NASA's EPOXI Mission Modeling Comets

Comet on a Stick!

EDUCATOR GUIDE

Created for the Deep Impact Mission, A NASA Discovery Mission
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Adapted by EPOXI E/PO

Mission Description:

The Deep Impact flyby spacecraft has sufficient fuel to undertake further studies. The new mission, named EPOXI, is comprised of two projects with different scientific objectives. The first is called Extrasolar Planet Observations and Characterization (EPOCh) and made extrasolar planet observations. The second is called Deep Impact Extended Investigation (DIXI) and continues the original Deep Impact theme of studying comets by flying past Comet Hartley 2. A primary focus of this second investigation will be to compare Hartley 2 with comets observed by other spacecraft missions. This study will help determine which cometary features are primordial and which are the result of subsequent evolutionary processes.

Activity Description:

Maura Rountree-Brown demonstrates *Comet on a Stick*

The "Comet on a Stick" activity is designed for students in grades 4-8 but can be used with a wide age range of students. In this activity, students strengthen their concepts of a comet by designing and building a model of a comet. The primary goal is to have students replicate the scientific processes of observing, modeling, forming an explanation, making new observations, and revising. In this manner, students have the opportunity to emulate the experience of scientific discovery that makes science so exciting. Students will learn the basic characteristics of a comet and practice evaluation and improvement of their comet model. The importance of this activity is not the design and construction of the comet model, but rather the fact that it will provide an opportunity for students to emulate a process that scientists and engineers follow on all missions.

Parallels in Science:

Scientists formulate scientific questions based on current scientific theory and observation of models of physical systems or phenomenon. NASA missions are designed to answer specific questions. To answer these questions, scientists start with a model which they then compare with observations and current scientific theory. As new data are gathered, the model is improved if needed and re-tested against observations.

The Activity:

"Comet on a Stick"—Student Activity
Gather household and art supplies for the students to design and build comet models.

Teacher background materials for this activity:

- *Consider This* - This page shows the history of perceptions about comets. http://deepimpact.umd.edu/educ/ExploringComets03.html
- *A Comet's Place in the Solar System* - A little history about comets and where they came from. http://deepimpact.umd.edu/educ/ExploringComets04.html
- *Ten Important Comet Facts* - A quick review of comet facts. http://deepimpact.umd.edu/educ/CometFacts.html
- *Small Bodies Missions* - Learn more about other missions to comets and asteroids. http://deepimpact.umd.edu/science/smallbodies.html

National Science Education Standards **addressed:**

Grades K–4

Science as Inquiry

- Ask a question about objects, organisms, and events in the environment
- Plan and conduct a simple investigation
- Use data to construct a reasonable explanation
- Communicate investigations and explanations

Earth and Space Science

- Changes in the Earth and Sky
  - Objects in the sky have patterns of movement

Grades 5-8

Science as Inquiry:

- Identify questions that can be answered through scientific investigations
- Think critically and logically to make the relationships between evidence explanations
- Develop descriptions, explanations, predictions and models using evidence
- Recognize and analyze alternative explanations and predictions

Earth and Space Science

- Earth in the Solar System
  - The Earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets
  - Most objects in the solar system are in regular and predictable motion

AAAS Atlas Concept Map:

Grades 3-5

Scientific Inquiry: Scientific Investigations

Scientific Investigations may take many different forms, including observing what things are like or **what is happening somewhere,** collecting specimens for analysis, and doing experiments.

Grade 3-5

Scientific Inquiry: Evidence and Reasoning in Inquiry

Offer **reasons for their findings** and consider reasons suggested by others.

Grade 6-8

The Universe: The Solar System

...Other chunks of rock mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen materials from their surfaces and pushes it into a long illuminated tail.

Objectives:

Students will

- build a model of a comet to study the way the Sun affects it,
- simulate the Sun's solar wind as it interacts with the comet, and
- evaluate the strengths and weaknesses of their comet model.

Tips for materials to improve or build comet models:

- One 2" styrofoam or other ball or an 8 ½" X 11" piece of paper
- Two 1–2' lengths of mylar gift strips, raffia, or ribbon
- Transparent tape and/or white glue
- One wooden skewer (shish kabob type)
- Optional: An electric hairdryer (with electrical power available) if you want students to model how the (ion) tail forms
- One marker
- Miscellaneous household or art supplies
    - Fruits and vegetables that might look like a comet nucleus
    - Different kinds of paper or streamers
    - Paints, markers, crayons, or colored pencils
    - Netting or other fabrics
    - Bulk cushion stuffing fiber or cotton balls
    - Tin foil
    - Playdough or clay
    - Any additional kind of textured covering that you think would be useful
    - Anything else you can come up with

Procedure:

1. As a class, discuss what is or might be true about comets. Build one list by writing students' ideas on the board. Add to that list the things they wonder about comets or don't know. *Explain to students that they will build a model of a comet to study the way the Sun affects it.*
2. Explain to students that they will be collaborating in teams to complete their models. Use a T-Chart to help students brainstorm what collaboration "sounds like" and "looks like." The following T-Chart is provided as an example.

Collaboration

Sounds Like	Looks Like
Use Person's Name	Smile
Ask For Feedback	Nod
What do you think?	Eye Contact
How are you doing?	Lean Forward
Is this O.K. with you?	
What doesn't make sense?	
What can I do to help?	
What's wrong?	
We need your ideas.	
Are we all together on this?	

3. Explain to students that they will evaluate their group at the end of the lesson to determine how well the group collaborated. Now, have students build a "*Comet on a Stick*."
4. Form teams of two or three students per team (depending on the size of your class) and distribute the student activity sheet to each student or one per team. Have each team choose three facts about comets they would like to show through their model. They can choose from their original brainstorming list, *Comet Facts to Model*, and/or from the list here:

- Shape
- Composition
- Formation Location
- Location and Path in Space (Orbital Size and Shape)
- Structure (parts) of a Comet
- Colors
- How Comets Affect the Earth

5. Ask students to develop a model of a comet using the directions on the student activity sheet. Tell students to use their model to illustrate their chosen characteristics about comets. Remember, the importance of the activity is not the initial model, but rather the students' evaluation of and improvement of their models.
6. Explain to students that they will assess their team on the following criteria (1 = outstanding, 2 = good, 3 = needs improvement):
    - Our model displays three characteristics of a comet.
    - We understand the relationship between parts of the model and actual comets.
    - We provided suggestions for improving our model.
    - We understand the effect of the Sun on comets.
7. Once the models are completed, have students use a hairdryer to simulate the Sun's solar energy (in the form of solar wind) as it meets the comet. Use the following explanation to accompany this simulation:

    The heat radiated from the Sun warms the surface of the comet nucleus. This causes gas, ice, and dust to flow from the comet in all directions forming the coma, which is the most visible part of a comet. In addition to the coma, comets have two types of tail: a tail made of dust particles and a tail of electrically charged gas. The dust tail is made up of larger particles and is like a trail of crumbs behind the comet. The other is composed of charged particles and smaller particles that react to the solar wind and therefore always points away from the Sun.

    Which tail is being simulated by the hairdryer?

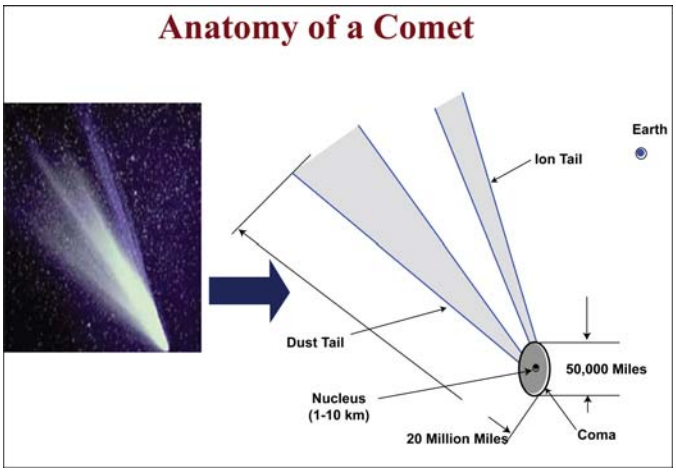
    After the comet reaches its closest distance to the Sun, it then starts to move away. As it gets further from the Sun, the temperature decreases so the gases and dust are no longer driven off. The coma and tails eventually become smaller or disappear altogether leaving the bare, frozen nucleus.

8. Have someone be the "Sun" and stand in place with the hairdryer. The hairdryer simulates the solar wind that blows the comet's "gas tail" in a direction away from the Sun. Have students aim the hairdryer at the head of the comet as it approaches and then as it moves away from the Sun. They will need to turn in a circle to do this. Have a second person hold the comet model by the stick and walk in an oval (elliptical) orbit around the Sun.
9. Use this interactive simulation http://www.windows.ucar.edu/tour/link=/comets/comet_model_interactive.html to further illustrate how a comet orbits the Sun. With this simulation, students can control a comet's forward or backward motion, its speed of revolution, and how oval shaped the comet's orbit is (eccentricity). Conclude this simulation by asking students to evaluate the strengths and weaknesses of their model for showing the influence of the Sun on their comets.
10. Ask students to respond to the following:
    - Describe your comet model.
    - Explain how your model shows three facts about comets.
    - What are the strengths of your model for showing the proper influence of the Sun?
    - How can your model be improved?
11. Ask students to show their model to other teams without explanation in order to determine if the other teams can identify what is being modeled about a comet.

12. Ask students to determine how well they collaborated as a team in building a clear and accurate model. Have them complete the team collaboration evaluation on the student activity sheet.

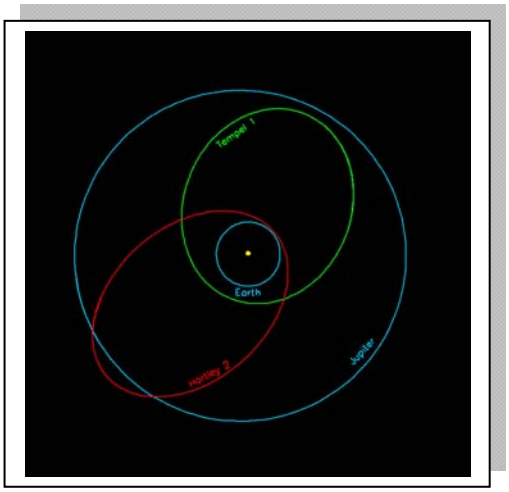
Background for the Teacher:

1. Comets can have three tails (in the Facts listed for the students, only the dust and ion tails are described):
    A. The dust tail is formed from dust carried off the nucleus when the ices sublimate. The particles in the dust tail are traveling at a slightly slower speed than the comet causing them to fall into their own orbits around the Sun. Eventually the dust spreads out along the orbit, so the dust tail appears very broad and curved. The dust tail is yellowish in color because sunlight reflects off the dust grains.
    B. The ion tail is composed of gasses that have been driven off the nucleus and then become charged or ionized. The ionized gas is now influenced by the solar wind. Since the solar wind is blowing from the Sun, the ion tail always points away from the Sun. In addition, the ion tale appears bluish because the charged atoms glow.
    C. The neutral sodium tail is very hard to see. Most discussion of comet tails relates to the dust tail and the bluish ion tail.
2. A hairdryer only blows air from one direction while the Sun radiates energy in all directions. However, relative to the comet, the Sun's energy is still going to be coming from just one direction.
3. The *Comet on a Stick* model demonstrates an ion tail resulting from the flow of air (modeling solar wind). However, it fails to show the formation of the coma itself (the outgassing of gas and dust from the illuminated portions of the nucleus) and how the tiny nucleus is hidden within the huge surrounding cloud of the coma.
4. The students' model probably does not show the dust tail of a comet. The dust tail is formed from larger particles of ice and dust that have fallen off the comet. The larger particles are like a trail of crumbs and mark the orbit of the comet which is curved. Having the students model the dust tail could become a messy proposition.
5. As the *model* comet moves away from the hairdryer/Sun, its tail droops because the model is here on Earth and subject to gravity. In space, as the comet gets further from the Sun, it returns to its frozen state and the coma and tails eventually disappear.
6. The comet nucleus is blacker than copy machine toner or charcoal. Although some dust is carried off the nucleus when the ices sublimate, dust is also left behind to accumulate a very dirty surface. When we see most comets, we are usually seeing the coma and tails which are reflecting sunlight or glowing, as in the case of the ion tail.
7. Comets also exist in different, irregular shapes and are not round "balls." They are shaped more like potatoes.



Comet Facts to Model:

1. Like our planets, comets are in orbit around the Sun.
2. Comets are composed of gas, ice, and dust left over from the early formation of the solar system about 4.5 billion years ago.
3. The path of a comet around the Sun is an ellipse (oval). The Sun is closer to one end of the oval. As the comet travels on its path, (see red line at right) it will sometimes be closer to the Sun and sometimes be farther away.
4. Short period comets orbit the Sun every 20 years or less. Long period comets orbit the Sun every 200 years or longer. Those comets with orbits in between are called Halley-type comets.
5. Comets have three parts: the nucleus, the coma, and the tails.
    a. The nucleus is the solid center of the comet made of gas, ice, and dust.
    b. The coma is the gas and dust cloud that surrounds the nucleus. The coma is formed when sunlight warms the surface and causes gas and dust to spew forth in all directions.
    c. Comets have two tails:
        i. A dust tail which is like a trail of crumbs left behind the comet. The dust tail is yellowish in color because sunlight reflects off the dust grains.
        ii. The ion tail is mostly gas and always points away from the Sun. In addition, the ion tail appears bluish because the gas is glowing.
6. Scientists have seen the nucleus of comets range in size from less than 1 km to as much as 40 kilometers, the approximate diameter of Comet Hale-Bopp.
7. The coma of a comet can extend for tens of thousands of kilometers while the tails can extend for millions of kilometers.
8. A comet nucleus has a dark surface with cliffs, circular features, raised hills and other structures on its surface. The nucleus of a comet is not visible when it is close to the sun because it is usually very small and hidden inside the much larger and brighter coma.



Comet orbits are ellipses (Hartley 2 and Tempel 1). Planet orbits are more circular (Earth and Jupiter).