



Kitchen Comets

Activity Guide

Adapted from *Making a Comet in the Classroom* by Dennis Schatz (Pacific Science Center)
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Adapted by Anna Hurst and Suzanne Gurton

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Type of Activity:	Indoor classroom demonstration, facilitated
Set up Time:	30 minutes (plus time to purchase dry ice one day in advance)
Time to Do:	20 minutes in classroom as demonstration OR 45 minutes if participants make their own comets
Audience age:	8 years and older, with help from adults
Group size:	varies

What's This Activity About?

This dramatic demonstration allows the audience to observe the uneven surface, dark composition, delicate character and even venting of trapped gas of a mock comet. It is a good way to introduce activities about comets or meteor showers and can be used as a demonstration in front of a group. You can also take some more time and let the participants make their own comets. The ingredients for a comet are not difficult to find and watching a comet being "constructed" is something the audience will remember for a long time.

Materials

For each comet:

- 2 cups water
- 2 cups dry ice
- 2 spoonfuls sand or dirt
- a dash of ammonia or window washing fluid

- a dash of organic material (dark corn syrup, cola, coffee or tea work well)
- an ice chest
- a large mixing bowl
- 4 medium sized plastic garbage bags
- work gloves
- a hammer, meat pounder or rubber mallet
- a large mixing spoon
- paper towels
- paper plates or other container for displaying the comets

Setting Up the Activity

Dry ice is available from ice companies in most cities (look under "ice" in the Yellow Pages for a local source). Some supermarkets, ice cream stores and butcher shops also sell dry ice. Day-old dry ice works best, so you might want to buy it the afternoon before the day you do the activity. Keep the dry ice in an ice chest packed with newspaper and tightly closed. Most ice companies have a minimum on the amount of ice they will sell (usually 5 pounds). But having extra dry ice on hand will be useful because some will sublime and also because it is advisable to practice this activity at least once before doing it for a group.

You will need the following set-up at each station - either one station where you will make a single comet as a demonstration in front of the entire group or a station for each group of 2-3 participants to make their own comets. Cut open one of the garbage bags and use it to **line the mixing bowl**. Arrange the other **materials and utensils** at each station.

Place the dry ice into 3 garbage bags inside of each other. Be sure to wear gloves when handling the dry ice to avoid being burned. **Crush the dry ice** by pounding it vigorously with a hammer. If you are making a single comet as a demonstration, you can wait to perform this step in front of the group for the dramatic effect. If the participants will make their own comets, you may want to do this step ahead of time and keep the crushed dry ice in a cooler to distribute to the groups at the appropriate time.

Suggestions for Introducing the Activity

You may want to jump right into making the comet(s) and save the discussion of the features of a comet for the time when you will be observing your own comets in front of you, so that you can compare.

If you would like to introduce some comet features before making your comet(s), ask participants what they know about comets. What is a comet? Have they ever seen one? A comet is a chunk of ice and rock, usually no more than 20 km wide, orbiting the Sun in a highly elliptical path (an ellipse is like a squashed circle). When it comes in close to the Sun, the ice begins to sublime (change directly from a solid to a gas). What is called a coma is then formed from the gasses and dust released from the comet. The solar wind accelerates these materials away from the rest of the comet, creating two tails, one of gas and one of dust. These glowing tails and the coma are what we see from Earth when we spot a comet in the sky. You may want to show an image of a comet and point out the two tails and the coma. Some images of the comet Hale-Bopp are available here: <http://www.noao.edu/noao/comets/hb/genhb.html>

One of the challenges of astronomy in comparison to other sciences is the lack of possibility for astronomers to study samples in a laboratory. Most of the objects astronomers studied are so far away that even with the fastest rocket ships, it would take more than a human lifetime to reach them. Comets are not quite so far away, however, and the capsule from the Stardust Mission recently returned to Earth with samples from the comet Wild 2.

We are not able to touch stars or nebulae or observe them up close. In this activity, we will have the opportunity to create a mock comet, hold it on our hands and observe how it changes over time. This is a rare opportunity for some true “hands-on” astronomy!

Doing the Activity

Even if you will have participants make their own comets, you should first demonstrate the procedure by making your own. This is your opportunity to ham it up with your best Julia Child or Emeril impersonation. In order to involve the audience, have a volunteer help you add each ingredient as you explain its significance. The comet assembled in the following steps:

1. Place water in mixing bowl.
2. Add sand or dirt, stirring well. This is what makes the comet a dirty snowball, although the findings of NASA’s Stardust mission suggest that many comets may be more “snowy dirtball” than “dirty snowball.” You could therefore add another dash of dirt.
3. Add a dash of ammonia. Comets contain some exotic ices as well, not just frozen water.
4. Add a dash of organic material (e.g. corn syrup), stirring until well mixed. This represents the complex carbon chains found in comets.
5. Place dry ice in 3 garbage bags that have been placed inside each other. Be sure to wear gloves while handling dry ice to keep from being burned.
6. Crush dry ice by pounding it with hammer.
7. Add the dry ice to the rest of the ingredients in the mixing bowl while stirring vigorously.
8. Continue stirring until mixture is almost totally frozen.
9. Lift the comet out of the bowl using the plastic liner and shape it as you would a snowball. Be sure to wear gloves for this step as well. As you squeeze the garbage bags, feel to see if everything is sticking together. If the mixture is too wet, add more dry ice, and if it is too crumbly, add more water.
10. Unwrap the comet as soon as it is frozen sufficiently to hold its shape.

After demonstrating the comet’s assembly, you can have the groups of participants cook up their own. Another variation is to create an assembly line and give each participant a small plastic baggie to collect the ingredients along the line. They can then take the comet with them and observe the changes on their way home. Everyone should wear gloves during the initial mixing to avoid being burned. You should also consider the possible mess should the baggies open after the comets have melted. You probably don’t want visitors walking around your museum or visitors center with their comet-in-a-bag.

Wrap-up

Now you can place the comet on display for the participants to watch during the day as it begins to melt and sublimate (turn directly from a solid to a gas - which is what carbon dioxide does at room temperature and comets do under the conditions of interplanetary space when they are heated by the Sun). You may want try some other comet activities (see suggestions below) and come back to look at the comets afterward. You can then ask the participants what changes they notice and explain the similarities to real comets.

The comet is reasonably safe to touch without getting burned by the dry ice, but it is still best to have a spoon or a stick for the participants to use while examining it. As the comet begins to melt, they may notice small jets of gas coming from it. These are locations where the gaseous carbon dioxide is escaping through small holes in the still frozen water. This type of activity is also detected on real comets, where the jets can sometimes expel sufficient quantities of gas to make small changes in the orbit of the comet.

After several hours, the comet will become a crater-filled ice ball as the more volatile carbon dioxide sublimates before the water ice melts. Real comets are also depleted by sublimation each time they come near the Sun. Ultimately, old comets may break into several pieces or even completely disintegrate. In some cases, the comet may have a solid, rocky core that is then left to travel around the comet's orbit as a dark barren asteroid.

Complimentary Activities

- Comet Motion Flip Books
- From Fire to Ice: Modeling Comet Orbits
- Creating Craters

Materials sources:

Dry ice is available from some ice companies, supermarkets, ice cream stores and butcher shops.



From Fire to Ice: Modeling Comet Orbits and Meteor Showers

Activity Guide

by Suzanne Gurton and Anna Hurst

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Type of Activity: Indoor or outdoor classroom, facilitated

Set up Time: 5-10 minutes

Time to Do: 15 minutes in classroom

Audience age: 8 years and older

Group size: 6 – 30 in a classroom

What's This Activity About?

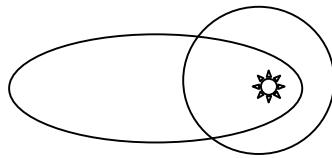
Comets have orbits that take them from the icy edges of the solar system to the fiery vicinity of the Sun. In this activity we'll look at comets whose orbits cross that of the Earth and examine what other phenomena may result from this crisscrossing of paths, including meteor showers.

Materials

- Foam packing peanuts
- Constellation figures from Kinesthetic Astronomy (optional)
- Yellow helium balloon or other object to represent the Sun

Setting Up the Activity

If you are doing this as an activity in a classroom, you will need enough **clear floor space** to create an Earth orbit around the Sun and an elliptical orbit for the comet. Place a **chair** in the center of the room and place your Sun on the chair. Participants will make a circle around the Sun in the center of the room. If you choose to use the zodiacal **constellation figures**, you will want to put them up around the edge of the room in the proper order. (See the Kinesthetic Astronomy set-up instructions.)



Suggestions for Introducing the Activity

To introduce this activity, ask participants if they have ever heard of the Perseids, Orionids, Leonids or Geminids. If not, ask if they've ever heard of a meteor or meteor shower. Each of these is the name of a meteor shower that occurs at the same time every year. When camping out, individual meteors or shooting stars can be a wonderful sight, one not commonly seen in the glare of city lights. Individual meteors are impossible to predict, but at certain times of the year showers of meteors are predicted on an annual basis. In this activity we're going to find out where those meteors come from. They are named for the place in the sky (usually a constellation) where all of their trails would meet if they were traced backwards.

Doing the Activity

This activity has 7 basic steps:

1. Create a circle of Earths (participants) around a Sun in the center.
2. Clarify the terms year, month and day with each person representing the Earth:
 - A. Walk counterclockwise around the circle once - that's a year.
 - B. If it takes twelve steps (which you could mark in advance), each step is a month.
 - C. Standing in place, rotate once going counterclockwise facing the Sun for daytime and away from it for night.
3. Put the other members of the solar system into perspective. Mercury and Venus would go closer to the Sun; Mars through Pluto would be farther away from the Sun in larger orbits.
4. Establish where comets come from and how their orbits are much more out-of-round than those of the planets.
5. Sprinkle packing material along the comet orbit.
6. Move Earths in orbit for one year to experience the meteor shower caused by crossing the comet's orbit.
7. Clean up the packing peanuts.

Fill in with the following details as needed:

The size of your Earth orbit will depend on the number of participants you have. With just 5, you can make this work, but the more the merrier. With just a few participants, you'll want to leave plenty of space between participants to make at least a 10-foot diameter circle/orbit around the Sun. Explain to your participants that they represent the Earth in space at different times of the year. If you've already done some basic Kinesthetic Astronomy activities, you can quickly review. For this activity, the basics that are needed are the understanding that the Earth moves around the Sun and that it takes a year to complete one trip around the Sun. To establish this, have each participant note their place in the room, then set them in motion, walking in a circle around the Sun and have them stop when they are a year older (when they've completed one orbit).

Now introduce the idea of other objects in orbit around the Sun. What else circles the Sun? Other planets - some are closer to the Sun and travel more quickly. For example it takes Mercury less than 3 months to complete one trip around the Sun. That's the same amount of time it takes us to get just a quarter of the way around the Sun. What about outer planets? Mars, Jupiter, Saturn, Uranus, and Neptune? It takes them much longer. It takes Mars twice as long and Neptune over 164 years to go just once around the Sun. What else is out there besides the planets? The answer you're looking for is comets and asteroids. [If they answer moons, you can clarify that while they do circle the Sun, they do it while circling their planet. So usually we think of them orbiting their planet and the whole system going around the Sun.] The majority of asteroids are found in the space between the orbits of Mars and Jupiter. Some are a little wonky and there are exceptions, but most stay in that space between the planets.

But what about comets? They are far less predictable than asteroids. They seem to come from one of two places: the Kuiper Belt or the Oort Cloud. Both of these places are named for the man who theorized their existence and observations have proven them right. The Kuiper Belt is a disk-shaped region past the orbit of Neptune extending roughly from 30 to 50 A.U. from the Sun containing many small icy bodies (including Pluto). [A.U. stands for Astronomical Unit, roughly the mean distance from the Earth to the Sun. 1 AU = 149,597,870.691 kilometers, or about 93 million miles.] It is now considered to be the source of the short-period comets (those are the ones with periods less than 200 years). The Oort Cloud is a vast cloud of comets, perhaps as many as a trillion (10^{12}) that surround the solar system, like a shell at a distance of some 50,000 A.U. This is the likely source of long period comets or those with orbital periods longer than 200 years.

Let's model a short period comet. [If you've made a comet before this, it's a great time to refer to it.] Comets are snowy/icy dirtballs. The ones that we see have orbits that carry them in close to the Sun and far out beyond Saturn, from fire to ice. Just like planets that are farther from the Sun, they move very slowly when out there and speed up as they get closer to the Sun. Ask for a volunteer to be the comet. Recall the dirty snowball model. What happens as the comet nears the warmth of the Sun? Its ices sublime (go directly from a solid to a gas) or melt leaving a dusty trail behind it. Your volunteer will start out several times farther from the Sun than Earth (5-10 times if room will allow) and as he/she moves in an elliptical orbit toward the Sun, he/she will sprinkle packing popcorn behind himself/herself. Have the orbit cross the Earth's orbit, round the Sun and return to the icy depths beyond Jupiter or Saturn (which ever you have room for). If you want to get really detailed, have them move slowly when far from the Sun and quickly when in close. This ellipse now contains the dirt left behind by one passage of the comet. Every few years -- 76 in the case of Halley's Comet -- the comet will return, but its whole orbit is filled with particles that are following the same path, orbiting the Sun with the same period.

Now set your Earths in orbit. At the same time each year they will cross the orbit of this comet, and regardless of whether the comet is there, some of its dust will be. What do you think that would look like from the Earth? Not quite a fireworks display, but it is a predictable shower of meteors. So, whenever you see a meteor shower (“shooting stars” – though not really stars at all!), you are seeing the dust left behind by a comet, perhaps decades ago! See the table of meteor showers and their parent comets below.

Meteor showers are best seen very late at night and early in the morning before dawn. We can understand this using our model. It’s just like a car driving through a swarm of bugs. Some will hit on the daytime side, but most will be visible in that window of time from midnight to dawn. To help participants make that connection, make sure they can figure out day and night, noon and midnight with their bodies.

Wrap-up

Remind participants that meteors can be seen pretty much any night, they are simply most easily seen during a meteor shower and after midnight because there are so many of them entering the Earth’s atmosphere at that time. Finish by having a contest to have the participants pick up the packing peanuts with a sticker or reward for the one who returns the most to the bag.

A partial list of annual meteor showers and their parent comets

Shower name	Dates visible	Best night	Max. # visible per hour on best night	Parent comet
Quadrantids	Dec. 28 – Jan. 7	Jan. 3, 4	45 – 200	Asteroid 2003 EH1
Lyrids	Apr. 16 – 22	Apr. 21, 22	10	7P/Pons-Winnecke
Eta Aquarids	Apr. 21 – May 12	May 4, 5	20 – 50	Halley’s comet
Perseids	Jul. 23 – Aug. 22	Aug. 12, 13	80	Swift Tuttle
Orionids	Oct. 15 – 29	Oct. 21, 22	20	Halley’s Comet
Leonids	Nov. 14 – 20	Nov. 17	10 – 15	Tempel Tuttle
Geminids	Dec. 6 – 19	Dec. 13	80	Asteroid Phaethon (not a comet!)

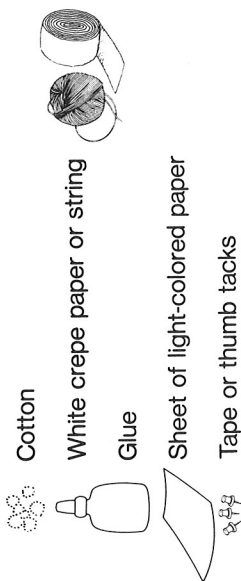
Complementary Activities:

- Kitchen Comets
- Comet Motion Flip Books
- Kinesthetic Astronomy: Sky Time

Make a Model Comet

Photographs of comets do not reveal how big the tail is compared to the coma or nucleus. In this activity you construct a scale model of Halley's Comet to understand its immensity. For this activity use 1 cm = 100,000 km (1 in = 150,000 mi).

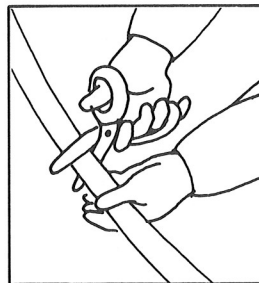
What you need



What to do



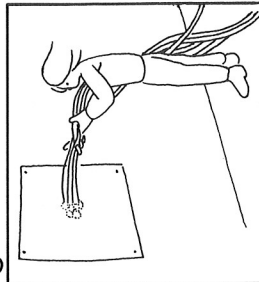
1. Glue a cotton ball that is about 5 cm (2 in) across near the center of the paper.



2. Cut 10 to 15 strips of crepe paper or string that are 4 to 5 meters long (12 to 15 ft).



3. Tack up the paper sheet with the coma on it at one end of the wall. Gather one end of all the crepe paper or string strips. Tape or glue them next to the coma so that they can easily be stretched along the wall.

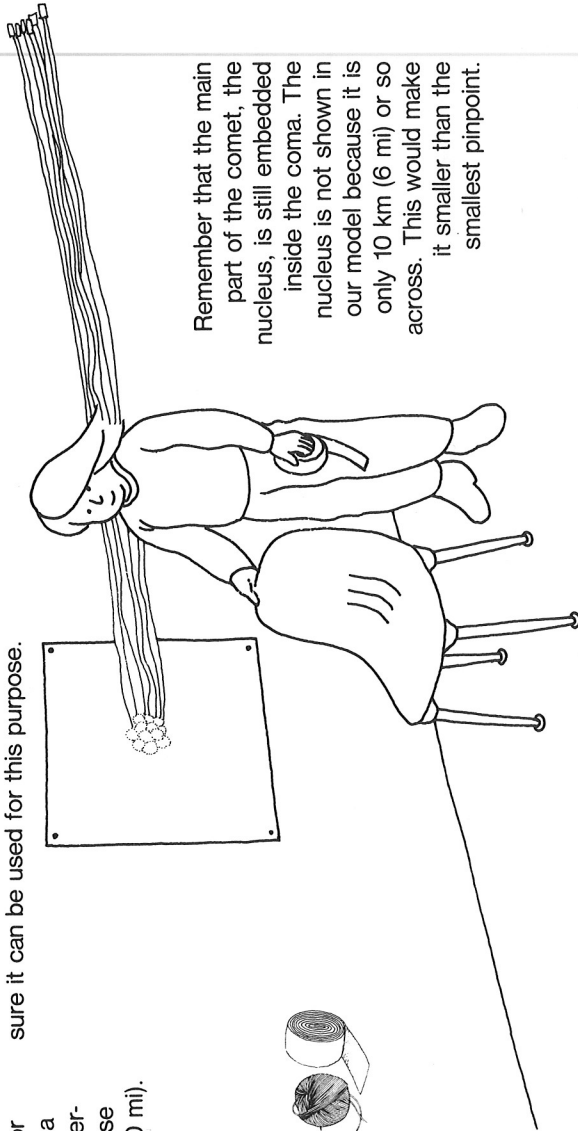


4. Stretch the crepe paper or string along the wall, tacking or taping the other ends so that the tail fans out slightly like in the photos of comets in this book. Put waves or knots in the tail for a more realistic effect.



5. Add labels to identify the comet and its different parts, such as the coma and tail.

This activity is best done on a wall. Be sure it can be used for this purpose.



Remember that the main part of the comet, the nucleus, is still embedded inside the coma. The nucleus is not shown in our model because it is only 10 km (6 mi) or so across. This would make it smaller than the smallest pinpoint.



Tail—The gas and dust that are blown out of the coma when the comet nears the sun. It may be 1 million to 100 million km (600,000 to 60 million mi) long.

Nucleus—The frozen central core usually 2 to 10 km (1 to 6 mi) across.

Coma—A gas and dust cloud that forms around the nucleus. It grows as a comet approaches the sun, becoming as large as 10,000 to 1,000,000 km (6,000 to 600,000 mi) across.

million mi), it begins to melt from the sun's heat. A cloud of gas and dust forms which is called the comet's coma (pronounced cō-ma). It is usually larger than the Earth and may be as wide as 800,000 km (500,000 mi). The core of the comet remains solid and is called the nucleus.

When the comet gets near the orbit of Mars or around 250 million km (150 million mi) from the sun, the gas and dirt in the coma are blown away. A long tail forms that may be 100 million km (60 million mi) long. It is the tail that has inspired the continual search to understand these beautiful and still mysterious comets.

WHAT IS A COMET

A comet is like a dusty iceberg that races around the sun at speeds as fast as one million km per hour (600,000 mi per hour). It is composed not only of frozen water, but other frozen gases, such as ammonia and methane. Ammonia is the strong smelling part of many cleaning liquids and methane is a type of natural gas used in some heaters.

Most comets are always far from the sun and frozen solid. A few comets, however, periodically travel close to the sun. When one of these comets approaches the orbit of Jupiter or around 800 million km (500