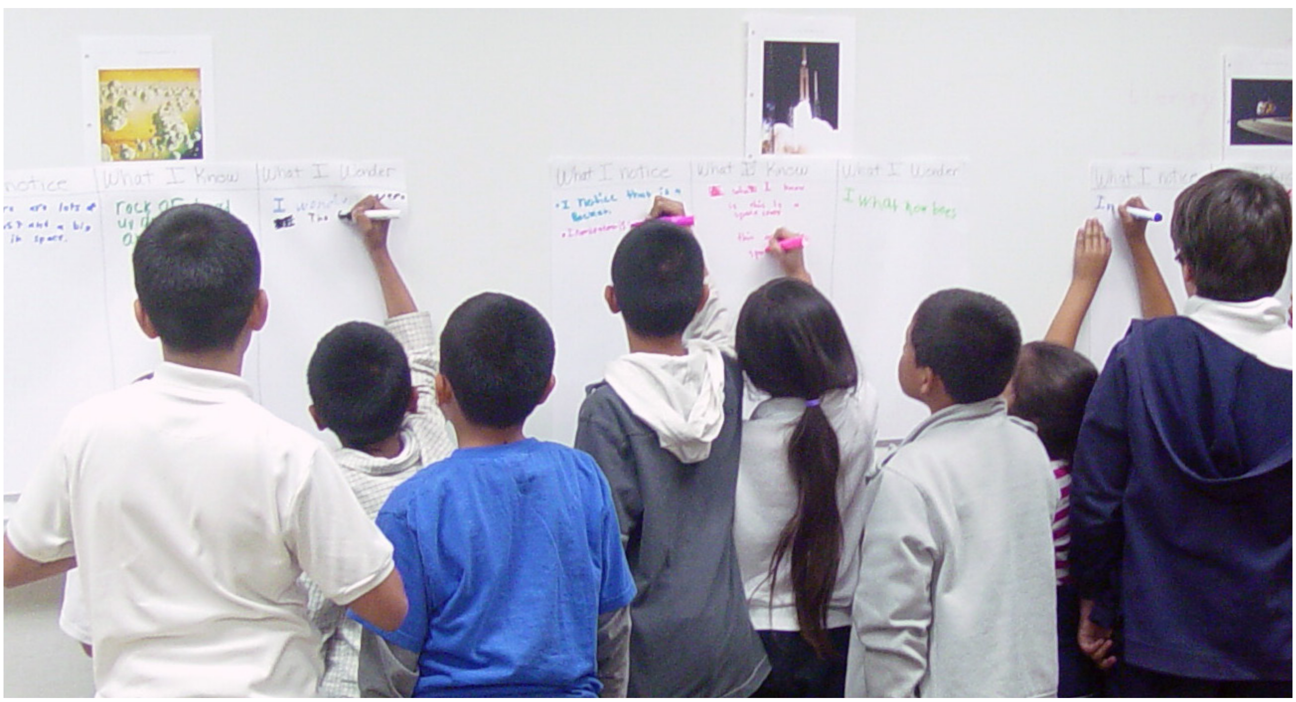
For Leader

Session 1

- Printouts of this activity’s 7 Leader Reference *Saturn/Cassini–Huygens images*

Session 2

- For optional Leader Reading: Copy of the mini-book “Introducing Saturn: Questions, Answers, and Cool Things to Think About” (from Activity 3 — “Discovering Saturn: The Real Lord of the Rings”)



What Do I See When I Picture Saturn?

Activity 1

Student Activity

Session 1 • Creating Saturn Discovery Logs

1. Read the following paragraph: "Imagine space, magnificent space. Now imagine our solar system with a blazing Sun in the center. Spinning around it are beautiful planets. One of these planets is Earth. Another is Saturn, and a spacecraft is flying through space to find out more about this mysterious planet."

2. Explain that for the next few sessions (days, weeks, etc.), they will be learning about Saturn and its moons and the Cassini–Huygens mission. The Cassini spacecraft has been zooming past Saturn regularly since 2004, and the Huygens Probe landed on Saturn's largest moon, Titan, in 2005. The Cassini mission is scheduled to continue through 2017!

3. (Optional) Leader Reading: Read aloud all of page 2 and the first paragraph of page 3 from the mini-book "Introducing Saturn," showing the illustrations.

4. Tell students that they will be keeping all of their work during this entire program in their own *Saturn Discovery Log*, just as scientists keep journals or blogs to record their thoughts. Tell the children that today they will make the cover for their *Saturn Discovery Log* and write their first log entry.

5. Pass out construction paper, sheets of white paper, and crayons, colored pencils, and/or markers. Ask the group to fold the construction paper in half to make a folder that will hold 8-1/2 x 11 inch paper. Ask students to write "Saturn Discovery Log" and his or her name on the front cover of the construction paper folder. As students work, check that everyone has written his or her name and today's date on the cover.

6. Get students thinking and drawing about the planet Saturn, with the following conversation guide:
    - Now it's time to make your first log entry. Many scientists log their thoughts and questions every day. It's part of recording their journey to discovery. Sometimes they draw pictures and illustrations and label key things about them.
    - You can look at these sample news articles to see how items can be documented and labeled to make them clear to others. (Show the students the sample(s) you've collected.)
    - For so many centuries, people have looked up into the sky but have not really known what Saturn looked like. Scientists wondered a lot of things about the planet. Then they were able to look through telescopes and see the planets more clearly. Now that NASA has sent a robotic spacecraft all the way to Saturn, we have views that early scientists never thought possible.
    - What do you picture of when you hear the word "Saturn"? Take 15 minutes and draw a picture that reflects the word "Saturn" to you! Be sure to label the parts you think need explanation.
7. Circulate around the room, ask students questions about what they are drawing, and encourage them to add more detail to their labels and captions.
8. When they have finished their drawings, give students a few minutes to decorate the front cover of their *Saturn Discovery Log*. Then have the students put their drawings inside the log. Collect the logs.

Session 2 • What I Notice and Wonder

1. (Optional) Leader Reading: Read aloud page 4 from the mini-book "Introducing Saturn," showing the illustrations.
2. Ask the children to count off by 7's to create 7 teams, and assign one team to each image. For the leader's knowledge and use, the images are described here:
    - Image 1 — Saturn (image by the Cassini spacecraft)
    - Image 2 — The Saturn system (Collage of natural-color Cassini images of Saturn and moons. The moons shown are, starting at upper left and proceeding clockwise, Dione, Titan, Enceladus (directly in front of Titan), Rhea (partially in front of Titan), and Helene.)
    - Image 3 — Cassini spacecraft approaching Saturn (artist's concept)
    - Image 4 — Cassini launch
    - Image 5 — Drawing of Cassini's path to Saturn, showing "swing–bys" that use the gravity and motion of planets to alter spacecraft path and speed
    - Image 6 — Time sequence of the Huygens Probe as it descends to Titan's surface (artist's concept)
    - Image 7 — Drawing of Saturn ring particles
3. Lead the students in their observations of the first image, using the following conversation guide:
    - Now we'll begin learning about the planet Saturn and the Cassini–Huygens mission by looking at some images and making careful observations about them. Note there are 7 different images around the room. Your team will start by studying one of the images, discussing it, and writing down only those things you notice from looking at the image. Only include observations and claims that you can support with evidence you see in the image. (Some examples include: I notice the planet has rings. I notice a dark space in the rings. I notice there appear to be bands of different colors on the planet.)
    - Write your team's observations in the "What I Notice" column of the chart paper next to the image.

- Scientists work as teams in all stages of a space mission, so as you discuss the image, make sure that everyone on your team contributes observations and questions.
- Next, think about what questions you have about what's pictured in the image. Write those down in the "What I Wonder" column. (Following from the previous examples, you could wonder why there are different colors on the planet, and what the weather is like on Saturn. I wonder what would cause the dark space in the rings. I wonder who or what took this picture of Saturn. I wonder if it is a real picture.)
- Leave the "What I Know" column blank for now.
- I'll give you a signal when it's time for your team to move to the next image and add to what the previous team wrote.

4. Give the teams time to rotate and contribute to the charts of at least 3 different images.
5. As the students view the images, you might add these two actual contributions from Cassini scientists before Cassini arrived at Saturn:
   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?
6. Bring the students back to the larger group, and lead them in suggesting two or three items to add to one of the "What I Know" columns, using the following conversation guide:
   - Let's discuss a few things we know about what's in these images, and how we know it. For us to be able to claim we "know" something, we need to have accurate evidence from a reliable source. Scientific claims can't be based on heresay or opinions. We need to think about how the claim has been tested and proven.
   - We might claim, for example, that the surface of Saturn's moon Titan is cold. We might think this because Saturn and Titan are so far away from the Sun. But we must have direct evidence for this before we can say it is true. If we are researching what others have already learned, we can look for reliable sources for that information, such as a teacher, textbook, science museum, or website that has been reviewed by scientists. If we are looking to discover it ourselves, we would need to design and conduct an experiment to measure the temperature (and perhaps send our own probe there to find out).
   - With that in mind, what are some things we can reliably say we know about Saturn and Cassini? How do we know they are accurate? (Examples: I know that Saturn has many moons. Cassini has taken images of them and scientists have published them on a NASA website. I know that Titan has an atmosphere, because engineers used a parachute to land the Huygens probe (a parachute needs an atmosphere to open). When students suggest a claim, ask them to name the reliable source and/or evidence that supports it. This can be an opportunity to reinforce internet literacy.)
   - We'll continue to learn about Saturn and record what we know throughout this program.

Questions for the Youth (Informal Assessment)

Pass the students their *Saturn Discovery Logs*. Give them time to write their own "What I Notice" and "What I Wonder" entries to their logs on one of their blank sheets of paper. Encourage them to write other questions they may have. Examples of questions or prompts are:

- What do you notice about Saturn that is different from Earth?
- What might be the explanation for Saturn's rings?
- Why are we interested in Saturn?

Sharing the Findings (Informal Assessment)

- Ask students to share their drawings with the group. Encourage the other students to voice what they like about each other's drawings.
- Encourage students to circulate to see what everyone wrote on the charts.
- Have the students write in their logs for 3 minutes about what they noticed during this activity and what surprised them.

Leader Reflection/Assessment

After each session ask yourself the following questions:

1. Were all of the students engaged?
2. Did some students take a leadership role? Did they know more about Saturn?
3. Did the students discuss the pictures? Were they surprised by any of the images?
4. Were some students more comfortable writing? Could you have done something different to support reluctant writers?
5. Did the students observe the images carefully? Is there detail in their observations or questions?
6. Did students find that observing leads to questioning?

Glossary

- **Engineer** — A person who designs, builds, or directs the use of engines or machines.
- **Spacecraft** — A vehicle designed for travel in space beyond Earth's atmosphere, to other planets or moons, or in orbit around Earth. Spacecraft can carry people or be robotic.

Information for Families

When Saturn appears in the night sky, it is bright enough to often be seen even in cities. Encourage families to pick up a public magazine on astronomy, call a local science museum, or contact an area amateur astronomy club to find out when and where to see Saturn for themselves! If families have Web access, they can also use an Internet search engine to look for "locate Saturn in the night sky."

Parents who would like to take a look at Saturn through a telescope with their kids can go to the Saturn Observation Campaign website to find out where local astronomers are participating. Events are open to the public — saturn.jpl.nasa.gov/education/saturnobservation

See "What's Up" in the night sky in these monthly podcasts:
solarsystem.nasa.gov/news/whatsup-archive.cfm

Is your weather bad when you want to observe Saturn? Try taking a picture with a remote telescope! mo-www.harvard.edu/OWN/

NASA Resources

Careers at NASA

NASA has opportunities for fascinating careers. Go to https://careerlaunch.jpl.nasa.gov to see the current job postings at NASA's Jet Propulsion Laboratory. Share one of the listings with your students (you will have to summarize the listing for most teams) and ask them to describe how to qualify for these positions. How does someone become the Senior Orbit Determination Engineer? The Origins of Stars and Planets Group Research Scientist? Ask students what other kinds of jobs they think might be at NASA. Chart their responses and post them in the room.

Role Model Resource

Dr. Bonnie Buratti is a research scientist, and her main interest is studying the icy moons of Saturn and other planets. She thinks they are fascinating because some of them are volcanically active. Some of them are heavily cratered. Some of them are covered in snow

and ice. She analyzes data from the Cassini spacecraft. She says "The most important thing about being a scientist is that you are always on the forefront of knowledge, discovering new things. As a student it is important to do well in math and science, but it is also important to do well in English, because a lot of what you do is write and communicate with other scientists. It's important to learn "how to play with others," because as scientists we are always working as part of a team."
Watch a video of Bonnie at: solarsystem.nasa.gov/multimedia/video-view.cfm?Vid_ID=1042

Resources

Find more information, pictures, and video about the exploration of Saturn at the Cassini mission website — saturn.jpl.nasa.gov.

Get the latest NASA summaries and news from the Cassini spacecraft at:
www.nasa.gov/mission_pages/cassini/main
This cartoon and video shows how the surface of Saturn's moon Titan was viewed by the Huygens probe during its descent to the surface:
www.esa.int/SPECIALS/Cassini-Huygens/SEMKVQOFGLE_0.html

This site provides child-friendly background about the Cassini–Huygens mission:
saturn.jpl.nasa.gov/kids

Taking Science to the Next Step

The Cassini spacecraft passes by Saturn and Titan regularly. The Cassini Status countdown clock at saturn.jpl.nasa.gov forecasts when the spacecraft will pass by next and send back pictures of these other worlds.

Consider asking the leader in another room to do the same exercise (perhaps just the drawing portion of the activity if it is a room of younger children). The children can meet to share and talk about what they drew and why.

You may want to have the gallery of images from the Cassini mission bookmarked on the computer for the students to explore — or print them and post them around the room — saturn.jpl.nasa.gov/photos

Literacy

- Postcards and letters are a fun alternative for publishing students' descriptive writing about Saturn. Student pieces can be compiled into a group book, used for individual mini-books, or as text for "Postcards from Saturn" to be shared with kids in another classroom, pen pals, or family/friends.

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 whole-group book of Saturn mail, with a description or story woven throughout the book and a letter related to that part of the story tucked in to every other page.

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).

Activity 1 Materials

Image 1

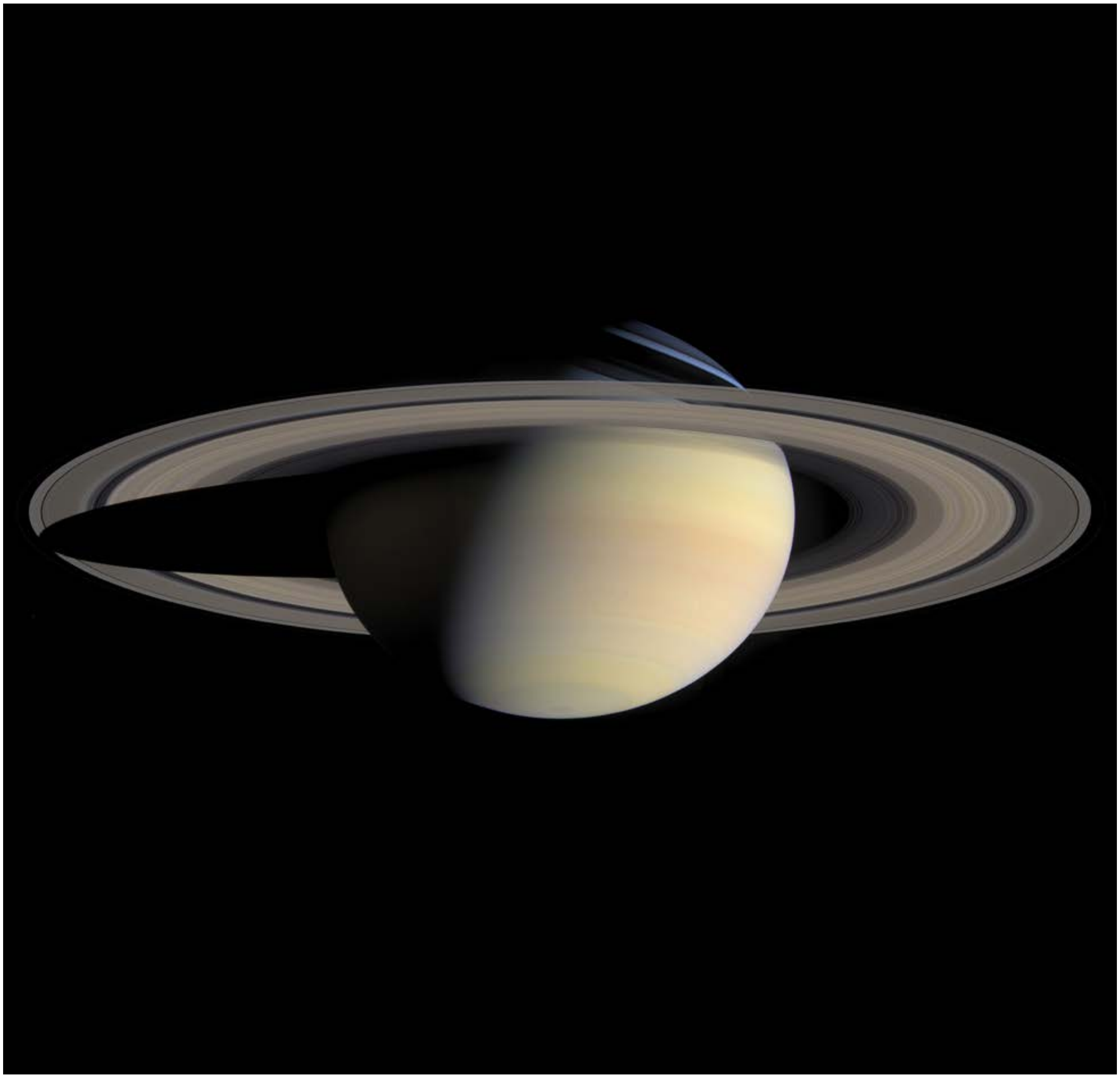


Image 2

Image 3

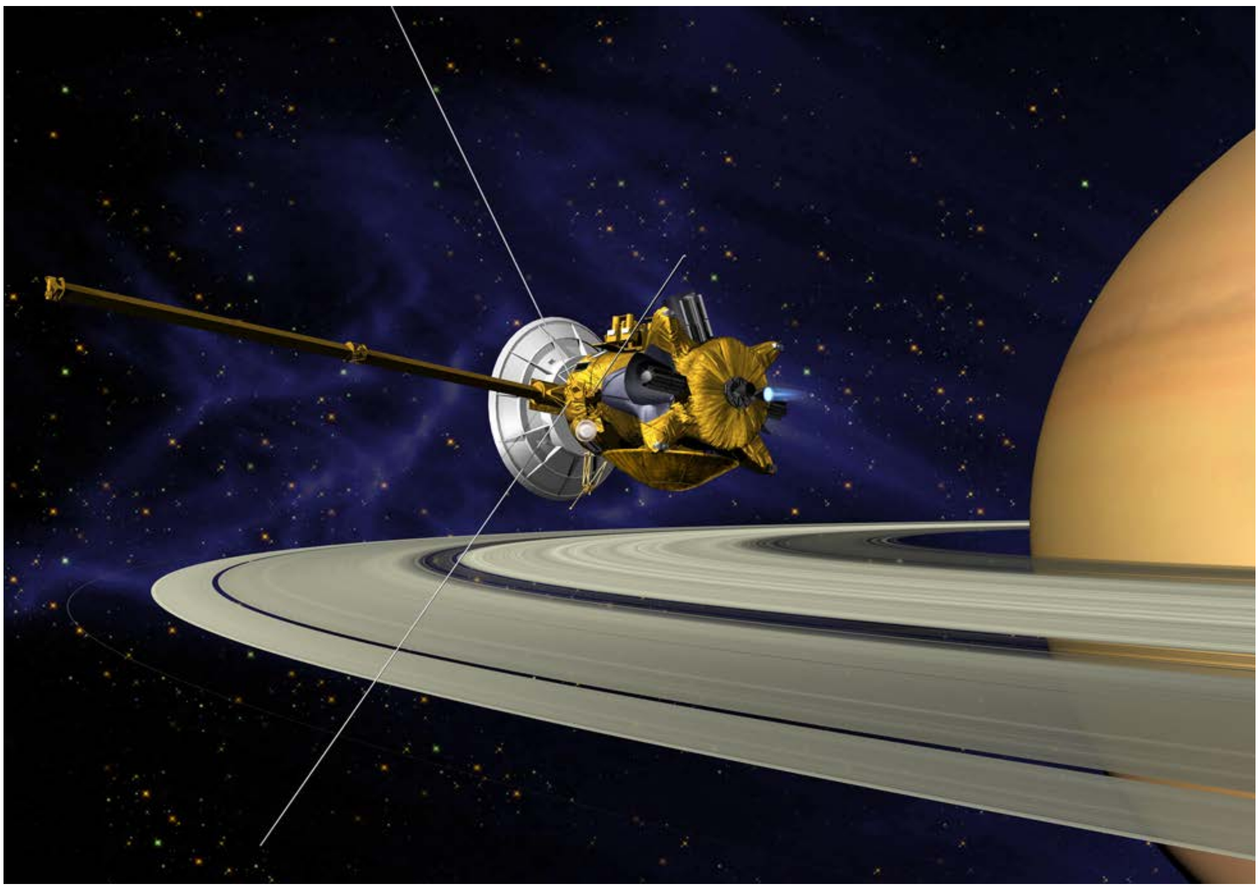


Image 4

Image 5

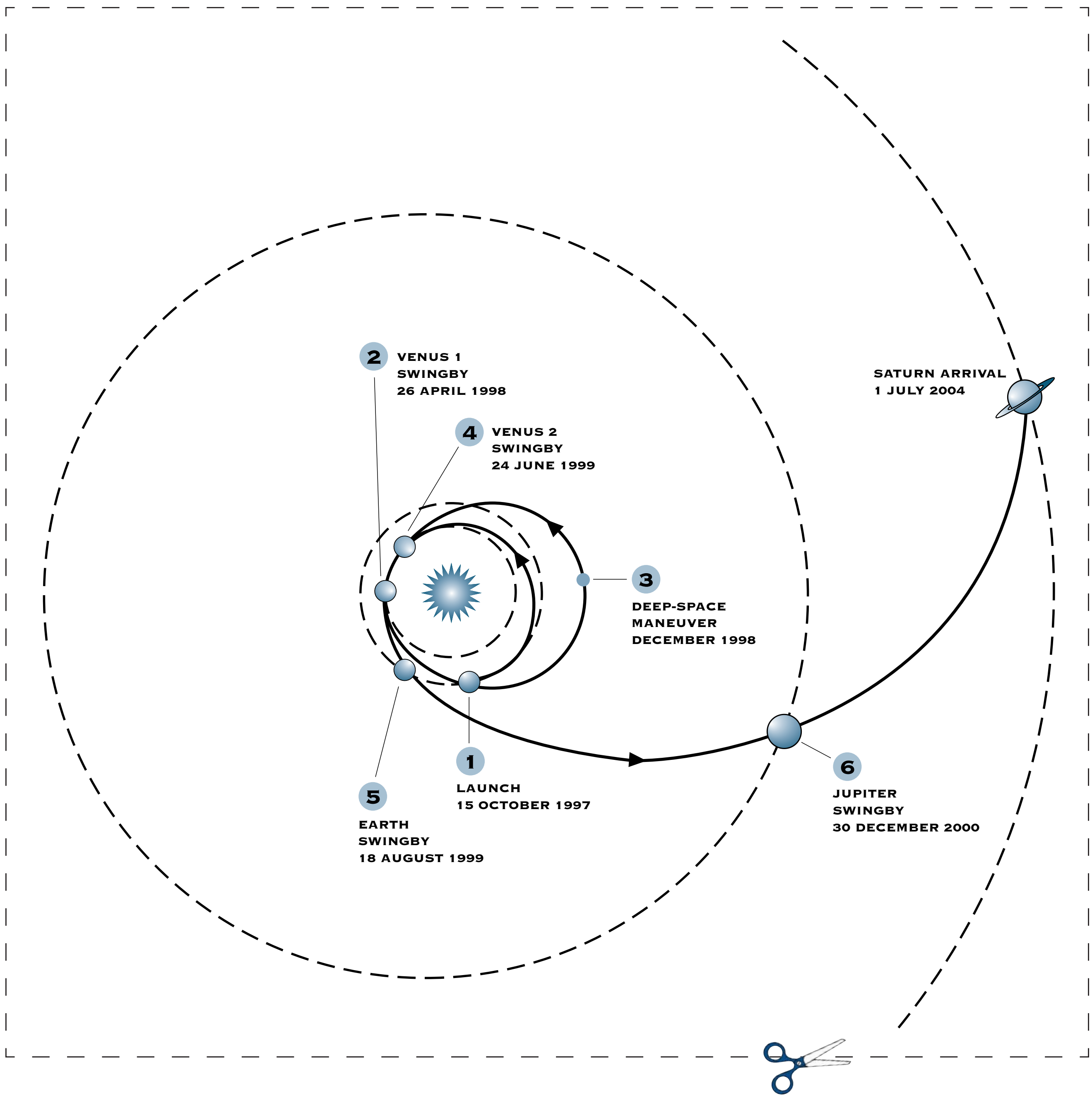

2 VENUS 1 SWINGBY 26 APRIL 1998
4 VENUS 2 SWINGBY 24 JUNE 1999
3 DEEP-SPACE MANEUVER DECEMBER 1998
SATURN ARRIVAL 1 JULY 2004
1 LAUNCH 15 OCTOBER 1997
5 EARTH SWINGBY 18 AUGUST 1999
6 JUPITER SWINGBY 30 DECEMBER 2000

Image 6

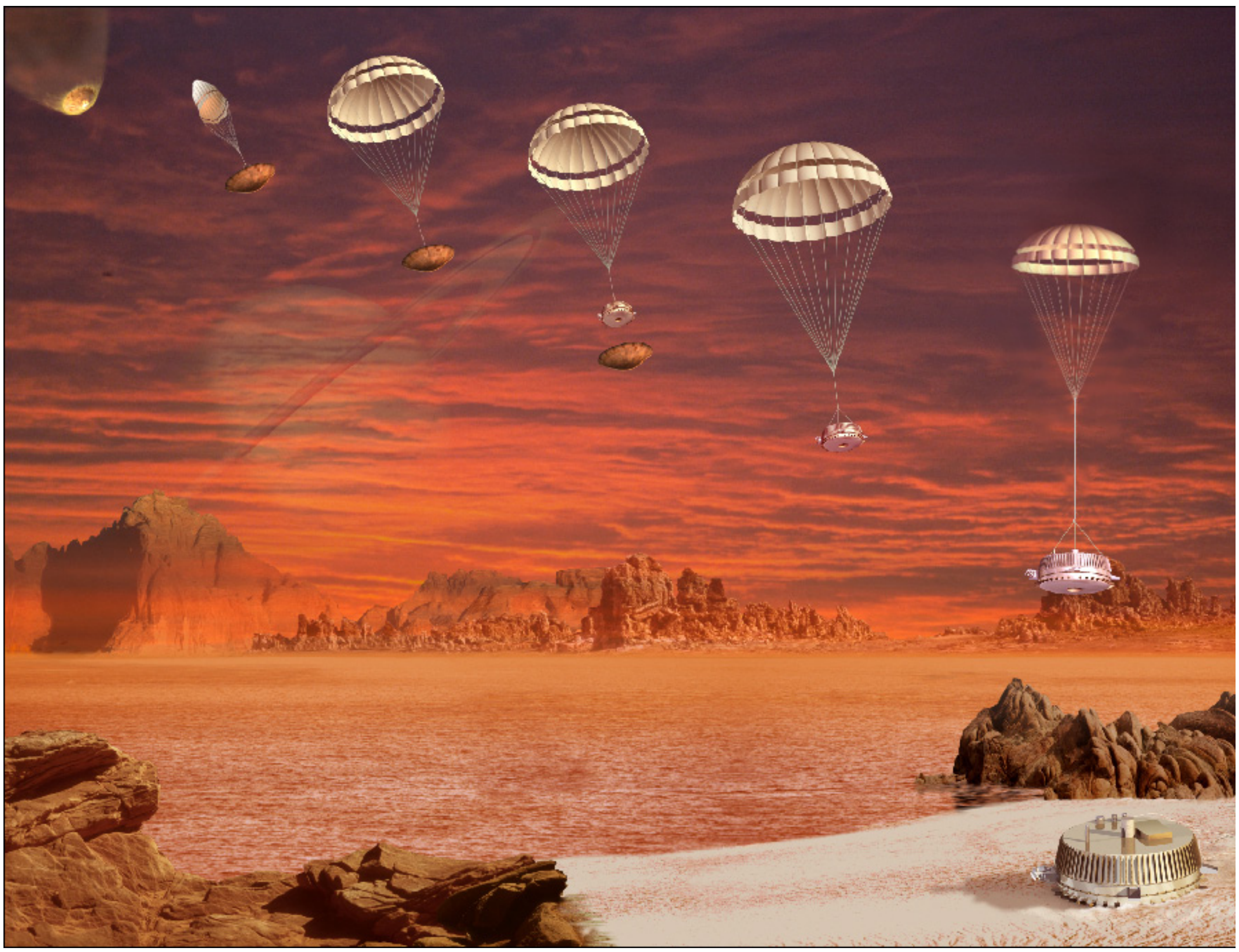
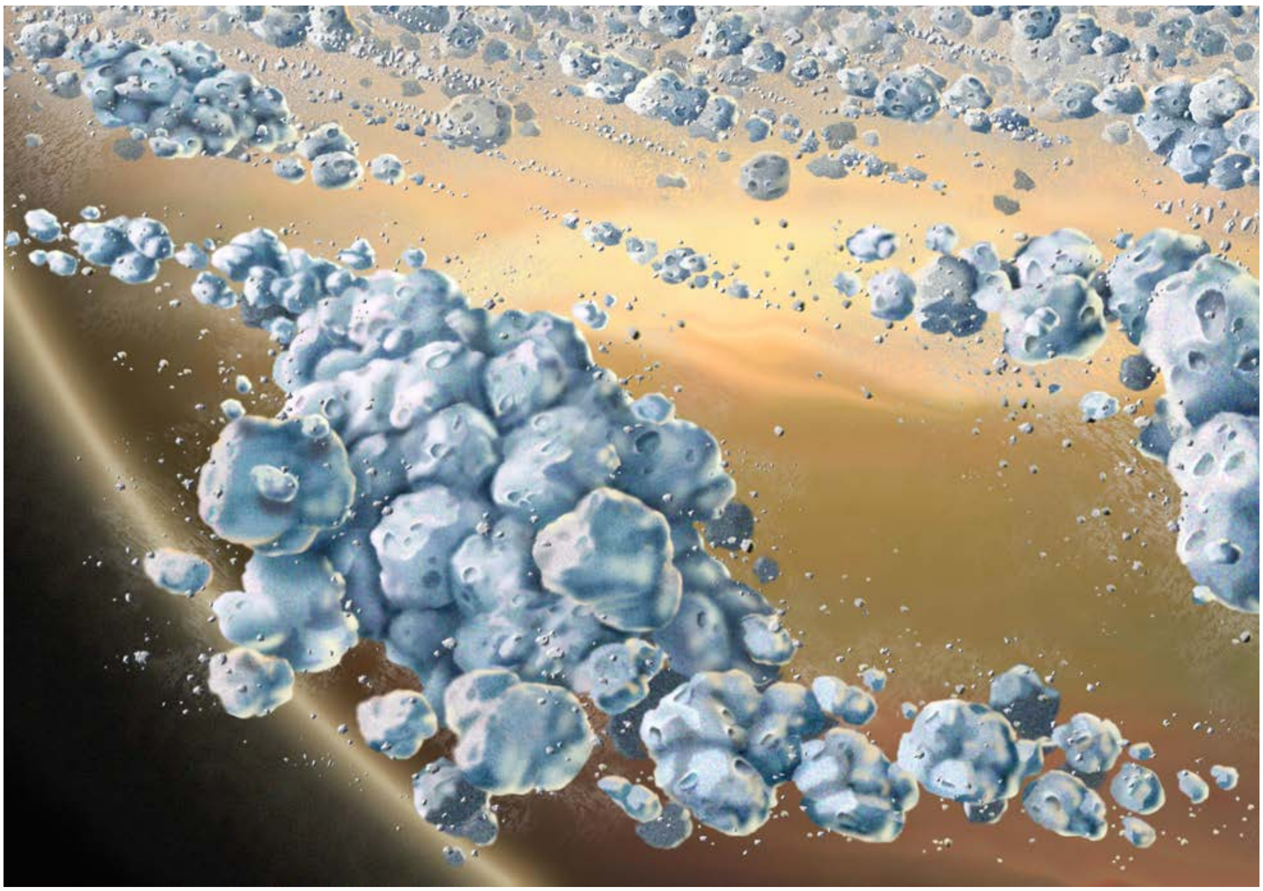
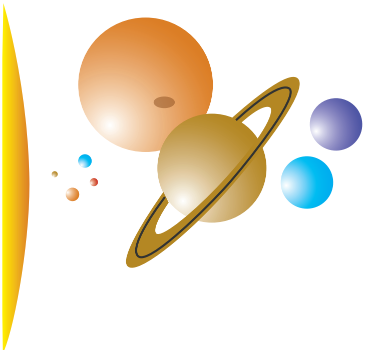


Image 7





Activity 2
Where Are We in the Solar System?

Overview

During this activity, your youth:

- Experience the vastness of the solar system and the size differences among the Sun, our home planet Earth, and this unit's theme — Saturn.
- Walk a playground or other large area to create a scale model for size and distance in our solar system. A variation for an indoor model is included.
- Participate in the creation of an orbital ("radial") scale model of the solar system.
- Compare their early thoughts about the solar system to their new experience and questions once they have participated in the scale and distance exercises.
- Reflect on what it would be like to travel to Saturn.

Time/number of sessions

Session 1 — 30 minutes
Sessions 2 and 3 — 40 minutes each

Activity Type

Kinesthetic and art

Space Needed

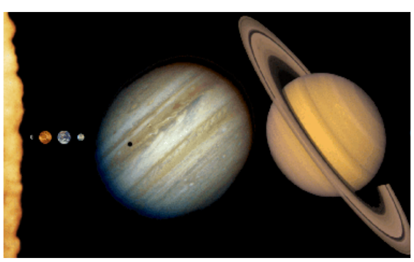
Session 1 and 3 — Classroom, cafeteria, or other space with tables, chairs, and extra floor space
Session 2 — School campus (to fit at least 247 yard-long walking paces)

Activity Goals

Youth will:

- Start to understand scale — in size and distance — in comparing the Sun, Earth, and Saturn.
- Begin to learn about Saturn and the Cassini–Huygens mission and spacecraft.
- Practice the scientific thinking skills of predicting, comparing, and relating.

Where's the Science and Engineering?



- The sizes and distances that we explore in space are far greater than those we are accustomed to on Earth. Students (and adults) may not easily grasp the enormity of space or the size difference between Earth, the Sun, and the other planets.
- Our solar system contains our star (the Sun), eight planets, dwarf planets, moons, and a variety of other objects.
- Distances in space are so vast that scientists use astronomical units (AU) for measurement. An AU is the distance from Earth to the Sun — 150 million kilometers or 93 million miles.

National Science Education Standards

K–4

Physical Science

- Position and motion of objects

Earth Science

- Objects in the sky

Equity/Leveling the Playing Field

- In this activity, youth present their work to the group. This may be more comfortable for some than others.
- Create an environment where they will feel comfortable presenting in front of the group telling them that they should think of themselves as “critical friends” who give positive constructive input.
- Explain that critical friends will give positive feedback and helpful suggestions for improvement.
- “Mirroring” is a good way to ensure this will happen, such as: “What I like about your work is...” “What you drew that is missing from my drawings is…”
- This can be followed by a “critical friends” statement, such as “What I would change about your drawing is…”
- Emphasize the idea of being supportive and helpful.

Materials

From Your Supply Closet

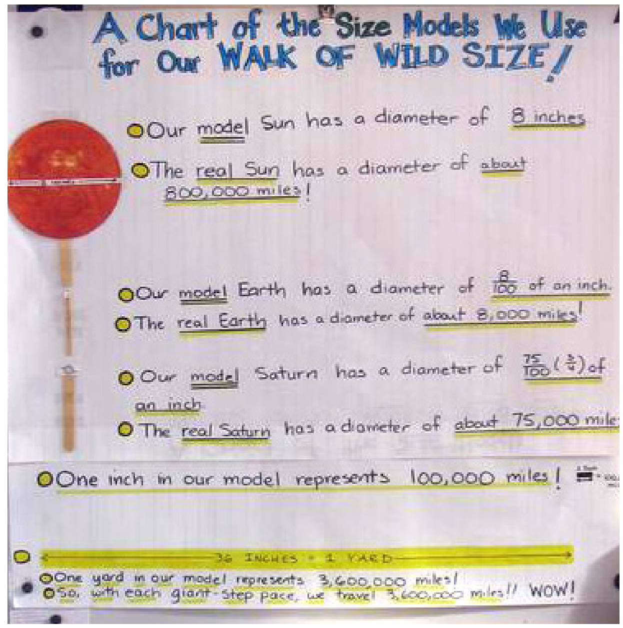
Session	For Leader	For Students
1	• Chart paper/white board, markers, tape	
2	• For *Chart of the Size Models* and *Walk on the Wild Size*: • Scissors, tongue depressors or Popsicle™ sticks, glue, thin cardboard or manila folder, tape • Large piece of chart paper (at least 4 feet by 4 feet square) • Yardstick, yellow highlighter, marker for writing titles	
3	• Metric measuring tape or meter ruler • Butcher paper or 4 poster boards glued/taped together to create a large square (about 2 meters on a side) • Chart paper, markers, tape • Pieces of tape to mark with the planets’ names	• Marking pens, string, scissors • Student’s *Saturn Discovery Log*

From a Photocopier/Printer

Session	For Leader	For Students
1	• Copy of the Sun, Earth, and Saturn image page, to make Sun on a stick, Earth on a stick, and Saturn on a stick • For optional Leader reading: copy of the mini-book “Introducing Saturn”: Questions, Answers, and Cool Things to Think About (from Activity 3 — “Discovering Saturn: The Real Lord of the Rings”)	
2	• Copy of Instruction Sheet *Take a Walk on the Wild Size*	• (Optional) Copy of Instruction Sheet *Take a Walk on the Wild Size* to take home

Getting Ready

For Sessions 1 and 2



- Cut out the images for the Sun on a stick, Earth on a stick, and Saturn on a stick, and glue each to a separate piece of thin cardboard or a manila folder. Tape each object to a tongue depressor or Popsicle™ stick so that students can easily hold them.
- Prepare the *Chart of the Size Models* for *Walk on the Wild Size* as shown. (Be sure to draw and label a 1-inch bar.) You will use this chart to show the students how the scale of the model compares to the actual distances in the solar system, and how much distance in space one pace represents.
- Brief yourself on the Instruction Sheet *Take a Walk on the Wild Size*, and optionally, print it out for each student to take home.
- Identify a large portion of a school campus. Because the distances in space are so big (247 yard-long paces to Saturn, 1019 paces to Pluto!), everyone will need to take a short hike to complete this model.

For Session 3

- Tape and/or glue butcher paper or 4 poster boards together to create a large square (about 2 meters on a side).
- Mark the center of the square, for the Sun's position in the model.
- Pre-cut a piece of string to be 80 cm or longer.
- Write the name of each planet on the right half of a separate piece of tape. (These will be used to wrap around string.) Since the inner planets are so close together, you might need to put several inner planet names in order on a single wide piece of tape, and/or cut the tape into narrower strips.
- Distribute each student's *Saturn Discovery Log* back to him or her for journaling.

Leader Tips

- Pace out the walking scale model in advance yourself to find the best location and to anticipate student questions. A very large space is required. It's impressive when done, but not every site has this kind of space. This scale was chosen to correctly model the size of the Sun to the distances to the planets at the same time. (All numbers are rounded.) See "Taking Science to the Next Step" if you need to adapt the walk for a smaller/indoor space.
- Set any ground rules you need to before taking the group outside — this could include staying with the group at all times or agreeing on a signal that it's time to stop.
- Some cities make their own permanent solar system scale models, such as the Smithsonian Institution in Washington, DC. Websites are listed in the "Internet Resource List" (see Appendix) to help you visualize representations of the solar system and Saturn's place in it.

Activity 2

Where Are We in the Solar System?

Student Activity

Session 1 • Wondering About and Sizing Up What's Out There

1. Lead the children in sharing their ideas about our solar system. Capture their thoughts on a white board or chart paper. (Do not worry about whether an idea is right or wrong for the moment.) Some suggested questions are:
   - What are the names of planets in our solar system?
   - What other kinds of bodies or objects are out there in the solar system?
   - What have you heard about traveling in space?
   - What questions do you have about the solar system?

2. Explain to the students that over the next few sessions, the group will learn about the planet Saturn and think about what it would be like to go that far into the solar system. Explain that they will model the size of the Sun, Earth, and Saturn, and how far they are apart, at the same time.

3. Ask the students how many stars there are in the solar system. Reveal that there is only one – our Sun. Explain that our Sun is also the largest object in our solar system — it would take 109 Earths to span the Sun's diameter. Remind students that the Sun is in the center of the solar system and the planets orbit (go around) the Sun.

4. Show the students the Sun on a stick that is approximately 8 inches in diameter, and say "This is a model of the Sun." Ask: "If this is our Sun, how big do you think Earth should be? How big do you think Saturn should be?" and have them respond.

5. Show the students the Earth on a stick and Saturn on a stick models, revealing the true size for Earth and Saturn in this model.

6. Display the *Chart of the Size Models* for *Walk on the Wild Size* you created and have the students take turns reading it out loud. Emphasize that for each "giant" (yard-long) step, they would travel 3.6 million miles (5.8 million kilometers - km) on the actual scale of the solar system! Then have them estimate some distances using this conversation guide:
   - Now that we have established the size scale for the Sun, Earth, and Saturn, how much space do you think we need to build our scale model of distances between them?
   - Let's have one volunteer come to the front of the room and be the Sun. (Have the volunteer hold the Sun stick.)
   - Let's have another volunteer be the Earth and stand next to the Sun. "Earth" will keep taking giant steps away from the Sun in a straight line and you all count them. Call out "Stop" as soon as you think that "Earth" is far enough from the "Sun." (The correct distance is 26 giant steps. If the students stop "Earth" earlier, respond "Not far enough" until they run out of room or get to the right distance.)
   - The distance between Earth and the Sun is 93 million miles (150 million km), or in our model, 26 giant steps.
   - How far apart do you think you need to stand to model the distance from the Sun and Earth to Saturn? (Have a volunteer come up to stand where the students think Saturn would be.)
   - We'll learn the right distance for Saturn in our next session, and walk the distances to the other planets. For that, we'll need to go outside!
7. Collect the Sun, Earth, and Saturn stick models.
8. (Optional) Leader Reading: Read aloud the last 2 paragraphs of page 3 from the mini-book "Introducing Saturn," showing the illustrations.

Quick Facts Reference: Size Comparison
- The Sun's diameter is about 864,337 miles (1,390,718 km).
- Earth's diameter is about 7,918 miles (12,740 km).
- Saturn's diameter is about 74,913 miles (120,535 km).
- It would take about 109 Earths to span the diameter of the Sun.
- It would take about 12 Saturns to span the diameter of the Sun.
- It would take about 9-1/2 Earths to span the diameter of Saturn at the equator.

Session 2 • Taking a Walk on the Wild Size

1. Repost the *Chart of the Size Models* for *Walk on the Wild Size* in the room.
2. Prepare the students for their walking adventure through the solar system, using this conversation guide:
   - Most of you have had some kind of experience with models. A model is a representation of something else, often something too big, too small, too far away, or too complicated to observe directly.
   - Scientists and engineers often build models to test a challenge or visualize how something will work. The model could be as simple as drawing something on a white board so that everyone sees the same thing and as complex as creating a computer program to test how their spacecraft will land on a planet. When scientists want to send a spacecraft to space, they often make a model of their destination to figure out how best to get there.
   - For our model, as we make the trip to Saturn, the distances are so big that we'll need to go outside.
   - We'll be pacing the distances from the Sun to the orbits of the planets, walking in a straight line. While this model is true for size and distance comparisons, it is not true

for the locations of planets in their orbits around the Sun. A straight line-up of the planets essentially never happens. Since models are only representations, they don't represent everything accurately.

3. Point out the facts on the *Chart of the Size Models* for *Walk on the Wild Size* and again emphasize that for each "giant" (yard-long) step, you would travel 3.6 million miles on the actual scale of the solar system!
4. Prepare the group to go outside, and make any recommendations for rules of conduct while there. Take and use the Instruction Sheet *Take a Walk on the Wild Size*.
5. Have the students line up at your selected large and/or outdoor location. Using the Instruction Sheet, begin pacing together, and read off the distances as you go, beginning at the Sun.
6. Once you have completed the walk, get their impressions:
   - What surprised you about the distance?
   - What do you notice about how the Sun looks from Saturn compared to how it looked from Earth? (The Sun is a smaller size. You cannot see as much detail on the Sun from Saturn's distance.)

Session 3 • Creating a Radial Scale Model

1. Prepare the students to think about a different kind of model, using this conversation guide:
   - Earlier we made a model to show the distance between planets and the Sun. Now we are going to make a radial model for the planets' distance from the Sun. The radial model shows the planets in their orbit around their common center — the Sun. Scientists, too, often create different models of the solar system for different purposes.
   - As we saw in the last session, because distances in space are so large, scientists have come up with different ways of measuring these distances. They use an astronomical unit (AU) for the distance from Earth to the Sun (93 million miles, or 150 million kilometers). Other measurements in space are then referred to as the number of AUs between two bodies (or the number of 93-million-mile segments).

2. Spread out the sheet of butcher paper/poster board and mark the Sun at the center.
3. For this model, every astronomical unit (AU) is about 2 centimeters (cm). Ask students to predict where they think Earth and Saturn will be, relative to the placement of the model Sun. They can also predict how many astronomical units they think this will be.
4. Measure the different distances along the string and put the piece of tape marked with each of the planets' names.
   - Mercury: 0.8 cm (0.4 AU)
   - Venus: 1.5 cm (0.7 AU)
   - Earth: 2 cm (1 AU)
   - Mars: 3 cm (1.5 AU)
   - Jupiter: 10 cm (5 AU)
   - Saturn: 19 cm (9.5 AU)
   - Uranus: 38 cm (19 AU)
   - Neptune: 60 cm (30 AU)
   - Pluto: 79 cm (39.5 AU)

5. On the large paper, attach the piece of string to the center of the Sun. Have the students mark the planets at the appropriate distance, as you rotate the string around the Sun as each planet is placed. Planets should be spread out in several directions — not lined up as they were in the earlier model.

Questions for the Youth (Informal Assessment)

Prompt a discussion about the activity with your students using this conversation guide. (Suggestions for starting/continuing the conversation are in parenthesis):

- What surprised you? (It's a lot farther between each planet and really far to Saturn.)
- What do you notice? (The radial model shows that the planets don't line up in a row.)
- What do you notice about how the Sun looks from Saturn compared to how it looked from Earth? (The Sun is a smaller size. You cannot see as much detail on the Sun from Saturn's distance.) Do you think it is colder on Saturn than Earth? (The heat from the Sun is much less because it is much farther away.)
- What problems or challenges do you think a spacecraft has to overcome in order to travel from Earth to Saturn? (The spacecraft needs enough energy to make all the instruments and cameras work during the several-year flight to Saturn.)
- What kinds of information about Saturn and Titan do you think a spacecraft could gather that we are unable to gather from Earth? (Because it is close to Saturn, it can see clouds and landscapes better. The spacecraft can take better pictures to send back to Earth)
- What questions do you have? ("I wonder…?" "What if…?")

Sharing the Findings (Informal Assessment)

Ask students to work in teams and spend a few minutes writing down everything they just discovered or learned in their *Saturn Discovery Logs*. Ask them to also list all of their new questions.

Leader Reflection/Assessment

After the activity, ask yourself the following questions:

1. Did the students show a curiosity to learn more about the solar system?
2. Did the students' discoveries indicate an understanding of the bigness of our solar system? Of how far away Saturn is?
3. Did the students understand that the planets are not lined up in a row, but in orbit around the Sun?

Glossary

- Astronomical unit (AU) — The distance from Earth to the Sun (93 million miles, or 150 million kilometers).
- Diameter — The length of a straight line through the center of an object — so, the diameter gives us the measurement of how far it is across a planet, moon, or the Sun.
- Model — A three dimensional example for imitation or comparison; a representation (sometimes in miniature) to show how something is configured or constructed.
- Radial — Radiating from, or situated around, a common center (the Sun).
- Solar system — The configuration of our Sun and planets and other bodies that revolve around the Sun.

Information for Families

Do the parents in your program have busy schedules — does working and taking care of the kids leave time to go to a museum? Is it difficult to get to museums? Use your Web browser and search for "science museum virtual tour" for locations that can be visited online or with a smart phone.

Young people today are living during the most amazing era of exploration in human history. For the first time, we are able send back pictures and information from other worlds. Encourage parents to share the adventure with their children at the SpacePlace parent's page at
spaceplace.nasa.gov/menu/parents-and-educators/

NASA Resources

Careers at NASA

What would a career exploring other worlds be like? How can you work at JPL as a student? Find out at www.jpl.nasa.gov/work

Ask students to brainstorm a new "job at NASA." What would it be? What would that person try to find out? Describe the mission that person would lead. Chart the students' responses.

Role Model Resource

Dr. Ed Stone is a professor of physics at the California Institute of Technology and the Chief Scientist for Jet Propulsion Laboratory's Voyager mission, which has traveled to the outer planets making amazing discoveries, and continued the journey beyond to the boundaries of our solar system. Since the launch of the two Voyager spacecraft in 1977, Dr. Stone has coordinated 11 teams of scientists in their investigations of Jupiter, Saturn, Uranus, and Neptune, and became nationally known as the JPL public spokesman during the planetary flybys, explaining the Voyagers' scientific discoveries to the public. He later served as the Director of JPL.

He's interested in how things work — science is, after all, about understanding how nature works. He found that learning about how things work is best done by actually trying to make and build things! He also feels that to be a successful scientist, as in most aspects of life, you need to develop skills for good listening and for talking with people.

Watch a video about Ed at solarsystem.nasa.gov/multimedia/video-view.cfm?Vid_ID=1048

Learn more about the Voyager missions at voyager.jpl.nasa.gov

Resources

To help you visualize representations of the solar system and Saturn's place in it, visit:
• solarsystem.nasa.gov/yss/display.cfm?Year=2010&Month=10&Tab=Classrooms. Build your own solar system scale model and find others around the country.
• solarsystem.nasa.gov/eyes/player (requires the free 3d-Unity player download)
• voyager.jpl.nasa.gov/pdf/VoyagerPoster2010_Back.pdf. A 2-dimensional model of planetary distances on a football field.

"The planets" section of this solar system website is particularly fun for students to explore — solarsystem.nasa.gov

For child-friendly information about space travel, including quiz games and a history of space travel, see — www.jpl.nasa.gov/kids/

Additional educator resources can be found on the NASA website (www.nasa.gov). Click on "Educators" to view.

Taking Science to the Next Step

If you need a smaller space for the scale model (such as a gym or playground), divide everything by 10:

- On "photo" setting, photocopy at 10% reduction the Sun, Earth, and Saturn image page. (Your copier may require you to do two reductions at 33% each instead.) Earth will be a pinpoint at this scale.

- In the *Chart of the Size Models* for *Walk on the Wild Size*, change the model Sun's diameter to 85/100 of an inch (0.85), model Earth diameter to 8/1000 of an inch (0.008), and model Saturn diameter to 75/1000 of an inch (0.075). One inch in this model represents 1,000,000 miles (1:1,000,000).
- Divide the number of steps needed by 10 (round to the nearest whole number) before pacing.

Send home the directions for pacing the solar system, so students can do the activity again with family and friends.

Convert the size model and pacing model to metric units, which are commonly used by engineers! (As you learn more about astronomy, read different books, and visit different websites, you may find information presented in miles, kilometers, or both.) Here is an easy was to convert from miles to kilometers, and kilometers to miles — 1 mile = 1.609 kilometers.

- To convert from miles to kilometers (km), multiply by 1.609. For example, if the diameter of Saturn is 74,913 miles, multiply 74,913 miles by 1.609 km per mile = 120,535 km.
- To convert from kilometers to miles, divide by 1.609. For example, if the diameter of Saturn is 120,535 km, to find out miles, divide 120,535 km / 1.609 km per mile = 74,913 miles.

Make other models of the solar system: see the "Solar System Model Builders' Guide" on the Windows to the Universe website at www.windows2universe.org/our_solar_system/distances.html (includes directions for scaling the solar system when Earth is represented by a marble).

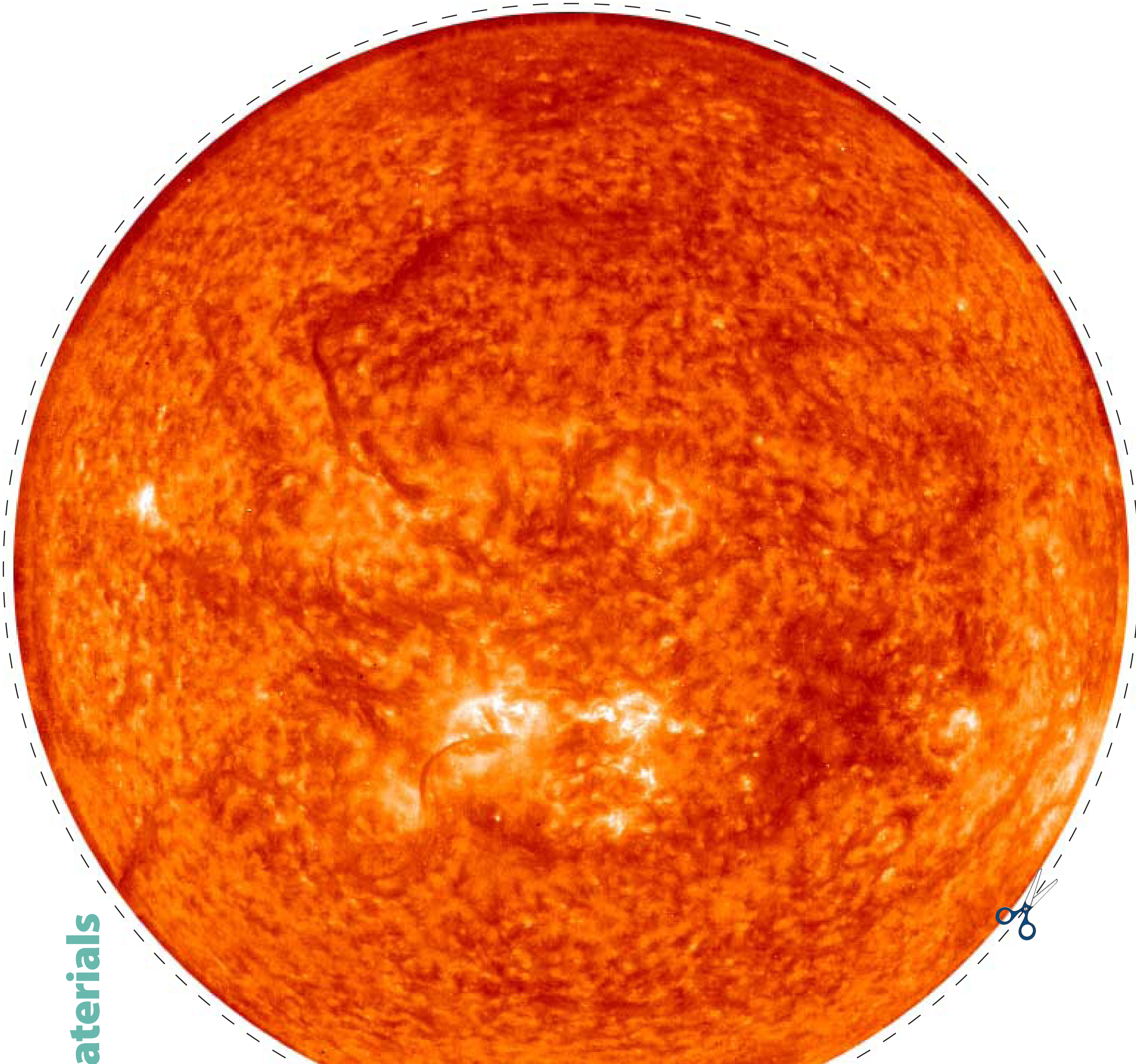
If there's enough space (for example, a football field), try pacing out the solar system but instead of lining up the planets, ask each student representing a planet to walk in a different direction and create a radial model. This way, students will understand that the planets are not "all lined up" in a straight line.

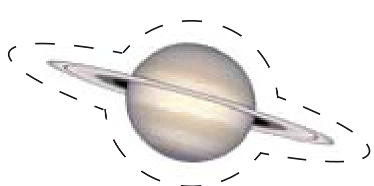
Literacy

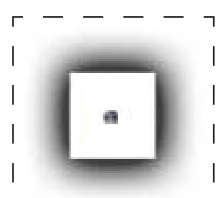
Ask the students to write a short science fiction story about going to Saturn. Tell them to include as many Saturn or space facts as possible. Include information like how far away Saturn is, or the name of its largest moon. Share the stories with the children.

- Discuss why it took Cassini seven years to get to Saturn.

Activity 2 Materials







Instruction Sheet — Take a Walk on the Wild Size

Directions for Pacing the Solar System

1. Pick a location for the Sun, and have the group start their "giant" paces from there. (The giant paces should be about 1 yard long each.) Read off the distances as you go.
2. Take 10 paces. Call out "Mercury."
3. Take 9 more paces. Call out "Venus."
4. Take 7 paces. Call out "Earth." At this point, have everyone look back at the Sun. Ask, "What do you notice?" "How big does the Sun look from Earth?" "Looking from our model Earth, does the model Sun look about the same size as we see it in the sky?" (It should.) Share fun facts:
   - Earth is 93 million miles from the Sun.
   - Astronomers give the distance from Earth to the Sun a special name — an astronomical unit.
5. Take 14 more paces. Call out "Mars." Ask everyone if they know which planet they will pass next on their journey to Saturn.
6. Take 95 paces. Call out "Jupiter." Ask the group which planet is next. Have them predict how many more paces it will be to Saturn.
7. Take 112 paces. Call out "Saturn." Saturn is 247 paces from the Sun, and 221 paces from Earth!
8. Stop at Saturn and discuss the model with the group. Ask them what they think about the size of the model they created. Are they surprised? Where do they think Earth's Moon would be located? How big does the model Sun look from the model Saturn?
   - Saturn is 890 million miles from the Sun, or 9.5 astronomical units.
   - So — Saturn is about 800 million miles from Earth, when they are both on the same side of the Sun.
   - Walking at 3 miles per hour, it would take you 30,441 years to get from Earth to Saturn.
   - Driving a racecar at 100 miles per hour, it would take you 913 years to get from Earth to Saturn.
   - Flying to Saturn in a jet plane, traveling at 600 miles per hour, it would take you 152 years to get to Saturn.
   - Flying in a rocket, traveling at 17,500 miles per hour, it would take you 5 years to get to Saturn.
   - It took the Cassini–Huygens spacecraft nearly 7 years to get to Saturn, because it did not travel directly to Saturn. It had to fly by several planets on its way, using their gravity to give it the "energy boost" needed to get all the way to Saturn. Cassini's journey covered nearly 3 billion miles.
9. If you have the space and the time, you can continue to the outer planets, and to Pluto!
   - It is 249 paces from Saturn to Uranus.
   - It is 281 paces from Uranus to Neptune.
   - It is 242 paces from Neptune to Pluto.

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

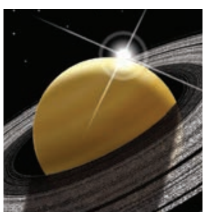
Session	For Leader	For Students
1		For each student team of 4: • Copy of the mini-book "Introducing Saturn" • Copy of the mini-book "Saturn — From the Outside In" • Copy of the mini-book "Those Amazing Rings!" • Copy of the mini-book "Saturn's Moons" • Copy of *Saturn/Cassini Match Game Question Cards*
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.

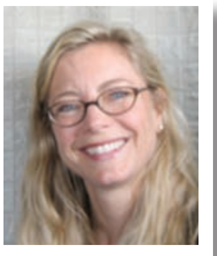
Information for Families

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

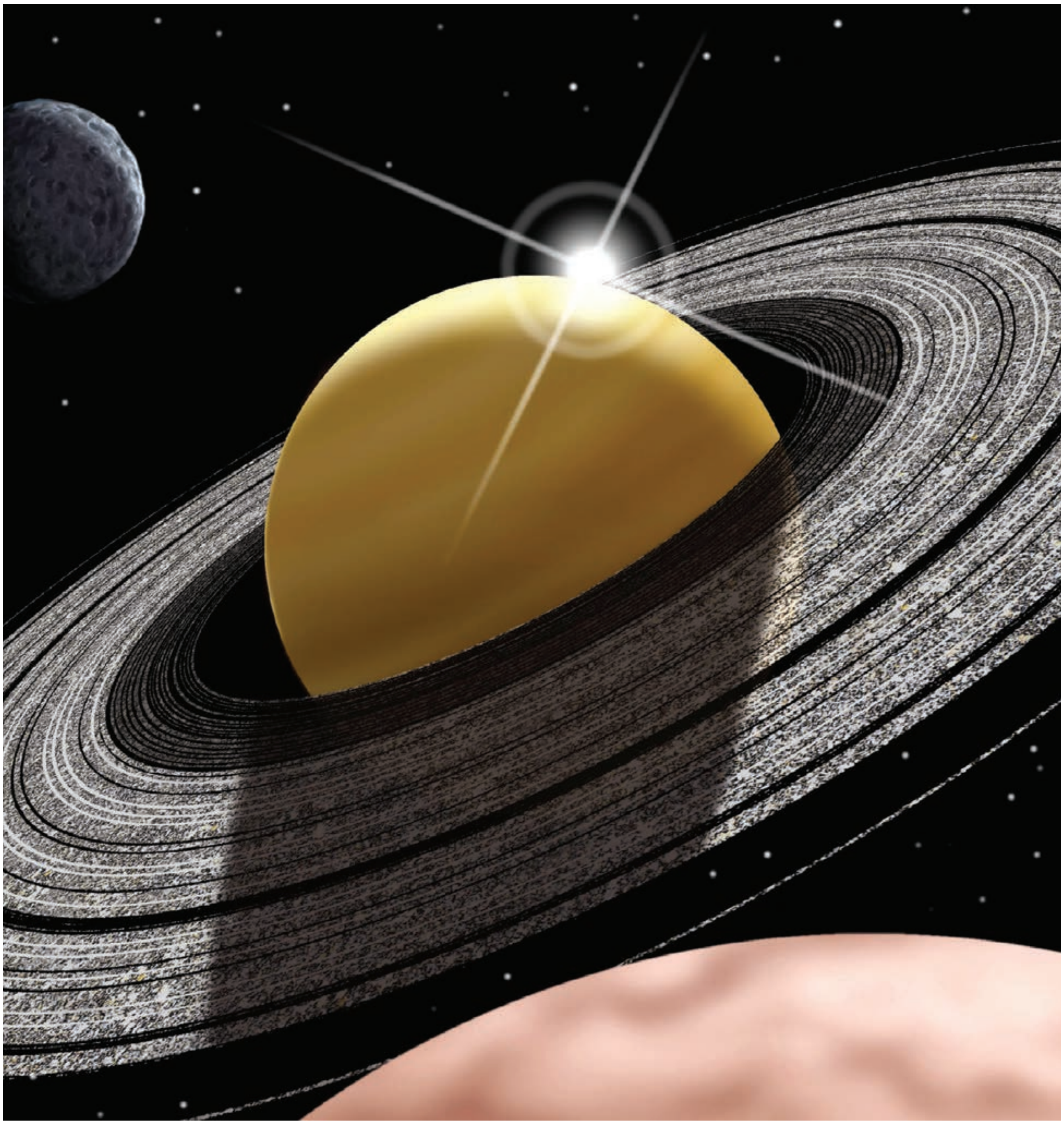
Write a poem about Saturn, the Jewel of the Solar System. Students can write haiku, odes to Saturn, a "rap" about Saturn, or nonsense rhymes. Ask students to read their poems aloud.

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."

National Aeronautics and Space Administration

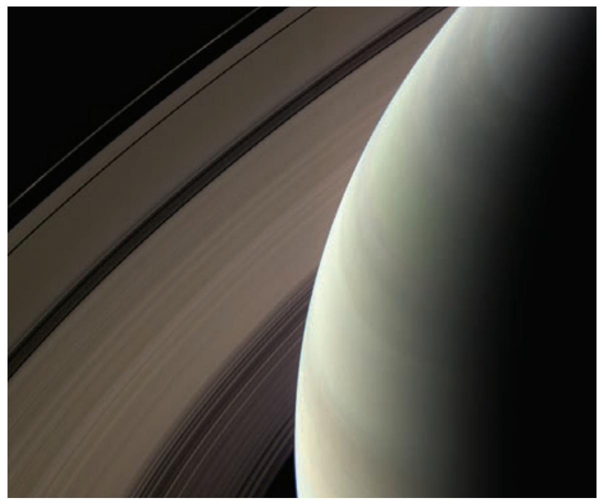
Introducing Saturn

Questions, Answers, and Cool Things to Think About



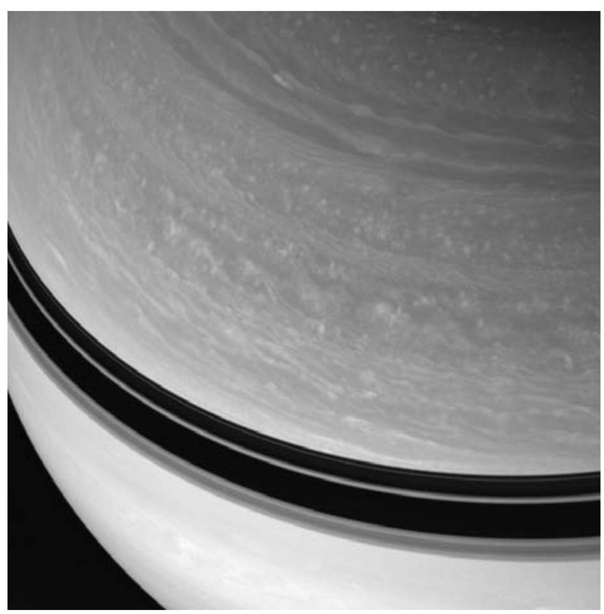
Discovering Saturn: The Real Lord of the Rings

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.



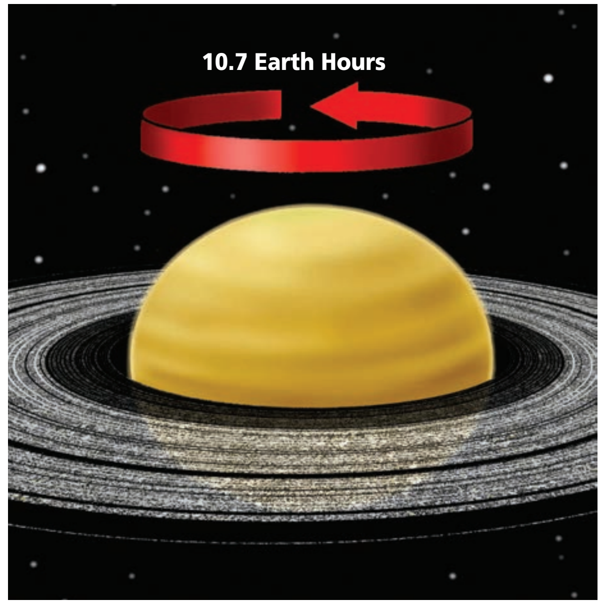
Natural-color image of rings and Saturn

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.

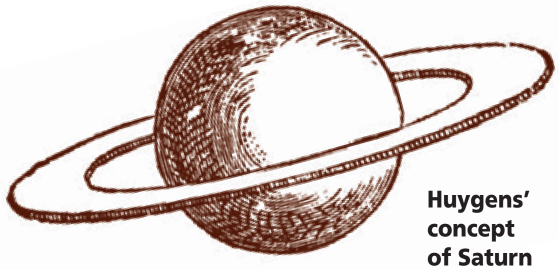


Length of a Saturn day

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 (HOY-gens) looked at Saturn through a more powerful telescope, and figured out that the

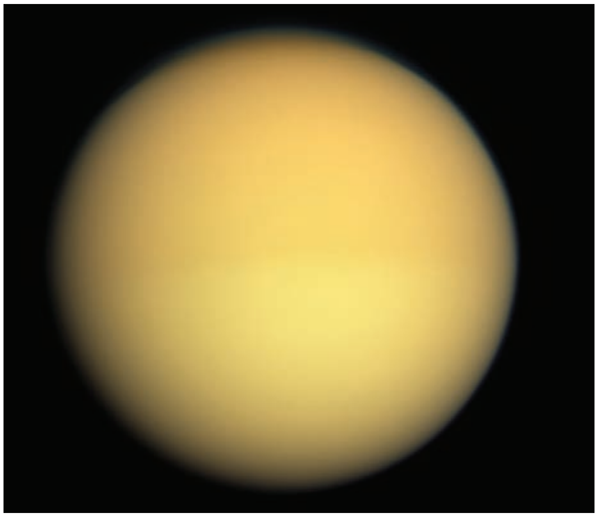


Huygens' concept of Saturn

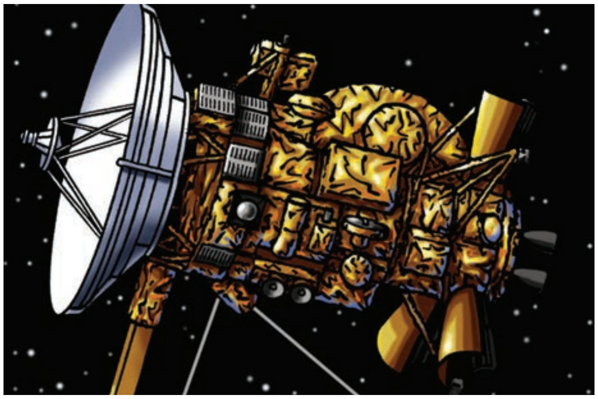
planet is surrounded by a giant flat ring.

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?

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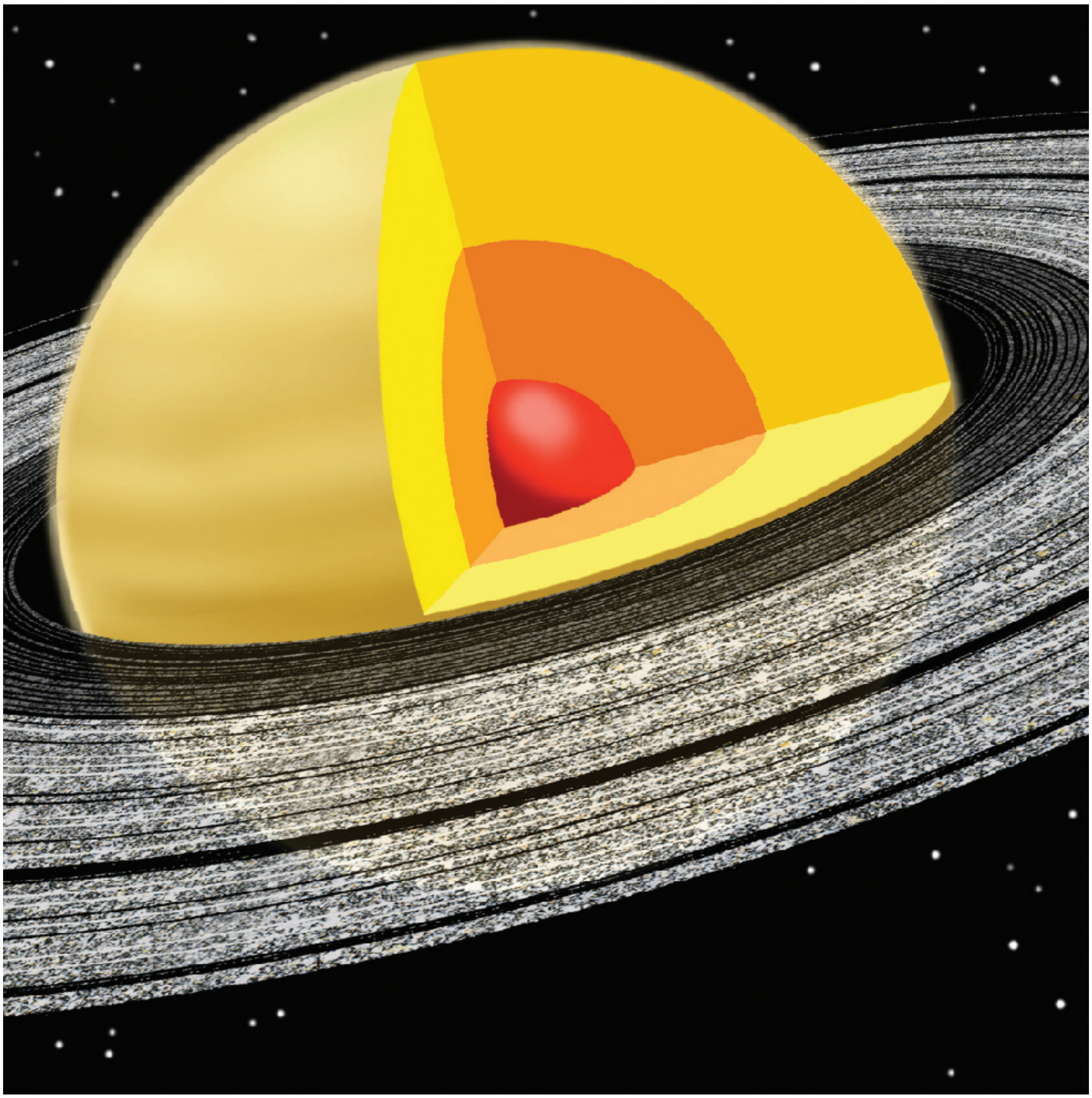
Saturn — From the Outside In

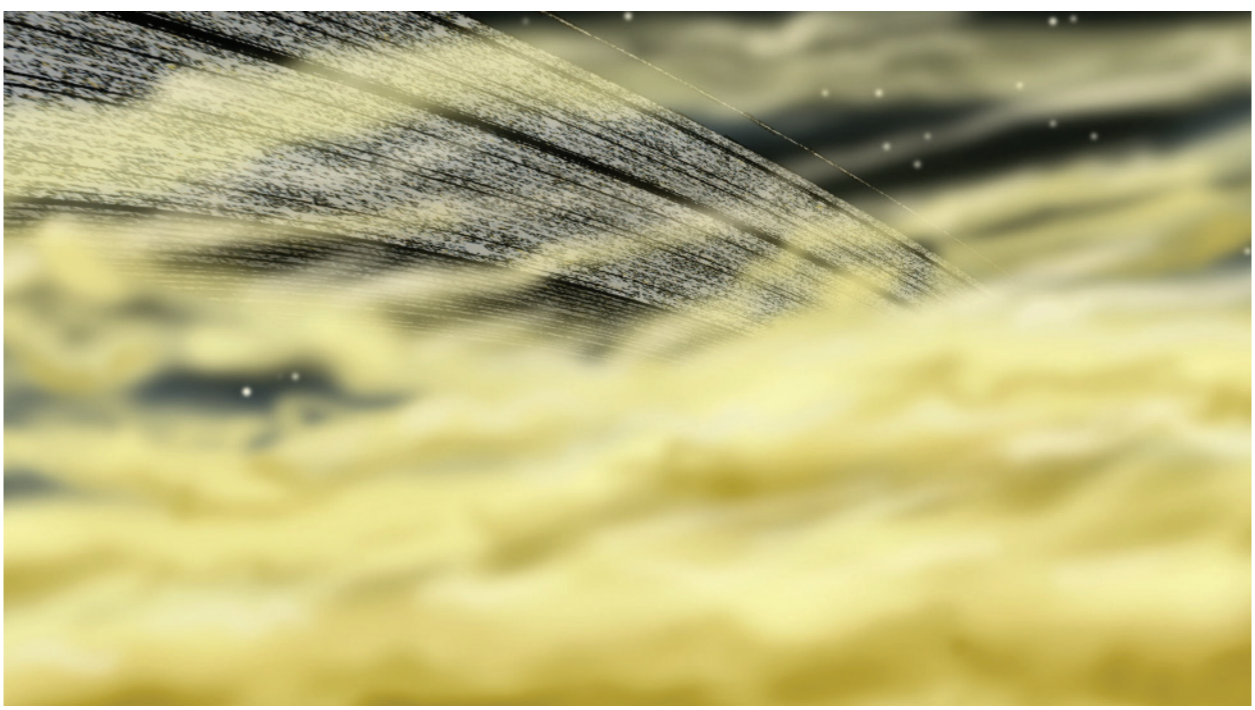
Questions, Answers, and Cool Things to Think About



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.



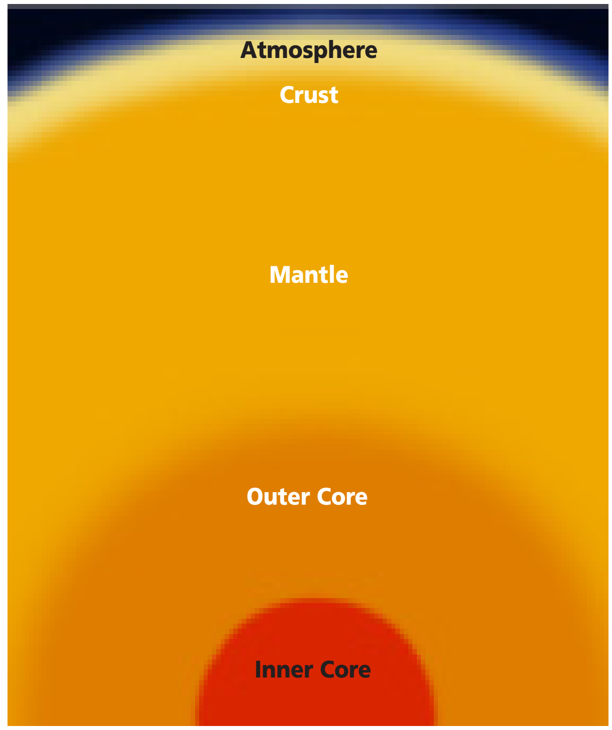
Fierce winds blow clouds of icy ammonia across Saturn's upper atmosphere.

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!

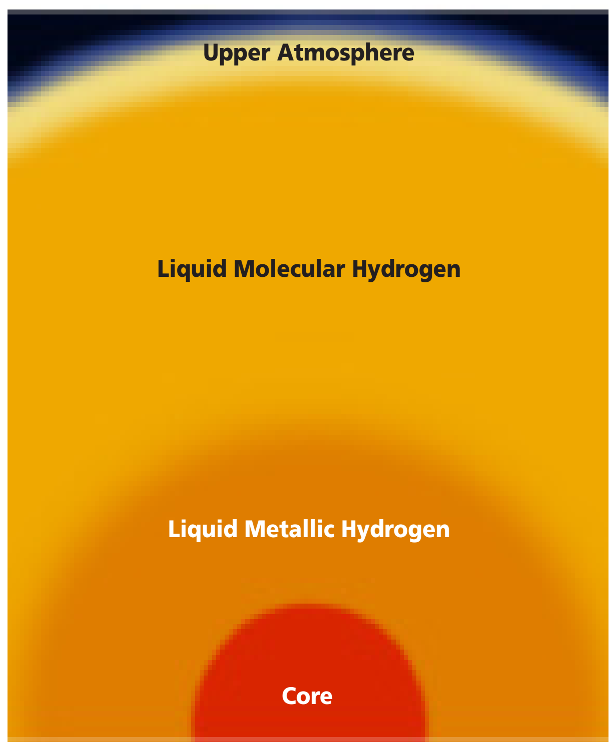
From far away, Saturn may look like a gigantic ringed version of the rocky planets in the inner solar system. However, it is really quite different. Unlike planet Earth, where there is a sudden change from the gases in the atmosphere to the solid crust (land) or liquid (oceans), the layers within Saturn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

Earth's Layers



Saturn's Layers

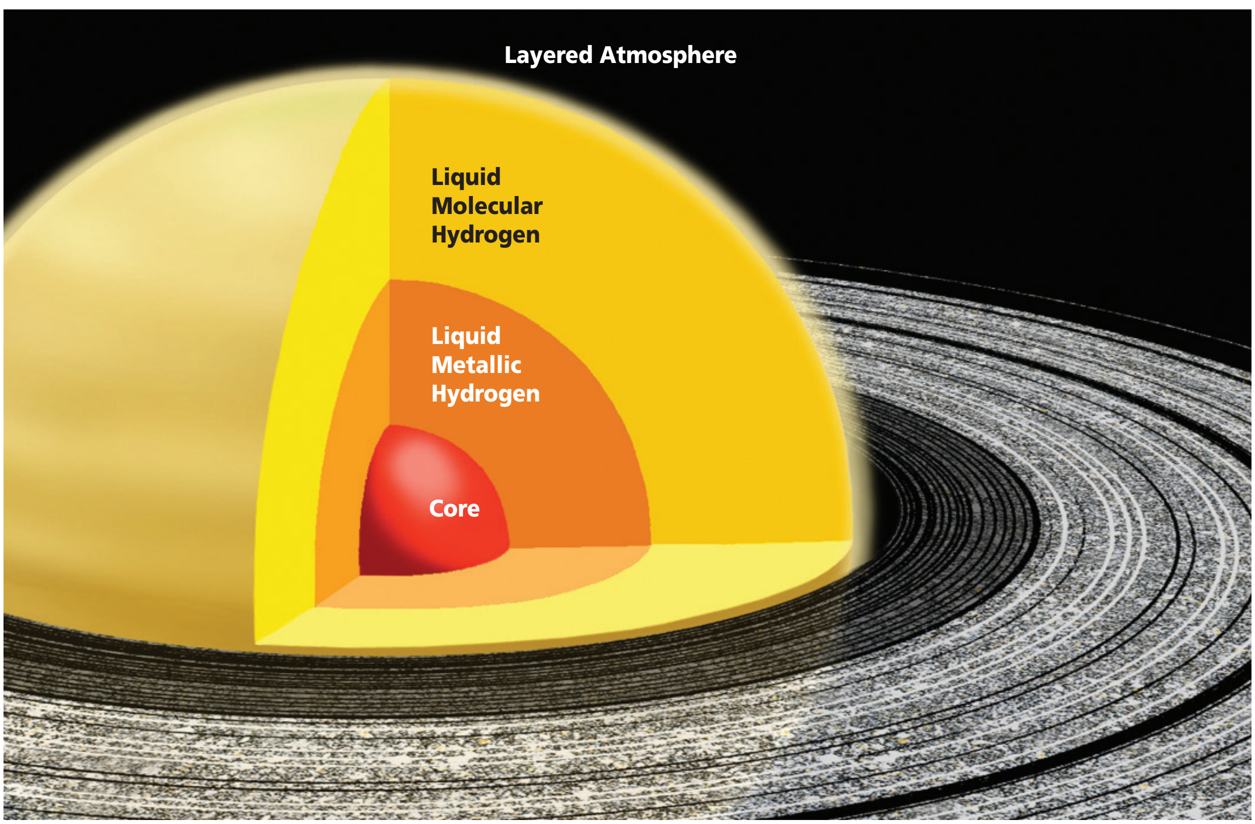


Comparing Earth's Layers to Saturn's Layers

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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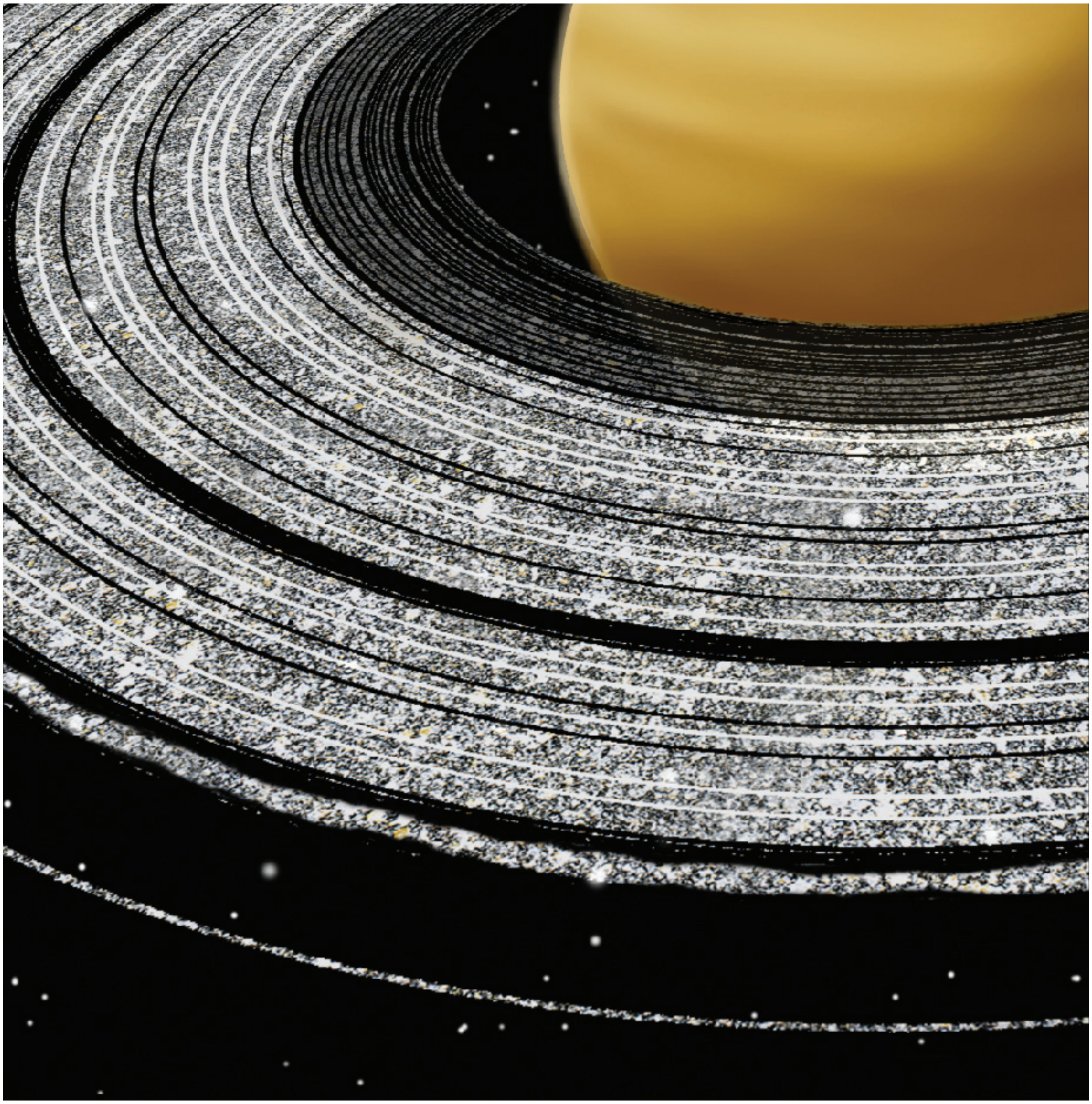
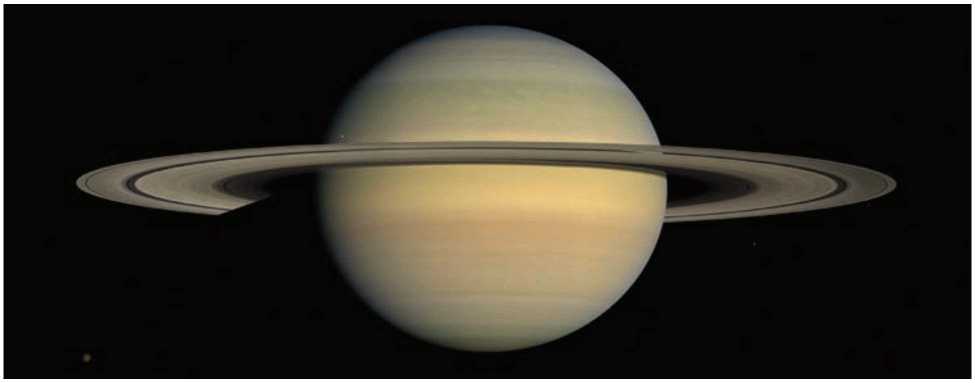
Those Amazing Rings!

Questions, Answers, and Cool Things to Think About



Discovering Saturn: The Real Lord of the Rings

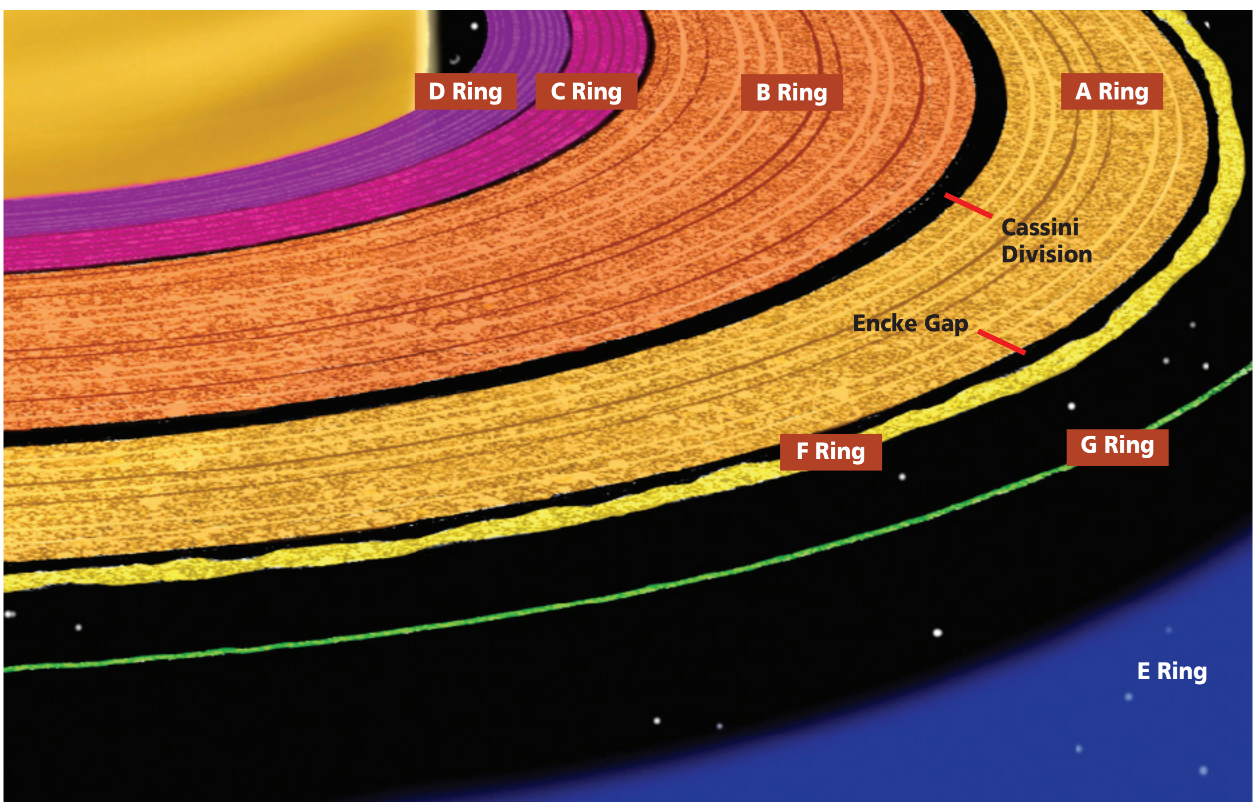


Cassini image of Saturn casting a shadow on its rings

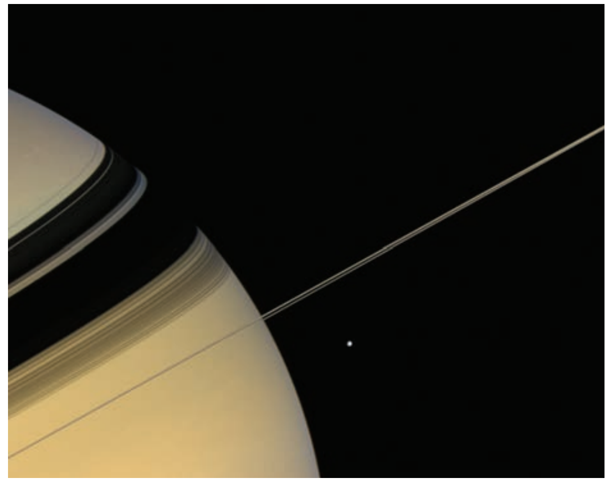
While all the gas giant planets have rings, Saturn's rings are the brightest and most spectacular, although we need a good telescope to see them from Earth. What other adjectives or describing words come to mind when you look at the rings?

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.)



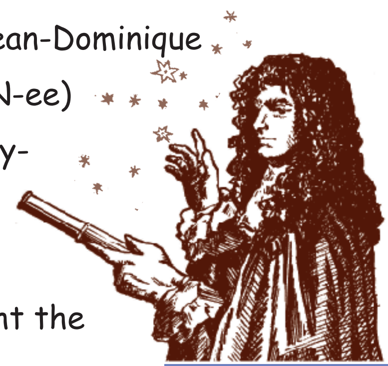
The rings stretch all around Saturn and are about 170,000 miles in diameter. That is almost the distance from Earth to the Moon! While the rings stretch for hundreds of thousands of miles to circle Saturn, they are less than a kilometer (about half a mile) thick. In fact, scientists have found that in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

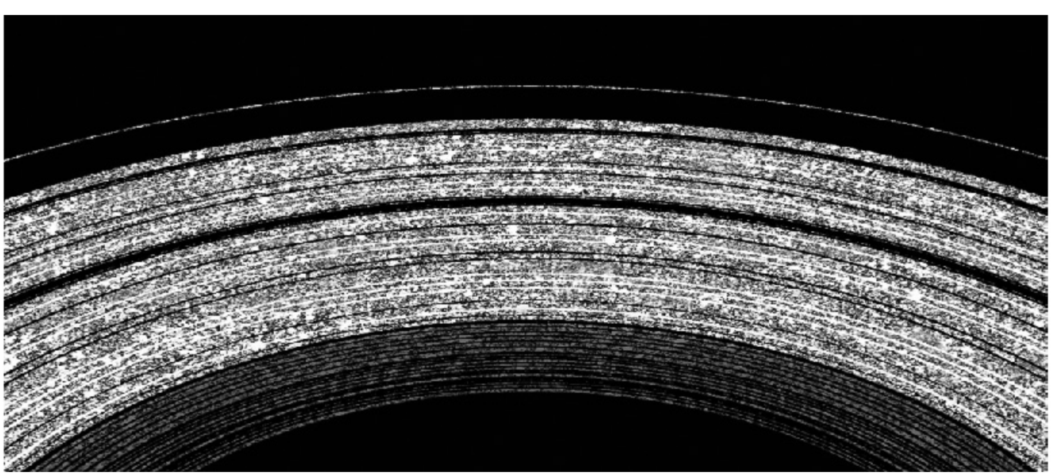
It is amazing that Saturn's rings can be hundreds of thousands of miles across and yet less than a soccer field in thickness. If you were to use a piece of paper to make a scale model of Saturn's A, B, and C rings, and have the thickness of the paper represent the thickness of the rings, you would need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

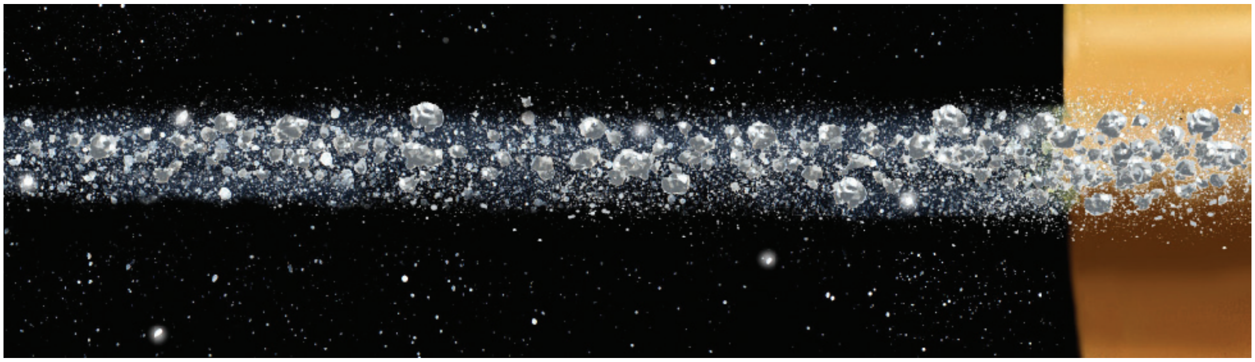


Cassini

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."

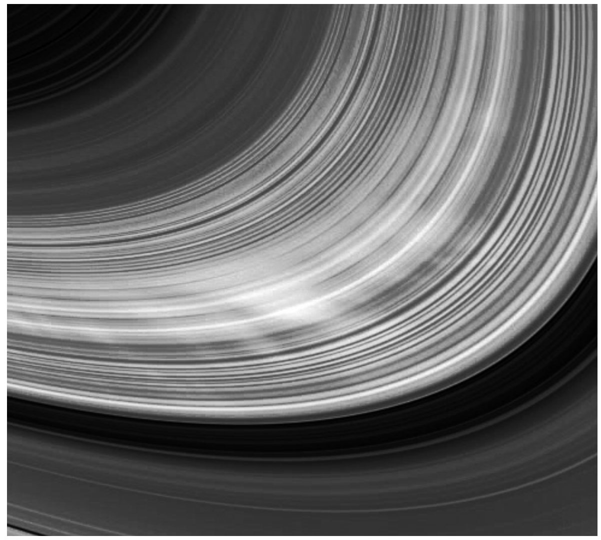
Shepherd moons are less effective at holding the smallest particles in place, however. Many of these particles gradually fall into Saturn. But they are replaced by new particles that come from the ongoing collisions of large rocks and moons, so the rings are always in the process of being rebuilt.

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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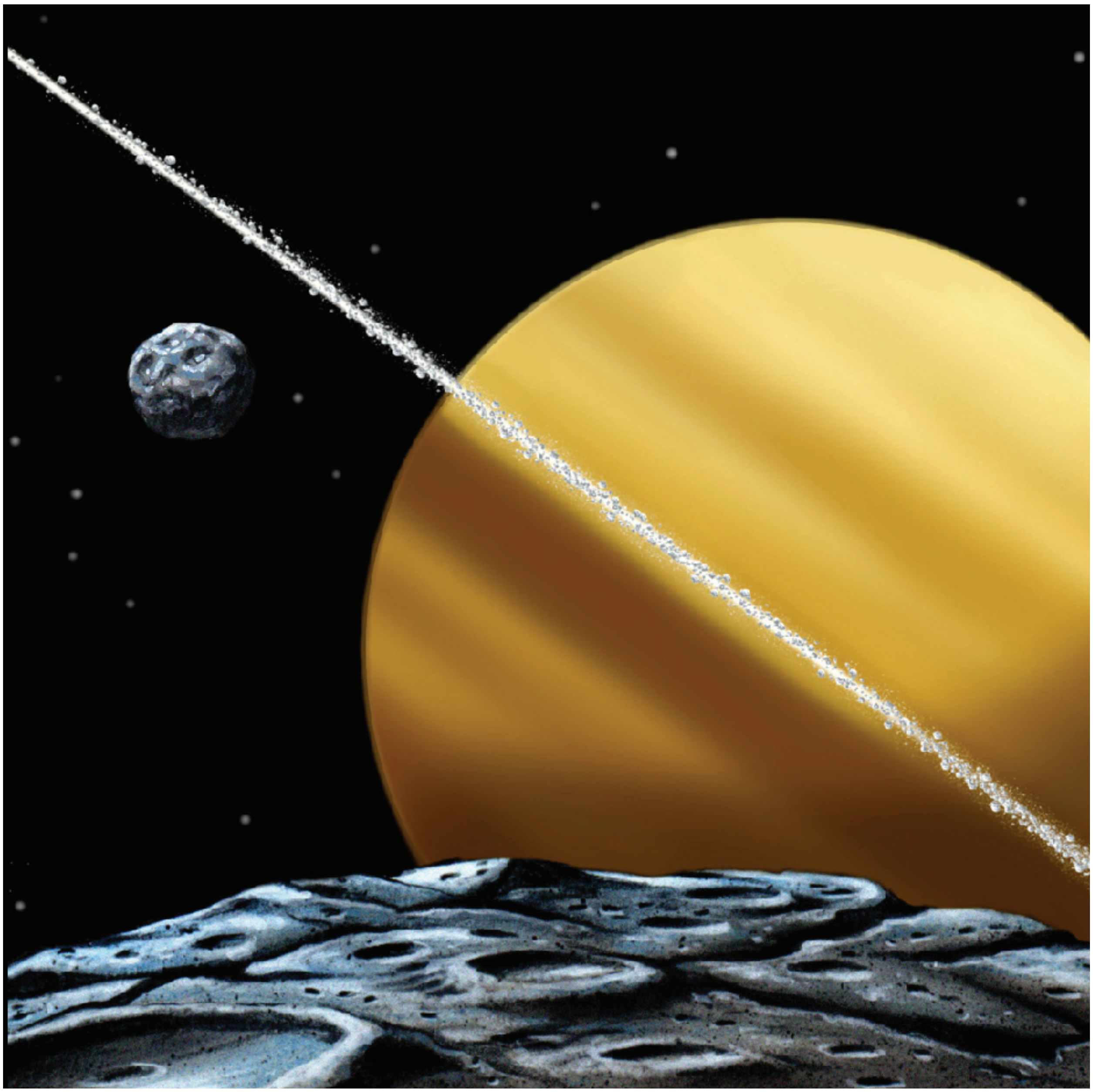
Saturn's Moons

Questions, Answers, and Cool Things to Think About



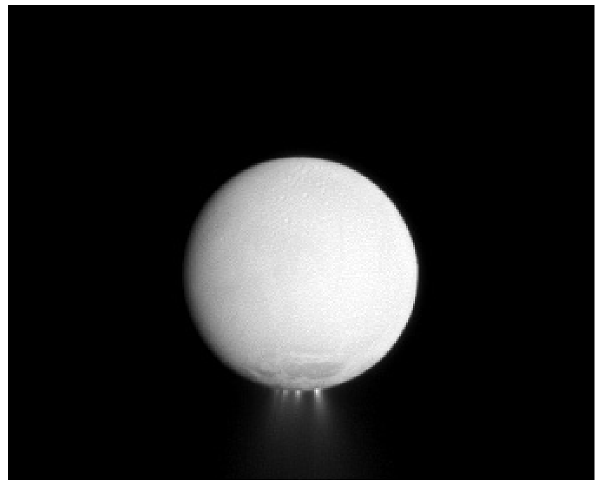
Discovering Saturn: The Real Lord of the Rings

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.

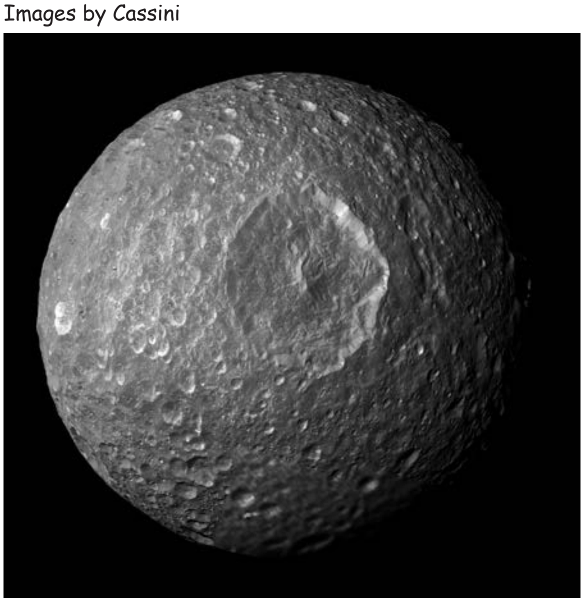
Iapetus (eye-A-pe-tus) may be the strangest of Saturn's moons. It looks like a big ball that's chocolate on one side and vanilla on the other side!

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!

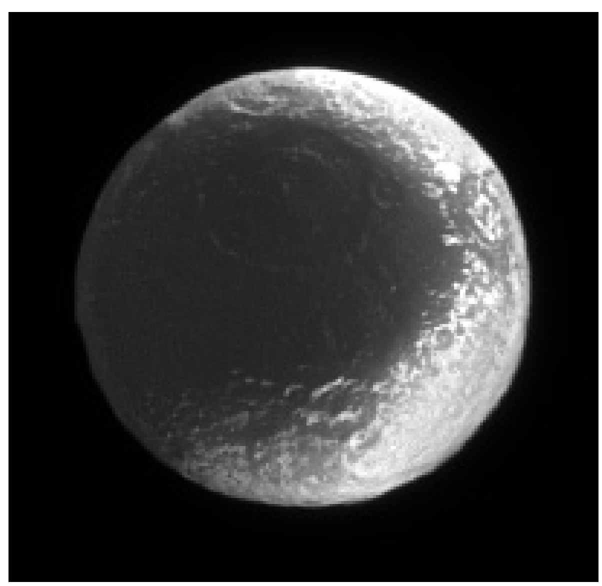
Titan's surface is hidden beneath a thick, deep-orange haze. But radar can "see" through the haze, and scientists on Earth using a powerful radar system to bounce microwaves off the giant moon found what they thought might be huge lakes or oceans on Titan. But there was no clear evidence yet.

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.

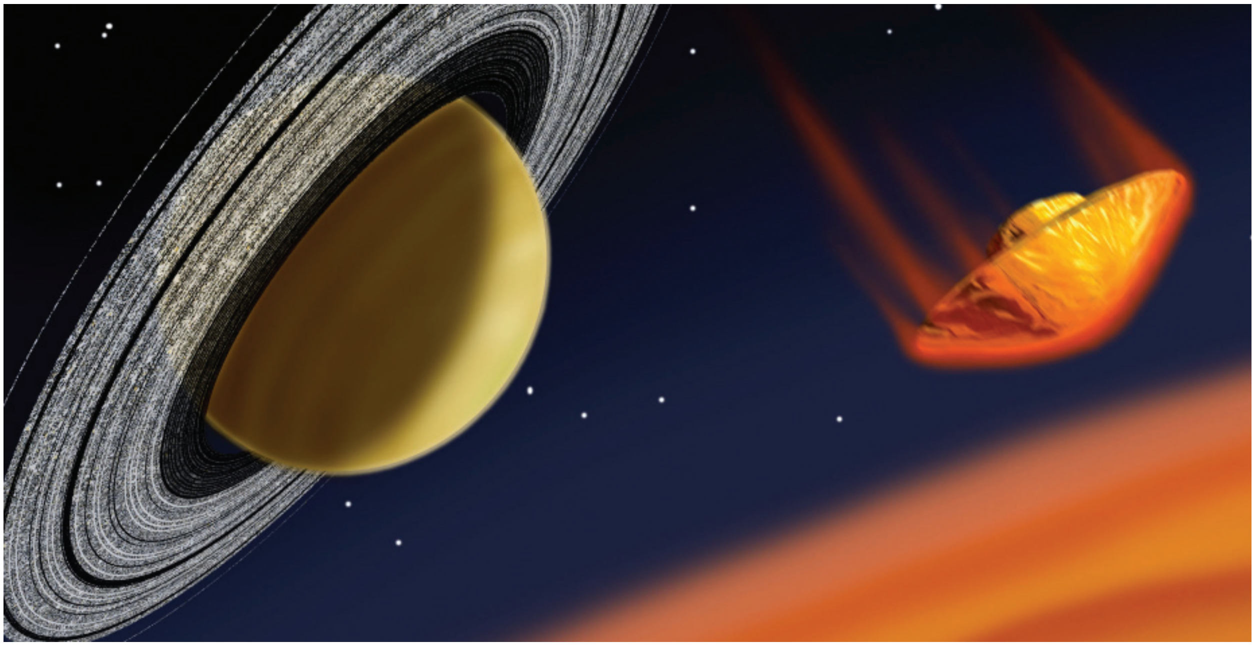
Images by Cassini



Mimas



Iapetus

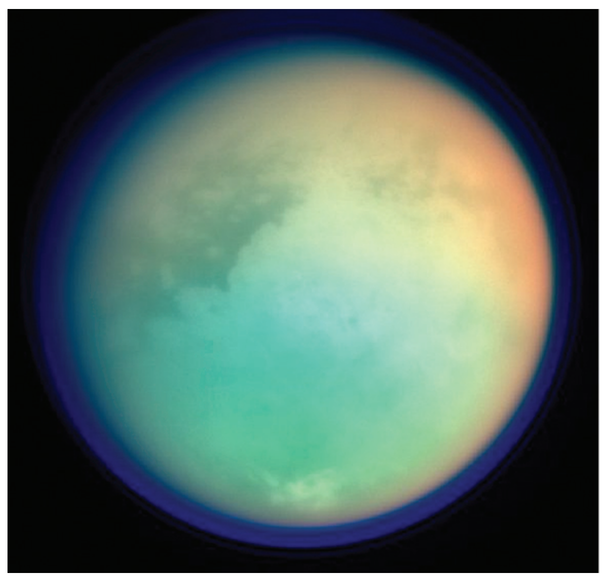


Before its parachutes opened, Huygens began to fall through Titan's atmosphere.

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

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

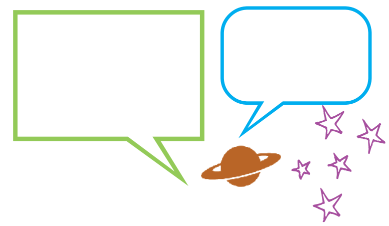
How many moons does Saturn have?	Which moon is a very cold version of early Earth?	Why don't some of my rings drift or fall apart?
My rings were named in what order?	Which moon has a crater that is one-third its total size?	Which moon is vanilla-colored on one side and chocolate-colored on the other?
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

MORE THAN 60	MIMAS	LIQUID METALLIC HYDROGEN
GRAVITY FROM THE "SHEPHERD MOONS"	IN THE ORDER THEY WERE DISCOVERED	TITAN
UPPER ATMOSPHERE	9.5	CASSINI-HUYGENS

Activity 3 Materials

ICY ROCK AND ICE PARTICLES	ROMAN GOD OF AGRICULTURE	GAPS
29 ½	HYDROGEN, HELIUM, METHANE, AMMONIA, OTHER CHEMICALS	10.7
LIQUID MOLECULAR HYDROGEN	TRADE ORBITS	IAPETUS

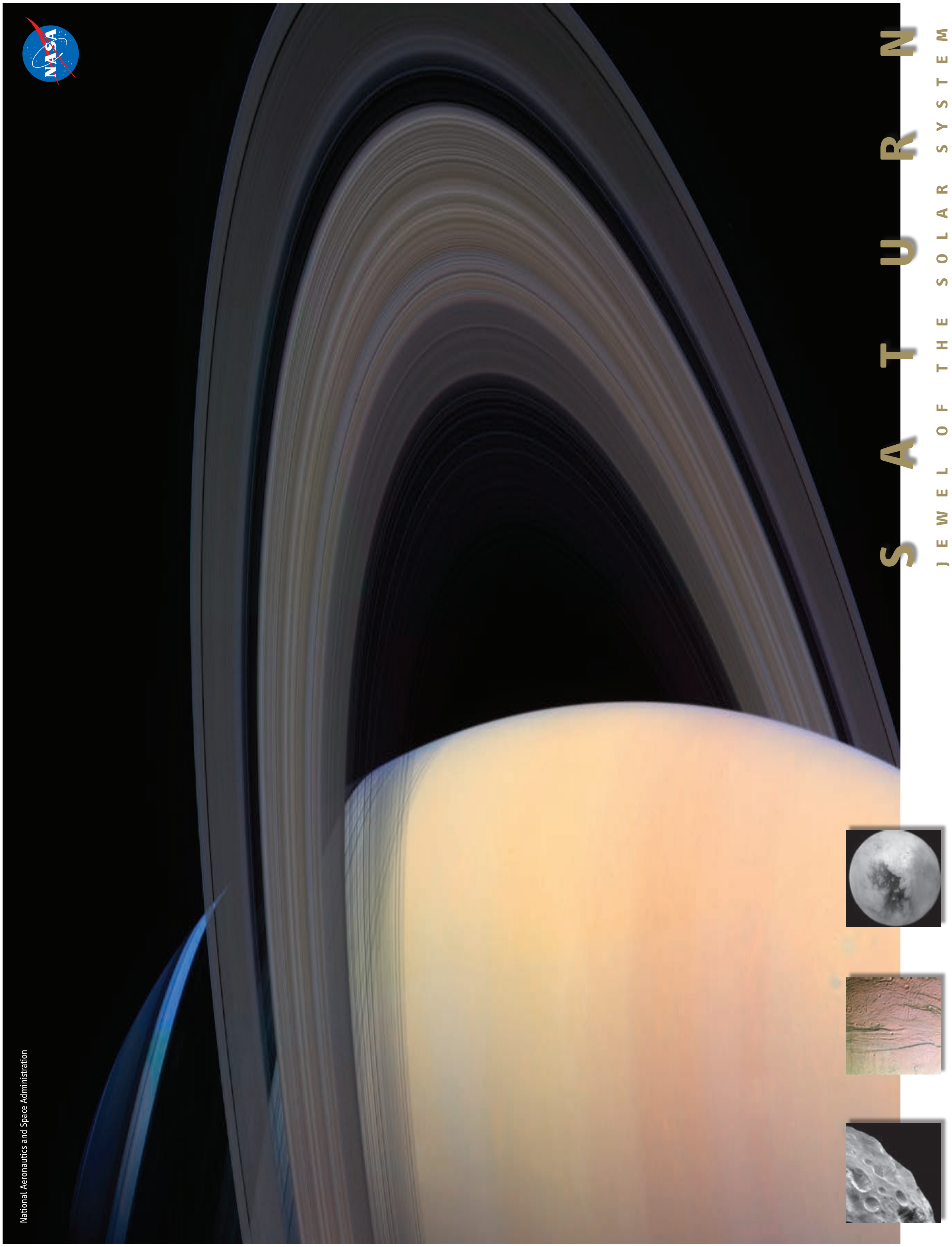


How many "Earths" would make up my diameter?	9.5
How many Earth hours long is my day?	10.7
How many Earth years long is my year?	29 ½
Where did my name come from?	ROMAN GOD OF AGRICULTURE
Which spacecraft visited me with a probe?	CASSINI-HUYGENS (cuh-SEEN-ee HOY-gens)
My layers have gas and ice particles 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

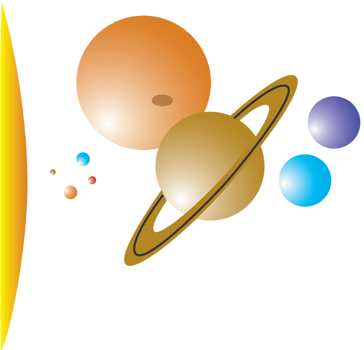
Poster Art


National Aeronautics and Space Administration
NASA
Features on Titan such as volcanoes, sand dunes, lakes, and a nitrogen-rich atmosphere are analogous to those on Earth. The Cassini mission discovered that Titan's lakes are filled with liquid hydrocarbons, making this moon of Saturn the only body in the solar system beyond Earth known to have liquid on its surface.
Titan
B E H I N D T H E V E I L

Poster Art



Activity 3 Materials



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

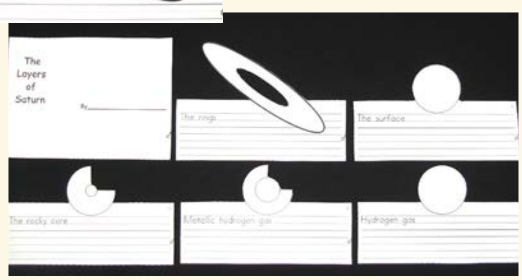
Earth and Space Science

- Structure of the Earth system

Equity/Leveling the Playing Field

- In this activity, youth present their work to the group. This may be more comfortable for some than others.
- Create an environment where they will feel comfortable presenting in front of the group telling them that they should think of themselves as "critical friends" who give positive constructive input.
- Explain that critical friends will give positive feedback and helpful suggestions for improvement.
- "Mirroring" is a good way to ensure this will happen, such as: "What I like about your work is..." "What you drew that is missing from my drawings is…"
- This can be followed by a "critical friends" statement, such as "What I would change about your drawing is…"
- Emphasize the idea of being supportive and helpful.

Materials



From Your Supply Closet

Session	For Students
1	Crayons Scissors; paper clips Silver glitter glue (optional)
2	Stapler Black construction paper, 8-1/2 x 11, cut in half

From a Photocopier/Printer

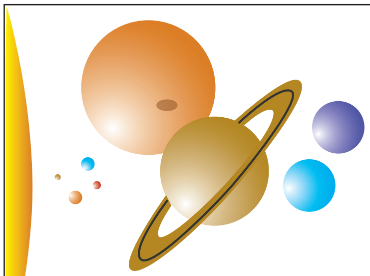
Session	For Leader	For Students
1	For optional leader reading: a copy of the mini-book "Saturn from the Outside In" (from Activity 3 — "Discovering Saturn: The Real Lord of the Rings") Several color images of Saturn of your choosing. Find them embedded in this guide, or go to: saturn.jpl.nasa.gov/photos	*The Layers of Saturn* 3-d book pages (a complete copy for each student)
2	For optional leader reading: a copy of the mini-book "Those Amazing Rings" (from Activity 3 — "Discovering Saturn: The Real Lord of the Rings") *The Ringed World of Saturn* Leader Instruction Sheet	

Getting Ready

Cut the black construction paper pieces width-wise (to make pieces about 4 x 6 inches).
Cut your own 3-d book pages. Cut along the line above the writing space, following the upper shape of the rings or the planet. Be sure to cut the oval inside the rings.

Leader Tips

- Practice cutting and constructing the 3-d book in advance.



Saturn’s Fascinating Features

Student Activity

Session 1 • Creating the Book Pages

(Optional) Leader Reading — Read aloud the second and third paragraphs of page 3 from the mini-book “Saturn — From the Outside In,” showing the illustrations.

Distribute one set of *The Layers of Saturn* book pages plus one piece of black construction paper to each student. The black paper will serve as the back cover for their books.

1. Model for the group how to cut each of the pages. Cut along the line about the writing space, following the upper shape of the rings or the planet. Be sure to cut the oval inside the rings.

2. Show the group the latest pictures of Saturn from books, the Internet, posters, or newspapers to give the students an accurate picture of what Saturn looks like. If you are limited on Internet access, show them pictures embedded throughout this guide. For excellent images, visit: saturn.jpl.nasa.gov/photos

3. Have the youth use crayons to color the various pages of Saturn. Explain to them that the colors they see in pictures of Saturn and its rings are often enhanced or color has been added to the images to bring out details. Suggested colors for the pages are as follows:

Features of Saturn	*Colors*
Rings	Light brown
Surface	Yellow or tan with wide brown stripes
Rocky Core	Orange
Metallic Hydrogen Gas	Orange and brown
Hydrogen Gas	Yellow

4. If you are using optional silver glitter glue, put a small amount of it on the rings and ask the youth to spread it around the rings to make them look icy.

5. Ask them to draw/decorate the frozen moons of Saturn on the inside of the back cover. They can be labeled. Don’t forget that Titan is the largest!

6. To add stars to the background, the youth can dot a small amount of glitter glue to the top half of the black construction paper.
7. Set the pages aside to dry.

Session 2 • Writing the Book

1. (Optional) Leader Reading — Read aloud all of page 3 from the mini-book "Those Amazing Rings," showing the illustrations.
2. Return the pages of the 3-d books to the youth.
3. Ask them to listen very carefully to what you are about to read about Saturn (using *The Ringed World of Saturn* Leader Instruction Sheet).
4. After you have read about each of Saturn's features, stop and ask the students to write in their books on the page that corresponds to the content you just read. Here are some sample sentences to show what successful youth writing may look like:
   - The rings: Saturn has rings. The rings are icy. The rings are big. The rings have gaps. One is the Cassini Division.
   - The surface: Saturn is cloudy. Saturn is windy. The wind makes Saturn look striped. Saturn's winds are fast.
   - The rocky core: The core is metallic — iron — surrounded by molten rock.
   - Hydrogen gas layer: The first layer of gas is hydrogen gas. Saturn has gases. You cannot stand on Saturn.
   - Metallic hydrogen gas layer: Saturn is made of different gases. This layer is hot.
   - The gases spin fast on Saturn.
5. Consider reading parts of the script again to assist the students in selecting information.
6. Staple the pages along the left edge of the bottom half of the black construction paper when the writing is complete.
7. Slip the planet into the rings and the book is complete.

Questions for the Youth (Informal Assessment)
- What is Saturn's system like?
- What Saturn layer would you like to visit? Why? Would you need special equipment? (Some ideas could be a protective suit, an airplane to fly through clouds, etc.)
- What other activities can the group do to learn more about what Saturn is like?

Sharing the Findings (Informal Assessment)
- Have the youth practice reading their books to each other.
- Have the youth make presentations to the group or to other groups.

Leader Reflection/Assessment
At the end of this activity, think about the following:
1. Were the children happy with and proud of their books?
2. Were they comfortable reading their books out loud, or presenting?
3. Were they interested and engaged in creating the books?

Glossary
Core — Center, middle, center of the mass.

Information for Families

Creating 3-d "books" is a great way for young people to become the "experts" on any topic.

Encourage parents to include their youth's Saturn book in the family library. Ask parents to help their child create a page labeled "About the Author."

Parents can go to the Cassini website with their child to collect information for a "Ten Facts About Saturn" book.

NASA Resources

Role Model Resource

Amy Simon-Miller is an astrophysicist at Goddard Space Flight Center, specializing in planetary atmospheres of the giant planets. She is a Co-Investigator for one of Cassini's instruments, responsible for science planning, command design, and data analysis. When Dr. Sally Ride became the first American woman in space, Amy knew then that she wanted to study space and work for NASA. One highlight in her career has been watching comet Shoemaker-Levy 9 fragments hit Jupiter from behind the scenes at the Space Telescope Institute. "We were just blown away by the spectacular images and the marks left by each impact."

"Sometimes you have to tackle a problem from many different ways to understand it and you should never be afraid to ask for help until you do understand," Amy says regarding science careers. "To advance in any field, we need people who think about problems in different ways!"

Read more about Amy at: solarsystem.nasa.gov/people/profile.cfm?Code=Simon-MillerA

Other Resources

Download wallpaper for the classroom computer! www.jpl.nasa.gov/spaceimages/searchwp.php?category=saturn

Taking Science to the Next Step

Give the youth time to go to the NASA website at www.nasa.gov. Encourage them to "surf" the site looking for more Saturn information to add to their Saturn logs or the Saturn books.

Ask them to brainstorm a list of questions they have after making the Saturn books.

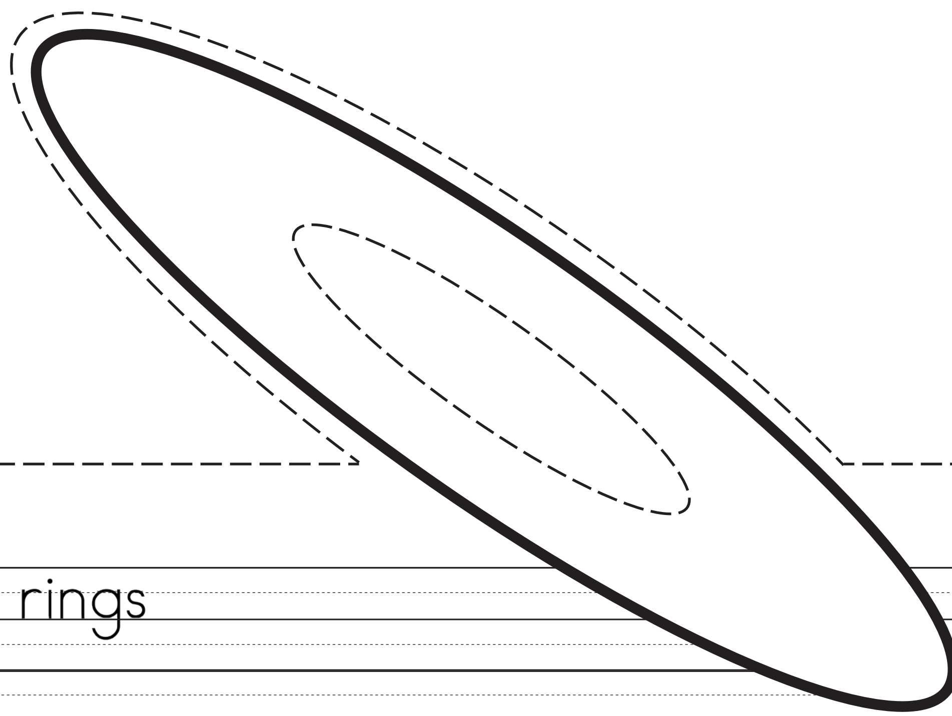
Literacy

Ask the youth to write a story about traveling to Saturn's moons. Encourage them to include information from the script.

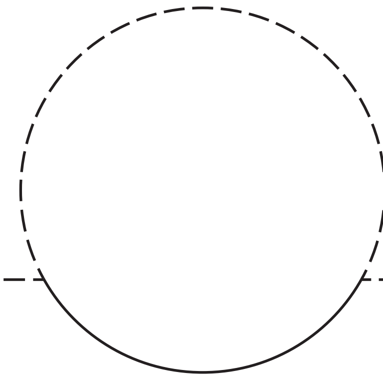
Have the youth add a page labeled "About the Author" and have them write a couple of paragraphs about themselves and their interest in Saturn.

The Layers of Saturn

By________________________

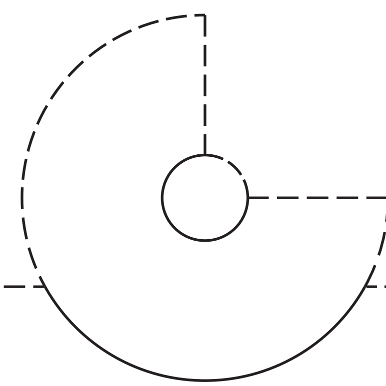


The rings



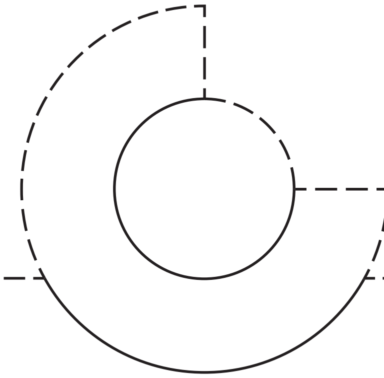
2

The surface



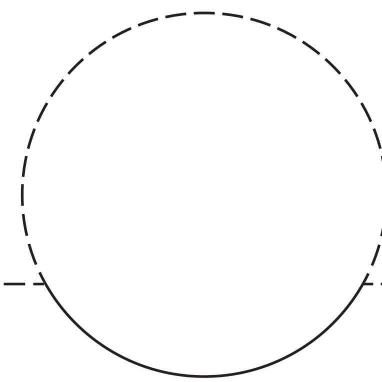
3

The rocky core



4

Metallic hydrogen gas



5

Hydrogen gas

The Ringed World of Saturn

Saturn is the sixth planet from the Sun. Because it is so far from the Sun, it doesn't get much sunlight and it is very, very, very cold! It is much sunnier and warmer on Earth. Don't worry about getting a sunburn on Saturn!

Saturn moves much slower in its orbit around the Sun than Earth does. It takes Earth one whole year — 365 days — to go all the way around the Sun. But it takes Saturn almost 30 Earth years to go all the way around the Sun! That's a long, long time.

The first thing most people notice about Saturn is its very special rings. They are very, very big. Saturn is far, far away from us — so far, in fact, that Saturn looks a lot like a small speck of light in the sky. While the Cassini spacecraft is close to Saturn and its rings, we are finding many new things about Saturn and what is around it.

Let's begin our trip to Saturn.

Imagine you are the Cassini spacecraft and you have been on the very, very long trip to Saturn. The trip from Earth to Saturn takes about 7 years, traveling day and night! Space is a very, very big place! After being in space for all that time, you see a beautiful planet in the distance. As you get closer, you realize it is a huge gas planet with rings. What do you think it is? It's Saturn!

First Stop — The Rings

You might think there are only two rings around Saturn, but hundreds of rings form the ring system of Saturn. Scientists use letters to name the rings, and they have named 7 ring zones so far. We can see some of the rings from Earth using telescopes. We can observe the outer zone, called the A ring, and the brighter, inner zone called the B ring. The big space between the A and B rings is called the Cassini Division.

The rings are very wide, but very thin! Some of the rings look like they are braided — they are pretty complicated. Some of the rings even look twisted. There are also some small moons in the rings.

The rings are made mostly of chunks of water ice and ice-covered rock. Some of the chunks are small and some are pretty big — some are the size of a grain of sand, some are as big as a house. The rings do not stay in one place, but orbit Saturn, just like Earth orbits the Sun. Things are really moving in space!

Saturn's Surface

Saturn is covered with thick clouds. The top layer of the clouds is very cold. We have seen big storms in Saturn's clouds. It is very windy on Saturn. The clouds move and make Saturn look striped. The moving clouds give Saturn the swirling yellow and gold cloud bands that we see. Saturn also has big white spots. Scientists think the white spots may be big storms.

Now let's look past the clouds at Saturn's core and its gas layers.

Saturn's Core

The very center of Saturn is called the core. The core is metallic — iron — surrounded by molten rock. Molten means melted — the center is made of liquid rock. Earth's core is also made of molten rock. Why do you think it is liquid rock? The reason is, it is very, very hot and rock that is so hot melts into a liquid, like lava from volcanoes here on Earth.

Saturn's Inner Layer — Metallic Hydrogen Gas

Except for the core, Saturn is made of lots of gas. One of the inner layers of Saturn is made of a gas or liquid called hydrogen (when it is hot and deep inside the planet there is no difference between gas and liquid). Don't forget we are still pretty close to the core of Saturn and it is very, very hot! Saturn isn't very dense because it is made mostly of hydrogen. If you ever got close to Saturn, you could put your hand right through it. Remember, Saturn is not solid like Earth, but a big ball of gas and liquid. You would sink into Saturn if you ever visited it. Scientists want to know more about the gases on Saturn.

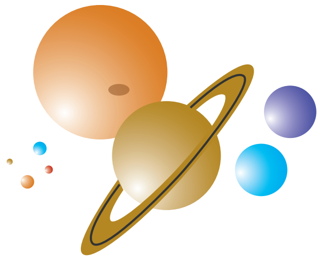
Saturn's Outer Layer — Hydrogen Gas

We find hydrogen gas in lots of places in the solar system. Not all parts of Saturn move at the same speed. When Earth spins, it all moves together because it is solid. (Remember, the water in the ocean is sloshing around on solid ground!) When Saturn spins, some parts move faster and some parts move slower — because it is made of gas. Isn't that surprising?

Saturn's Neighbors

Saturn is not in space all by itself. Many icy, frozen moons orbit around Saturn. Some of the moons are in the rings, but most of them are a little farther from Saturn. Earth has only one moon, but Saturn has more than 60 moons. It's kind of crowded up there with all those moons. Saturn's biggest moon is named Titan.

Can you think of something else that is in the sky? (Hint — we see them twinkle at night.) Stars! The stars are really far away from Saturn, but we can still see their light as they shine in the sky.

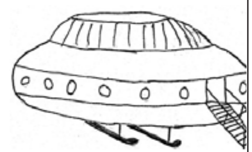


Activity 5
My Spacecraft to Saturn

Overview

During this activity, your youth:

- Can connect with the Cassini spacecraft and the designers who built it — by thinking like engineers.
- Follow the engineering process of building a spacecraft through team discussion, design drawing, model construction, and peer presentation — which emulates steps taken by the Cassini team in designing a spacecraft to travel to Saturn.
- Create and present their design drawing and their model spacecraft.
- Work as an engineering team to make changes, as in the engineering design process.
- Make and Take: A model of a spacecraft to go to Saturn, working together as a team.

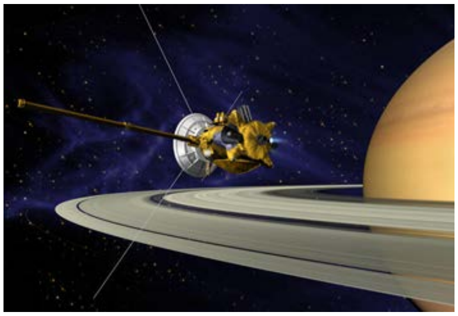


Time/number of sessions	Activity Type	Space Needed
Four 40-minute sessions	Hands-on construction	Classroom or cafeteria, space with tables and chairs

Activity Goals

Students will:

- Learn the way in which the requirements of space travel impact design of a spacecraft.
- Learn the value of "peer review" and revision as a normal part of the engineering design process — they learn to compare and contrast their solutions with the solutions of others.
- Learn to use illustrations with text to communicate their ideas to peers.



Where's the Science and Engineering?

- This activity presents an engineering challenge based on the science information students now have on Saturn and Cassini.
- Robotic exploration spacecraft are "built-to-order" to achieve specific science goals — they aren't typically "off-the-shelf." For the Cassini mission, the spacecraft was specifically designed for its destination, the distance, the risk and challenges of space, and the requirements of the science team's experiments to answer questions. It's the job of an engineering team to translate the goals of the scientists' experiments into the design and construction of a spacecraft.
- A robotic spacecraft has to be able to do many of the things we do as humans, but without our presence:
    - — "See" to navigate and send back pictures
    - — "Touch" with special instruments that can take samples
    - — "Hear" from and "speak" to engineers on Earth, through the use of communication antennas
    - — "Think" with computers and instruments that make measurements

National Science Education Standards

K–4

Technology
- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives
- Personal health

5–8

Physical Science
- Properties and changes of properties in matter
- Motions and forces

Science and Technology
- Understandings about science and technology

Science in Personal and Social Perspectives
- Populations, resources, and environments
- Natural hazards
- Risks and benefits

The National Science Education Standards state that students should be able to design solutions to problems. Drawing illustrations with accompanying text is a powerful way for students to organize and express their thinking.

Equity/Leveling the Playing Field

- In this activity, students are asked to brainstorm ideas. It is important to create an environment where all ideas are valued so that students will be more likely to share their ideas safely.
- Occasionally other students will laugh or ridicule ideas (or performance). Set the stage early — remind students to be courteous, that everyone's ideas are important, and that things we thought silly at one time are fact now (people have walked on the Moon, we've taken a peek at another world, we have evidence of planets around other stars!).

Materials

From Your Supply Closet

Session	For Students	
1 & 2	• Pencils and paper	
3	• Clean recyclable items (for example, empty cereal or pasta boxes, paper towel tubes, plastic bottles, etc.) • Pipe cleaners • Tape • Paper fasteners	• String • Paper • Aluminum foil • Glue

From a Photocopier/Printer

Session	For Leader	For Students
1	• *Designing a Spacecraft Script*	• *Design Questions* student handout

Getting Ready

- Read and review the activity step-by-step instructions in the "Do It!" section.
- Ask students to bring clean recyclable materials (cereal boxes, paper towel tubes, empty plastic bottles, etc.) from home to be used as building materials for the model.
- Gather recyclable materials from your site to have available as building materials.

Leader Tips

- While there are some interesting similarities in the functions of a spacecraft and those of humans, watch your students for signs of misconceptions that robotic spacecraft work just like a human body; for example, that spacecraft breathe or speak a human language.

My Spacecraft to Saturn

Activity 5

Student Activity

Session 1 • Brainstorming

1. Tell your group that they are going to be working today to design a spacecraft to go to Saturn. Read *Designing a Spacecraft Script* aloud to the group.
2. Organize the students into teams of three or four. Ask them to spend a few minutes brainstorming a way to protect their spacecraft in the space environment. Bring the group back and ask students to share their ideas.
3. Tell your students that they will work as design teams and record their ideas. Give each team a copy of the *Design Questions* student handout.
4. Ask the design teams to proceed in designing and sketching their spacecraft.
5. Circulate throughout the room to assist the students as they complete their designs.

Session 2 • Revising the Plans

1. Have each team share their spacecraft designs with the larger group.
2. Encourage the large group to offer a friendly critique of the designs as they are presented.
3. Ask the teams to revisit their designs to fine tune them and incorporate their peers' suggestions if they feel the suggestions are appropriate.

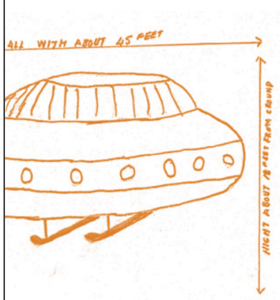
Session 3 • Building the Models

1. Have the students join their original teams.
2. Ask the students if they are satisfied with their designs. If not, allow them time to revisit and refine their designs. If so, tell them that they are going to build a model of the spacecraft based on their drawings.
3. Put all of the building materials out and ask the teams to think about how they can be used to make a model of the spacecraft in their sketches.
4. Remind the students to work together as a team. Ask students to make a "materials" list for their model and, when the group agrees on the list, take the materials back to their table.
5. Give students time to complete the model.
6. After they have completed building the model, ask them if they made changes to the design as they worked. If so, ask them to reflect those changes on their drawing.

Session 4 • Presentations

Ask each team to present their drawing and model. Ask them to:

1. Talk about their design process and the decisions they made in selecting that design.
2. Show their drawing and describe it.
3. Show their model and describe how they took a 2-dimensional drawing and created a 3-dimensional structure.



Questions for the Youth (Informal Assessment)

- What kind of changes happened when you translated the 2-dimensional design into a 3-dimensional structure?
- Did your design change as you started building? Discuss why or why not.

Sharing the Findings (Informal Assessment)

Have the class share things they like about each other's work, questions they have, and suggestions for the presented designs.

Leader Reflection/Assessment

Between sessions, ask yourself the following questions:

1. Are the students able to meet challenges or brainstorm successfully?
2. Did everyone participate? Did everyone feel comfortable sharing his or her ideas?
3. Were the students able to devise creative solutions to design challenges?

Encourage your students to visit the Cassini–Huygens website to see where Cassini is now, find more images of Cassini, and learn more about the spacecraft and the mission — saturn.jpl.nasa.gov/

Information for Families
Cassini on parade! A 50-foot tall robot featuring a "Family of Explorers" skated down Colorado Blvd. in Pasadena, California, during the Tournament of Roses Parade on New Year's Day 2005. Ten NASA spacecraft were featured in this float, made with 500 pounds of seed and 750,000 flowers! The crown jewel at the top of the robot's head was the Cassini spacecraft, sent to study Saturn. See the back of this page for a picture of the float that you can send home for families to enjoy, or view it at:
spaceplace.nasa.gov/robot-float

Get fun facts about the Cassini spacecraft at:
saturn.jpl.nasa.gov/kids/fun-facts-spacecraft.cfm

The Space Place offers simulations and space technology games for young children
spaceplace.nasa.gov/menu/people-and-technology

NASA Resources

Careers at NASA
Hear NASA/JPL mechanical engineer and mentor Kobie Boykins explain that curiosity and a variety of interests make for a great work intern. They are also creative, innovative, good organizers, big thinkers, and detail-oriented; they write well, and they can be influencers, competitors, and collaborators.
www.jpl.nasa.gov/education/videos/playVideo.cfm?videoID=2

Role Model Resource
Shonte Tucker is a thermal engineer at JPL, ensuring that items on a spacecraft are within flight temperature limits while making minimal use of spacecraft resources. Her job is critical to missions, because if an instrument's temperature range is not properly controlled, it may be unable to perform the task for which it was intended. Shonte advises students to "stay in school and have dreams, take as many math and science classes as possible, and don't give up your options. The skills acquired to fulfill a dream in one career direction could be used for a career in a completely different direction."

Read more about Shonte Tucker at:
solarsystem.nasa.gov/people/profile.cfm?Code=TuckerS

Resources
Where Is Cassini Now? Visit the Cassini website at saturn.jpl.nasa.gov for more information on Saturn and to view "Cassini Status."

See the Cassini spacecraft's "almost human" features at: saturn.jpl.nasa.gov/spacecraft/overview/

Taking the Science to the Next Step
Have the students write a paragraph describing everything about their spacecraft. For an extra challenge, you can hang the sketches of spacecraft around the room, and have the class members work in pairs to match descriptive paragraphs to the actual sketches.

Build a paper model of the Cassini spacecraft (or others):
solarsystem.nasa.gov/kids/papermodels.cfm

Spacecraft Design Research: After students finish their designs, you can encourage them to go to the NASA solar system website at
solarsystem.nasa.gov/missions
to look at other spacecraft and think about how the designs are the same or different from Cassini.

There are two NASA student-friendly interactive websites to see spacecraft and to virtually design and build a spacecraft of your own:
virtualfieldtrip.jpl.nasa.gov
www.jpl.nasa.gov/education/BuildMissionGame.cfm

Learn how robotic spacecraft communicate with people on Earth (requires free Adobe Flash™ download):
spaceplace.nasa.gov/dsn-game

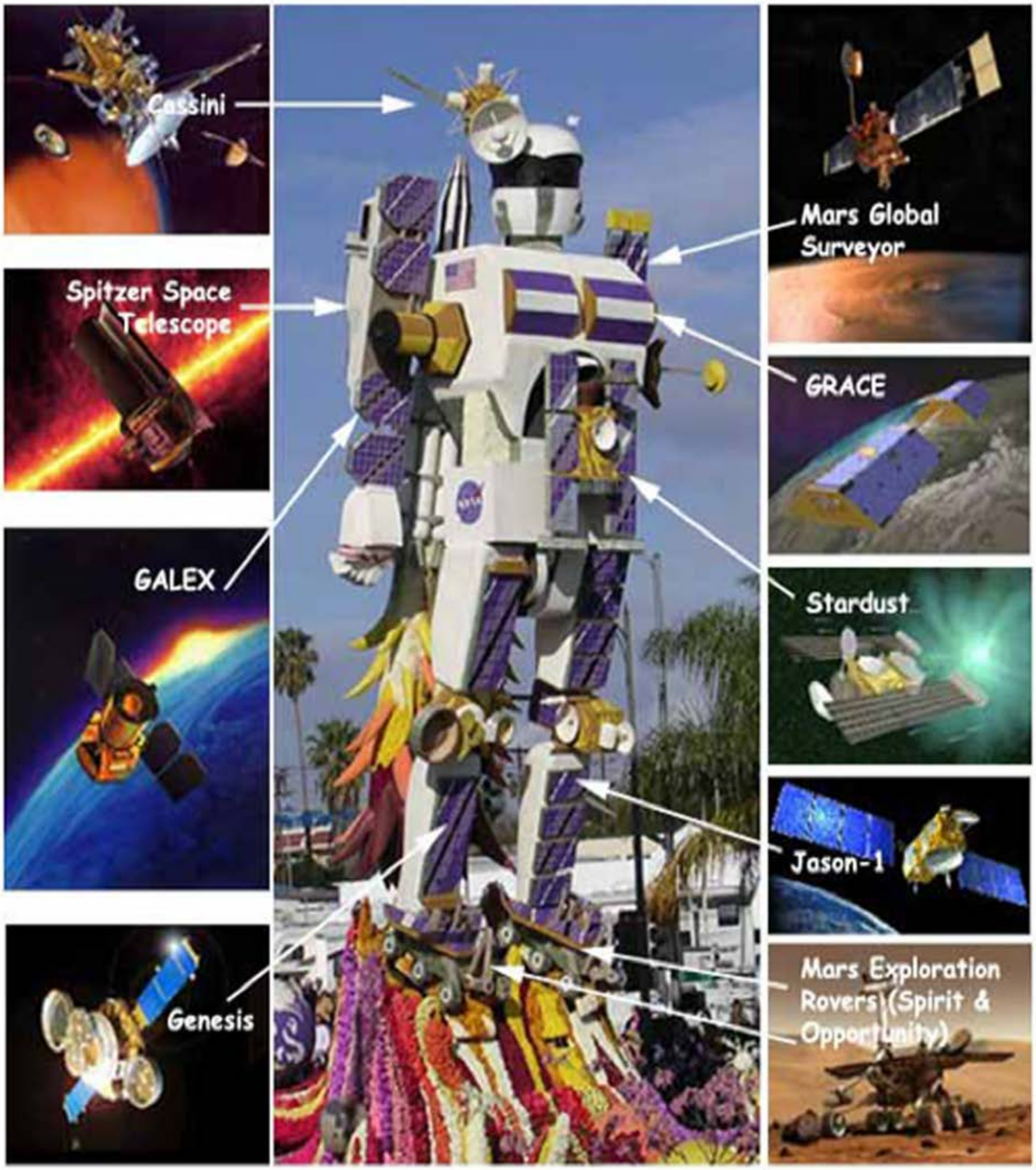
Literacy
Ask students to write a paragraph comparing a human to a Cassini spacecraft. Have students write one paragraph about how they are the same and another paragraph about how they are different.

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. As a group, ask students to write a song about Saturn to the tune of Old MacDonald.

Family of Explorers



Cassini on parade! A 50-foot tall robot featuring a "Family of Explorers" skated down Colorado Blvd. in Pasadena, California, during the Tournament of Roses Parade on New Year's Day 2005. Ten NASA spacecraft were featured in this float, made with 500 pounds of seed and 750,000 flowers! The crown jewel at the top of the robot's head was the Cassini spacecraft, sent to study Saturn.

Designing a Spacecraft Script (For Leader)

Today you are going to think like an engineer. Many of the people who work at NASA are engineers. It's the job of an engineering team to design and build a spacecraft to help answer the questions that scientists have.

Cassini is a one-of-a-kind spacecraft that was specifically designed to go to Saturn, to be able to travel the distance, to survive the risk and challenges of space, and to learn about Saturn, its rings, and its moons.

Here is your design challenge for today. How can you design your team's spacecraft to fly all the way to Saturn — about 800 million miles away from Earth? (Engineers often work in metric units — so Saturn is about 1,300 million kilometers away from Earth.)

A robotic spacecraft has to be able to do many of the same things we do as humans, while it is far away from our control:

- "See" to navigate and send back pictures
- "Touch" with special instruments that can take samples
- "Hear" from and "speak" to engineers on Earth, through the use of an antenna to communicate back and forth
- "Think" with computers that keep the spacecraft safe and take care of all the data from the instruments

To design your spacecraft, you and your design team are going to work together and make decisions about the following things.

- How will you protect the spacecraft in the icy cold temperature of deep space?
- How will you control and keep in touch with your spacecraft?
- How will you keep the spacecraft safe if it is hit by a space particle (a dust particle or ring particle)?

- What science question do you want the spacecraft to explore when it gets to Saturn?
- Do you think you should send humans on the spacecraft? If you think you should send humans, how will they survive? [Prompts: Food and water for 7 years? Bathroom/waste? Air?]

- What are some challenges that might be encountered with the spacecraft on the journey to Saturn?
- What will you name your spacecraft?
- Why did you choose that name?

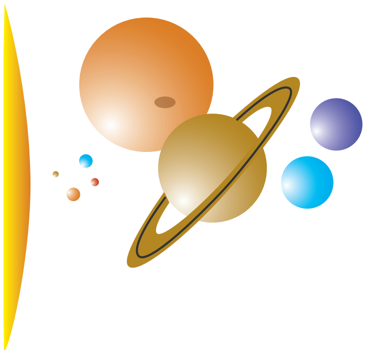
It's the job of an engineering team to design and make a "built-to-order" spacecraft to help answer the questions that scientists have. Once you think of possible solutions to these design challenges, your design team will draw a sketch of your Saturn spacecraft. Remember to include everyone's ideas!

Design Questions (For Students)

Here is your design challenge for today. How can you design a spacecraft that will make it all the way to Saturn — about 800 million miles away from Earth? To design your spacecraft, you and your design team are going to work together and make decisions about the following things.

- How will you protect the spacecraft in the icy cold temperature of deep space?
- How will you control and keep in touch with your spacecraft?
- How will you keep the spacecraft safe if it is hit by a space particle (a dust particle or ring particle)?
- What science question do you want the spacecraft to explore when it gets to Saturn?
- Do you think you should send humans on the spacecraft? If you think you should send humans, how will they survive?
- What are some challenges that might be encountered with the spacecraft on the journey to Saturn?
- What will you name your spacecraft?
- Why did you choose that name?

Once you think of possible solutions to these design challenges, your design team will draw a sketch of your Saturn spacecraft. Remember to include everyone's ideas!



Activity 6
All About Titan and the Huygens Probe

Overview

During this activity, your youth:

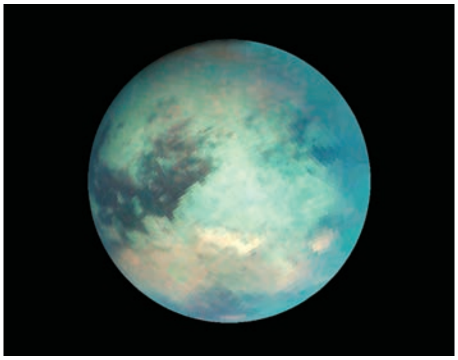
- Are introduced to Saturn's largest moon, Titan, and the history of and science questions for the Huygens Probe from the Cassini–Huygens Mission.
- Listen to a fictional narrative "told" by the Huygens Probe entitled *Memoirs of a Spacecraft*, which includes real science and engineering facts.
- Hear about the findings of the Huygens Probe about Titan, and express those findings through their own drawing.
- Use their imaginations to personalize themselves as robotic spacecraft and write a story, poem, or song about their own journey to Titan.

Time/number of sessions	Activity Type	Space Needed
Two 40-minute sessions	Art and creative writing	Classroom or cafeteria, tables and chairs

Activity Goals

Youth will:

- Increase their knowledge about Saturn's largest moon, Titan.
- Learn some of the science and engineering considerations that go into robotic spacecraft design and flight in space.
- Become familiar with the use of science instruments in space.



Where's the Science and Engineering?

- Engineers took the science questions for the Cassini–Huygens mission and interacted with scientists in different ways to express their concepts — from drawing and building models, to developing sophisticated computer plans. Once they had these plans, the engineers knew how to build the proper spacecraft and instruments for the mission.
- Instruments on the spacecraft function like the senses of our body, sometimes greatly enhanced. Each of the Cassini and Huygens instruments has a specific task to gather a certain kind of information (data).
- The Huygens Probe made several discoveries about the surface of Titan. Titan is like Earth in many ways but as much as it is similar, it is also extremely different. There are rocks, vast deserts with sand dunes, river-beds and lakes. But the rocks there are made of water ice, the deserts are hydrocarbon grains drifting down from the atmosphere and the rivers and lakes are liquid methane. Humans could not survive on this bizarre alien "Earth."

National Science Education Standards

K–4

Physical Science
- Properties of objects and materials

Personal and social perspectives
- Personal health
- Changes in environments
- Science and technology in local challenges

Technology
- Abilities of technological design
- Understandings about science and technology

5–8

Physical Science
- Properties of objects and materials
- Transfer of energy

Science in Personal and Social Perspectives
- Populations, resources, and environments
- Natural hazards

Technology
- Abilities of technological design
- Understandings about science and technology

Equity/Leveling the Playing Field
- Students have many different kinds of learning styles. Some students learn best when they hear information — others when they see it. In this activity, information is read aloud.
- To support a greater number of students, consider charting the most important information and posting the story for student reference. The more ways a student experiences the information the more likely they are to retain it.

Materials
From Your Supply Closet

Session	For Leader	For Students
1	• Chart paper/whiteboard/chalkboard and markers/chalk	• Tape or glue for attaching drawings to pages of *Saturn Discovery Logs*
1 & 2		• Pencil, drawing paper • *Saturn Discovery Logs*

From a Photocopier/Printer

Session	For Leader
1	• Copy of *Memoirs of a Spacecraft — The Huygens Probe Encounters Titan* Read-Aloud Passage
2	• For optional Leader Reading: copy of the mini-book "Saturn's Moons: Questions, Answers, and Cool Things to Think About" (from Activity 3 — "Discovering Saturn: The Real Lord of the Rings")

Getting Ready
For Session 1
- Gather the *Saturn Discovery Logs* to pass back to students

Leader Tips

Session 1
- Practice reading *Memoirs of A Spacecraft — The Huygens Probe Encounters Titan*

Session 2
- For optional Leader Reading: Practice reading mini-book 4 — "Saturn's Moons."
- Some students may have trouble visualizing themselves as an object, especially one with parts similar to their senses. Walk around as they write their story and help them add what their "spacecraft senses" are learning to their story. Remember that instruments are doing the sensing, not our bodies.

All About Titan and the Huygens Probe

Student Activity

Session 1 • Listening to the Memoirs of a Spacecraft

1. Tell students:
   - As we've discovered already, the Cassini spacecraft dropped a special robotic spacecraft called the Huygens Probe onto the surface of Saturn's moon Titan. This probe has collected information that will help answer many questions about Titan, such as "What is the surface like?"

2. Ask the students what questions they have about Titan or the Huygens Probe. Chart their responses.

3. Tell the students that you will read *Memoirs of a Spacecraft* to them. Encourage them to take notes in their *Saturn Discovery Logs* as you read. Explain to them that they will draw what they think the surface of Titan looks like based on clues they hear in the story.

4. Remind the students that it is a story written from the point of view of the Huygens Probe. The probe is not alive, so this part of the story is fiction. However, they will also be hearing actual scientific information about the Cassini–Huygens mission and about Titan.

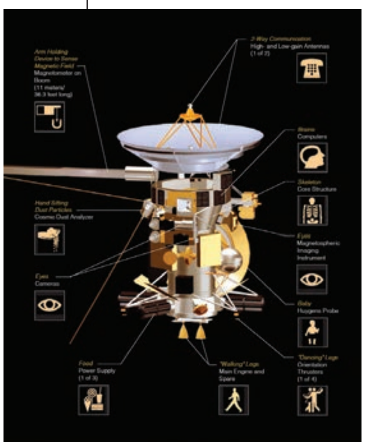
5. Read the *Memoirs of a Spacecraft — The Huygens Probe Encounters Saturn* to students. Remind students to take notes as you read to them.

6. Once the story is finished, have the students begin their drawing/sketch of Titan's surface based on the notes in their *Saturn Discovery Logs.* Tell them to label the parts of their drawing.

7. Tell the students that they will keep their drawings in their *Saturn Discovery Logs*. As they learn new information from the Cassini–Huygens mission, they can make changes to their drawings.

Session 2 • Writing About Our Spacecraft

1. (Optional) Leader Reading: Read aloud all but the last paragraph of page 4 from the mini-book "Saturn's Moons," showing the illustrations.
2. Prepare the students to pretend that they are a spacecraft probe sent to study Titan using the conversation guide below. (They learned some of this information in Activity 5, "My Spacecraft to Saturn.")
   - When the Cassini–Huygens scientists told the engineers what information they wanted to learn about Saturn and its moons, the engineers set to work deciding what kind of spacecraft should be built. In thinking about the data the scientists needed, the engineers had to decide what kind of instruments to build and how those instruments would be used to collect the right information.
   - Most instruments on the spacecraft function like the senses of our body, greatly enhanced. Each of the Cassini–Huygens instruments has a specific task to gather a certain kind of information (data).
   - The cameras are the eyes of the spacecraft because the team needed pictures of Saturn, its rings, and its moons. The computer on the spacecraft is like your brain running all the programs needed to keep the spacecraft safe and functioning. The spacecraft antenna is like your ears and mouth and it can both "hear" instructions from Earth and "speak" reports and data back to the team on earth.
   - Now, imagine that you have a science question you want answered and that your body is a spacecraft specifically built to go to Titan to find the answer. The instruments are like your senses and each has a specific job to do on your mission. The spacecraft looks very different from your body because it is built for space travel, but it performs many of the same jobs. Write about your journey through a story, poem, song, or rap. Be sure to answer the following questions:
     a. What does your spacecraft look like?
     b. In what ways does your body receive information and data like a spacecraft?
     c. How will your spacecraft get to Titan?
     d. What science question do you want to answer when you get to Titan?
     e. Why do you think your science question is important?



Available at:
saturn.jpl.nasa.gov/files/humanspacecraft.pdf

Questions for the Youth (Informal Assessment)

What are some reasons that knowing about Saturn and Titan is important?

Sharing the Findings (Informal Assessment)

- Give students time to share their drawings with partners and/or the whole group. Post their drawings, or direct the students to put them in their *Saturn Discovery Logs*.
- Ask the students to read their stories out loud. When they are finished, their stories should also go into their *Saturn Discovery Logs*.

Leader Reflection/Assessment

Ask yourself:

1. Did the students include information from the *Memoirs of a Spacecraft* in their drawings?
2. Can they clearly explain the different parts of their drawings?
3. Did others in the class comment with interest on each other's spacecraft designs?

Information for Families

Encourage the children to envision the food on their plate as the surface of a planet, and discuss with their family the different ways their body's "instruments" (senses) can detect what the food is like. Encourage them to describe to their families any kinds of food they think the surface of Titan might look like.

Encourage families to visit the Planet Quest website. Take an "alien safari" and find out about "extreme" life forms. Planet Quest has fun facts, animations, and "wild" information for families to share:
planetquest.jpl.nasa.gov/system/interactable/3/index.html

NASA Resources

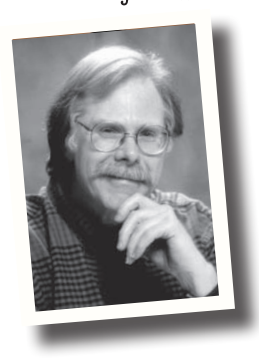
Careers at NASA

Give students an opportunity to learn what the folks at NASA's Jet Propulsion Laboratory experience. Read the staff blog at:
blogs.jpl.nasa.gov/

Meet members of the Cassini team and learn what they do at:
saturn.jpl.nasa.gov/news/cassiniinsider/

Role Model Resource

Jeff Cuzzi, Ph.D., is a research scientist at NASA Ames Research Center in Mountain View, California. One of his first jobs was lead scientist on the first Titan Probe study — an early concept in designing a probe mission to explore Titan — that helped lay the foundation for the Cassini–Huygens probe mission. Today, Jeff is the head scientist of Cassini's Rings Discipline Working Group, charged with leading Cassini's scientific study of Saturn's rings and its interactions with Saturn's environment. Jeff's favorite career moment was arriving at JPL for the Voyager 1 Saturn encounter and seeing the dozens of big media RVs lined up. Saturn was big news! "I was blown away by how well the images we had planned using my brightness models had turned out — beautiful, glowing images of the rings. Everyone was ecstatic, including me." In 2010, Jeff was awarded the Gerard P. Kuiper Prize, the most prestigious individual award in planetary sciences.



Read Jeff's profile at:
solarsystem.nasa.gov/people/profile.cfm?Code=CuzziJ

Read about the contributions of Jeff and his colleagues at NASA Ames Research Center to the Cassini–Huygens mission at:
www.nasa.gov/centers/ames/pdf/80661main_Cassini_Fact_Sheet.pdf

Resources

Hear all about Saturn and its moons in an interview with Bob Mitchell, Cassini mission Project Manager — podcast at
www.jpl.nasa.gov/podcast/cassini20080415.cfm

Watch an animation of the Huygens Probe's descent to the surface of Titan:
saturn.jpl.nasa.gov/multimedia/videos/movies/PIA06434.mov

Note to Leaders: What did Huygens find? Go online with your students to saturn.jpl.nasa.gov/multimedia/flash/Titan for an animated Flash™ video of Huygens on Titan that includes the latest pictures from that world. (Requires free Adobe Flash™ download.) Or download a poster on Titan: saturn.jpl.nasa.gov/education/titanposter/

See pictures of Titan — photojournal.jpl.nasa.gov/target/Titan

Taking Science to the Next Step

Ask the students to make a model of Saturn or Titan. Tell them to label any features they think are important. Have students bring recycled materials from home over the week before this project.

Here's an idea for making a model of Saturn from an old CD and a Styrofoam™ ball: solarsystem.nasa.gov/docs/saturn_model.pdf

Saturn has over 60 known moons! An excellent activity for comparing the moons, "Saturn's Moons," can be found in NASA's Saturn Educator Guide (EG-1999-12-008-JPL) at: saturn.jpl.nasa.gov/files/lesson2_saturns_moons.pdf. The lesson was designed for grades 5–8; here are instructions on how to adapt the "moon card" activity for younger students:

- Print and laminate copies of the moon cards for pairs of students. Have the students group the moon cards in at least three different ways. Then ask them to describe the criteria they selected for each of their groupings.
- Have the students observe the cards closely, and write a "show not tell" descriptive paragraph about a moon of their choice. Have students read their paragraphs aloud, and let the whole group/peers guess which moon they have described.

Work with the students to convert the measurements in the *Memoirs of a Spacecraft — The Huygens Probe Encounters Titan* into metric units, which are more commonly used by engineers. Here is an easy way 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

Create a room poster or bulletin board using images of Saturn or its moons. Have students write, "I notice" (observations) and "I wonder?" (questions) on notes and post on the board.

Students can select a moon that they would like to learn more about and write a creative piece. A writing piece might be a short report of information. It could also be a poem. Students could even write fictional autobiographies, and pretend that they are one of the moons.

Consider having your students enter the "Cassini Scientist for a Day" contest — a great way to combine science and literacy. The essay explaining how the best science can be observed from a choice of actual Cassini mission targets wins a teleconference with Cassini scientists!
saturn.jpl.nasa.gov/education/scientistforaday/

Glossary

Data — Facts and statistics collected together for reference or analysis.
Hydrocarbon — A compound of hydrogen and carbon.
Memoirs — An autobiography or a written account of one's memory of certain events or people.
Probe — something that is used to search or discover. It can be a tool, a machine, or a spacecraft.

Memoirs of a Spacecraft

The Huygens Probe Encounters Titan

December 25, 2004

More than 11 years and two billion miles ago, spacecraft Cassini and I bid farewell to the powerful rocket that carried us from Earth to outer space.

We're pretty big, Cassini and I — about as big as a school bus — and no rocket is big enough to send us straight to Saturn. So we needed to take a roundabout route, one that would allow us to whip around Venus and Earth and Jupiter on our way, so the gravity of those planets could give us the extra speed we needed. It worked really well, and we got to see some amazing sights along the way. Jupiter was awesome!

By the time we passed by Jupiter, we were traveling at an incredible speed — 50,000 miles per hour! If you could go from San Francisco to New York at that speed, it would only take you three minutes!

We might have zipped right past Saturn if it weren't for our rockets. They were aimed in front of us, to slow us down. It was very tricky! If they slowed us down too much, we would be pulled into the giant planet. If they didn't slow us down enough, we would zoom past Saturn and never be able to come back! So the rockets had to be programmed to switch on at precisely the right moment, with exactly the right amount of power, for just the right amount of time.

The rockets burned for 90 minutes straight, before slowing us down enough for Saturn's gravity to pull us into orbit. That initial jolt when the rockets first fired sure surprised me, even though I knew it was coming. Imagine how you might feel running into a brick wall!

But it didn't amaze me nearly as much as what happened next. As we began to orbit Saturn, we flew right through a gap in the rings, then across to the other side of the planet, and then right through the same gap on the other side of the rings. Now that's fancy maneuvering!

I remember talking to Cassini when we first reached Saturn, back in July of 2004 —

"Here we are, Cassini," I said. "We're finally at Saturn! Can you see the bands of color — white and yellow and brown— across the globe? They seem to be storm clouds riding and playing on the wind. Now the rings around the equator are shining brighter than ever. For so long they've looked like silvery bands, or a halo. But at this close distance, I can see that the rings are not solid bands at all! They're a dense ribbon of icy pebbles and sand and gravel and boulders lying in a path around the planet's middle, as if they were racing around Saturn on a gigantic track. Some of the pieces are finer than dust, some are bigger than a house, and others are every size in between! Some of those ice-covered rocks look like chunks of chips and nuts in frozen white cookie dough. I'm thrilled to finally be here, Cassini. But I'm a little sad, too, because in six short months I'll be leaving you. I'll continue on by myself to the mysterious moon called Titan."

January 2005

After three orbits around the beautiful ringed planet, Saturn, my time to say good-bye to Cassini is almost here. I'm the first machine from Earth to land on Titan. I like the fact that I was named after the astronomer who discovered this giant moon. His name was Christiaan Huygens, and he lived in the Netherlands. He spotted Titan in 1655 — more than 300 years ago using a telescope he had built himself.

I can tell you about some of the things I know about Titan. It has gravity, though not nearly as strong as the gravity on Earth. In fact, I weigh just one-seventh of what I weighed back on my home planet.

My elder cousins, the two Voyager spacecraft, took more than 1,000 pictures of Titan when they paid a short visit to Saturn years ago. Their cameras were not able to see through Titan's dense haze and clouds, but they did learn some very interesting things. Scientists already knew that Titan's atmosphere is mostly nitrogen, just like Earth's. But the Voyagers' infrared and ultraviolet cameras revealed that there is also methane and hydrogen in the atmosphere, as well as many other chemicals.

The Voyagers also measured Titan's size — it's 3,200 miles across. That's less than half as wide as Earth, but much bigger than Earth's Moon. In fact, Titan is the second biggest moon in the entire solar system! The Voyagers also measured Titan's temperature, and found that it's about 289 degrees below zero on the Fahrenheit scale. That's much colder than any-place on Earth — even the North and South Poles! And the Voyagers also learned that Titan's atmospheric pressure is 60 percent greater than Earth's. That's about as much pressure as a diver back on Earth would feel under 20 feet of water.

Now I will uncover some of the mysteries that have puzzled people ever since then. What will I find beneath those thick clouds? My partner Cassini has found some astonishing things about Titan's surface. In some amazing ways, it is like my home Earth. There are riverbeds and huge deserts covered in dunes and even lakes. But it is so cold here, so much farther away from the Sun, and it is made so differently, that I expect it will not be like Earth in many ways. I have to get closer and see for myself.

To tell you the truth, I am just a bit nervous about this journey. When Cassini releases me, I will be on my own for the first time, traveling through space and then down through Titan's atmosphere. But it's exciting, too. I'm having a great adventure!

Some things concern me about my mission once I arrive at Titan. My onboard instruments have been carefully programmed, and they were tested numerous times on Earth. But when I send my radio messages to Cassini, and Cassini passes them along to my trusted team of engineers and scientists back on Earth, will they arrive? Earth is so very, very far away — the radio signals will be incredibly faint by the time they get there.

January 14th, 2005

Well, I've been sending pictures and information for a while now!

I'm sure thankful for my special heat shield, which saved me from being burned up when I entered Titan's atmosphere. Then my parachutes opened, and — because there is no great and wild wind in that mysterious atmosphere — I drifted slowly down to the surface.

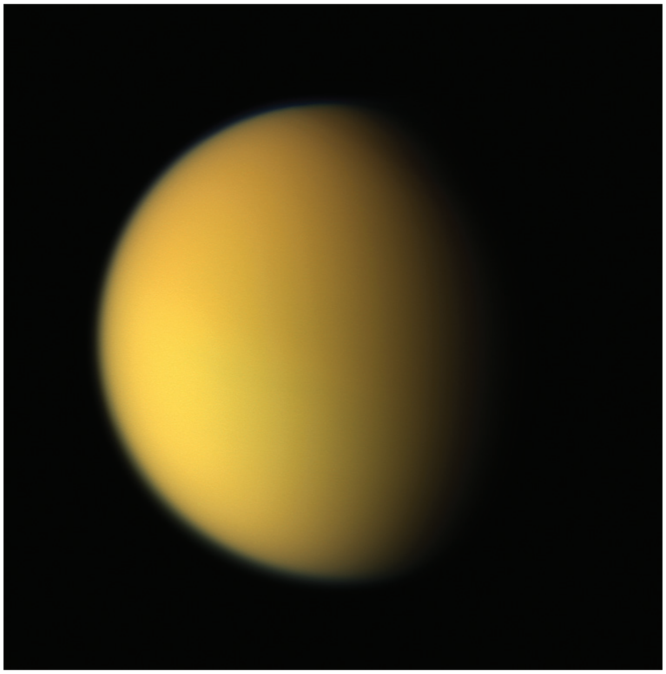
I wondered what Titan's Earth-like surface would look like up close. And now that I'm here, I realize that, as much as Titan is like Earth, it is also extremely different. I am so excited to share what I see with my team on Earth that I am sending back images as fast as I can. My other instruments have sampled the atmosphere and I'm sending back that information too.

It is so cold here that, while I do see rocks, those on Earth are made of silicate, but the ones here are made of water ice. There are lakes and rivers here, and on Earth they are made of liquid water, but here, they are made of liquid methane. On Earth, methane is usually a gas but here in the cold it is liquid. On Earth, desert dunes are made of sand but here; they are formed from the dark hydrocarbon grains that drift down from the atmosphere.

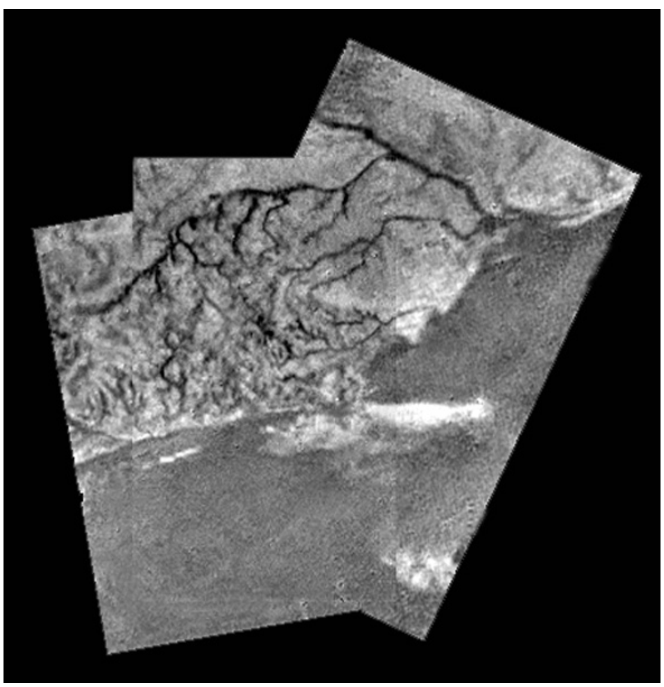
What a remarkable world. My team of scientists and engineers must be so excited by my findings. I wish I could be there to celebrate with them. I wish they could be here to celebrate with me. Will that ever be possible?

My job is now done and my partner Cassini will continue my work by flying close to Titan many times to continue my discoveries. Thanks for bringing me to such an exciting place, my friend.

Memoirs of a Spacecraft (4 of 4)

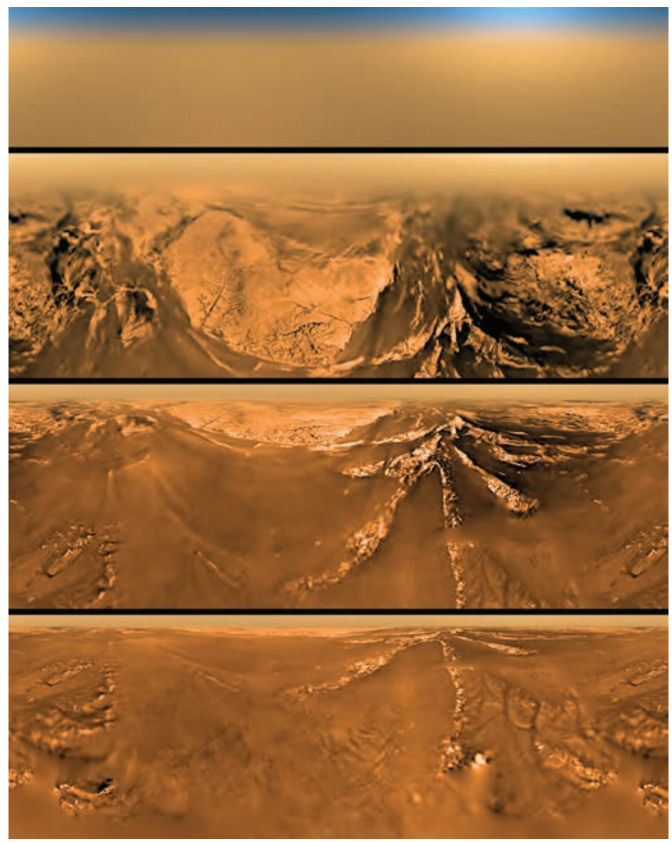


Haze on Titan hides the surface below
(Cassini image)

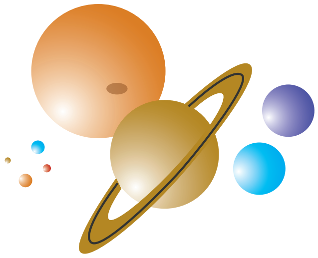


A flowing river channel on Titan
(Cassini image)

Rounded rocks on Titan (left) and Earth (right)
Credit: NASA/JPL/ESA/University of Arizona and S.M. Matheson



Huygens Probe views of Titan as it descends to surface

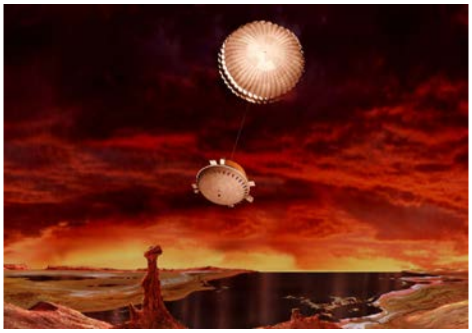


Activity 7
Drop Zone! Design and Test a Probe

Overview

During this activity, your youth:

- Build a parachute and probe that can descend and land safely from a high point.
- Creatively use the information learned in previous lessons to perform science and engineering techniques of design, construction, and testing.
- Learn the value of experimentation that allows testing, improvement, and refinement as a professional part of engineering.



Time/number of sessions	Activity Type	Space Needed
Four 40-minute sessions. Sessions 3 and 4 may be repeated.	Hands-on construction	Classroom or cafeteria for construction; gym or schoolyard for testing

Activity Goals

Youth will:

- Include data from readings in their experimental design.
- Use experiment and analysis to study, force, motion, and mass.
- Consider real-world challenges in their parachute/probe designs: proper descent, and on-target landing on varied surfaces using the "habits of mind" of engineers.

Where's the Science and Engineering?

- For engineers, experimentation to test, fail, learn, and improve is a natural part of the design–build–test process and is not considered a failure but an opportunity for progress and eventual success in space.
- Engineers design and build spacecraft and instruments as solutions for science objectives rather than for looks or for their own personal goals.

National Science Education Standards

K–4

Physical Science
- Properties of objects and materials
- Position and motion of objects

Science Inquiry
- Abilities necessary to do scientific inquiry

Technology
- Abilities of technological design
- Understandings about science and technology

5–8

Physical Science
- Properties and changes of properties in matter
- Motions and forces

Unifying Concepts and Processes
- Evidence, models, and explanation
- Systems, order, and organization
- Form and function

Equity/Leveling the Playing Field

- Students who don't have experience with building activities, or who need opportunities to increase their fine motor skills may need additional time or days to re-visit their structure. They may also need technical assistance from you.
- You can group students who have more experience with those who have less — remember, one child may take over and may require careful facilitation.
- Remind students that a "failed" probe is an opportunity to re-design and not a reflection of the team's potential or ability.

Getting Ready

For Session 1

- Find location for later testing parachutes and parachuting probes (Session 4)

For Session 2

- Copy the student *Parachuting Probe Packets* as in materials list.
- Set up a safe testing area from which to drop the probes. If it is not safe to use an elevated, protected, common traffic area, use a ramp or volleyball net. Draw a "target" landing area with chalk or place a hula-hoop.
- Make a clay ball for the probe drop, to use as a baseline time test.
- If you have access to a small portable wading pool, use this for the landing in liquid test. (Be sure the students understand that there will not be liquid water on Titan's surface, though there are lakes of liquid methane.)
- For the volleyball net drop zone, wrap the probe in its parachute and launch by throwing it over the net. The parachute must open and float to the ground without harming the probe. The net establishes a minimum height for the probe to climb before falling to Earth, and also a "safe zone" that is kept student-free until all probes have been thrown. They are retrieved after throwing.

Leader Tips

- Allow 20 minutes or more to make the probe packets and to set up construction materials for the parachutes and probes.
- To think like engineers, give the measurements for the parachute and string to students in metric units. To convert inches to centimeters (cm), multiply inches by 2.54. Example: 14 inches = 2.54*14 cm = 35.56 cm.
- Students may have "unlimited" or set distribution from the type and amount of materials you gather. You can set "prices" on the materials, and give students a limited budget or you can give them a set of supplies and a budget to buy more.
- If napkins or tissue paper are not available, opened sheets of 2-page newspaper are an option. Cut the 4 pieces of string the same length as the edge of the paper and use a heavier test object.

For time limitations, students can conduct a parachute inquiry only. The questions in the *Parachuting Probe Packet* can be applied to parachutes rather than probes. You can still design/re-design for a slow descent in a targeted area. Discuss "controlled testing" where only one design factor changes at a time: material type, string length, or washer size.

Materials — From Your Supply Closet

Session	For Leader	For Students
1		For student teams of 4 — For Parachutes • Tissue paper or paper napkins (about 14 inches on a side when opened up) • Self-adhesive, 1/4-inch hole reinforcements or clear tape • Lightweight string (such as kite string) or packing string, cut into four 14-inch lengths • Metal washers or a number of large-size paper clips At a separate table, additional materials for experimentation • Hand-held hole punchers • 14 by 14 inch sheets of sturdy plastic material (cut from garbage bags) • Several large sheets of plastic to be cut into various sizes • Plenty of additional (uncut) string for adaptations/ variations • Masking tape; clear tape • Several metal washers, can be of various sizes • Boxes of large-size paper clips; rubber bands • Drawing paper
2	• Long-arm stapler • Chart paper/whiteboard/ chalkboard and markers/chalk	
3		At a separate table — For Probes • Paper cups/plates of various sizes • Clean pint-size milk cartons • Paper cylinders (e.g., paper towel or toilet paper tubes) • Pipe cleaners; straws; Popsicle™ sticks • Foil • Tissue paper • Corks • Tape • Stapler • Whatever you can scavenge and/or students can bring in • Optional: materials for decoration • Student's *Saturn Discovery Log*
4	• Clay to make small ball • Stop-watches or watches with timers (2–3) • Sidewalk chalk or hula hoop • (Optional) small inflatable wading pool and water	

From a Photocopier/Printer

Session	For Leader	For Students
2	Leader Reference *Huygens Probe Components*	• Back-to-back photocopy of the student *Parachuting Probe Packet* for each student team of 4. Nest the pages, and fold (check to make sure the pages are in order). Staple into booklets (5-1/2 by 8-1/2 inch) using a long-arm stapler.

Drop Zone! Design and Test a Probe

Student Activity

Session 1 • Building and Testing a Parachute

1. Prepare the students to build and test their parachutes using the following conversation guide.
   - Once engineers understand the challenges of landing a probe in space like the one that the Cassini and Huygens engineers landed on Titan, they often build models and experiment with testing. First, they start with a model they think will work. If it does not land successfully, they don't call it a failure but rather an opportunity to improve and draw closer to success.
   - There may only be one thing that isn't working: the material, the size, measurements of the parachute, etc. So they only change one thing at a time and then test again. That's called "controlled testing." The engineers "control" changing one thing that might work and then if it doesn't, they go back to the original model and change something different until they have a successful landing.
   - At some point, they may begin to combine some of the successful parts of the experiment and they may end up with a very different model from the original parachute and probe.
   - Think of these things as you work to make a team parachute and later a probe.
   - Remember to include your whole team in the design and the construction. Everyone should have an engineering task to do.
   - When you feel you may have your best parachute design built, try it out in a clear area of the classroom to see how it does.
   - If you find you need to do some controlled testing, decide as a team which one thing you believe should change and then test again.

2. Assign the students to small teams of 3 to 4.
3. Have the students use tissue paper or paper napkins (approximately 14 inches square) to create a parachute. Use a paper punch to make one hole in each of the four corners as far into the paper as possible. Strengthen with a self-adhesive binder paper hole reinforcement, or 4 short pieces of tape surrounding the hole.
4. Attach 14-inch lengths of string to each corner, and tie these to a small washer or other light object (such as several large-size paperclips arranged side-by-side and held together with a rubber band). Each team should use the same kind of items.
5. Students need to figure out how to fold and toss the parachutes so that they open and slow the fall of the washer/object. These experiments can be done in the classroom.
6. Once students have mastered this, they can experiment with different lengths of string, different-size washers, and/or different parachute materials. Be sure they understand that they should only change one variable at a time in order to have a true controlled test!
7. Collect the parachutes to save for the coming sessions.

Session 2 • Designing a Probe

1. Tell the students that they now have the opportunity to put themselves in the shoes of spacecraft designers and engineers. Distribute the *Parachuting Probe Packets* and read the text aloud.
2. Ask students to summarize the activity aloud and ask them what questions they have. Show the students the materials that will be available for them to use for building the probes.
3. Regroup the students into their small teams of 3 to 4. Recombine teams as needed to accommodate new or missing students.
4. Have a member of each team collect their parachute from Session 1.
5. Explain to the students that they will be doing an illustrated plan of their probe before they start building. The illustration should be carefully labeled and detailed. Use the Leader Reference *Huygens Probe Components* as an example, and as a reference for yourself in guiding the students' designs. Encourage the students to include design notes for the illustration. They should use the guidelines set forth in the probe packets. Remind them to record information in their *Parachuting Probe Packets*.
6. When students have completed their plans, reviewed them as a team, and everyone is satisfied, you may allow them move on to building the probe as in Section 3.
7. Collect the *Parachuting Probe Packets*.

Session 3 • Building the Probe

1. Regroup the students into their small teams of 3 to 4. Recombine teams as needed to accommodate new or missing students. Redistribute the *Parachuting Probe Packets*.

2. Have materials available for probe construction, and for an appropriate sized parachute if needed. Allow students to select materials and construct probes (and parachutes if needed) as a team.

3. Explain to the group that the next session will be the testing day for the probes. Provide time for students to share their designs with one another, and the whole group. Each design team can explain their choices and designs BEFORE testing begins.

4. (Optional) If time allows, provide a test area each day for the students to test their progress and allow for modifications to their design, based on the information from the testing.

Session 4 • Testing the Probe

1. Remind the students about the definition for controlled testing using the following conversation guide:
    - As we test our parachutes and probes, we have a controlled test. Remember what that means? What is the same about this test? What will all your tests have in common? (You are looking for: They are all dropped from the same height and in the same way. The landing surface is the same). What do we have that is different? (Their parachute probes are different.) If you make any changes to your parachute probe between your tests, your team should make note of it in your packets
    - We need to figure a baseline time of descent from our drop point. To do this, we'll drop an object, of similar weight to the probe that does not have a parachute attached. We'll use this clay ball and we need to record the time it takes for it to drop. Then we need to estimate how much slower we think the parachute probes will fall and that will become our target time for your teams to meet. Record all of this in your *Parachuting Probe Packets*.

2. Each team drops its own probe (or throws it over the volleyball net). They should try to drop the probes in the same manner each time. If possible, have two or three students timing the descent of each probe, and average the times. Also, if possible, there should be three trials for each probe — the test page in the *Parachuting Probe Packets* is set up for three trials.

3. Have students write their observations of the group's experiments in their *Saturn Discovery Logs*. This will help them in recalling this information during the whole-group discussion. It also reinforces the idea that the group is a community of learners, and that we learn from one another.

Questions for the Youth (Informal Assessment)

Give the students time to complete the last page of the *Parachuting Probe Packet* — "Questions for Spacecraft Engineers." Bring the group together, and ask each question and get responses from the students. It is a good idea to chart their responses.

Sharing the Findings (Informal Assessment)

Ask the following questions, and record student responses on the board or on chart paper:

- Which designs or design elements seemed the most stable, or added stability?
- Which parachutes seemed to take the longest to land?
- Which designs or design elements seemed to hit the target, or closest to the target, most often?
- Is there a "best weight" the probe needs to be in order to land accurately?
- Is there a relationship between parachute size and probe weight?
- What do you like best about working like a spacecraft engineer?
- What do you think are the biggest challenges they face?
- What questions do you still have?

Leader Reflection/Assessment

As you circulate and look at the students' writing, ask yourself the following questions:

1. Is the experimental plan clear and sequential?
2. Has the data been recorded in an organized way?
3. Does the reflective writing show evidence of critical and creative thought?

Glossary

Control — In an engineering experiment, a condition that doesn't change.
Controlled Test — An experiment where only one condition changes from trial to trial, so that the effects of that condition are clear.
Engineering Design Process — Consists of these steps: identify problem; brainstorm; iterate the design: build, test and evaluate, and redesign; share solution
Impulse — Impulse is the force of an impact multiplied by the amount of time the force is exerted. There are two types of impulse: hard and fast, and soft and slow.
Variable — What changes in an engineering experiment.

Information for Families

In the week prior to this activity, alert the students that they will be building a model of a probe — encourage them to describe to their families what a probe does, to get their family's ideas about what kinds of household recyclable material to use, and to ask them to contribute to the collection of materials.

Tired of the same old home videos? Check out videos from another world — Saturn!
saturn.jpl.nasa.gov/video/
www.jpl.nasa.gov/video/index.cfm?search=cassini&submit.x=0&submit.y=0

NASA Resources

Careers at NASA

Putting a probe into space around another planet takes a team of dedicated scientists, engineers, and others at NASA working together. Learn about some of the people who make space exploration possible.

Role Model Resource

Ayanna Howard is a robotics engineer at Georgia Tech University. She designs, builds, and programs robots to help scientists (and humans) perform jobs that are either too dangerous, tedious, or currently impossible for humans. Her interest in engineering and NASA was sparked one day in junior high school, when people from the Jet Propulsion Laboratory came to her school to judge the students' parachute egg-drop contest. "I decided at age 11 that I wanted to create artificial limbs for people. I planned to go to medical school, but discovered I hated biology in high school — especially dissecting frogs. Then I heard about robotics and realized that, if I became an engineer, I could do exactly what I wanted to do — and no frogs!"

When talking to young students, Ayanna says, "It's really rewarding when you hear people say, 'Maybe I can do that,' or 'I want to hear more.' I look at their eyes and think: Wow, I really do have a cool job."
More about Ayanna:
www.ece.gatech.edu/personnel/bio.php?id=135

Hear students share their stories of "My (High School) Summer at JPL"
www.jpl.nasa.gov/video/index.cfm?id=862

Resources

Are there volcanoes on Titan?
www.jpl.nasa.gov/video/index.cfm?id=951

Find lots of solar system educational resources
solarsystem.nasa.gov/educ

Taking Science to the Next Step

Special thanks to Dr. Jean-Pierre Lebreton and Dr. Ralph Lorenz, Cassini mission scientists, for the extension activities offered here.

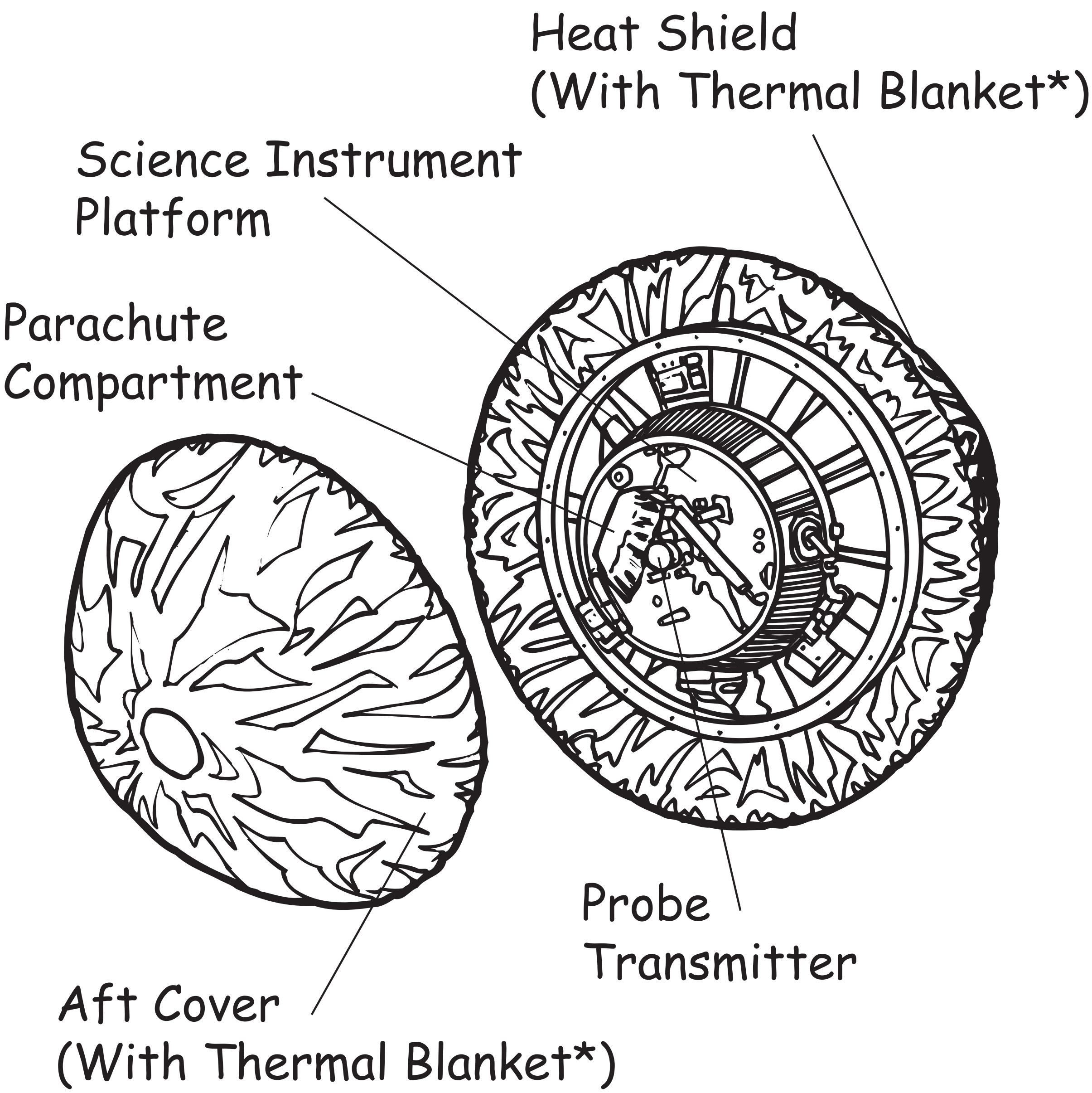
Optimization Exercise. Students can experiment with parachuting paper or cardstock cone-shaped "shields." A broad cone gives more drag (slows you down more) while a narrow cone is more stable, given the same amount of material. Students can first measure the time it takes a washer or ball of clay to fall from a given height. Parachuting shields earn points based on how much more slowly they fall. They also earn points for stability — specifically for how close they fall to a target drawn on the ground. Points can be "charged" for how much material is used to construct the shields. There should be some optimum where the cone is sharp enough to fall in a stable fashion and to land close to the target, but not so sharp it needs lots of material to have enough drag.

Characterizing an Unknown Surface. One of the Huygens Probe's responsibilities was to characterize the surface of Titan from the impact as recorded with onboard instruments to measure the probe's acceleration and deceleration. You can model this for the children by creating different surfaces hidden enclosed in cardboard boxes: for example, sand, gravel, brick, and water. Students can make a hole in the box top, and drop a "probe" (marble) into the hole at the top of the box, and try to guess what the surface is from the sound it makes. If a facilitator had a microphone/computer hook up, students could even "look" at the sound.

Literacy

Give each team of students time to write a set of step-by-step directions to go with their drawing to facilitate construction of a probe. Have teams exchange plans and build.

Huygens Probe Components



*The protective thermal blanket is a layered material known as multi-layered insulation or MLI.

Questions for the Spacecraft Engineers

1. What did you find most surprising or interesting?

2. What problems did you encounter as you built and/or tested your probe? What changes did you make, and why?

3. Based on your trials, and observations of your classmates' designs and tests, what changes, if any, would you make to your design?

4. What questions do you have now?

5. What questions would you like to ask of the Huygens Design Team?

6. What would you like to try next? Why?

Parachuting Probe Packet

The ____________________ Probe

Design Team/Spacecraft Engineers

____

____

Date______________________________

Engineering and Design Team Challenge:

Design a parachuting probe that will land upright on both solid and liquid surfaces, remain intact (not break apart), weigh as little as possible (while still meeting the other criteria), and meet the requirements for time of descent (how long it takes the parachute to land after being dropped).

Background information for Design Team:

Spacecraft engineers face many challenges. They design machines that survive the forces of being launched into outer space and operate there with little assistance from Earth.

Once in space, the spacecraft must protect its delicate instruments throughout the journey. We are counting on Cassini to protect Huygens on its seven-year journey from Earth to Saturn.

Any heat absorbed or produced by the spacecraft must be managed to prevent the instruments from overheating or getting too cold. The probe must be strongly anchored to the spacecraft, yet able to separate in a controlled fashion at the right time. Both spacecraft and probe must be protected from dangerous radiation and from high-speed dust particles.

The probe must remain able to operate after many months or even years of inactivity. It must also be able to respond to commands and to radio its data back to Earth as accurately as possible.

Testing the ________________________________Probe

Trial Number	Condition Upon Landing	Time of Descent	Notes, Observations, Questions
1			
2			
3			

Idea 3 — Final Plan (draw and write):

Weight of Probe:

Your Task:

You will design and build a parachuting probe. Given an assortment of materials commonly found at home or in the classroom, you will construct a parachuting structure that will:

1. Land upright on a solid or liquid surface. (To simulate the requirement for the Huygens instruments — camera and other instruments — to be able to take pictures and measurements)

2. Land undamaged. (To simulate the requirement for the instruments to be able to work — they must not break on impact.)

3. Take as long as possible to land, but land within in a designated area. (Huygens' parachute size will control its descent time. Huygens will be collecting data as it descends.)

4. Weigh as little as possible. (A fourth property to consider is weight. The more a spacecraft weighs, the more it costs to launch it and maneuver it in space. So, you want your probe to be as light as possible.)

Imagine the possibilities! Wonder! Create!

Helpful Science Hints

Scientists use the word "impulse" to describe an impact.

Impulse is the force of impact multiplied by the amount of time the force is exerted. There are two types of impulse: hard and fast, and soft and slow. Hard and fast is usually not the way you would like to experience a change in speed. That's when you run into a brick wall at full speed, going from fast to stopped in a fraction of a second. The great amount of force you experience over the short amount of time can result in broken bones, or worse. So, soft and slow is the way to go.

If the wall you run into is padded like a mattress, you will enjoy the result more than if you run into bricks. To give your probe the best chance for survival, you need to think about how to give it the soft and slow type of impulse. Anything you can do to increase the amount of time the probe spends slowing down before hitting the ground will increase its chances of landing intact.

Your parachute will be central in this endeavor. You may want to do some initial experimenting with parachutes. Think about these questions:

- What happens if you change the size of the parachute?

- What happens if you change the length of the strings that attach the parachute to its load?

- What happens if the parachute is attached in different places?

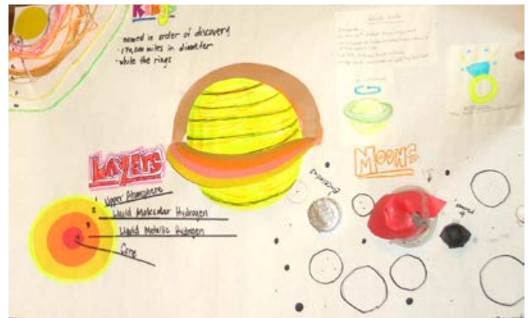
Idea 1 (draw and write):

Idea 2 (draw and write):

Activity 8
Celebrating Saturn and Cassini

Overview

During this activity, your youth:



- Design a culminating "celebration" display and event, based on their *Saturn Discovery Logs* full of notes and observations and on products produced from their working knowledge of Saturn and Cassini. They have sketches of spacecraft and probes, models, and test results.
- Can invite their parents or classmates in for an event to view the displays and hear them talk about their work and their discoveries.
- Will show an assessment of both their personal and knowledge growth from this unit through the way they choose to share their presentations and through the products themselves.

Time/number of sessions

One or more 40-minute sessions, plus time for a parent/school/community event

Activity Type

Art and communication

Space Needed

Room with tables and chairs to create the displays; open space for display and presentations

Activity Goals

Youth will:

- Learn how to organize their knowledge of science to create a display.
- Learn how to communicate this knowledge to others.
- Consolidate learning that has taken place during the program unit.

Where's the Science and Engineering?

- Synthesizing, communicating and presenting are essential skills in science and engineering careers and across NASA. Students, scientists, and engineers alike discuss, display, and publish their findings for peers, supporters, and their community.
- As mission results come in, Cassini–Huygens scientists discuss and share their findings, and build on each other's work as the body of knowledge grows. As the mission proceeds, some questions are answered, but often more arise.
- An important area of any NASA mission is Education and Public Outreach, which has the responsibility to translate the work of science and engineering into engaging and informative presentations for the educational system and the public.

National Science Education Standards

K–4

History and Nature of Science

- Science as a human endeavor

5–8

History and Nature of Science

- History of science

Equity/Leveling the Playing Field

- The role models for the "Jewel of the Solar System" activities were chosen carefully. All of them work at NASA and do science and engineering related to the Cassini–Huygens mission. Just as important, the team includes women and men, people from very different backgrounds, interests, and skills.
- Encourage students that the message they want their presentations to convey to their families or peers is that science is a way of thinking and doing things, that everyone can do science, and that science and engineering can be many things requiring many different skills and abilities.
- Have your students incorporate the questions they had or still have into their presentations to encourage family and peers to be curious. Remind them that adventure begins in the mind! To learn and discover they need to be curious and persistent.

Materials — From Your Supply Closet

Session	For Leader	For Students	
1	• Chart paper/ white board, markers	• *Saturn Discovery Logs* • Crayons, markers, colored pencils, writing pencils • Poster boards • Products from previous activities	• Photos of previous activities • Display materials (this will depend on the kind of display the students want to create)

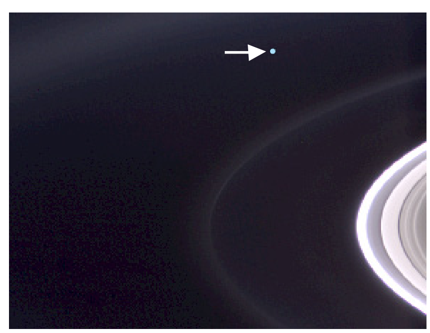
From a Photocopier/Printer

Session	For Leader	For Students
1		• Pictures or information from this activity guide — see the *Cassini Extras* student handout — or that they can find on the Internet

Getting Ready

- Decide on the range of activities you can support the students to do (displays with art/written material, video, skit, etc.) and gather materials accordingly

Leader Tips



The pale blue planet Earth as seen behind Saturn's rings (upper right) by the Cassini spacecraft.

- Consider ending this program unit with a parent event. Identify a time and place for the displays when parents can be invited to see their children's work and hear their presentations.
- To help with the families' personal/social connection to the material, guide students to compare Saturn to what they and their families know about Earth — what is similar? What is different? Encourage them also to describe the enormity of the distance between Earth and Saturn.
- Consider a "career corner" with students describing the types of jobs it takes to run a robotic spacecraft mission — role model resources and career activities are found in the "Take It Further!" section of each activity. Students may want to select those they find most interesting as part of their display or event.
- NASA has national volunteer networks of specially-trained members in local communities, who can serve as content experts, mentors, or speakers at events. Request information on your local Solar System Ambassador at ambassadors@jpl.nasa.gov. See the "NASA Resources" section of this activity for websites of many NASA networks.
- See "Taking the Science to the Next Step" section on the "Take It Further!" page of this activity for suggestions on multimedia resources to use.

Celebrating Saturn and Cassini

Activity 8

Student Activity

Session 1 • Collect Information, Select Key Points, and Design Display/Event

(May extend into additional sessions)

1. Tell the students that they have completed their journey to Saturn. Tell them that, as scientists and engineers, they have the opportunity to present their findings about Saturn and the Cassini–Huygens mission through prepared displays (or video project, student panel discussion, skit, etc.). Get their ideas about who they would like to invite to their presentation: family, another class, the whole school, their teachers, etc.. Tell them they are going to collect ideas and pull together their final piece to present what they know.
2. Have students go through all the work in their individual *Saturn Discovery Logs*, and pull out the key pieces of information they would like to present. Make sure that any pieces taken from a student's *Saturn Discovery Log* bear his or her name so that they can be returned to them after the presentation or event.
3. First, work with the class to chart an outline for their presentation or event and lead them in the following questions:
   - Who will we invite to this event?
   - What do you think they will know about Saturn or the Cassini–Huygens mission?
   - What are some of the questions you had, discoveries you made, interesting facts you learned and things you would like to know for the future that you think should be part of your presentation or exhibit?
   - What should be our biggest message to share?
   - How shall we organize all your ideas to follow this message?

4. Form teams of students to work on particular concepts, such as the different parts of Saturn, spacecraft designs, current status of the Cassini mission, people and careers that make the mission happen, etc.

5. Previous material they created in this unit, such as the NASA-style Saturn poster and 3-d book on Saturn, can be incorporated into the display. Materials the students and you will have created in previous units include:
   - Activity 1 — Notice/Wonder charts for Saturn and Cassini–Huygens images
   - Activity 2 — *Chart of Size Models* for *Walk on the Wild Size*, radial scale model of the solar system
   - Activity 3 — Saturn/Cassini Match Game board and giant poster of Saturn
   - Activity 4 — Multilayer 3-d book of Saturn
   - Activity 5 — Spacecraft to Saturn models and designs
   - Activity 6 — Drawings of Titan and story, poem, or song about a spacecraft to explore it
   - Activity 7 — Parachutes, probes, and *Parachuting Probe Packets*

6. Give students as much time as they need to work on their final project.

Questions for the Youth (Informal Assessment)

- Now that you have had the chance to think and explore like scientists and engineers, what do you think you might enjoy doing further with NASA?
- What should be explored next?

Sharing the Findings (Informal Assessment)

This can be a presentation to the rest of the group, to other students in the program or for a family night. If the group does mostly art and written projects, they can be published in a book sent home to share with their families or hung as an exhibit in a hallway wall. If the teams choose to make presentations, put on a panel discussion, or perform a skit, they can be presented at a final performance on family night. Use your imagination and find a way to work this presentation into your end of the semester or end of the year festivities.

Leader Reflection/Assessment

As you review the students' work, ask yourself the following questions:

1. Where do I see growth in the students' understanding of Saturn and the Cassini–Huygens mission? Look at what they are producing and check for enhanced interest and understanding as the unit has progressed.

2. Are there any misunderstandings that I would like to address? If so, ask the students to critique (and in the process they will correct) each other's displays. Remind them to be courteous to each other.

3. Do I see growth in the students' curiosity and their ability to ask questions and research or experiment to find answers?

Information for Families

Send home a letter to families describing the event and inviting them to attend!

If appropriate, give families suggestions on websites to look at with their children — you can use the "Internet Resource List" at the end of this unit.

NASA Resources

Careers at NASA

NASA's Jet Propulsion Laboratory (JPL) is home for many of this generation's space explorers. They're not astronauts — they don't leave the home planet — but they are the creators and stewards of the spacecraft, rovers, telescopes, and other instruments that enable us to look into, and for, new worlds. They are the women and men who listen to signals from Mars and Saturn, who have reached beyond the limits of our solar system and beyond the limits of our imaginations. Many people contribute to the cause — the educators who teach the next generation of explorers, the folks who do the day-to-day tasks of any organization, and the folks who document and record the adventure.

Create a chart that says "Jobs at NASA" and ask students to brainstorm what some of the jobs might be. Chart their answers and post the chart in the room.

Investigate the actual job possibilities at NASA and the subjects that students should study in school:
nasajobs.nasa.gov/jobs/occupations.htm
www.nasa.gov/audience/forstudents/5-8/career

Role Model Resource

Communication is essential in space, too! Belinda Arroyo is NASA's "air traffic controller," negotiating tracking communication time with the dozens of robotic space missions sprinkled around the solar system. She manages the Deep Space Network Planning and Scheduling organization, making sure the needs of the robotic spacecraft beyond Earth are

met. Spacecraft commands are sent from Earth, and the spacecraft returns data to Earth on its health and the data it has collected. NASA's Deep Space Network has three sites located in key areas around the world — Spain, Australia, and California. Each site has a 70-meter (230-foot) diameter antenna and a variety of smaller ones. "It's very exciting to be part of a flight project," says Belinda. "I really like learning about each mission, interfacing with the different people in the missions, and working with my team."

Read more about Belinda at:
stardust.jpl.nasa.gov/news/news92.html

Read other inspirational stories of women at NASA at: women.nasa.gov

Resources

NASA has several national networks of volunteers who are specially trained for working with the public and in educational settings. Instructions for requesting a local volunteer are on their websites.

- The Solar System Ambassadors are motivated volunteers across the nation, who communicate the excitement of JPL's space exploration missions and information about recent discoveries to people in their local communities. Learn more at: www2.jpl.nasa.gov/ambassador

- The Night Sky Network is a nationwide coalition of amateur astronomy clubs bringing the science, technology, and inspiration of NASA's missions to the general public. They share their time and telescopes to provide unique astronomy experiences at science museums, observatories, classrooms, and under the real night sky — nightsky.jpl.nasa.gov/

- NASA Student Ambassadors are high-performing interns and fellows, who volunteer their time to advance the NASA mission, by focusing on STEM research, education, and outreach. They are looking for opportunities to serve, learn, and inspire. The ambassadors serve as speakers and exhibit supporters. Learn more at: intern.nasa.gov/intern/

- The NASA Speakers Bureau is composed of engineers, scientists, and other professionals who represent the agency as speakers at civic, professional, educational and other public venues. Each year, NASA speakers provide hundreds of presentations to thousands of people — www.nasa.gov/about/speakers/

Sign up to get the latest education information from NASA: www.nasa.gov/audience/foreducators/Express_Landing.html

Taking Science to the Next Step

Create a multimedia presentation — Have the students adapt their final writing projects with computer-based multimedia authoring tools for kids, and present the projects to each other or invited guests.

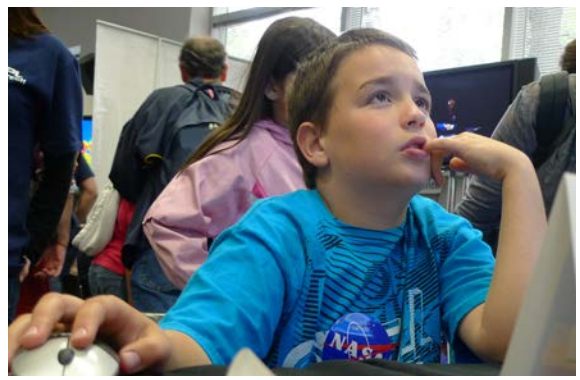
- Try these multimedia resources:
  Actual sounds recorded by the Cassini–Huygens spacecraft — saturn.jpl.nasa.gov/news/cassinifeatures/feature20060424

- 30-minute video podcasts of Ring World 2, the story of the Cassini–Huygens mission, in both English and Spanish — saturn.jpl.nasa.gov/video/videodetails/?videoID=114

- Monthly 3-minute video podcast of what to see in the night sky and how it connects to NASA's exploration of the solar system — solarsystem.nasa.gov/news/whatsup-archive.cfm

Students can visit the following website to track Cassini's progress and discoveries, and give summary updates to the group — saturn.jpl.nasa.gov/

Consider implementing in your afterschool or summer school the other program guides in the "From Out-of-School to Outer Space" series. More information is available at: www.jpl.nasa.gov/education/os2os

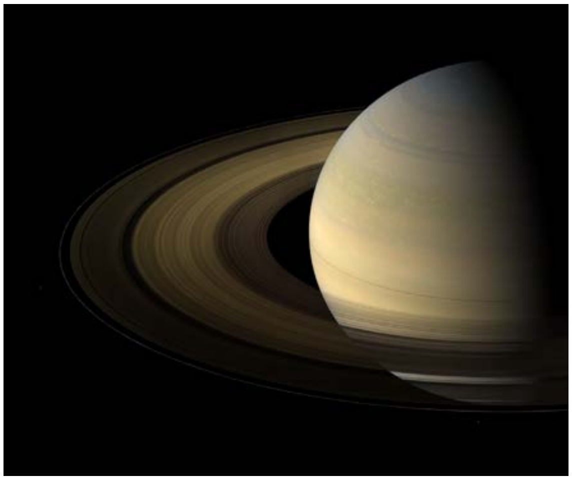


Literacy

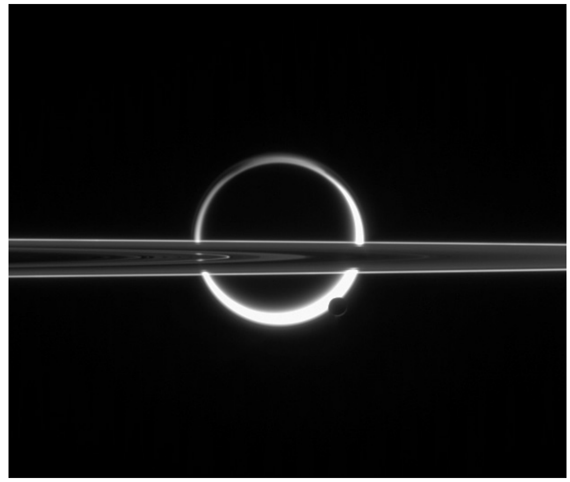
Compile the final writing projects into a whole-group book, and have students read from it to other rooms, to a community organization, or invite the parents in for a reading.

Publish! You may want to encourage students to share their final projects with a local newspaper or science museum.

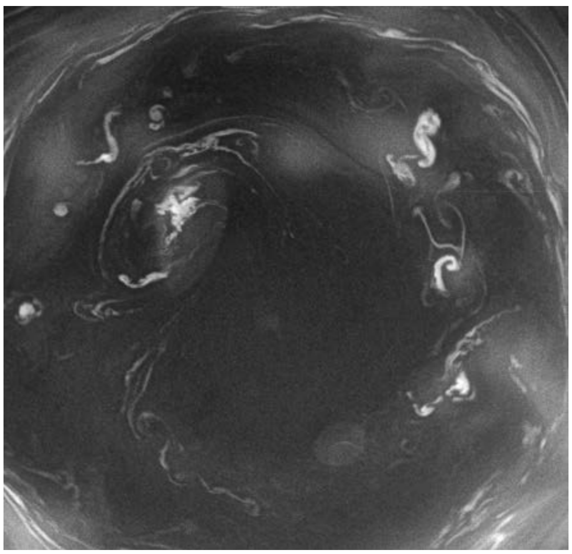
Cassini Extras



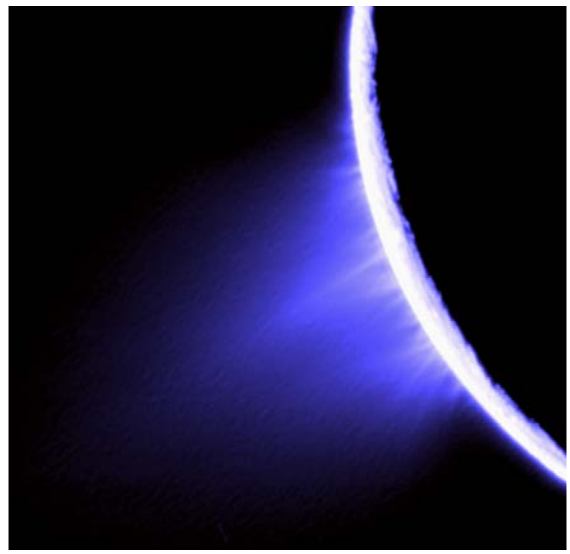
Mosaic of Saturn on the Second Day of Spring



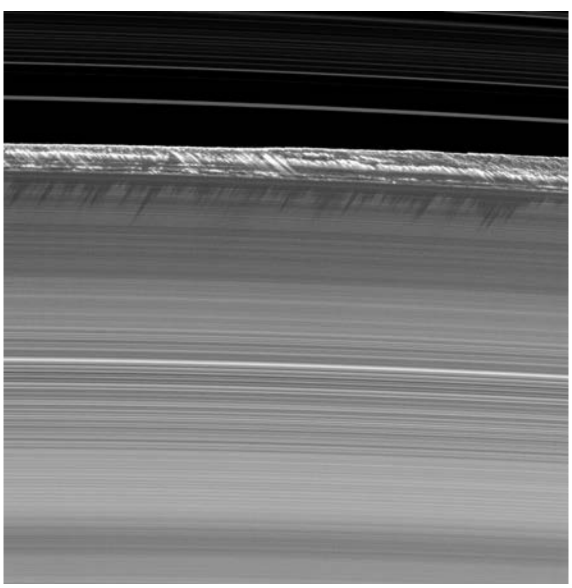
Saturn's Rings, Titan's Glowing Atmosphere, and Enceladus



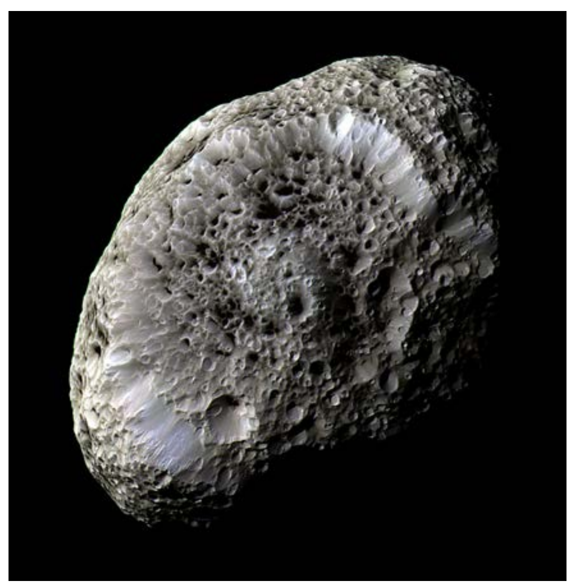
Clouds Near Saturn's South Pole



Jets on Saturn's Moon Enceladus (colored blue for dramatic effect)



Tall Peaks Edge Saturn's B Ring



The Odd World – Saturn's Moon Hyperion

Appendix

Internet Resource List

Jewel of the Solar System Internet Resource List

Information, photos, podcasts, video podcasts, and interactive features

Saturn and Cassini Websites

saturn.jpl.nasa.gov
General information on Saturn and the Cassini mission
Cassini Status countdown clock

solarsystem.nasa.gov/saturn
Facts on Saturn and a history of the exploration of Saturn

saturn.jpl.nasa.gov/video/videodetails/?videoID=114
Podcast of Ring World 2, the story of the Cassini–Huygens mission

www.esa.int/SPECIALS/Cassini-Huygens/SEMKVQOFGLE_0.html
This cartoon and video shows how the surface of Saturn's moon Titan was viewed by the Huygens probe during it's descent to the surface

saturn.jpl.nasa.gov/photos
Gallery of images from the Cassini mission

saturn.jpl.nasa.gov/video/
www.jpl.nasa.gov/video/index.cfm?search=cassini&submit.x=0&submit.y=0
Videos from Cassini data

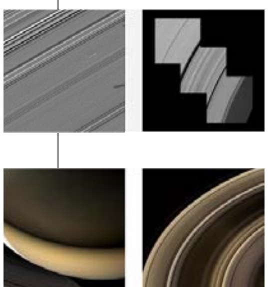
www.nasa.gov/mission_pages/cassini/main
NASA summaries and latest news about the Cassini mission

www.jpl.nasa.gov/podcast/cassini20080415.cfm
Hear all about Saturn and its moons from the Cassini Project Manager in this podcast

saturn.jpl.nasa.gov/spacecraft/overview/
See Cassini's "almost human" features

saturn.jpl.nasa.gov/kids
Child-friendly background about the Cassini–Huygens mission

saturn.jpl.nasa.gov/kids/fun-facts-spacecraft.cfm
Fun facts about the Cassini spacecraft



saturn.jpl.nasa.gov/news/cassinifeatures/feature20060424/
Actual sounds recorded by the Cassini–Huygens spacecraft

saturn.jpl.nasa.gov/science/moons
Explore all of Saturn's moons and get the latest count!

saturn.jpl.nasa.gov/multimedia/flash/Titan
Animated flash video of Huygens' probe mission (requires free Adobe Flash™ download)

www.jpl.nasa.gov/video/index.cfm?id=951
Cold Case: Possible Ice Volcano on Titan

photojournal.jpl.nasa.gov/target/Titan
Images of Titan

www.jpl.nasa.gov/spaceimages/searchwp.php?category=saturn
Download Saturn wallpaper for the classroom computer

spaceplace.nasa.gov/robot-float
See Cassini and other spacecraft represented on a parade float

spaceplace.nasa.gov/search/?q=saturn
For Saturn-related games, live streaming videos, and just plain fun

Cassini Team Member Features

solarsystem.nasa.gov/multimedia/video-view.cfm?Vid_ID=1042
Dr. Bonnie Buratti video

blogs.jpl.nasa.gov/author/hendrix
science.jpl.nasa.gov/people/Hendrix
Dr. Amanda Hendrix blog and biography

solarsystem.nasa.gov/people/profile.cfm?Code=CuzziJ
www.nasa.gov/centers/ames/pdf/80661main_Cassini_Fact_Sheet.pdf
Dr. Jeff Cuzzi biography and contributions to Cassini mission

solarsystem.nasa.gov/people/profile.cfm?Code=Simon-MillerA
Dr. Amy Simon-Miller biography

saturn.jpl.nasa.gov/news/cassiniinsider/
Meet members of the Cassini team and learn what they do

Saturn and Cassini Education Resources

saturn.jpl.nasa.gov/education/scientistforaday/
Students write an essay to select a target in Saturn's system for the Cassini spacecraft to study. Winners get a telephone conversation with a scientist!

solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=163
Jewel of the Solar System poster of Saturn and Rings with educational activities

solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=762
saturn.jpl.nasa.gov/education/titanposter/
Titan: Behind the Veil poster on Saturn's moon Titan with educational activities

spaceplace.nasa.gov/saturn-model/
Make your own Jewel of the Solar System from an old CD or DVD

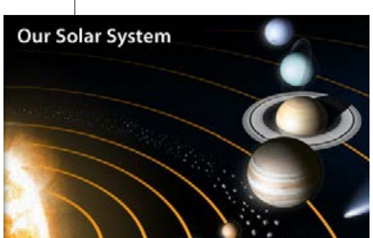
saturn.jpl.nasa.gov/education/saturnobservation
Take a look at Saturn through a telescope — find out where on the Saturn Observation Campaign website

saturn.jpl.nasa.gov/files/lesson2_saturns_moons.pdf
Activity for comparing Saturn's moons

Spanish Language

"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

spaceplace.nasa.gov/sp/search/?q=saturno
Saturn games and videos in Spanish



Our Solar System Websites

solarsystem.nasa.gov
Background information on the solar system

solarsystem.nasa.gov/planets
"Compare the Planets" using the feature at this site

solarsystem.nasa.gov/eyes/player
Visualize representations of the solar system and Saturn's place in it (requires the free 3d-Unity player download)

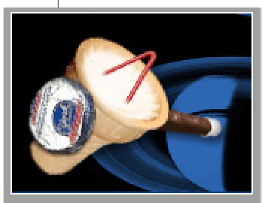
solarsystem.nasa.gov/yss/display.cfm?Year=2010&Month=10&Tab=Classrooms
Build your own solar system scale model and find others around the country

www.windows2universe.org/our_solar_system/distances.html
Explore the relative sizes and distances of the planets

solarsystem.nasa.gov/missions
Information on all robotic solar system exploration missions

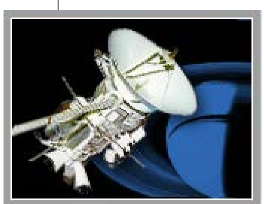
voyager.jpl.nasa.gov
The Voyager Interstellar Mission — beyond the planets

voyager.jpl.nasa.gov/pdf/VoyagerPoster2010_Back.pdf
2-dimensional model of planetary distances on a football field



solarsystem.nasa.gov/news/whatsup-archive.cfm
See "What's Up" in the night sky in these monthly podcasts

solarsystem.nasa.gov/kids/papermodels.cfm
Model building can be done for a variety of spacecraft



planetquest.jpl.nasa.gov/system/interactable/3/index.html
Take an "alien safari" or find out about "extreme" life forms

solarsystem.nasa.gov/educ/
Solar system educational resources

From Out-of-School to Outer Space Website

www.jpl.nasa.gov/education/os2os
Check out all the afterschool activity guides in the series

NASA Volunteer Networks

www2.jpl.nasa.gov/ambassador
Solar System Ambassadors — trained volunteers from across the country

nightsky.jpl.nasa.gov/
Night Sky Network — amateur astronomy clubs

intern.nasa.gov/intern/
Student Ambassadors — student interns

www.nasa.gov/about/speakers/
Speakers Bureau — NASA employees

Other NASA Websites

www.nasa.gov
Continue learning about space exploration beyond the Cassini mission. Click on "Educators" to view additional educator resources.

www.nasa.gov/ntv
Live coverage of International Space Station, solar system launch events, and more

www.nasa.gov/audience/foreducators/Express_Landing.html
Register to receive the latest educational news from NASA

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

www.nasa.gov/audience/forkids
Educational information, activities, and videos

spaceplace.nasa.gov/menu/parents-and-educators/
Parents and educators help kids explore the exciting space facts and discoveries

spaceplace.nasa.gov/menu/people-and-technology
Simulations and space technology games

www.jpl.nasa.gov/kids
Child-friendly information about space travel, including quiz games and a history of space travel

virtualfieldtrip.jpl.nasa.gov
See how spacecraft are designed and built

www.jpl.nasa.gov/education/BuildMissionGame.cfm
Kids can interactively design, launch, and build their own spacecraft

spaceplace.nasa.gov/dsn-game
Learn how robotic spacecraft communicate with people on Earth (requires free Adobe Flash™ download)

mo-www.harvard.edu/OWN/
Take a picture of Saturn or other planets with a remote telescope

Careers and Role Models

www.jpl.nasa.gov/work
What would a career exploring other worlds be like? How can you work at JPL as a student?

https://careerlaunch.jpl.nasa.gov
The current job postings at NASA's Jet Propulsion Laboratory

www.jpl.nasa.gov/video/index.cfm?id=862
"My (High School) Summer at JPL" video

www.nasa.gov/audience/forstudents/5-8/career
What do I need to study in order to work for NASA?

nasajobs.nasa.gov/jobs/occupations.htm
Jobs that NASA needs

www.jpl.nasa.gov/education/videos/playVideo.cfm?videoID=2
Video — what JPL looks for in intern candidates

solarsystem.nasa.gov/people/archive.cfm
Some of the people who make space exploration possible

blogs.jpl.nasa.gov/
Staff blogs about their experiences with robotic spacecraft missions

solarsystem.nasa.gov/multimedia/video-view.cfm?Vid_ID=1048
Dr. Ed Stone video

www.ece.gatech.edu/personnel/bio.php?id=135
Dr. Ayanna Howard biography

solarsystem.nasa.gov/people/profile.cfm?Code=TuckerS
Shonte Tucker biography

stardust.jpl.nasa.gov/news/news92.html
Belinda Arroyo biography, spacecraft “air traffic controller”

women.nasa.gov
Inspirational stories of women at NASA

Glossary

Glossary

Ammonia — A pungent, colorless gas compounded of nitrogen and hydrogen

Astronomical unit (AU) — The distance from Earth to the Sun (93 million miles, or 150 million kilometers).

Conduct — To act as a medium for conveying or transmitting

Control — In an engineering experiment, a condition that doesn't change.

Controlled Test — An experiment where only one condition changes from trial to trial, so that the effects of that condition are clear.

Core — Center, middle, center of the mass.

Core — The central part of a celestial body (as Earth or the Sun) usually having different physical properties from the surrounding parts

Data — Facts and statistics collected together for reference or analysis

Diameter — The length of a straight line through the center of an object — so, the diameter gives us the measurement of how far it is across a planet, moon, or the Sun.

Engineering Design Process — Consists of these steps: identify problem; brainstorm; iterate the design: build, test and evaluate, and redesign; share solution

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

Impulse — Impulse is the force of an impact multiplied by the amount of time the force is exerted. There are two types of impulse: hard and fast, and soft and slow.

Mass — The measure of the amount of material

Memoirs — An autobiography or a written account of one's memory of certain events or people.

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)

Model — A three-dimensional example for imitation or comparison; a representation (sometimes in miniature) to show how something is configured or constructed.

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.

Probe — Something that is used to search or discover. It can be a tool, a machine, or a spacecraft.

Radial — Radiating from, or situated around, a common center (the Sun).

Solar system — The configuration of our Sun and planets and other bodies that revolve around the Sun

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.

Variable — What changes in an engineering experiment

Pronunciation Guide

Pronunciation Guide

Cassini — cuh-SEEN-ee

convection — kon-VEK-shun

Enceladus — en-CELL-uh-dus

Encke — EN-kee

Epimetheus — ep-uh-ME-thee-us

Huygens — HOY-gens

Janus — JAY-nuss

Iapetus — eye-A-pe-tus

Mimas — MY-muss

Phoebe — fee-bee

National Aeronautics and Space Administration

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Pasadena, California

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