

ScienceNews

IN HIGH SCHOOLS | EDUCATOR GUIDE



Juno's view to JUPITER



About the Guide

The *Science News* article “Juno's view to Jupiter” explores what we could learn as a newly launched space probe approaches and orbits the solar system's largest planet.

“Juno's view to Jupiter” can be used across a wide range of curricula, with a focus on **physics, engineering and astronomy**. The activities, questions and discussions in this educator guide can be used to support the following education standards:

Next Generation Science

Motion and Stability: Forces and Interactions: [HS-PS2-4](#)
 Earth's Place in the Universe: [HS-ESS1-4](#), [HS-ESS1-6](#)
 Earth and Human Activity: [HS-ESS3-4](#)
 Engineering Design: [HS-ETS1-2](#)

Reinforcement for Middle School:

Motion and Stability: Forces and Interactions: [MS-PS2-2](#), [MS-PS2-4](#), [MS-PS2-5](#)

Common Core

ELA Standards: [Reading Informational Text](#) (RI): 1, 3, 4, 5
 ELA Standards: [Writing](#) (W): 1, 2, 3, 4
 ELA Standards: [Speaking and Listening](#) (SL): 1, 3, 4
 ELA Standards: [Language](#) (L): 1, 2, 3, 5
 ELA Standards: [Reading for Literacy in History/Social Studies](#) (RH): 1, 3
 ELA Standards: [Reading for Literacy in Science and Technical Subjects](#) (RST): 1, 2, 3, 5, 8
 ELA Standards: [Writing Literacy in History/Social Studies and Science and Technical Subjects](#) (WHST): 2, 4, 7, 9

Prior to reading

Guide student reading by pointing out connections between this article and what students are learning in class. Here, find ideas for standard-aligned paths to follow while reading:

- The names we assign to things often tell a story. Students might want to research the Roman gods Jupiter and Juno, as well as the naming of the planet and the new NASA spacecraft. Why do students think the planet was named for Jupiter? And why was the mission named for Juno? Encourage students to think of other objects, missions or entities named after Greek or Roman gods. (*Company logos often use gods, such as Mercury in the case of FTD florists. Saturn cars are another good example.*) What other historical or cultural references are often incorporated into names?
- A K-W-L experience (what I Know, Want to know and Learned) can be a powerful tool to tap into student interests and focus instruction. Ask students what they think they know about the planet Jupiter and its relationship to the other planets in the solar system. (*Students might know that it's the fifth planet from the sun. They also might know that it is the largest planet, and they might know something about its properties and composition.*) How have researchers learned about Jupiter in the past? (*Students might talk about the use of telescopes to map its orbit around the Sun, images as seen through these telescopes or images captured by previous flybys.*) Ask students what they want to learn about Jupiter and about how scientists are exploring the planet today. If students chart responses to these questions, the class can return to the chart later to see what has been learned based on the article.

After reading: Comprehend

You can adapt and print these questions ([Blackline Master 1](#)) to check for comprehension and analysis before or after discussion:

1. **What is Juno's task?** (*To peer beneath the clouds of Jupiter for the first time and to see how much water there is, to map Jupiter's interior and to study its polar regions.*)
2. **What onboard technology will help Juno achieve its mission?** (*Solar panels, the largest flown on any interplanetary spacecraft; a titanium vault to protect electronics from radiation; a radio link for studying Jupiter's gravity; magnetometers to learn more about Jupiter's magnetic field and a camera, spectrometer and plasma and particle detectors.*)
3. **Why is Jupiter considered an extreme planet?** (*It is the biggest planet, the size of about 1,000 Earths; it spins faster than any other planet; it has storms that have lasted for at least 150 years; the center of the planet is believed to be hotter than the Earth's core; the sheer quantity of gases create enormous pressure.*)
4. **Why is the exploration of Jupiter's poles so interesting to scientists?** (*Scientists have never seen the poles, which aren't visible from Earth and haven't been visited by other craft. Also, the poles have been hard to study from Earth because the planet's axis is almost perpendicular to its orbit. The poles will give a good view of the auroras, which might help scientists understand the planet's magnetic field.*)
5. **Why will Juno plunge to its death?** (*Scientists are concerned about Juno hitting Europa, which might harbor life, and contaminating it with Earth microbes.*)

After reading: Analyze

1. What does it mean for a planet to have a core, and why don't scientists know for sure whether Jupiter has one? (A core is a seed from which the planet formed and would be a solid center part of the planet. Scientists haven't been able to see beneath the clouds so [they don't know exactly what the center of Jupiter is like.](#))
2. How do lessons learned from the recent exploration of Saturn influence scientists' thinking about what Juno might find at Jupiter? (The Saturn mission uncovered many unexpected results, so scientists are expecting the same thing at Jupiter. Some long-believed ideas about the planet might turn out to be false. By combining and comparing what they find at the planets, scientists hope they can learn about planet formation and the early solar system.)
3. Examine "Plotting a course around Jupiter," a companion piece to "Juno's view to Jupiter" that shows the paths of previous spacecraft around Jupiter as well as the planned orbit of Juno. How is Juno's path around Jupiter unique? What about it makes this an important mission? (People have sent many spacecraft near Jupiter, but Jupiter has rarely been the goal of previous missions. Most previous spacecraft have used Jupiter's gravity to slingshot elsewhere. Only the Galileo mission orbited several times. The Juno mission is positioned to monitor Jupiter's gravitational pull in order to better understand the planet. The different path that the probe takes will influence the types of data that can be collected. The path that Juno takes will protect the craft from radiation most of the time, increasing the likelihood that its instruments will be able to withstand the conditions around the planet and provide more data to scientists on Earth.)

Discuss and Assess

After students read the article independently, return as a group to the concepts outlined prior to reading. Invite students to share their answers and observations from the article and lead a class discussion that further underscores your current curriculum. The discussion can serve as an informal assessment. Ideas for further reading discussion or writing prompts include:

- Based on the information presented, was the Galileo mission a failure? (Students might consider Galileo a failure because the probe jettisoned from the craft hit a dry area, which didn't get the scientists the information they wanted. At the same time, Galileo acquired other details about chemical abundances, temperature and pressure.) How did the results of the Galileo mission inspire what became the Juno mission? (Scientists changed their thinking about how to collect data about the quantity of water on Jupiter since using a single probe could have highly variable outcomes.) There are numerous examples of scientists aiming to study one thing and discovering something unexpected (for example, in the 1950s when Bernard Burke and Kenneth Franklin identified [Jupiter as a strong source of radio waves](#) or when scientists [discovered active volcanism](#) on the Jovian moon Io). How do mission designers and engineers incorporate what they have learned from the past and also prepare for the unexpected?
- Discuss the concept of a citizen science. How is this mission tapping into the general public's interest in being part of the culture of discovery? Do students think that a lot of people will get involved in the Juno mission's citizen science opportunity? Students might want to try out the citizen science camera and find out. You can stay focused on this citizen science effort or broaden the discussion to other opportunities. There are many ways to find out about and get involved in citizen science. Students might start with the [Citizen Science Alliance](#) for ideas or explore offerings from local museums, such as the [Museum of Natural History](#) in Los Angeles, from nonprofits like [TreePeople](#), or from clubs like the [Girl Scouts of America](#). Once students know what it means to be a citizen scientist, they might come up with their own local projects.
- Ask students to think about the benefits of comparing and contrasting data. In what situations in life do they compare and contrast? How does it help them make decisions? How does it help them better understand themselves? What about the world around them? (Consider deciding between products at a grocery store, politicians in an election, sports teams, works of literature, or tools for solving a problem.) Scientists including astronomers rely heavily on comparing and contrasting. Why? What can they learn by comparing and contrasting multiple objects in the solar system? How is comparing and contrasting related to the idea of categorization?

Extend

Offer students other ways to explore the content of the article as it relates to your curriculum, such as:

MAKING SCIENCE CLEAR

Purpose: Science writers have the difficult task of making complex ideas accessible to their readers. This activity explores some of the ways Christopher Crockett makes this story accessible and asks students to try it out for themselves.

Directions:

1. Have students scan through the article and highlight words and phrases that help them understand complex scientific ideas. Give them [Blackline Master 2](#) to chart their findings and explain the concepts in their own words.
2. Recognizing that students have deep knowledge in areas of personal interest, challenge them to explain something they know deeply to a novice. For example, how would an expert skateboarder explain a trick to a novice? What words would students choose to make the complexity involved understandable? Give students some time to develop their ideas.
3. Have students share their descriptions. Encourage them to give each other feedback on how to make their descriptions even easier to understand.

4. Discuss how this experience can benefit their writing in the future. How can what they learned in this activity help them in other situations? Discuss other circumstances when it would be helpful to use visualizations, humor and metaphors and to break ideas down into simple language.

DEMONSTRATING PRESSURE

Purpose: Pressure is a challenging concept for many students. Making a change in pressure visual can be very helpful. This demonstration can be done by the teacher using the talking points provided or, with additional materials, can be done by the students so they can see the impact of changing air pressure on a substance.

Background: Jupiter's atmosphere is incredibly thick. As an object moves from the outermost edge of the atmosphere toward the center of Jupiter, the amount of gas pressing on that object increases. The same phenomenon happens here on Earth. As you move from the top of a mountain toward sea level, the air pressure increases because more of the atmosphere is weighing down on you. The compression from above means that the same amount of air takes up less space (density increases). In this demonstration, you will see how changing the volume occupied by air changes the air pressure. (Remember that Boyle's Law states that for a fixed amount of gas at a fixed temperature, volume and pressure are inversely proportional.)

Materials for the teacher or for each team:

- Transparent [flavor injector](#) or 100 ml syringe
- 2 to 3 miniature marshmallows for each test

Directions:

1. Ask students to explain the major components of air (*nitrogen, oxygen and trace gases including argon, carbon dioxide and water vapor*) and remind them that the components that make up air are mostly in gas form. Ask students to describe the characteristics of a gas. How do the molecules in a gas move?
2. Pass out the marshmallows and syringes (or decide to do this as a demonstration).
3. Ask a student to place the marshmallows into the syringe and position the plunger into the syringe close to the marshmallows without touching them. Ask students to predict what will happen to the marshmallows when the plunger is pulled and why. Record all reasonable comments.
4. Have students place a finger on the end of the syringe and pull the plunger out to the end of the syringe (they may have to help each other). Have students observe what happens to the marshmallows. (*As the plunger is pulled out, the volume of air inside the syringe increases, causing a drop in pressure, as seen by the expansion of the marshmallows.*)
5. Next, have students release their finger from the end of the syringe and reset the syringe with the plunger at the end of the syringe. Then, once again place a finger on the end. Have them push the plunger into the syringe and observe the marshmallows. (*Students will notice that the marshmallows shrink. As the plunger is pushed into the syringe, the volume of air inside the syringe decreases, causing an increase in pressure. This can be seen by the compression of the marshmallows.*)
6. Ask students how the marshmallow changed in each situation. Brainstorm ways that students might be able to measure or otherwise quantify the change in marshmallow size. If time allows, have students try out their ideas to see which ideas work and which might be most accurate.
7. Ask students to consider how they might explain atmospheric pressure to someone much younger than themselves.

BRAVE NEW WORLDS

In a previous guide on the New Horizons mission to Pluto, "A world like no other comes into view," we included an activity that helps students learn how astronomers explore distant planets using various techniques. You can find that activity on Page 4 [here](#).

PLANETARY BILLIARDS

Purpose: This NASA activity, which can be found [here](#), provides a hands-on way for students to explore the concept of a gravity assist, or slingshot method, to get spacecraft to the outer planets.

Materials: The models described in the activity can be made with simpler materials, including stiff board for the base, putty or clay to secure the base and cardboard or any other stiff material for the shoot.

Additional procedure:

1. You can modify the activity to include an experiment by asking students to first consider the variables that can be modified. Make sure they understand what each variable represents:
 - the size of the ball bearing (the size of the craft)
 - the strength of the magnet (the size of the planet)
 - the slope of the launch ramp (speed at spacecraft launch)
 - distance from ramp to magnet (distance to planet)
2. Have students decide what variables they would like to test and then run their experiments.

3. Students can use rulers, protractors and other tools as needed to make quantitative measurements. Students can measure the angle of deflection by marking the location the ball bearing enters the baseboard and where the ball leaves the board with a pencil. See Figure 3 in [the NASA document](#).
4. Students can create a chart to track their results.
5. Have students discuss their results. Which variables affected the craft's path? Which had the greatest effect?
6. Discuss how realistic this model is. What does it include? What does it leave out? Planets are not stationary, but instead move along their orbits. How would students change the model to represent this? How might their results change? Students can visit this [Planetary Society site](#) to visualize the new scenario.

Comprehend

After reading the article "Juno's view to Jupiter," answer these questions:

1. What is Juno's task?
2. What onboard technology will help Juno achieve its mission?
3. Why is Jupiter considered an extreme planet?
4. Why is the exploration of Jupiter's poles so interesting to scientists?
5. Why will Juno plunge to its death?

Analyze

1. What does it mean for a planet to have a core, and why don't scientists know for sure whether Jupiter has one?
2. How do lessons learned from the recent exploration of Saturn influence scientists' thinking about what Juno might find at Jupiter?
3. Examine "Plotting a course around Jupiter," a companion piece to "Juno's view to Jupiter" that shows the paths of previous spacecraft around Jupiter as well as the planned orbit of Juno. How is Juno's path around Jupiter unique? What about the path makes this an important mission?

Making science clear

Directions: Science writers have the difficult task of making complex ideas accessible to their readers. Find examples of how the article’s author, Christopher Crockett, makes this story accessible. A few are done for you.

Word or phrase from the article	How it helps understanding
Jupiter is “a massive time capsule”	We know what a time capsule is – something that stores something from the past.
“Jupiter is no stranger to robotic explorers”	We know what robots are and we know what explorers are. The phrase “robotic explorers” gives the spacecraft a personality.

Now think of something you are really good at. Maybe you can do a great trick on a skateboard or maybe you have a special family recipe. Think of something you know that requires technical skill. What is it?

How would you describe your skill to someone who has never seen or done it? What words would you use to help that person visualize what you are describing? Practice your explanation here: