

Lesson Plan D2

Comets and Meteoroids

Introduction

Comets have always fascinated people because of their unpredictability and their beauty. At one time they were seen as omens of evil. Later they were viewed as beautiful but harmless objects. Now we know they are a bit of both.

In this lesson, students will learn what comets are made of and a little of how they behave. Students will build a model that mimics the composition of a real comet nucleus. After making the model comet nucleus, students will use the Starry Night computer exercise to “hitch a virtual ride” on a comet as it **orbits** the Sun.

Key Concepts

- Comets are mostly made of dirt and ice.
- Comets are often called dirty snowballs or icy mud balls.
- A comet develops a tail when it gets close to the Sun.
- A comet’s tail always points away from the Sun.
- Meteor showers are caused when Earth moves through the debris left behind by comets.
- Comets move in **elliptical** orbits with random orientations.
- Most comets come from the **Oort cloud** at the outer edges of the solar system.

Materials Required

- 2 kg (4-5 pounds) dry ice (it can be wrapped in newspaper and stored in a picnic cooler)
Note the SAFETY WARNING in the Activity section below.
- 2 liters (quarts) of water
- A handful or two of soil
- 2 spoonfuls of molasses, dark corn syrup or pancake syrup

- 1 spoonful of rubbing alcohol or ammonia (window cleaner will do)
- 10-20 plastic bags (grocery bags with **NO HOLES**)
- Plastic dishpan or other large plastic container
- Plastic bowls or large ice cream containers (enough for each group of students)
- Wooden or sturdy plastic spoons (not metal!) for mixing
- Thick winter gloves
- Hair dryer or lamp with an exposed bulb
- Protective eye goggles
- Cloth towels
- Hammer

Time Required

Hands-on Activity: 40 minutes

Starry Night Computer Exercise: 20-30 minutes

Conceptual Background

Both comets and **asteroids** are small solar system bodies. They are both dark in color, irregular in shape, and made of ancient material from the formation of the solar system. They differ in their compositions and orbits. Asteroids are composed mainly of rock and metal, while comets are made of ice and rock. Asteroids tend to have near-circular orbits that lie in the plane of the solar system. Comet orbits are very elongated and are usually not in the plane of the solar system. Comet material has not changed since the formation of the solar system.

Comets move in random **orbits** around the Sun. This means their orbits can be tilted in all directions with respect to the plane of the solar system. Most comets orbit the Sun in a distant outer region of the solar system called the **Oort cloud**. The Oort cloud is a spherical shell of comet nuclei that surrounds the entire solar system. New comets are completely unpredictable. Every once in a while something happens to nudge a comet out of its place in the Oort cloud and it begins its long, slow fall inward toward the Sun. A comet can approach the inner solar system at any time and from any direction.



If a comet collides with a planet, it is very destructive. Comets have struck Earth repeatedly over Earth's history. Much of the water in Earth's oceans may have come from comets.

As a comet approaches the Sun and develops a tail, it also sheds small particles of itself. These particles stream out behind the comet and form a debris stream in the comet's orbit. If the comet's orbit crosses Earth's orbit, this debris stream can produce a **meteor shower**.

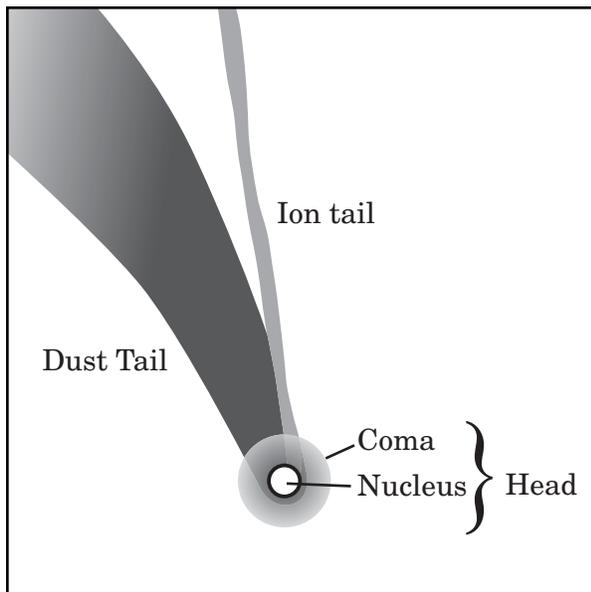


Figure D2.1
These are the main parts of a comet.

Activity

This is a messy activity best done outdoors. Certain safety precautions must be followed during this activity.

SAFETY WARNING:

Dry ice is -79 degrees C (-110 degrees F). Even brief exposure will cause "burns." Be careful when handling it. Always wear gloves to protect your hands, and safety goggles to protect your eyes.

This recipe makes a scientifically accurate model of a comet nucleus. Comets are made of frozen water, ammonia, organic (carbon-based) material, and silicates (dirt).

1. In the dishpan or large plastic bowl mix together about one half liter (one half quart) of water, half of the dirt, and all of the syrup, ammonia or rubbing alcohol.
2. Line the ice cream containers with plastic bags. There should be enough for each group of students to have one.
3. Divide the muddy-water mixture up between the lined plastic containers.
4. Have everyone put on gloves and goggles.
5. Place your dry ice in a double plastic bag. Wrap it completely in the cloth towel and put it on the ground.
6. Use the hammer to smash the dry ice into tiny pieces.
7. Pour equal amounts of the crushed dry ice into each of the lined ice cream containers with the water-dirt mixture. It will make lots of vapor.
8. Use wooden or plastic spoons to stir the mixture. Keep stirring until it gets thick.
9. Lift the plastic bags out of the containers.
10. Using gloves, pack the slush (still in the plastic bags) into balls. Keep packing until you have a solid frozen lump.
11. Remove the lumps from the plastic bags.
12. Sprinkle more dirt onto your comets. Pour water over them until they have a frozen layer of water all over them.

Now you have some comet nuclei. Watch what happens to them. Watch them hiss and pop as the dry ice **sublimates** from a solid to a vapor.

You can speed up the process with a hair dryer or other heat source like a lamp. Your comet nuclei are most impressive outdoors in bright sunlight where they may form a small **coma** or vapor cloud around themselves. Carry (with gloves!) your comets around and see if you can see them forming tails.



Discussion Questions

- Describe the surface features of your comet nucleus.
- Why does the model comet nucleus hiss and pop?
- What effect might jets of gas bursting from a comet nucleus have on the comet's motion?
- If the comet was made entirely of ice with no dirt, would it behave the same way?
- How might a comet appear different when it is far from the Sun compared to when it is close to the Sun?

The model comet nuclei should be irregular and lumpy. As the dry ice is heated it sublimates, or converts directly from a solid to a gas. As it does this, small pockets of gas are released explosively from the comet nucleus. This is why it hisses and pops. When this happens to a real comet, the gas jets make the comet nucleus tumble in space. The tumbling makes small changes to the

comet's orbit. This in turn makes predicting a comet's path through space difficult.

As you watch your model comet, you may notice that it hisses and pops more where there is more of the dark-colored dirt. Dark material absorbs more heat energy from the Sun than does light-colored material. These darker areas are where the comet surface heats up the quickest and more dry ice sublimates into gas. A comet without the dirt wouldn't be as active or as interesting as a comet with lots of dirt. As your model comet sits around, its surface will become more cratered and irregular as the dry ice sublimates away.

When a comet is far away from the Sun's light and heat, it stays frozen. It has little or no coma and no tail. As it nears the Sun and is subject to more solar radiation, its frozen gases begin to sublimate more and more. Gas jets release bursts of comet material and the comet develops its tail. As the comet continues in its orbit and moves away from the Sun, its tail and coma shrink. The tail and coma reform every time the comet approaches the Sun.

Starry Night Computer Exercise Lesson D2: Comets and Meteors

Since antiquity mankind has looked at comets with awe and wonder. This exercise allows students to learn some basic facts about the nature of comets and how they orbit the Sun.

Teaching Strategies

Many students believe that comets come from "way out in space". While this may be true, they are members of our solar system.

Students may be interested to know that in the last century the Earth has probably "collided" with a comet twice. In 1910 the Earth passed through part of comet Halley's tail without any negative effects. And in 1908 a small cometary nucleus may have collided with the Earth in Tunguska in central Siberia causing devastation over an area of about 5000 square kilometers. Students should be encouraged to suggest

why two different parts of the comet gave such different results.

Comet Halley has been observed over many returns. Unfortunately the giant planets can affect the comet's orbit sufficiently to make predictions of its return only approximate. In this exercise such planetary effects are ignored and hence predictions of the comet's return far into the future are unreliable.

Students are probably aware of the Perseid meteor shower in mid-August every year. This shower, however, is caused by debris from a different comet.

Students usually have misconceptions as to the size of "shooting stars". Most "shooting stars" or meteors are caused by particles no bigger than a grain of sand.

This exercise should take students about 20 to 30 minutes to complete.



Conclusion

At the end of this lesson, students should have a good understanding of what real comets are made of. They should know how a comet's composition affects its behavior as it approaches and draws away from the Sun in its orbit. They should know that most comets move in very elongated orbits around the Sun, and they spend most of their time far away from the Sun.

Lesson Specific Resources

SkyGuide

Guided Tours>Our Solar System, the Stars and Galaxies> Meteor Showers (all sections)

Guided Tours>Our Solar System, the Stars and Galaxies> The Comets (all sections)

Guided Tours> Our Solar System, the Stars and Galaxies> The Planets> Jupiter> A Comet Comes to Call

SkyTheater DVD

Main Menu: Earth Zone>Meteorites

Main Menu: Planet Zone>Oddballs



Starry Night Computer Exercises

Name: _____

Lesson D2: Comets and Meteors

Class: _____

Instructions for the Student

Open the **SkyGuide** pane, and navigate to **Student Exercises > D – Asteroids, Comets and Meteors > D2: Comets and Meteors** and follow the instructions given. Record your answers to the questions in the spaces provided.

Ask your teacher for a worksheet if you plan to do the Extra Credit exercise.

Question 1: They came from outer space

a) Describe what the comet looks like.

b) List two things that happen to the comet's tail as it passes the Sun.

c) In what direction does the comet's tail always face?

Question 2: A famous comet

a) Describe the size and shape of the comet's orbit.

b) What is the date? (Only the year is important)

c) During what year was the comet closest to the Sun?

d) Does the comet maintain its speed as it orbits the Sun? Describe and explain any differences.

e) How long does it take Comet Halley to go once around the Sun?

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Lesson D2: Comets and Meteors

f) Predict when comet Halley will be close to the Sun again.

Question 3: Meteor showers

a) On what dates (approximately) can we expect a meteor shower?

b) Does comet Halley have to be near the Earth to give us a meteor shower? Explain.

Extra Credit

a) Use this chart to compare the similarities and differences between comets and asteroids.

	Asteroids	Comets
Size		
Appearance		
Composition		
Location of orbit in solar system		
Circular or elliptical orbit		
Orbital inclination compared to plane of solar system		
Short or long period of orbit		

b) Determine the orbital period of Comet Wild.

