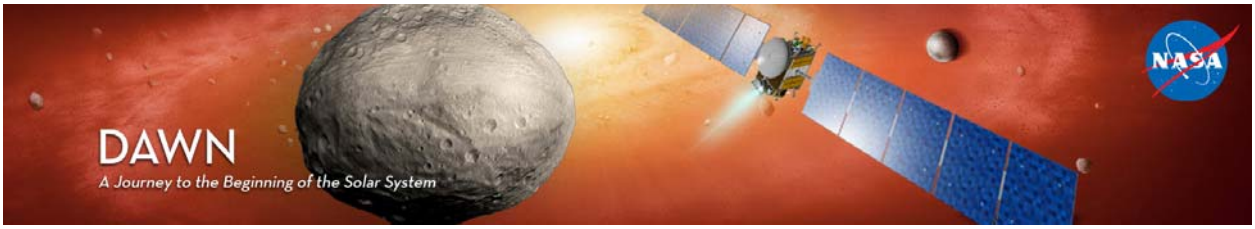


Visualizing Vesta

TEACHER GUIDE

BACKGROUND

Small worlds in the Solar System, such as asteroids and comets, tell us about the conditions that existed when the Sun and planets were still forming. Asteroids are among the "original members" of the Solar System. Often too small to support the evolutionary processes we see on large planets like Earth, they are leftovers, remnants of the process that built the inner planets.

This full view of the giant asteroid Vesta was taken by NASA's Dawn spacecraft, as part of a rotation characterization sequence on July 24, 2011, at a distance of 3,200 miles (5,200 kilometers).

The main asteroid belt lies between the orbits of Mars and Jupiter. Two of its largest bodies are Vesta and Ceres, the targets of NASA's Dawn mission. Scientists think they have remained intact since the earliest stages of their formation. Dawn's goal is to characterize the conditions and processes of the Solar System's earliest epoch. This will be accomplished by investigating two of the largest objects in the asteroid belt. Even though they are both members of the main asteroid belt, Ceres and Vesta followed very different evolutionary paths. Their diverse formation was influenced by many factors at play during the first few million years of Solar System evolution.

Dawn began orbiting Vesta in mid-July of 2011. The spacecraft imaged one of the largest mountains in the Solar System in the asteroid's southern hemisphere. Science findings also include an in-depth analysis of a set of troughs near Vesta's equator, and a close look at its intriguing craters. Vesta's surface appears to be much rougher than most asteroids in the main asteroid belt. In addition, preliminary data (gathered by a method that uses the number of craters) indicate that areas in the southern hemisphere may be as young as 1 billion to 2 billion years old, much younger than areas in the north and mid-latitudes spanning back to 3.5 to 4 billion years old.

In this activity, students will join scientists taking a closer look at some of the first images returned from Dawn.

Lesson Objectives

- Compare features of two different areas of Vesta's surface.
- Hypothesize some possible causes for differences between the two images.
- List questions that you have about the surface of Vesta.

National Science Education Standards Addressed

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise scientific explanations and models using logic and evidence

DRAFT Next Generation Science Standards, May 2012, ESS.1A, Middle School

Disciplinary Core Idea: Earth and the Solar System

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

Crosscutting Concept: Patterns

- Patterns can be used to identify cause and effect relationships.

Science and Engineering Practices

- Base explanations on evidence and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

Big Idea

The surface of Vesta is highly complex. Preliminary images of Vesta show many intriguing craters. The surface appears to be different from most asteroids in the main asteroid belt with tectonics (ridges and troughs) as well as interesting regolith properties (surface dirt and dust).

Key Concept

Recent observations of Vesta at close range reveal diverse surface features that indicate complex characteristics and history of these small bodies in our Solar System.

Essential Questions

- How are surfaces of asteroids varied?
- What can cause of the differences in the surface features?

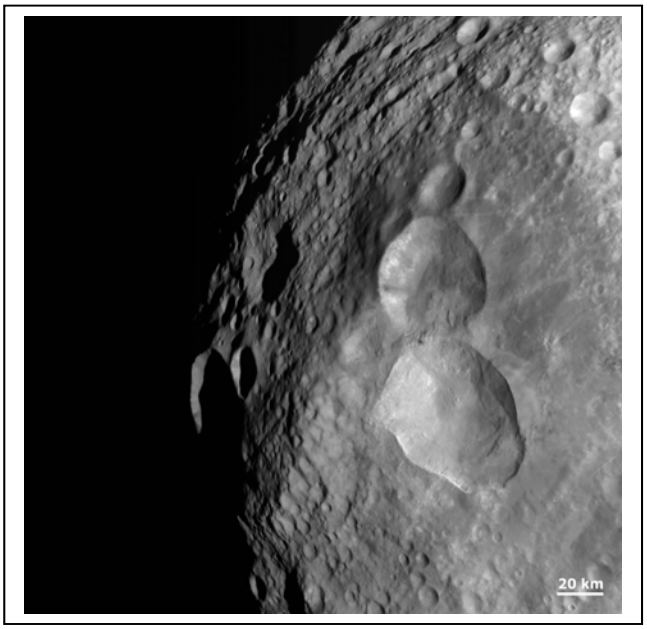
Materials

- Sticky Notes
- Image of Vesta from Hubble Space Telescope: https://dawn.jpl.nasa.gov/multimedia/images/image-detail.html?id=PIA13427
- Dawn Dictionary for definitions of terms: http://dawn.jpl.nasa.gov/dictionary/index.asp

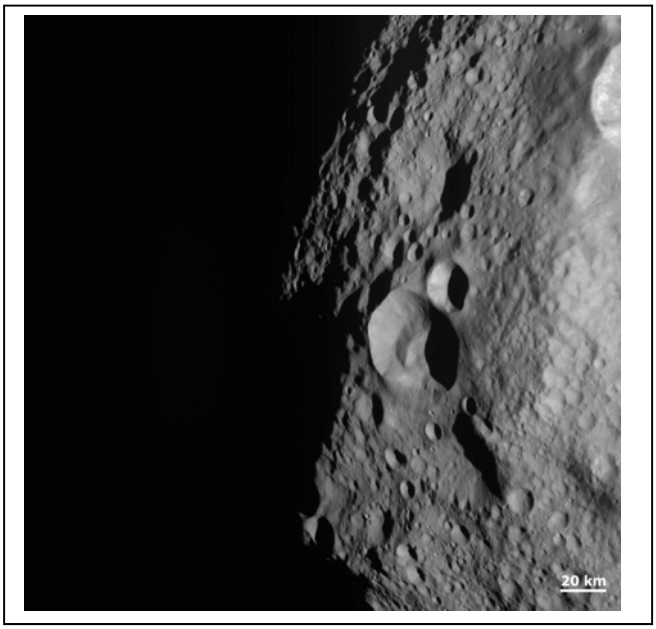
Procedure

1. Ask students what they know about asteroids. Elicit student responses without comment. You may want to list these initial ideas on the board. Show an image of Vesta from Hubble Space Telescope and ask them to think about what the surface might be like.
2. Assemble students into small groups of 2 to 4. Distribute the student activity sheets and ask students to record both qualitative and quantitative observations on the Venn diagram on their sheet. Hand out the rubric and explain that students will be completing a peer assessment for their comparison exercise.
3. Provide students with enough time to make several observations. Once they have had ample time to record observations, ask them to report out some of the similarities and differences they recorded.
4. Ask students questions similar to the following:
    a. Based on your comparisons and contrasts, why do you think the two surface images are different?
    b. What factors may have caused these differences?

5. Accept student responses. Students might suggest that the two surfaces are from different parts of Vesta and that there is uneven cratering, or there may be different ages or depths to the craters, or have been effected by volcanism.
6. Have one group trade papers with another group and conduct a peer assessment using the rubric.
7. Explain the assessment option of making additional comparisons of an image of Vesta of their choice.



NASA's Dawn spacecraft obtained this image with its framing camera on **Aug. 20, 2011**. This image was taken through the camera's clear filter. The image has a resolution of about 260 meters per pixel.



NASA's Dawn spacecraft obtained this image with its framing camera on **Aug. 11, 2011**. This image was taken through the camera's clear filter. The image has a resolution of about 260 meters per pixel.

Strategy: Teaching Students to Be Metacognitive

Using sticky notes, teach students to peer-assess. Have students check another's work, looking for specific indicators of performance. After checking for these indicators, students can practice writing comments that point out one thing that was done well and provide one suggestion for how to improve future work.

Student Procedure

Based on your observations of these images, how are the surfaces similar? How are they different? Use the Venn Diagram on the next page to help organize your descriptions. Write descriptions that are unique to the August 20 image on the **left**. Write your descriptions that are unique to the August 11 image on the **right**. For those features that are common to both images, write the descriptions in the middle, where the two circles intersect. Observations can be qualitative (using word descriptions) or quantitative (using numbers and measurements).

Note

In comparing the surfaces:

- We suggest including observations first, then adding interpretation afterward.
- When you are comfortable with the observations and have experience, the interpretation flows as in the case with some experienced astronomers.

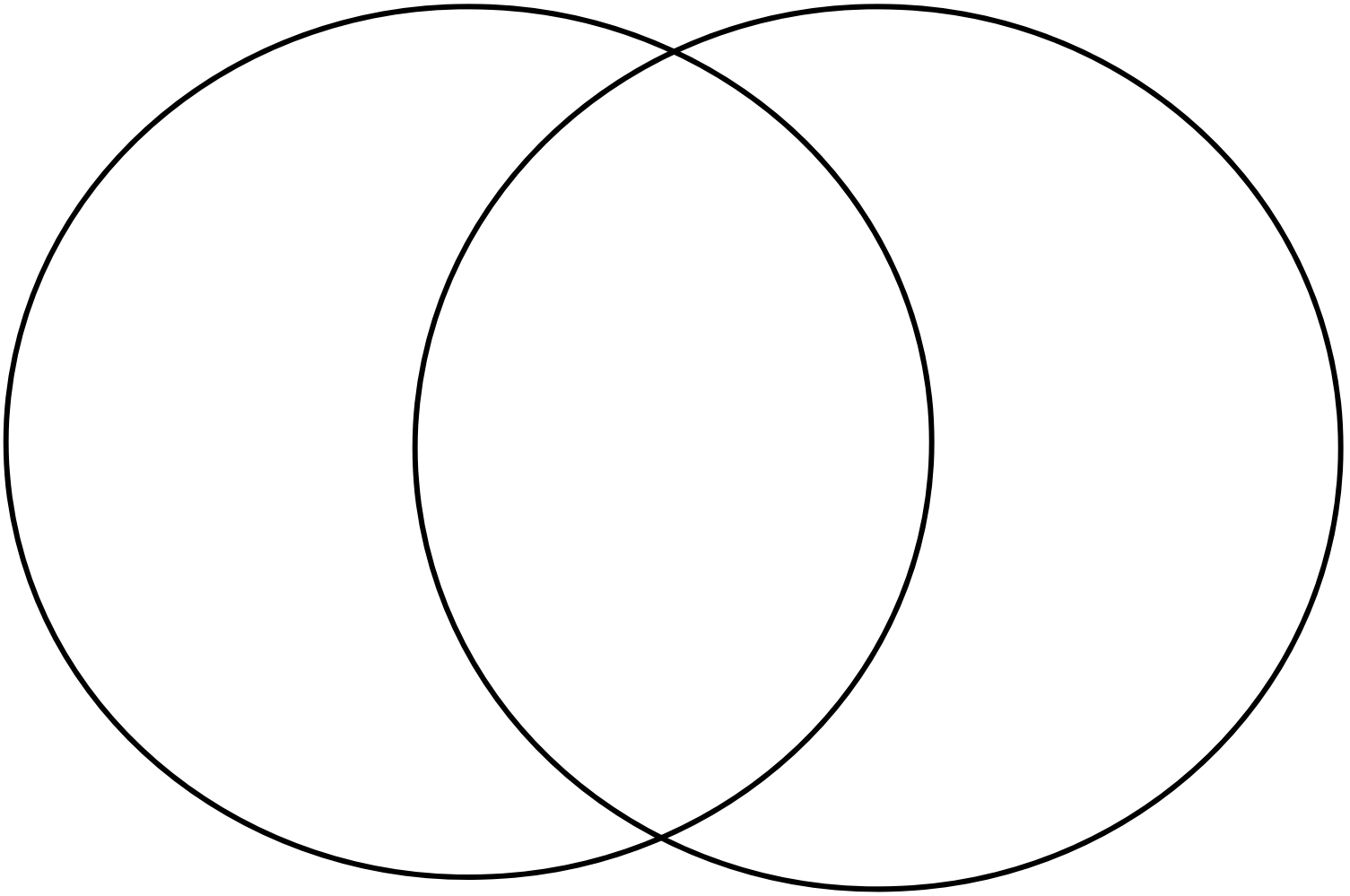
Examples of Differences

August 20 Image

- have three large circular features that resemble a snowman
- snowman feature seems to surrounded by a smoother area (than surrounding surface)

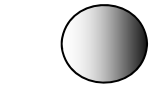
August 11 Image

- overall rougher surface
- not as many smooth areas
- some craters seem to have craters inside of craters
- seem to have more craters overall



August 20, 2011 Image **August 11, 2011 Image**

1. Can you tell the Sun's position in relation Vesta in these images? Is it the same for both? Explain your reasoning (feel free to include sketches to help illustrate your ideas!).
   Possible answer: The Sun is located to the right of Vesta as we look at both of these images. We can tell because the shadows on the craters (depressions) are on the right, meaning the craters are casting shadows from the Sun being on the right. This can be demonstrated using sand in a tray. Make crater depressions in the sand and hold a light source to create shadows.



Crater View from Above

Crater Cross-Section View

2. Based on your comparisons and contrasts, why do you think the two surfaces are different? What factors may have caused these differences?
   Possible answers: In the past these two areas of the same surface have had different impacts with smaller objects. The impacts occur at different times. In more recent impacts the debris that was kicked up settled back on the surface causing smoother areas. In older areas smooth areas are covered with additional smaller craters. The illumination is different. One area is older.

3. What questions do you have about the surface of Vesta? How would you go about answering these questions?
   Questions will vary but may include: How old are the different features on Vesta? Are the three large craters that form the snowman feature about the same age? What are the sizes of objects that formed the various crates? What causes the different light and dark areas on the surface? What is it like under the surface of Vesta? Does the surface of Vesta have dirt or dust like the moon? What kind of material makes up the surface of Vesta? What would it be like to visit Vesta in person? Are there minerals that would be valuable there? Is there any ice present in the craters? What are the polar regions like?

In the assessment that follows, students will make careful observations and interpretations of a new image from Vesta using the same skills you practiced above.

Assessment

Examine Vesta images from Dawn. Choose one to observe and interpret. Images can be found in the Vesta Image of the Day Gallery located here: http://dawn.jpl.nasa.gov/

Use the rubric provided on the next page as a guide.

Indicate the name and date of the image.

Observations:

Interpretations:

Scoring Rubric

Criteria	4	3	2	1
Makes accurate observations	Clearly describes almost all of the features of the image in detail. Includes great clarity of the entire surface as a whole.	Clearly describes the features of the image in detail.	Describes a few of the features of the image but doesn't provide many details.	Describes only one or two features in the image, but provides so few details that the reader has trouble distinguishing them
Interprets and synthesizes information	Explanations of observations about the features of the Vesta image are reasonable and thorough.	Explains observations about the features of the Vesta image in ways that are reasonable.	Provides explanations about observations of the features of the Vesta image which may not be reasonable.	Explanations about the features of the Vesta image do not match the observations.

Asteroid Mappers Extension

http://dawn.jpl.nasa.gov/DawnCommunity/asteroid_mappers.asp
Asteroid Mappers: In this project the students can access and analyze high-resolution Dawn images of Vesta including craters and other features from your own computer.

Related News Releases:

https://www.jpl.nasa.gov/news/news.php?feature=3532
Giant Asteroid's Troughs Suggest Stunted Planet

https://dawn.jpl.nasa.gov/news/news-detail.html?id=3512
Vesta in Dawn's Rear View Mirror

https://dawn.jpl.nasa.gov/multimedia/images/image-detail.html?id=PIA15506
NASA's Mission Video Shows Vesta's Coat of Many Colors

https://dawn.jpl.nasa.gov/news/news-detail.html?id=3352
Dawn Reveals Secrets of Giant Asteroid Vesta

https://dawn.jpl.nasa.gov/news/news-detail.html?id=3317
Dawn Sees New Surface Features on Giant Asteroid