How Far Away Is Saturn?

The Cassini spacecraft in JPL test chamber.

LESSON TIME

One to three class periods

MATERIALS CHECKLIST

For the teacher:

- *Copy of "Solar System Background Information"; "Chart of the Size Models for the Walk of Wild Size"*
- *Copy and overhead of Taking a Walk of Wild Size"; "Traveling to Saturn: My Predictions and Some Cool Facts"*
- *Tongue depressors or popsicle sticks, glue, tagboard, tape*
- *Chart paper, marker, yardstick, yellow highlighter*

Per groups of 3 students:

- *18 x 24 inch drawing paper for posters; markers, crayons*
- *One each "Sun on a stick," "Earth on a stick," and "Saturn on a stick"*

Per student:

- *Saturn Discovery Log*
- *For extension #2, copy of "Traveling to Saturn: My Predictions and Some Cool Facts"*

TO SEE EXAMPLES OF STUDENT WORK, CLICK HERE

LESSON NO.4

- *Language Arts Focus*
  —*Nonfiction Writing Practice: Descriptive Paragraph*
  —*Nonfiction Writing Practice: Compare/Contrast Paragraph*
- *Science Focus — Understanding Size and Distance by Creating Sun/Earth/Saturn Models*

OVERVIEW

In this lesson (and extensions), students will be "Thinking and Writing About Scale: Taking a Walk of Wild Size!" We provide invitations and opportunities for students to begin to understand the vastness of the solar system and the size differences between our home — Earth — and our destination, Saturn. Using the "Sun on a stick," "Saturn on a stick," and "Earth on a stick" props, students create a scale model for size and distance in our solar system. Because the distances in space are so vast, you and your students will need to take a short hike to complete this model. A special Solar System Fact Sheet provides background information for teachers, and can be used as a lesson extension. We also include an indoor model as an option if teachers have limited time or space. Writing activities engage students in reflecting on experience, and in comparing and contrasting what they thought the trip to Saturn would be like, from the "real" thing!

WHY THIS WORKS

At the beginning of this unit on Saturn, or any astronomy unit, it is useful to give students a sense of the neighborhood we'll be studying. The sizes and distances that we explore in space are far greater than those we are accustomed to on Earth. Children (and adults) may not easily grasp the vastness of space or the size differences between Earth and the other planets. When students "walk to Saturn," they discover firsthand that it is very far away from Earth! This early, shared experience becomes a useful "touchstone" throughout the unit, as well as a point of departure for our trip to Saturn. When students write about an experience or activity, they have a chance to learn again. Students clarify ideas, questions, and understandings. This activity provides an authentic context for both descriptive and compare/contrast genres.

Objectives

Students will:

1. Practice descriptive writing.
2. Practice compare/contrast writing.
3. Build an operational understanding of scale — both size and distance — in comparing the Sun, Earth, and Saturn.

4. Increase/enhance their understanding of and interest in Saturn and the Cassini–Huygens mission and spacecraft.
5. Practice the scientific thinking skills of predicting, comparing, and relating.

Teacher Preparation

- Print out and read teacher reference 2: "Solar System Background Information."
- Print out a copy of teacher reference 3: "Chart of the Size Models for the Walk of Wild Size" (instructions for making the chart).
- Allow about an hour to gather materials and make stick puppets.
- Print out copies of teacher reference 4: Sun, Earth, and Saturn image page for the "Sun on a stick," "Earth on a stick," and "Saturn on a stick." Cut out the images and glue (or laminate) them to tagboard. Then tape each object to a large tongue depressor or popsicle stick, so that students can easily hold them. Make enough so that you have enough for students to work in groups of three; make one extra set for the Chart of the Size Models for the Walk of Wild Size.
- Print out and prepare an overhead of teacher reference 5: "Taking a Walk of Wild Size" (Directions for Pacing the Solar System).
- Make the Chart of the Size Models for the Walk of Wild Size — you will need the three stick models, tape, a large marker to write the titles, a large piece of chart paper, a yard stick, and a highlighter or yellow marker.
- Create a special Saturn envelope that you open upon arrival at Saturn as your class paces the solar system. There could be photos or facts about Saturn written on strips of paper that students could take turns reading aloud.
- Optional (extension activity #2):

  —One copy of teacher reference 6: "Traveling to Saturn Fact Sheet"
  —Overhead for the teacher, plus print one copy per student, of student handout 1, "Traveling to Saturn: My Predictions and Some Cool Facts."

Teacher Tips

1. Do the activity yourself before having students do it, so you can find the best location and better anticipate student responses and questions.
2. It is critical to talk with the students about scientific models — particularly how models are alike or different from the objects or phenomena they represent, and why we use models. While this particular model holds true for size and distance comparisons, it is inaccurate or misleading because students may conclude that the Sun, Earth, and Saturn are all lined up in a straight line. Be sure to talk to students about the shortcomings of this model (it works for size and distance but it does not model locations in space). Additionally, since the planets have elliptical rather than circular orbits, their actual distances from the Sun are always changing. Distances suggested here are averages. It is okay if your "line" from the Sun to Saturn is not straight; your line can curve and twist, or go back and forth. What is most amazing to the students (and adults as well) is the relationship of size to distance.

3. Because much of this activity is done outdoors, you will want to clearly establish behavior expectations, or "signs of success," with your students beforehand. For example, "stay with the group," "stay focused on the activity," and so forth. If your students are used to doing "T" charts for behaviors, this will be helpful (see example below):

   "Staying Focused Outside"
   Looks Like: Sounds Like:

teacher TIP

If your students' responses indicate that they know very little about the solar system, you may want to do a whole-class read aloud. (Suggested title: *Our Solar System* by Seymour Simon)

Before You Begin

- A note on grouping:
  — Triads and Whole Class for outdoor activity
  — Partners or triads for Prior Knowledge posters, and follow-up projects

What to Do

Introduction/Sharing What We Know — Suggested time 30–60 minutes

Optional — if your class is already familiar with the solar system, you may skip this section.

1. Begin with a whole-class discussion of what the students know about the solar system.
2. Have students work in groups of two or three to make charts or posters of the following on 18 by 24 inch paper:
   • What We Know About The Solar System
   • What We Know About Space Travel
   • Questions We Have
3. Have groups share with the class. Keep posters up throughout the unit, so students can compare how their understandings, ideas, and questions are changing.

Understanding Size and Distance — Suggested time 40–60 minutes

1. Tell students that "we are going to begin our journey to Saturn with a scientific model that will help us understand both size and distance." Explain to the students that the Sun is the largest object in the 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 the Sun.
2. Show the students the "Sun on a stick" that is approximately 8 inches in diameter. This is our model Sun. Have students predict: If this is our Sun, how big do you think Earth should be? How big do you think Saturn should be? Have students draw their ideas in their Saturn Discovery Logs.
3. Show the students the "Earth on a stick" and "Saturn on a stick" models. Earth and Saturn will be exaggerated in scale (compared with the 8-inch-diameter Sun) so that they can be seen by everyone in the classroom.

4. Students can make changes to their log drawings, and label "first ideas" and "actual model size."
5. Display the Chart of the Size Models for the Walk of Wild Size you have made and have the students read it with you. Fourth graders can copy the information into their Saturn Discovery Logs. You may want to have "glue-in" mini-charts for third graders.
6. Ask the students, "Now that we have established the size scale for the Sun, Earth, and Saturn, how much space do you think we need for a scale model of distance between the Sun, Earth and Saturn?" Record predictions on the board.
7. Tell students: The distance between Earth and the Sun is 93 million miles. In the model, this will be 26 yards. Have a student volunteer take 26 paces in the classroom. (Students will see that it will be necessary to go outside to complete the model.)
8. Take the class outside.
9. Take a few minutes to demonstrate, and have students practice, pacing as close to a yard in length as possible. This is another good place to talk about the difference between a model and "real life," and that our giant-step paces will be almost, but not exactly, the same.
10. Distribute sets of Saturn on a stick, Sun on a stick, and Earth on a stick to student groups of three. Have the oldest student be the Sun, the second oldest be Earth, and the third oldest be Saturn.
11. Ask the students, "How far apart do you think you need to stand in order to model the distance that the Sun, Earth, and Saturn are from one another?" (Give students a few minutes to discuss.)
12. Have the groups model what they think are the scaled distances between the Sun, Earth, and Saturn.
13. Bring students back together and have a brief discussion about what they noticed.

Taking The Walk of Wild Size — Suggested time: 25 minutes to Saturn and back, 45 minutes to pace the entire solar system

1. Collect the Sun, Earth, and Saturn stick models.
2. Have a volunteer Hold ONE Sun stick model. Have the students line up. Begin pacing together (teacher reads directions). Note: the pacing directions tell where the other planets are located. You can call these out as you pass each one. Also, you can continue past Saturn all the way to Pluto, if desired.
3. Stop at Saturn and discuss the model with your students. Prompt them with the questions on the "Taking a Walk of Wild Size: Directions for Pacing the Solar System" sheet. You may want to have students record responses in their Saturn Discovery Logs, especially if they are fourth graders.

If you have created a special Saturn envelope, it can be opened upon arrival at Saturn. There could be photos of Saturn, or facts about Saturn written on strips of paper that students could take turns reading aloud.

Optional: This would be a good time to do the "Traveling to Saturn" activity (extension activity 2).

4. Return to the classroom and have the students complete their Saturn Discovery Log entries.

If you are able to secure two adult volunteers for this activity (one to hold the "Sun" and one to hold the "Earth"), then all your students will be able to participate in pacing out the distance from the Sun to Earth to Saturn.

Writing About Saturn in Saturn Discovery Logs — Suggested time 30–45 minutes

Options:

- A compare and contrast paragraph about the activity: "My ideas about the distance from Earth to Saturn before and after the activity."
- A descriptive paragraph about the activity.

1. Have students talk with a partner before beginning to write. They can share notes from their logs, or discuss one or both of the suggested writing activities.
2. Talking before writing gives students a chance to rehearse their ideas, to clarify ideas, and to learn from one another. A suggested format is to have students sit facing their partners "knee-to-knee and eye-to-eye." Give one partner 2 or 3 minutes to talk. The listener can then ask clarifying questions. Have students reverse roles.

Sharing/Closure — Suggested time 10 minutes

1. Students can first discuss with partners and small groups what they learned, what they found most interesting or surprising, and what questions they now have.
2. They can also read their writing to one another, and give feedback on both content and structure. One way would be for partners to tell one another "remembers," reminders, and questions. Remembers are specific sentences, words, or ideas that the listener/audience remembers from the piece. Reminders are statements where the listener connects to the author and piece of writing. "That reminds me of...." Finally, questions can be about the content, or, about parts of the writing that are unclear. For more ideas about peer response to writing, see Ralph Fletcher's or Nancy Atwell's books. After sharing with partners or in small groups, students can be invited to share with the class.

Extensions

1. Send home the directions for pacing the solar system, so students can do the activity again with family and friends.
2. Have students complete the "Traveling to Saturn: My Predictions and Some Cool Facts" worksheet (suggested time 15–20 minutes).

   —Display teacher's copy of "Traveling to Saturn: My Predictions and Some Cool Facts" worksheet on an overhead projector.

—Tell the students: "Most objects in our solar system are really, really big; and really, really far apart. We're going to focus our attention on getting to Saturn."

—Ask students: How long do you think it will take to get from Earth to Saturn? Walking? In a racecar? In a jet? In a spacecraft? Students can record responses in their Saturn Discovery Logs, or on their personal copies of the "Traveling to Saturn" worksheet.

—Share the information from the "Traveling to Saturn Fact Sheet" with the students as they respond to each of the questions on their copies of the worksheet.

—Discuss why it is going to take Cassini seven years to get to Saturn.

3. Make other models of the solar system: see the "Solar System Model Builders' Guide" on the Windows to the Universe website at *http://www.windows.ucar.edu/tour/link=/our_solar_system/distances.html&edu=elem*

   (Includes directions for scaling the solar system when Earth is represented by a marble.)

4. Build a radial model of the solar system. This way, students will understand that the planets are not "all lined up" in a straight line.

5. Indoor Alternative to the "Walk of Wild Size" — Astronomical Unit Scale Model for Distance Only

   Overview: Students will create a distance-only scale model of either the Sun, Earth, and Saturn, or the Sun and all nine planets, using their own feet to equal one astronomical unit.

   Background: Astronomers have given a special name to the distance from Earth to the Sun. It is called an astronomical unit, abbreviated AU. An AU is 150 million kilometers or 93 million miles. Because distances in space are so vast, astronomers sometimes use astronomical units (or other units such as light-years) for measurement.

Materials for Indoor Alternative:

- Paper cups/marking pens (3–10 for the whole class, or 3–10 per student or group), or index cards/marking pens, modeling clay
- Sidewalk chalk
- Envelopes containing the number of steps needed from the Sun to each planet (if you want this to be a surprise for the students), or written directions for each group of how many steps to take.
- Saturn Discovery Logs for recording observations and questions

Directions:

—Discuss with the students that they will be creating a model for the distance from the Sun and Earth to Saturn (or the entire solar system, if you wish). Talk

about ways that models are useful to scientists, and also ways that models are alike and different from "real life."

—Tell the students that because distances in space are so vast, scientists have come up with some different ways of measuring these distances. One way is to use a unit called an astronomical unit. An astronomical unit is equal to the distance from Earth to the Sun (93 million miles, or 150 million kilometers). For our model, the length of _____'s foot will be one astronomical unit!

—Practice measuring the astronomical units by walking slowly, placing the heel of the foot against the toes of the other foot (some people call these "baby steps" or "heel-toes").

—Place the Sun cup or card at one end of the classroom, hallway, sidewalk, or schoolyard. (If it is windy at your school, you can place a clay ball or other little weight inside the paper cups)

—Ask students to predict (they can mark their predictions with chalk X's on the pavement if you do this out-of-doors) where they think Earth and Saturn will be, relative to the placement of the model Sun. They can also predict how many astronomical units (real feet) they think this will be.

—If you are doing this as a whole-group demo, select the student whose feet/steps will be used for the model. Otherwise, distribute written directions (or envelopes) to partners/groups. Remind students of how to measure the astronomical units, walking heel-toe.

—Have your astronomical unit model place her or his heel against the Sun cup, or index card set in a clay ball. Place the planets as follows:

- Mercury: instep
- Venus: big toe joint
- Earth: tip of the big toe
- Mars: 1.5 steps
- Jupiter: 5 steps
- Saturn: 9.5 steps
- Uranus: 19 steps
- Neptune: 30 steps
- Pluto: 39 steps

—Use the "Traveling to Saturn Fact Sheet" to discuss the activity with the students.

Assessment

As you observe your students working, and read the work after the lesson, ask yourself the following questions:

1. Are the students able to stay on task in their groups? If they are able to do this, take notes on what you see the students doing, and share these with your class.
2. Do the students' paragraphs indicate an understanding of paragraph structure, e.g., main idea, details, and examples? Are students able to use transition words? Do descriptive paragraphs give a clear picture to the reader of the model journey to Saturn? Do students accurately describe the distance traveled? Do compare and contrast paragraphs include at least two examples of "what I expected" and "what really happened."

Standards

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

All students must have opportunities to:

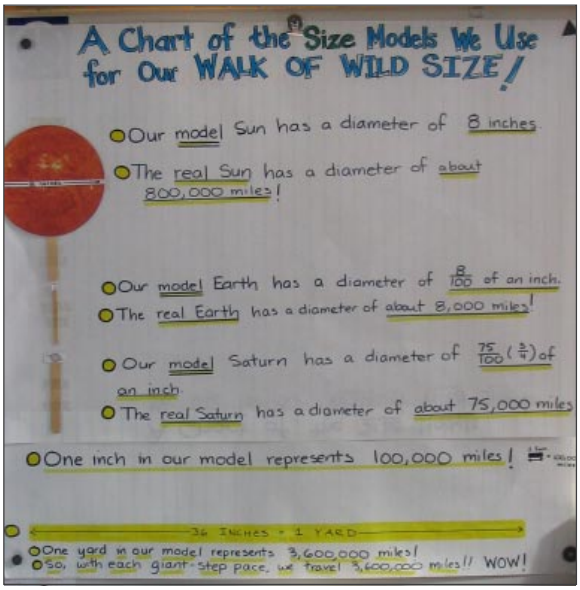
- Participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities.
- Use spoken, written, and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information).

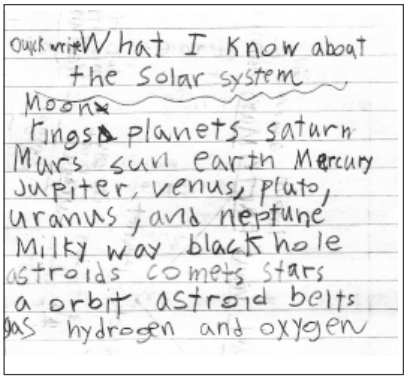
National Science Education Standards

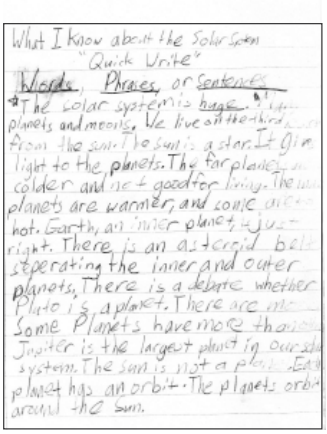
As a result of their activities in grades K–4, all students should develop understanding:

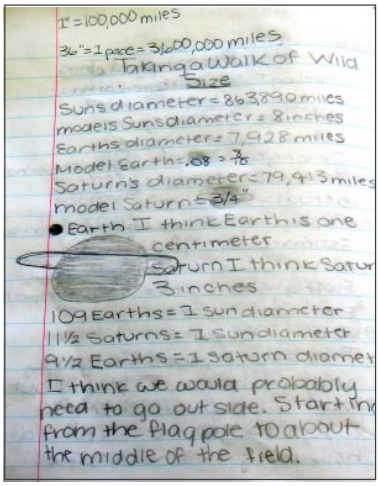
- Of objects in the sky (Earth and Space Science).

Examples of Student Work




Quick write What I know about the Solar system
Moons
rings planets saturn
Mars sun earth Mercury
Jupiter, venus, pluto,
uranus, and neptune
Milky way black hole
astroids comets stars
a orbit astroid belts
gas hydrogen and oxygen


What I know about the Solar System
"Quick Write"
Words, Phrases, or Sentences
The solar system is huge.
planets and moons. We live on the third
from the sun. The sun is a star. It gi
light to the planets. The far planet
colder and ice + good for living. The
planets are warmer, and some
hot. Earth, an inner planet, is just
right. There is an astroid bel
seperating the inner and outer
planets. There is a debate whether
Pluto is a planet. There are mo
Some Planets have more than
Jupiter is the largest planet in our
system. The sun is not a pla
planet has an orbit. The planets orb
around the sun.


1" = 100,000 miles
36" = 1 pace = 3600,000 miles
Taking a Walk of Wild Size
Suns diameter = 863890 miles
models Suns diameter = 8 inches
Earths diameter = 7,928 miles
Model Earth = .08 = 8/100
Saturn's diameter = 79,913 miles
model Saturn = 3/4"
Earth I think Earth is one centimeter
Saturn I think Satur
3 inches
109 Earths = 1 sun diameter
11½ Saturns = 1 Sun diameter
9½ Earths = 1 saturn diamet
I think we would probably need to go out side. Start fr
from the flagpole to about the middle of the field.

Solar System Background Information

Information on Size

Diameter is 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.

- The Sun's diameter is about 863,890 miles.
- Earth's diameter is about 7,928 miles.
- Saturn's diameter is about 74,913 miles.
- It would take about 109 Earths to span the diameter of the Sun.
- It would take about 11-1/2 Saturns to span the diameter of the Sun.
- It would take about 9-1/2 Earths to span the diameter of Saturn.

Information on Distance

- The Earth is 93,000,000 (93 million) miles from the Sun.
- Astronomers give this distance a special name: an astronomical unit, abbreviated AU.
- Saturn is 890 million miles from the Sun, or 9.5 astronomical units
- So....Saturn is about 800 million miles from Earth.
- Walking at 3 miles per hour, it would take 30,441 years to get to Saturn. (yikes!)
- Driving a race car at 100 miles per hour, it would take 913 years to get from Earth to Saturn. (WOW!)
- Flying to Saturn in a jet plane, traveling at 600 miles per hour, would take 152 years (too long!).
- Flying in a rocket at a constant speed of 17,500 miles per hour, it would take 5 years! (Cassini will spend 7 years on its journey. This is because the spacecraft is too heavy to travel directly to Saturn. It must fly by several other planets to give it the "energy boost" needed to get to Saturn. Cassini's journey covers nearly 3 billion miles).

Information on Converting Miles to Kilometers, or Kilometers to Miles

The metric system is often used in science. As you learn more about astronomy, read different books, and visit different Web sites, 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.

Chart of the Size Models for the Walk of Wild Size

- On a large piece of chart paper, write the title:
  "A Chart of the Size Models We Use for Our Walk of Wild Size"
  (or "Walk to Saturn")

- You will be using one set of the "Sun on a stick," "Earth on a stick," and "Saturn on a stick."

- Tape a "Sun on stick" on the left margin.

- Write: Our model Sun has a diameter of 8 inches.
  The real Sun has a diameter of about 800,000 miles.

- Tape an "Earth on a stick" below the Sun.

- Write: Our model Earth has a diameter of 8/100 of an inch (0.08).
  The real Earth has a diameter of about 8,000 miles.

- Tape a "Saturn on a stick" below the "Earth."

- Write: Our model Saturn has a diameter of 75/100 of an inch (3/4 inch or 0.75 inch).
  The real Saturn has a diameter of about 75,000 miles.

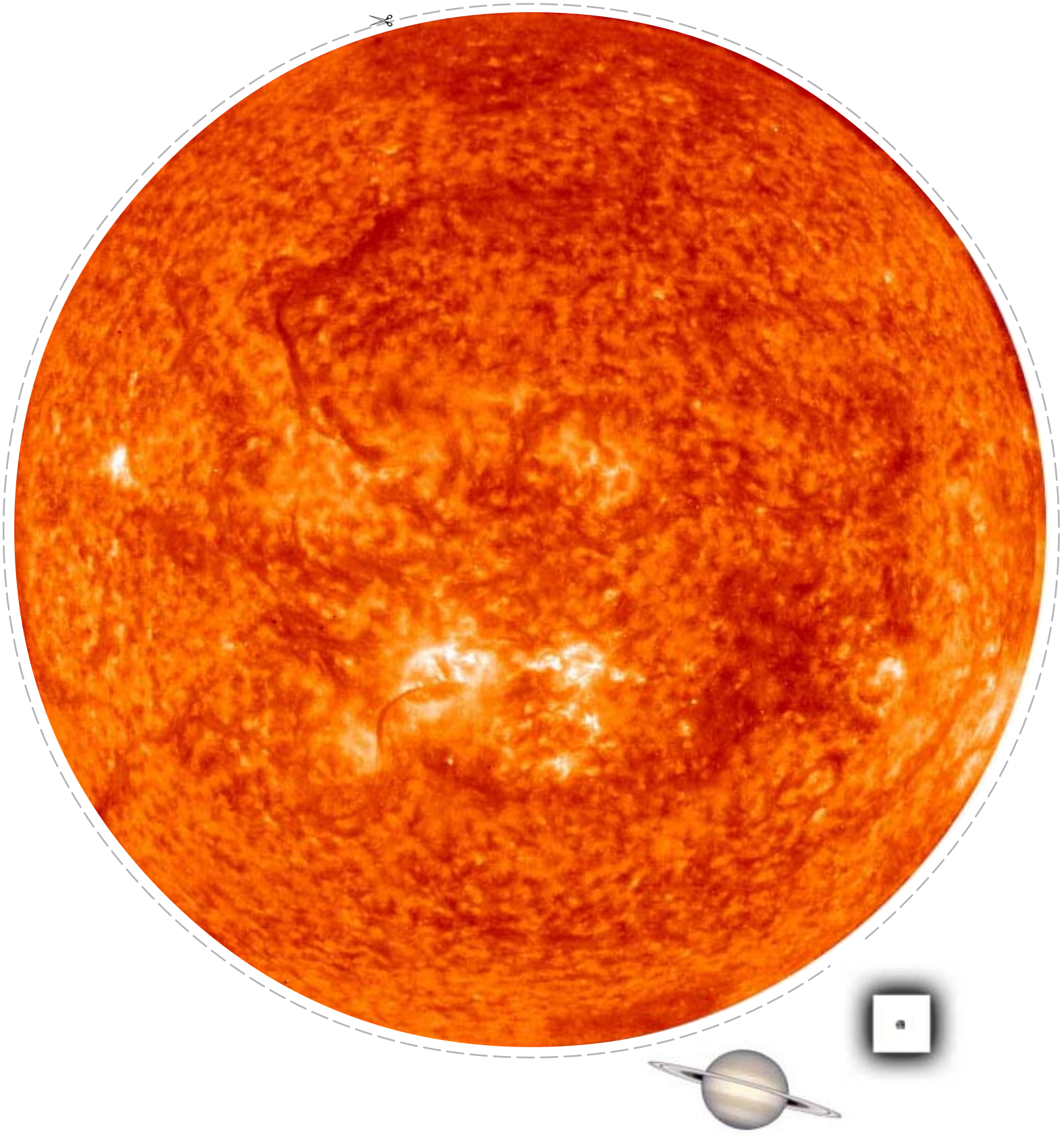
- Write: One inch in our model represents 100,000 miles (1:100,000).

- Draw a little rectangle, or fat line, that is exactly one inch long, and label it.

- Trace a yard stick, color in with a yellow marker or highlighter, and label it "36 inches or 1 yard."

- Write: One yard, or 36 inches in our model represents 3,600,000 miles.

So, with each giant-step pace, we will travel 3,600,000 miles!



Taking a Walk Of Wild Size

Directions for Pacing the Solar System

1. Start at the Sun.
2. Take 10 paces. (Remind student that these are "giant steps" and should be as close to a yard in length as possible.) Call out "Mercury."
3. Take 9 more paces. Call out "Venus."
4. Take 7 paces. Call out "Earth."

   (At this point, have the students look back at the Sun. Ask, "What do you notice?" "How big does the Sun look from Earth?")
5. Take 14 paces. Call out "Mars."

   (Ask students if they know which planet they will pass next on their journey to Saturn.)
6. Take 95 paces. Call out "Jupiter."

   (Ask students which planet is next. Have them predict how many more paces it will be to Saturn.)
7. Take 112 paces. Call out "Saturn."

WOW! Saturn is 247 paces from the Sun, and 221 paces from Earth!

Discussion

Talk about the model with your students, using the following questions to guide the discussion. Students can also write notes in their Saturn Discovery Logs.

- How do you feel?
- What do you notice?
- Can you see the Sun? Can you see Earth?
- What do you notice about how the Sun looks from Saturn compared to how it looked from Earth? (size, brightness)
- Do you think it is colder on Saturn than Earth? Why?
- What problems or challenges do you think a spacecraft will have to overcome in order to travel from Earth 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?
- How did the trip feel?
- What was most surprising?
- What questions do you have? ("I wonder...?" "What if...?")

To The Outer Planets

If you have time, you can continue 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.

Traveling to Saturn Fact Sheet

- Earth is 93 million miles from the Sun.
- Astronomers give the distance from Earth to the Sun a special name — an astronomical unit.
- Saturn is 890 million miles from the Sun, or 9.5 astronomical units.
- So — Saturn is about 800 million miles from Earth.
- Walking at 3 miles per hour, it would take you 30,441 years to get from Earth to Saturn.
- Driving a race car 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 takes the Cassini–Huygens spacecraft nearly 7 years to get to Saturn, because it is not traveling at a constant speed.)

Traveling to Saturn: My Predictions and Some Cool Facts!

How Long Would It Take to Travel To Saturn?

Walking at 3 miles per hour?

I predict it would take _____

Actual time _____

My response:

Driving a racecar at 100 miles per hour?

I predict it would take _____

Actual time _____

My response:

Flying a jet airplane at 600 miles per hour?

I predict it would take _____

Actual time _____

My response:

Flying a rocket at a constant speed of 17,500 miles per hour?

I predict it would take _____

Actual time _____

My response: