

Build-a-Comet

Building your own Comet

With every-day materials (and dry ice)

What's Going on Here?

Few celestial wonders evoke the feelings of wonder, awe, and yes, fear as comets do. Historically viewed as harbingers of calamity and bad omens, not much has changed over the centuries for these far-flung travelers. Even today, comets are a mainstay of the “astronomical gloom and doom” crowd. The true nature of comets, their orbital paths, and their returns at regular intervals was unknown until the beginning of the 18th century with the work of *Edmund Halley*.

Studying historical records, Halley put forth the theory that several of the comet sightings over the previous few hundred years were in fact the same comet returning on a regular 76-year orbital path. He even predicted that the comet would again return in 1758. Sadly, Halley did not live to see his vindication; he passed away in 1742 at the age of 85 – sixteen years before the comet that now bears his name re-appeared just as predicted.

We now know that comets are generally made up of *primordial material*, stuff that went into our Solar System when it was born. This is part of the reason that comets are at the center of much astronomy work – *Giotto*, *Deep Impact*, and *Stardust* were some of the most famous projects.

Comets live most of their lives in the *Kuiper Belt*, or in the even more distant *Oort Cloud*. When gravitationally disrupted or perturbed, they “fall” in toward the Sun. Most comets are regular visitors, some with orbits of only a few years, others taking decades, centuries, or even millennia to return. A few never return, being instead gravitationally flung out into distant space.

This exercise allows students to make a fair representation, using common ingredients, of what these deep space denizens look like, and how they act as they heat up in their approach toward the Sun. The classical and stereotypical “tails” do not appear until a comet reaches the “*relative warmth*” of the inner solar system – somewhere inside the orbit of Jupiter.

Comet Materials & Ingredients

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| 1 Pair heavy garden gloves | 1 Large plastic mixing bowl |
| 2 Heavy-duty kitchen garbage bags | 1 Long handled wooden mixing spoon |
| 3 Small plastic drinking cups | 2 Measuring cups (2 cups minimum) |
| 1 Teaspoon dirt (or potting soil) | 1 Teaspoon ammonia |
| 1 Teaspoon Karo dark corn syrup | 2 Cups water |
| 2 Cups crushed dry ice (1 lb.) | 1 Pair safety goggles |
| 1 Rubber mallet | 1 Canvas bag |
| 1 Small cooler | 1 10-inch plastic plate or bowl |

Optional: Extra heavy gloves for others to handle the comet.

Preliminary Setup

WEAR GOGGLES AND GLOVES FOR SAFETY!

Use mallet and canvas bag to crush dry ice to powder. (some small chunks are fine)

Put two cups crushed dry ice into measuring cup, and keep all dry ice in cooler.

Put 2 cups of water into second measuring cup and set aside.

Put dirt, syrup, and ammonia into three small plastic cups, set aside with water.

Open plastic garbage bags, and place one inside the other (double it up!)

Keep doubled-up plastic bags under mixing bowl for use later.

Place wooden spoon in bowl for mixing ingredients. You are ready!

Mixing It Up

WEAR GOGGLES AND GLOVES FOR SAFETY!

Comets are mostly water – pour it into bowl (stirring isn't required...it's just water!)

Comets have a small amount of dirt or dust – add it to bowl and start stirring.

Comets also contain a small amount of ammonia – add to bowl and keep stirring.

Next, comets have “organic material”. Add the syrup and keep mixing – don't stop!

Obviously, comets are wet, dirty, stinky, and sticky, but...

Finally, comets (spending much of their life in deep space) are VERY cold – so, they also contain ice...a special kind of ice. It's Carbon Dioxide, what we know as “dry” ice.

Carefully add the dry ice to the bowl and KEEP STIRRING. As the mixture begins to freeze stop mixing and transfer the whole mess to the double-thick trash bags.

Keeping the bag of slush over the mixing bowl, squeeze the bag and mixture together to form it into a frozen, “smoking”, hissing dirty snowball.

Be careful not to close up the bag to tight – the gas needs to escape as you shape the comet into its snowball shape.

Now, reach in and pull out your comet. Voila! Set it on the plate for all to admire!



Kitt Peak National Observatory

<http://www.noao.edu/kpno/>

Activity Observations and Extensions:

1. Sometimes the activity doesn't yield a very "pretty" comet! The exact mixture, temperatures, and the experience of the person molding the ice-ball will once in a while create a "crumbly" comet made up of randomly sized chunks. This too is borne out in actuality. Smaller comets being loosely packed material will often "fall apart" as they approach the Sun. If their orbit brings them in on *short periods*, they may eventually disintegrate. Don't worry if you don't have a perfect ball – celebrate your unique but factual "chunky" comet pieces!
2. Comets don't get their stereotypical "tails" until they get close enough to the Sun to "melt" their volatile materials (like *Carbon Dioxide*). Typically, this happens as they get about to the orbit of Jupiter. Coincidentally, this is about the same time they get discovered. It is the "fuzzy" halo around the bright core that is often seen and used to visually discover comets. In this experiment, you can see the gases "sublimating" in the warm air. Carbon dioxide isn't a liquid in our Earthly conditions – frozen carbon dioxide turns directly from a solid to a gas. Solids that turn into a liquid *melt*, but a solid that turns into a gas *sublimates*.
3. Another interesting observation about comet tails is that they always point away from the sun. It is the solar wind, the sun's radiation that "pushes" the material off the surface of the comet as it approaches. Obviously it pushes the gases to the rear at this point. But, when the comet rounds the sun and heads back into space, then the tail is pushed to the front. You can simulate this property by using an electric fan. As you hold your gaseous comet moving toward the fan in the fan's wind stream, you can see the gases blown toward the rear. But as you go around the fan and move it away, as a comet would orbit around the sun, the gases are now blown to the front of the comets path.
4. Comets are also closely related to another astronomical spectacle – *meteor showers*. Notice when you finish your frozen ice-ball that not every piece is stuck to the comet. There are little chunks of ice and dust left in the bag, on the plate, and all around your work area. And, as the ice-ball melts, more pieces are falling off. This is just like real comets...they are cosmic litter bugs, leaving a trail of trash in their wake and all along their orbital paths. When the Earth approaches this point in its own orbit around the sun, these mostly sand-grain sized pieces left over from the comets passage, slam into the atmosphere and create a hail of meteors. This is why most meteor showers are associated with orbiting comets, and why certain meteor showers happen on the same nights every year. The annual Leonid shower on November 18th is associated with comet Tempel-Tuttle, the August Perseid shower has been linked to comet Swift-Tuttle, while December's Geminid shower has been famously associated with an asteroid, and not a comet, called 3200 Phaethon
6. One final suggestion is to leave the comet out for a while, and watch how it physically changes over time. As the gases dissipate, and the ices dust and organic material are left behind, the "dirty snowball" begins to look more like a dark and cratered *asteroid*! Many comets, at the end of their lives, when all the gases are gone, end up as a "dead comet", an icy ball of rock, pitted by the loss of gas and material to look more like asteroids.

Facts about Comets

- Comets orbit the Sun, but their orbits are stretched out ovals.
- The frozen center, called the nucleus, is made of rock, gas, and ice.
- They start their journey toward the Sun in the Kuiper Belt, a region of the Solar System beyond Pluto's orbit! The Kuiper Belt is really cold! It's -370°F !
- As the comets near the Sun, the nucleus melts, forming the coma.
- The dust tail is yellow in color and made of rock and dust that breaks off the comet as it heats up. It is warm enough for the tail to form when the comet is near Jupiter.
- The gas tail is blue in color and is made when the gases in the comet 'sublimate' or go from a solid to a gas. It is warm enough for this tail to form when the comet is near Mars.
- The tails are pushed by the solar wind from the Sun. The tails always point away from the Sun.
- Debris from the dust tails of comets falling to Earth causes meteor showers!
- Some famous comets are Halley's Comet, which orbits the Sun once every 75 years, and Comet Shoemaker-Levy 9, which crashed into Jupiter in 1994.



NOAO Provided by the National Optical Astronomy Observatory