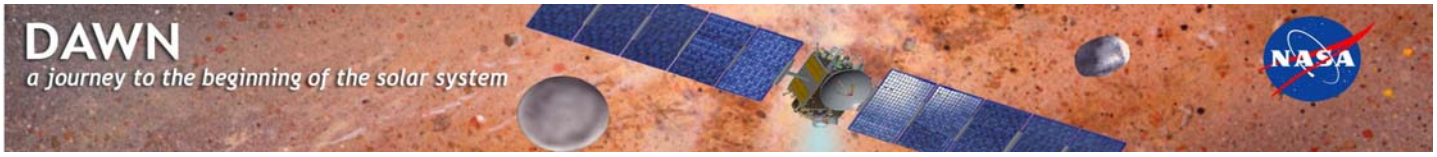


Art in Science: Value in Albedo

STUDENT ACTIVITY

The Dawn spacecraft entered orbit around the asteroid Vesta in July 2011. As it approached, the framing camera (one of the instruments on board) began taking beautiful images like the one in *Figure 1.* Before Dawn, the best source of that information was a set of images taken by NASA's Hubble Space Telescope in 1994 and 1996 (see *Figure 2* below). The Hubble pictures were little more than "fuzzy circles," in shades of gray. That's because though one of the largest members of the main asteroid belt, Vesta is small compared to say Mars or Jupiter, and that when Hubble took the pictures, Vesta was 131 million miles away!

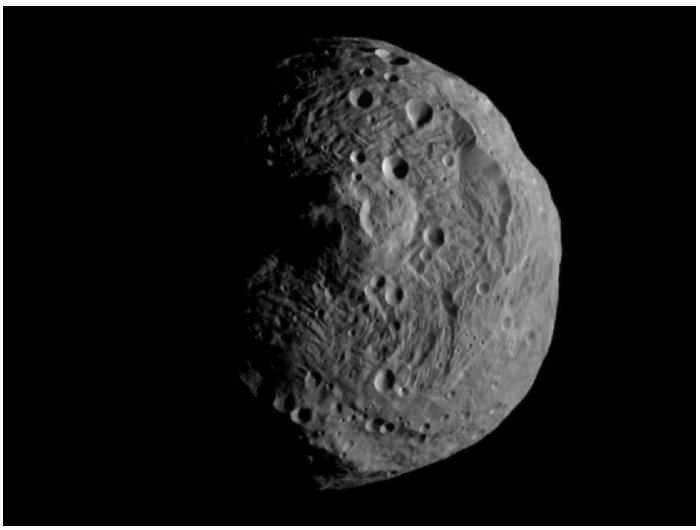


***Figure 1*: NASA's Dawn spacecraft's framing camera captured on July 17, 2011. It was taken from a distance of about 9,500 miles (15,000 km) away from the asteroid Vesta. Each pixel in the image corresponds to roughly 0.88 miles (1.4 kilometers).**

Have you ever wondered how we get pictures from space? Images of large and small bodies in the solar system taken from spacecraft are acquired as a table of numbers. Each number represents the brightness of one "square," or pixel, in an image. Look at the Hubble picture of Vesta again (*Figure 2*). Can you see the "squares" in the picture? The Hubble image represents average values (from 0 to 100) of lots of individual small squares that are then put together to make the bigger image. Those squares are the *pixels*!

Albedo is the amount of "whiteness" of an object. Huh? Here's another way to think of it: albedo is the amount of light reflected from a surface. Measuring the amount of light reflected from planets, moons, or asteroids gives us information about their composition and topography.

For a more in depth experience with albedo, use the activity "Seeing Circles" in the development section of the *History and Discovery of Asteroids* module at http://dawn.jpl.nasa.gov/DawnClassrooms/1_hist_dawn/.

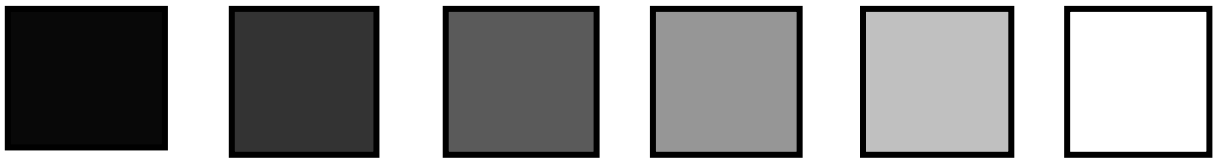
Pixels are the individual photo elements, or the smallest units, of a picture that can be represented by the instrument taking the photo. "Higher resolution" images contain more detail than "low resolution" images. Sometimes the resolution is a function of the instrument taking the photo; but sometimes resolution can also be a function of the distance that you are from the object itself. In other words, if you are very far away from something, you will get a fuzzier picture than if you take a picture closer to that object. That's why, even though the framing camera on the Dawn spacecraft is a lower resolution camera than can be found on the average cell phone nowadays, it is taking crisp, clear pictures of Vesta. The Dawn spacecraft is a lot closer to Vesta than we are here on Earth! In the text box under *Figure 1* above, it says, "Each pixel in the image corresponds to roughly 0.88 miles (1.4 kilometers)." That means that the smallest thing you can see in the picture is at least 0.88 miles in size. Smaller features are "lost" in the averaging of the pixel.

When scientists are recreating pictures from a table of numbers transmitted from a spacecraft, the numbers are assigned "brightness values" and those values are assigned to each pixel. For example, 0 can represent black and 100 can represent white, with each number in between representing a different shade of gray. This measure of "brightness" is termed *albedo* (see text box for more on albedo).

Let's do some activities to help make sense of all this!

Part A

Estimate the brightness (where 0= black and 100= white) of these example pixels. Discuss with a partner how and why you decided on the values between 0 and 100.



a. 0 b. _____ c. _____ d. _____ e. _____ f. 100

Figure 2 below is the best image we had of Vesta before the Dawn mission. In *Figure 3*, we have magnified 97 pixels of varying brightness that represent a small sample of the larger area (640 by 480 = 307,200 pixels) in *Figure 2*. For planetary remote sensing, the numbers are first recorded on the spacecraft, and then transmitted back to Earth where they can be reconstructed into images.

Figure 2: Image of Vesta from the Hubble Space Telescope

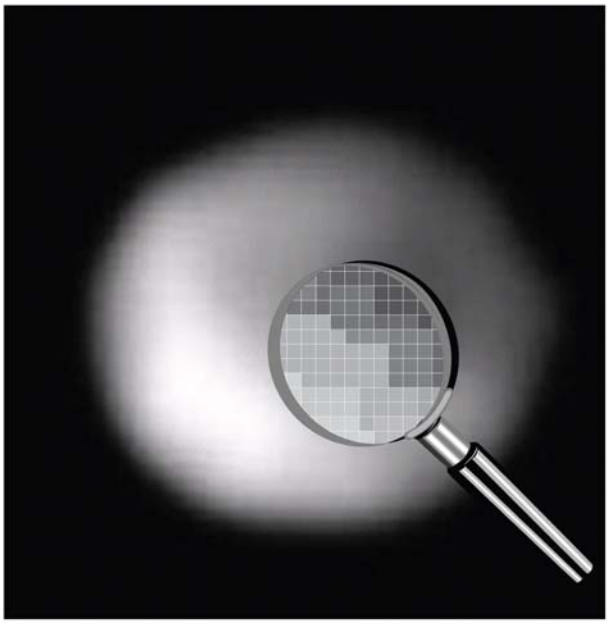


Figure 3: Enlarged area showing individual pixels

Using the larger image of the magnifying glass in *Figure 4*, work with a partner to draw lines around each region of similarly colored pixels. Next, estimate a brightness value between 0 and 100 for each region of similar pixels, where 0 = black and 100 = white.

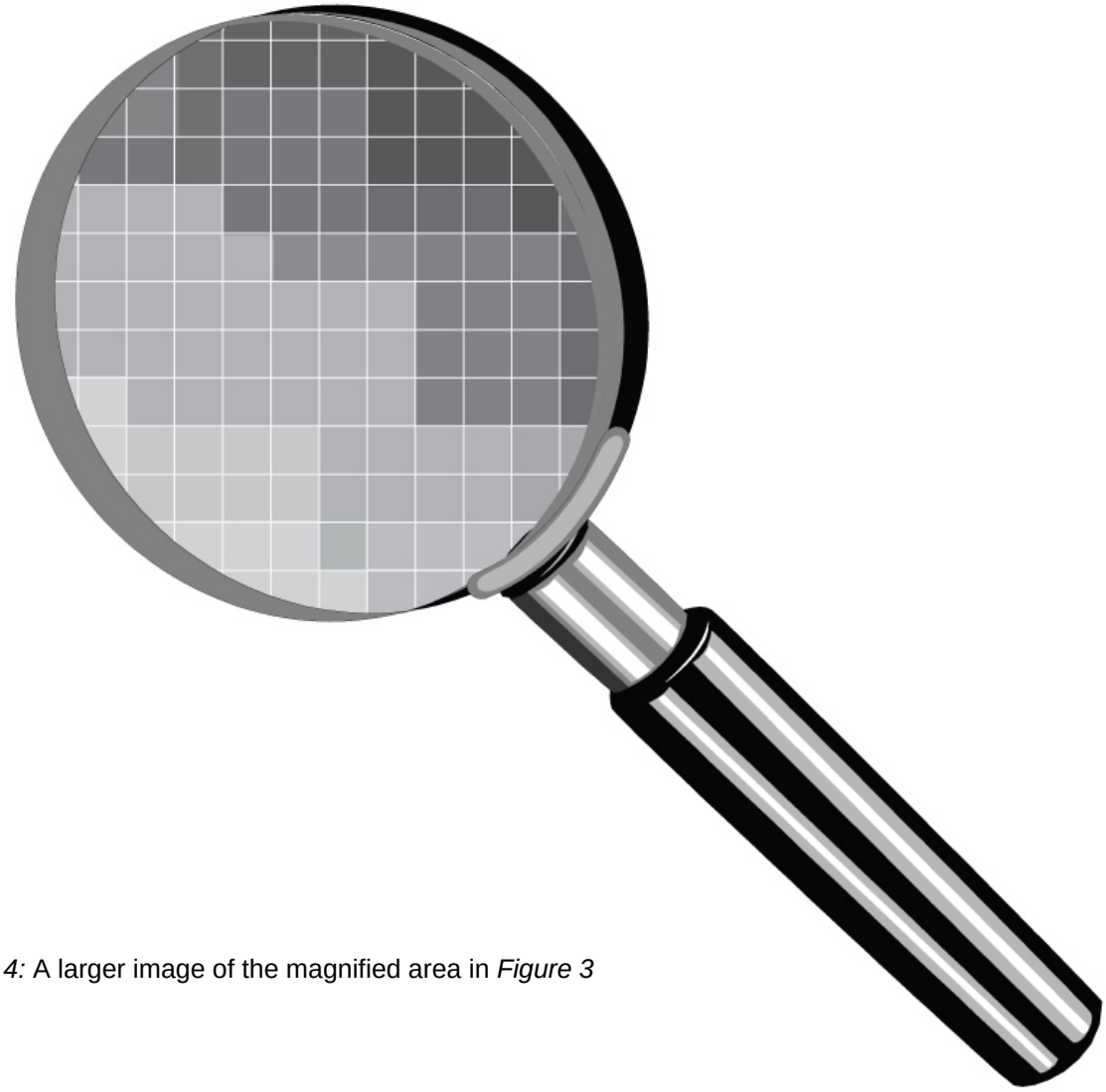


Figure 4: A larger image of the magnified area in *Figure 3*

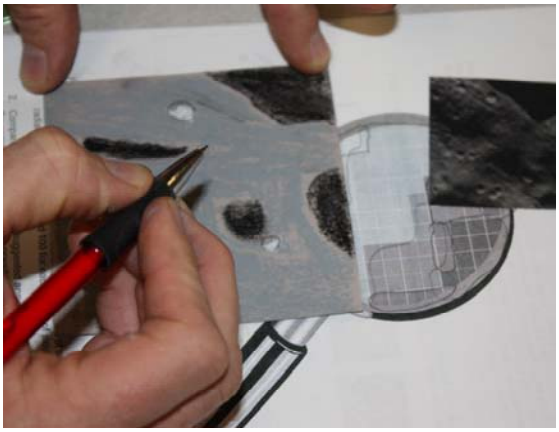
Once you have agreed on your areas and assigned values, answer these questions.

1. Compare your answers to the suggested answers in the Leader Guide and to other groups working on the same image. Are they the same? If not, why do you think that you outlined different areas?

2. How might these challenges be similar to the ones faced by scientists studying Vesta today? Write down your ideas then discuss your thoughts with a partner.

Part B

Science and Art have a lot in common. For example, in Art, ***value*** is the term used to describe light and dark in an image. This light and dark is similar to the "brightness" (or ***albedo***) of a pixel in a digital image from space.



You will be given a small portion of an image. Enlarge that image, paying close attention to the lights and darks, by drawing it onto a larger square of paper. Once you have finished drawing your small portion, or "pixel," look on the back of your image. There is a number and an arrow. Use that number and arrow to orient your square onto the large grid hung on the wall by your teacher or group leader. The arrow points to the top of the image. Be sure to affix your drawing in the correct orientation (i.e. make sure "up" is "up").

Once you have contributed your "data" to the group, answer the following questions. Use the back of this sheet or another piece of paper, if necessary.

1. Look closely at the larger image you have created collectively as a group. Describe the physical features that are light. Describe what you see that is dark.

2. What challenges, if any, did you face in drawing your small image onto a larger piece of paper?

3. Looking at the larger image created by the whole group, compare how this process is similar and/or different from the creation of digital images from the framing camera data transmitted from the Dawn spacecraft.