Traveling with Dirty Snowballs

Lesson Development

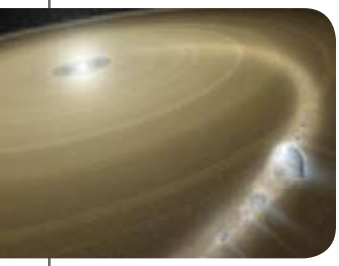
GRADES 3-5

INSTRUCTIONAL OBJECTIVES

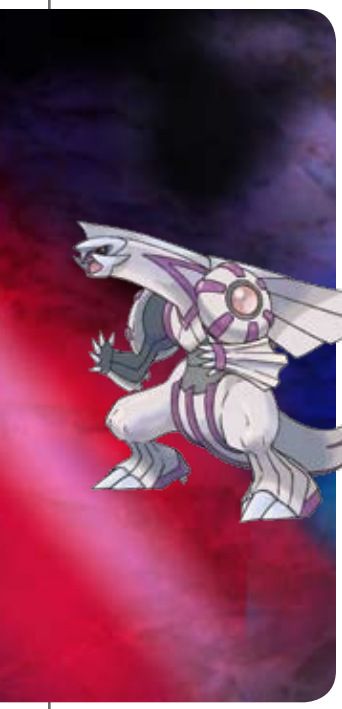
Students will

- analyze "mystery comets" to make inferences about the comets' origin and composition;
- use the Internet to explore the history and composition of comets;
- develop PowerPoint presentations to present their findings to the class;
- discover how scientists collect and analyze comet dust; and
- create their own models to represent comets.

Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



Comet 'Bites the Dust' Around Dead Star (Image: NASA)



BACKGROUND

People have wondered about comets for centuries. Their unpredictable and erratic behavior led early people to believe that they might be omens foretelling disasters. Through time, their sightings were noted and often blamed for catastrophic events on Earth. The first known sighting of a comet was recorded as early as 1059 B.C. by a Chinese astrologer.

Through more careful observation, scientists learned that a comet's path could be charted and predicted. Sightings that were once believed to be different comets, turned out to be sightings of returning comets. Edmund Halley was, at first, surprised to see significant similarities in comets seen in 1531, 1607, and 1682. Careful study helped him realize those were sightings of the same comet, traveling on an unusual, yet predictable path. Halley predicted the return of this comet using Newton's theory of gravity but, sadly, died 12 years before Comet Halley returned to view in 1758. It has since reappeared in 1986 and is expected back in 2061.

Scientists believe that comets may be the oldest, most primitive bodies in the solar system, originating at the outer ends of the solar system. Recent findings suggest that they may have also been responsible for carrying materials to Earth that later led to life here on Earth.

Small and unevenly shaped, comets are often described as "dirty snowballs." But, based upon analysis of comet particles captured and returned to Earth by NASA's Stardust mission, scientists now believe that comets may be much more than simple chunks of water ice, frozen carbon dioxide and dust. Stardust samples contained some high- and low-temperature minerals, suggesting that comets may form in different locations and under a range of conditions.

It was particularly exciting to see particles rich in organic matter in these samples. This discovery led scientists to consider that comets may have carried water and organic matter to early Earth. These materials are important to the origin of life.

A comet's elliptical or egg-shaped orbit carries it close to the Sun and then back into deep space. When a comet travels near the Sun, heat changes some of its core, or the ***nucleus***, into a cloud of gas and dust. This cloud is called the ***coma***. Some of these particles create a long, flowing tail. Solar winds cause this tail to point away from the Sun. When a comet's tail can be seen from Earth, the view may be spectacular. It's no wonder early people coined the name comet from the Greek "Icometes" meaning "long-haired star."

Observatory spacecraft have increased scientists' abilities to study and view comets. Since its first mission in 1988, the Solar and Heliospheric Observatory (SOHO) spacecraft has discovered over 1000 comets. That's about half of all comet discoveries with computed orbits in the history of astronomy. Many of these comets have actually been discovered by amateurs using SOHO images on the Internet.

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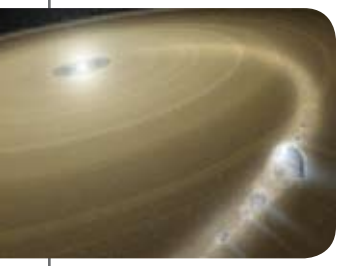
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



Comet 'Bites the Dust' Around Dead Star (Image: NASA)

ENGAGE

Use the image of Comet Halle-Bopp to discuss with your students their understanding of comets (TEACHER RESOURCE). Use a KWL (KNOW/WANT TO KNOW/LEARNED) chart to help organize what your students **KNOW** and **WANT TO LEARN** about comets.

These questions can help guide your discussion:

- What do you **KNOW** about comets?
- Based on the picture of Comet Halle-Bopp, what state(s) of matter might be found in a comet?
- What would you like to **LEARN** about comets?
- What technology tools help us learn more about comets?

Comet Halle-Bopp

EXPLORE

It's challenging for astronomers to study the composition of comets because it's difficult to capture much more than comet debris and dust. In this EXPLORE experience, students observe and analyze comet models to gain a better understanding of comet composition.

A. Mystery Comets A and B

1. Pre-teaching preparations:
   Prior to this experience, make enough Mystery Comets A and B to have one comet for each pair of students. The recipe for Mystery Comets A and B was originally suggested by NASA astronomer Dr. Sten Odenwald at "The Astronomy Café," http://www.astronomycafe.net/qadir/q838.html.
2. Materials to Make 24 Mystery Comets A and B (12 of each):
   - water
   - about 55 ml (¼ cup) sand
   - about 55 ml (¼ cup) oatmeal
   - about 110 ml (½ cup) cocoa
   - blue food coloring
   - crushed ice
   - two ice cube trays
   - 24 foam cups
3. Directions to Make Mystery Comets A and B:
   a. Mystery Comet A:
   - Mix about 480 ml (2 cups) water with 55 ml (about ¼ cup) sand and cocoa. The cocoa simulates graphite.
   - Pour this mixture into an ice cube tray and freeze the mixture. Add a small amount of blue food coloring for a hint of color, but not so much that you can't see the cocoa in the water.
   - Put some crushed ice in the bottom of a foam cup. Then, place one cube on top of the bed of crushed ice. Surround the cube with crushed ice until the cup is about half-filled with ice. Add water to the crushed ice and freeze until this hardens. Repeat this step to make 12 comets.
   - You've just created a clump of ice that contains suspended chunks of colored, dirty ice. This simple comet model shows how some comets are formed by accumulating pieces of ice. These ice pieces never really blend with the original nucleus. The sand and cocoa represent pieces of rock and asteroid debris swept up by the comet as it travels through space.
   - Label the cups "A."

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Lesson Development (continued)

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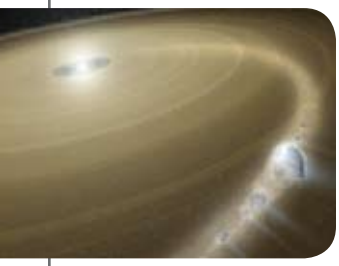
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



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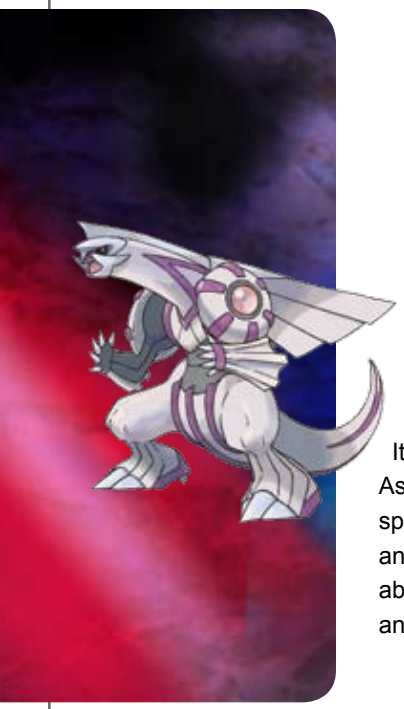

b. Mystery Comet B:
   - Follow the directions above, replacing the sand with oatmeal.
   - Label the cups "B."

4. Students will work with a partner to observe and analyze a mystery comet.
   a. For each team, you'll need:
      - a comet (Mystery Comet A or B)
      - paper plate
      - piece of cloth or towel
      - metric rulers
      - spoons
      - safety glasses
      - hammer (for an adult to crush the comets)
   b. Give each team a comet cup and ask students to peel away the foam cup. Ask students to use the paper plate as a work space.
   c. Ask students to sketch and record what they observe. Use these questions to help guide student observations about the comets:
      - What can you measure while observing your comet? (These are quantitative observations.)
      - Describe your comet. What kind of materials can you identify in your comet? (These are qualitative observations.)
      - How is your comet changing?
      - What might you learn about the origin of your comet by analyzing the materials found in the comet?
      - How are comets A and B alike?
      - How are comets A and B different?
   d. Ask the students to wrap their comet in the cloth or towel. An adult will crush the comets with a hammer so that students may continue to analyze their comets.
   e. Use these questions to help guide student observations:
      - Now that you can see "inside" the comet, have any of your observations changed?
      - Continue to observe and compare comets A and B.
   f. Ask students to discuss whether they think naming a comet a "dirty snowball" is accurate? Based upon their observations, how else might they describe comets?

It is hard to learn much about comets by simply observing them, especially from a distance. Astronomers use many tools and techniques to help them study comets. One technique, spectroscopy, splits light into a spectrum of colors. Different materials can be identified by distinct patterns and colors. By viewing comets and their tails using visible and ultraviolet spectroscopy, astronomers are able to identify some of the chemical composition of comets. For this experience, students will use red and blue transparencies to simulate making observations spectroscopically.

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Lesson Development (continued)

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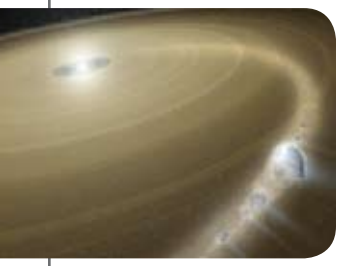
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



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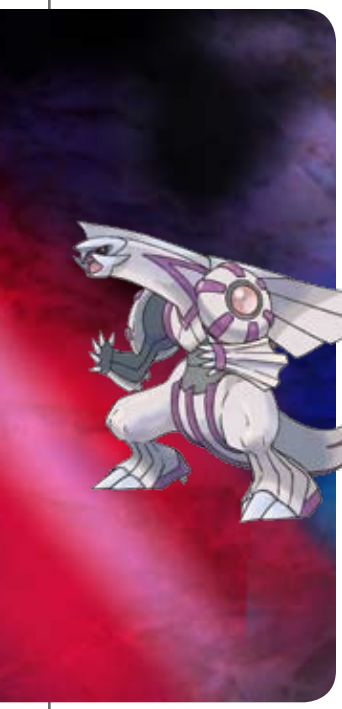

B. Mystery Comets 1, 2 and 3

1. Pre-teaching preparations:
   Prior to this experience, make enough Mystery Comets 1, 2 and 3 to have one comet for each pair of students. The recipe for Mystery Comets 1, 2 and 3 is an adaptation of an activity found in an educator guide for NASA'S 21st Century Explorer program, http://education.jsc.nasa.gov/explorers/pdf/p7_educator.pdf.
2. Materials to Make 24 Mystery Comets 1, 2 and 3 (eight of each):
   - water
   - 24 small, foam plates
   - 24 quart-size sealable plastic bags
   - 24 effervescent tablets
   - crushed ice
3. Directions to Make Mystery Comets 1, 2 and 3:
   a. Mystery Comet 1:
      - Make eight plates of Comet 1. Cover the surface of a small, foam plate with crushed ice. Seal the plate in a quart-size plastic bag marked "Comet 1." Store the plate in the freezer until needed.

   b. Mystery Comet 2:
      - Make eight plates of Comet 2. Crush one effervescent tablet and mix with enough crushed ice to cover the surface of a small, foam plate. Seal the plate in a quart-size plastic bag marked "Comet 2." Store the plate in the freezer until needed.

   c. Mystery Comet 3:
      - Make eight plates of Comet 3. Crush two effervescent tablets and mix with enough crushed ice to cover the surface of a small, foam plate. Seal the plate in a quart-size plastic bag marked "Comet 3." Store the plate in the freezer until needed.
4. Students will work with a partner to observe and analyze a mystery comet.
   a. For each partnership you'll need:
      - a comet (Mystery Comet 1, 2, or 3)
      - one 8.5" x 11" red transparency
      - one 8.5" x 11" blue transparency
      - metric rulers
      - stopwatches
      - safety glasses

   b. Give each team one plate that represents material gathered from a comet. Ask students to carefully remove the plate from the plastic bag.
   c. Ask students to sketch and record what they observe on the plate. Use these questions to help guide student observations about the comets:
      - What can you measure while observing your comet? (These are quantitative observations.)
      - What kind of materials can you identify in your comet? (This is a qualitative observation.)

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Lesson Development (continued)

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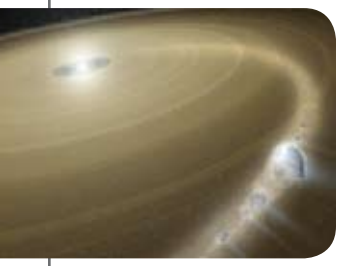
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



Comet 'Bites the Dust' Around Dead Star (Image: NASA)

d. Show students how to place a red transparency on half of the plate and a blue transparency on the other half. Looking through the different colored transparencies simulates how spectroscopy enables astronomers to identify different materials in comets. Ask students to compare what they saw before and after using the transparencies. Ask students to look at all three mystery comets.
e. Ask students to dump all the comet material into the labeled plastic bag. Show them how to remove as much air as they can from the bag and then to tightly seal the bag.
f. Show the students how to flatten the bag and observe the bag from the side for a profile view. Ask students to sketch the profile of the bag and measure the highest point of the bag. This will be their zero-minute observation. Sketches and observations should be recorded in the data chart found as a STUDENT HANDOUT at the end of this lesson.
g. Place the bags in a sunny location. This simulates what happens as the comets travel near the Sun. Heat from the Sun causes some of the solid material of the comet to quickly change to gas. This is called ***sublimation***. Astronomers can identify some of the comet nucleus by analyzing the gases that sublime. For the model, heat from the Sun melts the ice. The liquid water dissolves the effervescent tablets, producing carbon dioxide.
h. Ask students to make predictions about how the "comet material" might change over the next 15 minutes. They will make observations every three minutes for the next 15 minutes.
i. Ask students to compare changes observed in comets 1, 2 and 3. The bag containing comet 1 should not rise since it is only ice. This is the "control." The bag containing comet 2, with one effervescent tablet, will rise less than the bag containing comet 3 and two effervescent tablets.
j. Use these questions to help guide a discussion with your students.
    a. What change in matter do you observe?
    b. What changes do you observe in the height of each bag?
    c. What do you think is causing these changes?
    d. What inferences can you make about the materials in each bag?
    e. How does this model simulate changes observed in comets?

EXPLAIN

A. Use these questions to help lead a discussion with your students about the EXPLORE experiences:

- How do your experiences with the two different comet models compare?
- How were you modeling how astronomers study comets?
- What are some limitations to these models?
- What role does technology play in comet study?
- What have you learned about the composition of comets and how these materials change?

Take your students to the Stardust Comet Sample Return Mission Website, http://stardust.jpl.nasa.gov/photo/mission.html, to see samples of comet dust. Compare the image of ITALICS Red/Green Stereo Anaglyph of Comet Wild 2 to the work students were doing during the EXPLORE experiences:

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LESSON DEVELOPMENT

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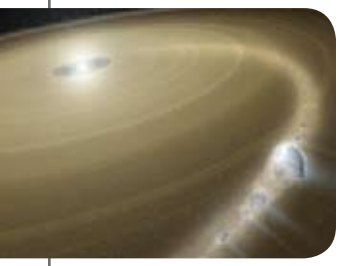

Comet 'Bites the Dust' Around Dead Star (Image: NASA)

B. Guide students to these Internet resources for more information about comets, famous historical comets, and how scientists study comets.
   1. Encourage your students to read, "NASA's Spitzer and Deep Impact Build Recipe for Comet Soup" to find out what scientists learned about comets when Deep Impact smashed into comet Tempel 1.
      http://origins.jpl.nasa.gov/news/2005/090705-a.html
   2. Help students discover the difference among comets, meteors, and meteoroids by visiting NASA's Space Science: "Adventure is Waiting" site:
      http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Space_Science_Adventure_Is_Waiting_Activity_3-5.html
   3. Although rare, comets sometimes hit the surface of planets, moons and the Sun. Encourage your students to learn more about impact craters created by meteors, asteroids, and comets at
      http://ares.jsc.nasa.gov/Education/websites/craters/Intro1.htm
   4. These sites help students learn more about the role comets have played in history:
      - Comets Throughout History
        http://www.windows.ucar.edu/tour/link=/comets/comets_in_history.html
      - Comets in Ancient Cultures
        http://deepimpact.jpl.nasa.gov/science/comets-cultures.cfm
   5. Advancements in technology help astronomers learn more about comets. Guide your students to these sites for more information about past and current comet missions:
      - History's Greatest Comet Hunter Discovers 1000th Comet
        http://www.nasa.gov/vision/universe/solarsystem/1000comet.html
      - NASA's Solar System Exploration – Past Missions to Comets
        http://solarsystem.nasa.gov/missions/profile.cfm?Sort=Target&Target=Comets&Era=Past
   6. Through the years, some comets have stood out. Encourage your students to learn more about some of these comets by visiting:
      - Famous Comets
        http://amazing-space.stsci.edu/resources/explorations/cometmyth/lesson/facts/Fact6/index_nf.html
      - Comet Hale-Bopp
        http://www2.jpl.nasa.gov/comet/
      - Shoemaker-Levy 9
        http://nssdc.gsfc.nasa.gov/planetary/comet.html
      - Hyakutake
        http://www2.jpl.nasa.gov/comet/hyakutake/
      - Comet Halley
        http://seds.org/nineplanets/nineplanets/halley.html

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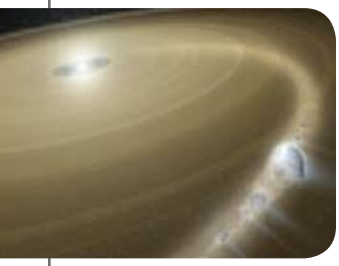

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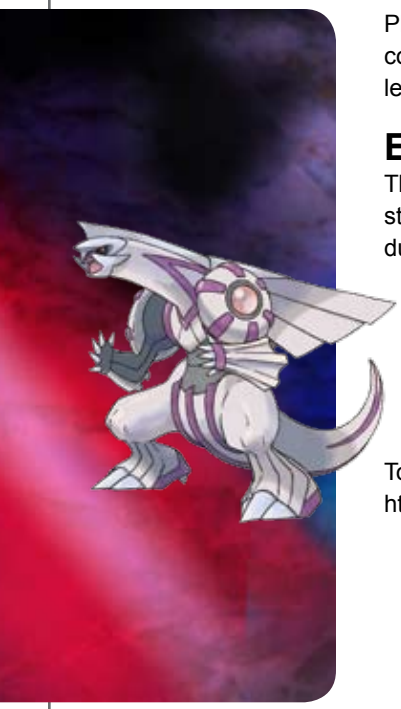

ELABORATE

Challenge your students to create a PowerPoint presentation using information and images they've discovered throughout this study of comets. Some may want to create a presentation about a particular comet; others may want to analyze current comet missions.

Before you begin, you may want your students to use a storyboard to help them plan and organize their slides. One example of a storyboard can be found at http://nortellearnit.org/resources/Handouts/

It may also be helpful for your students to review some Nortel LearniT video tutorials for help in creating their PowerPoint presentation.
They can be found at http://nortellearnit.org/technology/PowerPoint_Presentations/

Your students may want to use images found during their review of Websites in the EXPLAIN section of this lesson. They can either download those pictures to the hard drive, or save the URL as a "Favorite" in the Web browser.

Encourage your students to put a descriptive title screen, credits and references at the end of the PowerPoint presentation.

Please remind students to use only images that they have permission to include. Review copyright and copywrongs by watching the Nortel LearniT video tutorial at http://nortel-learnit.org/technology/Digital_Ethics/

EVALUATE

Through discussion and the results of the EXPLORE experience, determine if your students have an accurate understanding of comets. Complete the K/W/L chart started during the ENGAGE experience.

Ask students to answer this journal prompt to assess their understanding of the composition of comets.

- Comets can be described as "dirty snowballs." Is this an accurate description of comets? Why or why not?

To evaluate the PowerPoint slides, use a rubric found at the Nortel LearniT site: http://nortelearnit.org/resources/Handouts/

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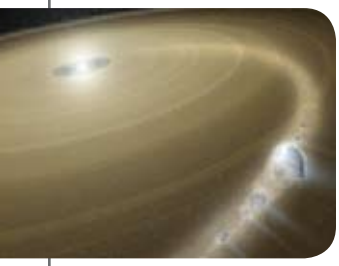

Comet 'Bites the Dust' Around Dead Star (Image: NASA)

EXTEND

These activities may be used to extend or continue your students' exploration.

A. EXPERT INTERVIEWS - WHAT DO YOU WONDER NOW?
What are your students wondering now that they've learned more about comets? Generate a list of questions that your students might ask "the experts" from NASA, the National Institute of Aerospace and research universities. Submit this list following the link on this Website. Several questions from all submitted will be used in video interviews with "experts" and posted to this site. Students may "ask an astronomer" their own questions by visiting the Astronomy Café: http://www.astronomycafe.net/qadir/qanda.html. The Astronomy Cafe is run by Dr. Sten Odenwald, a NASA astronomer. This site has been "open for business" since 1995. More than 360 FAQ can also be found by visiting this site.

B. Because it's difficult to study comets as they travel through space, scientists look for ways to catch and bring comet dust back to Earth. Launched in 1999, Stardust was the first US space mission with a primary goal to explore a comet, gather comet and interstellar dust, and return these samples back to Earth. Enclosed in a capsule, these dust samples were returned to Earth on January 15, 2006. Since then, they've been studied by scientists and, via the Internet, by citizen scientists.

- More can be learned about Stardust at http://www.nasa.gov/mission_pages/stardust/news/stardust-20070201.html
- NASA's Captain Comet can help your students discover more comet and Stardust mission activities at http://stardust.jpl.nasa.gov/classroom/captaincomet.html
- Encourage your students to become spacecraft engineers and learn more about the Stardust spacecraft at http://stardust.jpl.nasa.gov/classroom/jason/index2.html
- Guide your students to this Website to download parts and directions for building their own Stardust spacecraft model: http://stardust.jpl.nasa.gov/classroom/model/index.html
- Tails of Wonder! Work with your students to help the Stardust spacecraft capture comet dust and bring it back to Earth: http://spaceplace.nasa.gov/en/kids/stardust/index.shtml

C. Encourage your students to create other models of comets. Some suggestions can be found at: http://www.lpi.usra.edu/education/explore/comets/extensions.shtml

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Teacher Resource

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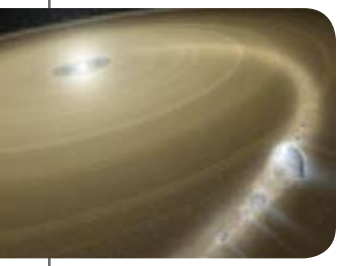
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



Comet 'Bites the Dust' Around Dead Star (Image: NASA)

Image: National Astronomical Observatory of Japan.
Comet Halle-Bopp

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Student Handout

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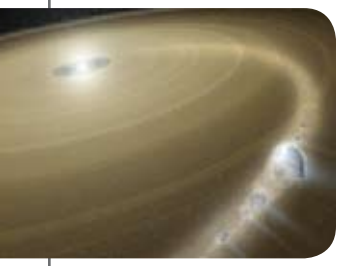
Comet Hale-Bopp in the constellation Andromeda (Image: NASA)



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DATA CHART
MYSTERY COMETS 1, 2 OR 3

Mystery Comet 1, 2, or 3	0 minutes	3 minutes	6 minutes	9 minutes	12 minutes	15 minutes
Sketch outline of the bag's profile						
Prediction: *height of the bag in cm*						
Observation: *height of the bag in cm*						
Other observations						