



# Comets – A Physical Model

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Dark Skies, Bright Kids  
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**Activity Time:** 35 min

**Prep Time:** 15 min

**Grade:** 3rd+

## Standards of Learning Topic

- Primary SOL
  - Science 3.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which l) models are designed and built
  - Science 3.3: The student will investigate and understand that objects are made of materials that can be described by their physical properties. Key concepts include c) visible physical changes are identified
  - Science 4.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which l) models are constructed to clarify explanations, demonstrate relationships, and solve needs
  - Science 5.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which j) models are constructed to clarify explanations, demonstrate relationships, and solve needs
  - Science 5.4: The student will investigate and understand that matter is anything that has mass and takes up space; and occurs as a solid, liquid, or gas. Key concepts include
    - a) distinguishing properties of each phase of matter
    - b) the effect of temperature on the phases of matter

## Description

The students (individually or in small groups) build a physical analog of a comet, including carbon dioxide (CO<sub>2</sub>) and water ices, dirt (for silicates), window cleaner (for ammonia), and corn syrup (for complex organic materials). As the CO<sub>2</sub> sublimates, students can observe the processes of outgassing that lead to comet tails. For younger students or limited time/space, the instructor can build a single comet.

## Materials

- Teacher needs
  - Rubber Mallet (preferable) or hammer
  - Window cleaner containing ammonia
  - 2 heavy-duty garbage bags



- Large bowl or tub
- Cooler or ice chest for storage
- Large plastic serving spoon
- Each group or student needs
  - Oven mitts
  - Gallon-sized bag with secure zip top
  - Water (~1/3-1/2 cup per student)
  - Dry ice (3/4 cup per student)
  - Dirt and/or sand (~3/4–1 cup per student)
  - Pebbles or small rocks (1-2 per student, optional)
  - Dark corn syrup or cola (~1 Tbl per student, optional)
  - Charcoal briquettes (1/2 brick per student, optional)

### ***Additional Information***

- Dry ice can often be purchased at grocery stores and can be stored in a cooler for about 5 hours, but leave the lid of the cooler ajar to permit gas to escape.
- Materials can be omitted as desired based on teaching needs.
- Oven mitts can be shared within a group, but must be worn when handling dry ice.
- A hair dryer or fan can be used to simulate the effects of the comet's orbit around the Sun.

### **Goals**

- Illustrate the structure and composition of comets
- Visualize the physical effects of sublimation
- Demonstrate how the structure of comets change during their orbits
- Emphasize that comets are largely made of the same types of materials found on Earth

### **Introduction to Topic**

Comets are made of rock, organics, nitrates and water. They typically orbit in the outer parts of the solar system. From time to time comets are knocked into orbits that bring them into the inner solar system. When this happens, the ice in the comet sublimates to form the characteristic tail of the comet.

### ***Pro Tips***

- To better visualize the effects of sublimation, the students can break their comet to look inside. As dry ice pieces sublimate, cavities will be left in the structure of the comet.

### **Pre-Activity Instruction**

To understand this activity, students need an introduction to the structure and features of a comet, as well as how comets move around the Sun.

### **Preparation**

- 1) Put on the oven mitts, double-bag the dry ice with the garbage bags, and crush the dry ice with a mallet or hammer. The goal is to have most of the ice become a fine powder—larger chunks won't mix well with the other ingredients—though a few fingertip-sized chunks will lead to more visible outgassing.
- 2) Place the charcoal briquettes in one of the extra bags and crush to a fine powder.
- 3) Fill the large bowl with water.
- 4) Divide the comet ingredients (dirt, sand, charcoal, pebbles, corn syrup) in whatever manner suits the group's size and abilities. DSBK sets up a station where each individual



student can get a teacher-measured amount of each ingredient, or you can split the students into groups of 3–5 and provide each group with the components.

## Procedure

- 1) Give each student or group a plastic bag and a pair of oven mitts. Explain the components of the model comet and what each represents in a real comet, at the appropriate level.
- 2) Distribute the comet components (dirt, sand, charcoal, pebbles, corn syrup) and instruct the students to mix them in their bag. An instructor can circulate among the students with the ammonia cleaner and add a few sprays to each bag.
- 3) Add ~3/4 cup of dry ice powder and ~1/3 cup of water to each bag, and instruct the student to mush the bag quickly to mix the ingredients, and then form the mixture into a ball and apply pressure until it freezes. The bags will be dangerously cold at this point – only someone wearing oven mitts should touch the bag for any length of time.
  - a. If a student's mixture is not freezing or they do not apply enough pressure, it may be necessary to add more dry ice.
- 4) After a hard ball forms, the instructor or student (wearing oven mitts) can pull it out of the bag to examine it. Look for jets of escaping CO<sub>2</sub> and the “craters” they leave behind. Students can move the comet through the air, watching the jets sweep back in a sort of tail, or use a hair dryer to simulate the motion of the comet through the solar system. Point out how dark and “dirty” the actual nucleus is, in stark contrast to the bright coma or tails we see in the sky!

### Safety Tips

- Dry ice can cause serious burns when handled improperly. The students require supervision while interacting with the dry ice in this lesson.

## Post-Activity Discussion

- *What parts of a real comet are represented by each of the model's ingredients?*  
The purpose of this activity is to get the students to connect the common everyday ingredients used in their model with the actual materials that comprise a comet. All ingredients are roughly equivalent to those found in real comets, with the exception of the ammonia in the window cleaner – this would be in solid ice form in cold outer space. The corn syrup or cola represents the complex organic molecules found mixed in comets.
- *Why do jets escape from the nucleus, and what are they?*  
Depending on the ages of the students, this activity can be used to demonstrate the process of sublimation and the concepts of phase change and phase change temperatures. Dry ice is much colder than water ice because CO<sub>2</sub> freezes at a much lower temperature than water, which is why water freezes when placed in contact with dry ice. Dry ice also sublimates (compare to melting and evaporation) at a lower temperature than water ice, so it becomes gaseous (and expansive) while the water ice remains solid.
- *Where is the comet in its orbit around the sun when we see its tail?*



While our comet model is outgassing, it resembles a comet as it approaches the Sun, which causes its surface to warm. After the gas ejection has ceased, the dirt-ball looks like a comet far from the Sun, more similar in appearance to an asteroid, with no bright coma or tail to reflect sunlight. The model emphasizes that comets are not static, unchanging objects—their appearance and properties depend strongly on their distance from the Sun, which is constantly changing.

### Extensions and Related Activities

- Related Lesson Plans:
  - Pocket Solar System
  - Scale Solar System
  - Edible Solar System
- Pin the tail on the comet.

A game where there is an orbit drawn on the board and students "pin" or draw the tail on the coma at different locations within the orbit. The tail is not formed by the motion of the comet but rather by the Sun's solar wind, which pushes materials away from the sun.
- The students can pin a strip of paper on a comet and carry it towards and away from a fan (the Sun) to show the tail always points away from the Sun regardless of motion.

### Resources

- NASA's Deep Impact mission impacted with a comet to better determine their composition.
  - [http://deepimpact.umd.edu/flash/di\\_science.html](http://deepimpact.umd.edu/flash/di_science.html)
- An interactive comet animation from Window To The Universe.
  - [http://www.windows2universe.org/comets/comet\\_model\\_interactive.html](http://www.windows2universe.org/comets/comet_model_interactive.html)

### Glossary

- *Coma* – Nebulous envelope forming the surrounding the nucleus of the comet.
- *Comet* – A celestial object in orbit around the Sun with a nucleus of ice and dust, which forms a tail of gas, and dust pointing away from the Sun on its approach.
- *Meteor Shower* – A number of meteors that radiate from a specific point in the sky on a given date yearly. Showers occur when Earth passes through comet debris.
- *Orbit* – The motion of celestial objects around each other when they are bound by gravity.
- *Phases of Matter* – The states in which matter can exist - a solid, liquid, gas or plasma.
- *Sublimation* – Change in the state of matter directly from solid to gas without passing through the liquid phase.
- *Tail* – Debris from the head of a comet that points away from the Sun.