A Comet in Your Kitchen

Based on a paper by the Jet Propulsion Laboratory

www.perkins-observatory.org

This is a VERY messy activity which should help your students to understand and remember what comets are made of. Materials will run about $20. Each comet you make should cost less than three dollars each.

Materials:

- Plastic Bucket or Large Bowl
- Small Trash Bags (2)
- Water Proof Insulated Gloves (from a gardening store or chemistry department)
- Cloth Towel (one you don't mind messing up real bad)
- Plastic Table Cloth
- Stack of Old Newspapers
- Small Ice Chest
- Cloth Towels
- Hammer or Rubber Mallet
- Mixing Spoon
- Small Trash Bags (2)
- Small Stuffed Cow
- Apron (I wrote “Astro-Chef” on mine with fabric paint, just for fun)

Consumable Materials (Used to Make Each Comet):

- Dry Ice (3 - 5 lbs) available from ice companies or ice cream parlors
  CAUTION: Dry ice is -79.8° C (-110° F). Any more than brief exposure will cause "burns”. Be careful when handling it.
- Water (one gallon) in a plastic milk jug
- Ammonia (a few drops or sprays of Windex window cleaner)
- Sand or Fine-Grained Dirt (one handful)
- Corn Starch, Worcester Sauce, or pure Carbon (crushed charcoal briquettes or used photocopy machine toner works very well).
- Salt

These ingredients are either actual components or handy analogous ones. The dry ice is frozen carbon dioxide. Water, ammonia, organic (carbon based) molecules, and silicates are all present on comet nuclei. They have been identified through spectral measurements of comet tails. Sodium was recently detected in the tail of comet Hale-Bopp (hence the salt).

What is a Comet Nucleus?

Comets are dirty balls of ice. Or, if you prefer, icy balls of dirt. They are thought to contain materials left over from the formation of the solar system, essentially unchanged for 5 billion years. By studying comets, scientists hope to learn more about the conditions that existed when the planets were forming.

Sometimes the orbit of a comet nucleus brings it into the inner solar system. Then it begins to heat up. The volatile materials (ices) from which it is made boil off to form the head and tail that have amazed, baffled, and frightened people throughout history. This tremendous light show is produced from just the small solid nucleus measuring only 15 or 20 kilometers long.

Here is the Recipe:

Put your plastic tablecloth on the table. Put on the apron (you'll need it). Double-line the bucket with two trash bags.

Pour about a half-gallon of water into the bucket. Throw in a handful of sand. Add the "organic molecules" (corn starch, Worcester sauce, or carbon). Spray in a bit of the window cleaner (ammonia). Mix a bit. Add some "methane" by holding the stuffed cow over the bucket, lifting its tail, and explaining that the primary source of methane on Earth is bovine flatulence. Sure, your audience will laugh, but you can bet they'll remember it! Finish up with a pinch of salt (sodium).

Now you are ready for the final ingredient. Put on the gloves. Wrap the dry ice in a cloth towel (I use a denim bag that was specially made for this demonstration) and place it on the stack of newspapers. Use the hammer to pound up the dry ice into a powder (the newspapers prevent damage to the table). Dump the dry ice powder into the water all at once. There will be lots of vapor formed. The dry ice, water and other ingredients should form a thickening slush. Keep stirring for a few seconds as it thickens.

The actual proportions of water to dry ice is not very critical. If you have more water, it will just take a little longer to freeze. Once it has begun to harden, gather up the trash bags and pull your comet out of the bucket. If you don't do this, it will likely freeze to the inside of the bucket. Place it on the newspapers (still in the bags) and add a bit more sand to the top (most of the sand will have sunk to the bottom before freezing). Let it sit for a few minutes to harden up. The newspapers now provide some insulation for the table as well.

When you are ready to show it to your students, peel back the trash bag.

Observe the behavior of your miniature comet nucleus. It can be handled without gloves if most of the CO_2 has evaporated, but it is probably best to just use the gloves. It hisses and pops as carbon dioxide sublimes (goes from the solid state directly into a gas) and forces its way through weak spots in the water ice crust. On real nuclei this results in slight jetting forces that can cause the nucleus to spin, slightly alter its orbit, or split apart. Blow gently on the comet to create a "solar wind" and watch the "tail" (the CO_2 gas) stream away.

One good thing to do: Bust the comet in half with the mallet, and show how the structure is "foamy" with gaps in an ice matrix where the more "volatile" dry ice has flashed away to gas - like in the real thing. This is what makes the density of comets so low (about 10% the density of water).

Another thing to try if you used photocopy toner for the carbon molecules: Let the comet sit for awhile and melt a bit. As it melts, the carbon will accumulate on the surface, turning it darker and darker until it is covered in a black goo. This is very similar to what happens with real comet nuclei. Although they are made mostly of ice, their surfaces are extremely dark due to the carbon compounds coating their surfaces.

Remember that, as with anything, presentation is the key. The more you ham it up and get your audience involved, the better it will go and the more memorable the activity will be. Make sure that at each step they understand exactly why you are adding each ingredient.

It's great fun! It's a total mess! It's one of the most accurate AND memorable demonstrations in astronomy! Enjoy!