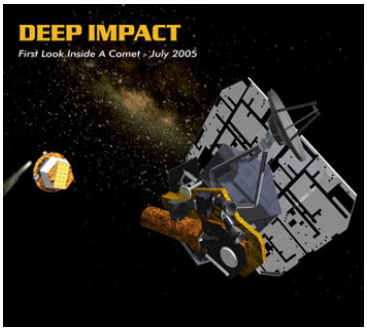


Make a Comet Model and Eat It!
Instructor Page

Created for the Deep Impact Mission, A NASA Discovery Mission
Maura Rountree-Brown and Art Hammon
Educator - Enrichment

The "Make a Comet and Eat it" activity can be used with a wide age range. Younger students will come away with three important ideas: Comets are cold, they have debris from the early solar system and we still aren't exactly sure what is in them or how they behave. Older students will be able to discuss their own theories about what we will find out about Comet Tempel 1 when we dig deep inside it in July 2005. They can compare their current theories with our results.

The Activity:
"Make a Comet and Eat it!" - The activity
"Make a Comet and Eat it!" - Student Data Sheet - The student work sheet

Background material:
Consider This - This page shows the history of perceptions about comets.
A Comet's Place in the Solar System - A little history about where comets came from
Ten Important Comet Facts - A quick review of comet facts
C-O-M-E-T-S - A comet acrostic. Good for younger students or comet quick fact reference
Deep Impact - Interesting Mission Facts - Some fun facts about our mission
Small Bodies Missions - Learn more about Deep Impact and about other missions to comets and asteroids.

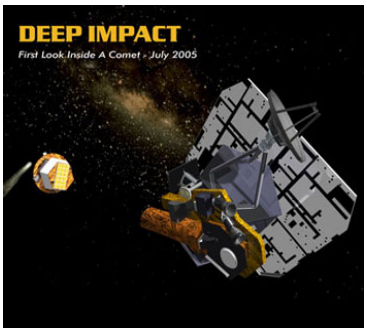
Want to know more about the chemistry of this activity?
The Chemistry of Ice Cream - Learn more about the chemistry of ice cream and how it freezes.
Building a Butterfat Molecule - Gum drops and toothpicks are all you'll need for this one.

National Science Education Standards related to this activity:
Thematic Organizing Standards:
- - Personal Social Connection
- - Nature and History of Science
- - Unifying Concepts and Processes

Curriculum Content Standards:
- - Size, Scale and Properties of Solar System Objects
- - Energy-Nature of and Properties

Classroom Management:
- A. Materials need to be purchased fresh and kept in store-bought containers. Anything that is used to measure, hold or eat with/out of should never have been used for any classroom chemical storage.
- B. A mop and sponge is very helpful for desks or floor areas where measuring is done. You may choose to pre-load cream bags and salt bags at home.
- C. The ice needs to be either freshly bought or well frozen in storage. The container for transporting and storing the ice should be pre-cooled if possible or very efficient. If the ice has "warmed", it will be difficult to get the milk/cream to solidify.

Questions: Maura Rountree-Brown at Maura.Rountree-Brown@jpl.nasa.gov



Make a Comet Model and Eat It!

Created for the Deep Impact Mission, A NASA Discovery Mission
Maura Rountree-Brown and Art Hammon
Student - Inquiry

Comets have sometimes been described as dirty snowballs, snowy dirtballs or something in between. But what does that really mean? It means that these dirty snowballs are believed to be a cold mixture of frozen water, dry ice, and other sandy/rocky materials left over from the early formation of our solar system. In this activity, we are going to develop a comet model that you can eat. You'll trade "comets" and pretend to be an instrument on the Deep Impact Spacecraft called a spectrometer. It analyzes the structure and composition of comets by using nine different filters. You will use four of your senses individually to decide what is in the ice cream. Most of the ingredients can be found in your home or can be incorporated there after the activity.

Form small research groups of 2 - 4 students. Survey your class ahead for any allergies (milk, peanuts, etc) that you plan to use. You'll need to gather the following materials for each group:
- One sandwich size re-closable plastic bag per team of 2 - 4
- One Gallon size re-closable plastic bag per team of 2 - 4
- Small cups for eating ice cream - one for each person on the team and one extra cup for ice cream to feel
- Plastic spoons
- Pairs of rubber kitchen gloves or have them use cloths or sweaters (comet gets cold!!)
- Ice (enough to fill a gallon size bag ½ full per team) - or bring in fresh snow from outside.
- Chunky cookies in black or brown, crushed candies (like toffee or peppermint), gummy bears, coconut flakes and peanuts
- Whole milk (2% won't work)
- Sugar
- Vanilla extract
- Evaporated milk
- Salt
- Can opener
- Something to use to crush cookies and other additives

****
To begin: Wash hands! You may choose to use food gloves.

HINT: One person should hold the bag while another pours ingredients into the bag. To cut the activity time, you can pre-mix the milk, evaporated milk, sugar and vanilla to the small bags and pre-measure the salt into the large bags. Make enough sandwich bags of ice cream for each team to have one. Squeeze the air out and seal the sandwich bags carefully each time they are opened to add ingredients.

STEP #1: Mix to the sandwich size bag
One-third cup evaporated milk (or cream)
Two-thirds cup whole milk
5 level spoonfuls of sugar
Less than ¼ tsp of vanilla
Comet connection: Discuss with your class the following ingredients to be added to the ice cream to represent dust (Black/brown cookies in fine and large chunks), rocks (peanuts), carbon dioxide (coconut flakes). Then have the students begin to add ingredients. Make sure they are also adding some ingredients to represent what we might find in a comet. Possibilities are: gummy bears (early organics for life?),

peppermint, toffee or other ingredients you might choose. Remember to choose food that will not dissolve while the ice cream is setting. Now close the bags.

HINT: Squeeze any extra air out of the sandwich bag and close it. **Be sure it cannot leak.** [Turn it upside down to check]

STEP#2
Place the sandwich bag into the bottom of the gallon bag. Put in approximately 10 heaping spoonfuls of salt if you did not pre-load the salt earlier. You can pre-load salt into the bags at home.

STEP #3
Fill the gallon bag (containing sandwich bag) at least 1/3 full of ice.

STEP #4
1. Close the larger bag tightly to remove as much air as possible. Check for leaks.
2. Gently shake and roll the bag while keeping it in constant motion for approximately 6 - 10 minutes or until half the bag has turned to water.
   [SUGGESTION: Rubber gloves, mitts, cloth towels or other thick fabric may be needed to hold the bag because it will get extremely cold. Start with bare hands so students can feel the temperature change].
3. Gently feel the sandwich bag through the icy mixture. When the milk/sugar mixture in the sandwich bag has hardened into soft ice cream, open the gallon bag and remove the sandwich bag containing the ice cream.

STEP #5
Trade your comet with another team so the ingredients are a mystery. Each team should briefly rinse the outside of the sandwich bag they were given with fresh water before opening so that no salt flavor is transferred to the ice cream.

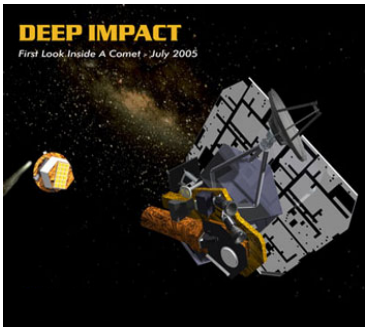
Split the ice cream comet by spooning some into the cups provided, one for each team member. **Make one extra cup and put it aside. Don't eat this one!**

A spectrometer takes different kinds of data through different filters. Pretend that your eyes, hands and taste buds are scientific instruments taking data from your "comet". Take the following "data" and record it on the data sheet:
- Look at the "comet" and see what you can observe **visually.**
- Take the extra cup you laid aside and have your team **feel** the contents with your fingers. Record your data.
- **Smell** the ice cream and see if you find any additional information.
- **Taste** the ice cream and record any final information about what is in it. Compare your results with the team who made the ice cream you tasted.
- Record what you discovered as you watched the elements in the bag become ice cream.
- Share your conclusions about your comet with your class.

SUGGESTIONS FOR LARGER GROUPS: For a class of 20 (10 groups of 2)
- 3 – 4 cans – 12 fl oz each)
- 1 gallon of milk (you'll have some left over)
- 20 cookies
- ¼ lb of sugar
- 1bag of peanuts and 1 bag of coconut flakes
- ¼ bottle of vanilla or leave this ingredient out
- 10 sandwich size re-closable bags (but best to make a couple extra)
- 10-gallon size re-closable bags
- 2 – 3 containers of table salt (you'll have some left over)

SOME TIPS FOR THE TEACHER:
- If the students toss the bags back and forth or bang them against a surface while freezing the ice cream, they may break.
- Bring dishtowels, cloths or other insulator for hands to guard against discomfort while they are turning their bags over and over.
- Have a mop available for dripping water or do the activity outside.

- Limit the amount of any material students put into their ice cream to one plastic spoonful so supplies last.
- Mark one of your serving cups with sugar and salt measurements to pre-load bags faster. Mix all ingredients in class if you want your students to work on measurements.



Make a Comet Model and Eat It!

Student Research Data Sheet

Created for the Deep Impact Mission, A NASA Discovery Mission
Maura Rountree-Brown and Art Hammon
Student - Reflection

Throughout history, scientists have used different methods of observation and testing to find out more about comets. First, they used their eyes to look into the sky. Over time, they applied what they knew about math, science and finally technology to further study these icy travelers. Now we have the ability to visit comets. Scientists are always careful to record their observations and data. They use this research to build models to test and confirm their theories about comets. Deep Impact will use a spectrometer with a series of filters to collect different kinds of information about a comet. What can you discover about your ice cream "comet" using your sight, touch, smell and taste "filters" as though you were a spectrometer?

What visual observations do you make about your ice cream comet?

Take the cup you laid aside. Don't taste this one. What are you able to tell by using your fingers to feel the ice cream comet?

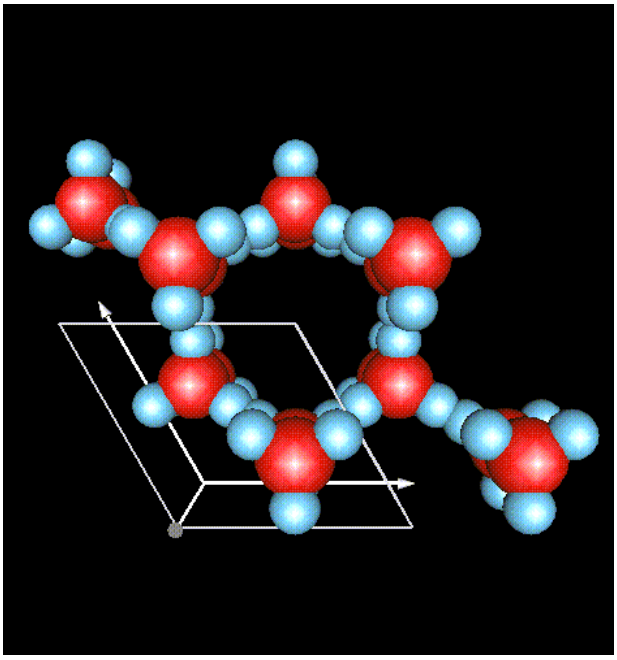
What are you able to tell about your comet using only your sense of smell?

What are you able to tell about your comet adding your sense of taste?

What explanations do you draw about the composition of your comet?

The Chemistry and Thermodynamics of Ice Cream

Created for the Deep Impact Mission, A NASA Discovery Mission
Maura Rountree-Brown and Art Hammon
Educator/Student - Enrichment



"The Reason for the Seasons:" - Snowflake Shapes

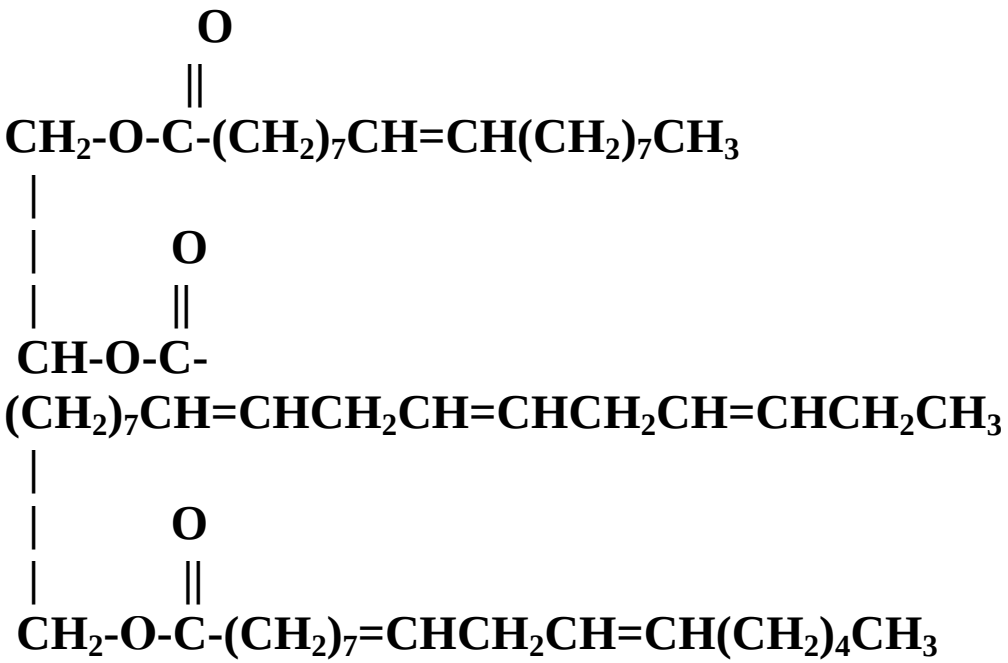
The picture above was created at the Institut Laue-Langevin an international research centre and world leader in neutron science and technology. It is based in Grenoble in the South-East of France. It shows an ice crystal. The crystal is made of many molecules of water (H_2O). The atoms are shown by different colors. The darker atoms are oxygen. The lighter atoms are hydrogen. The hydrogen atoms are attached at an angle near 120 degrees. The hydrogen atoms are attracted to each other and form hexagonal rings in all directions.

As ice crystals or snowflakes grow, they expand by attaching new water molecules to each other. Looking at them with a hand lens or microscope tells us about how they join together. The angles are always the same so the designs always have six sides. Whether ice crystals or snowflakes, observing the shape under "atomic microscopes" reveals a shape that is always hexagonal.

If the angle had been different, the shape would have been different. Salt crystals (NaCl) are made of two elements, sodium (Na) and chlorine (Cl) which join at 90 degree angles. Under a hand lens or microscope, the crystals of salt appear as little dice or cubes. The shape of the crystal is determined by the angle of chemical bonding (joining together).

What does “ice” have to do with “ice cream”?

Below is a typical triglyceride butterfat molecule from which ice cream is made. Ice cream is formed when many tiny ice crystals form between the "arms" of the triglyceride butterfat molecule.



Typical molecule of butterfat, a triglyceride, found in ice cream.

Extensions: Chemistry, Crystals and Calories

A. Look at the drawing of the butterfat molecule. The letters stand for chemical elements, joined together in long chains. You can make a “MODEL” of the molecules with gum drops and toothpicks

B. You can make up a code…which element (gumdrop) is which color:
The elements are:
Carbon (C) Color_____
Oxygen (O) Color_____
Hydrogen (H) Color_____

C. Build the molecule with groups assembling a part of a chain. Connect them with toothpicks (chemical bonds…the glue that holds elements together in molecules). . The symbols "=" or "||" mean use two toothpicks. These are called double bonds in chemistry. Then lay them out and connect the whole butterfat molecule on the floor or table.

D. At the same time, make lots of water molecules (H_2O- Oxygen in middle, Hydrogens on each side like a boomerang) and oxygen molecules (O_2). Lay the water molecules between the long chains of the butterfat. Now "freeze" them by connecting three boomerang shaped water molecules together in a hexagon shape, touching the hydrogen atoms together.

E. Why does ice cream make people gain weight? After you eat ice cream, the only way to get rid of it is to "burn" it out of your body. That involves the same idea as burning a match…fuel and oxygen…except this burning is flameless. The ice cream is the fuel and the air you breathe gives you oxygen.

F. "Burn" the ice cream by using the oxygen molecules you made. Oxygen breaks ice cream apart by attacking and breaking the toothpicks and carrying away the Hydrogen and Carbon. Here is the formula:
$C + O_2$ makes one CO_2 (carbon dioxide you breath out)
$H + H+O$ makes one H_2O (water) which you breath out (cold morning breath?)

G. How many oxygens does it take to carry away the butterfat molecule? This is why "Aerobics" is a good idea for weight loss…makes you fill your body with lots of Oxygen to "burn" the butterfat, releasing "heat" measured in calories (a way of measuring energy content).

The Thermodynamics and Chemistry of Ice Cream
(Where is the heat going and what happens to ice cream after you eat it?)

What is going on in the bags?

A. The inside of the ice is very cold, -10^o to -20^o F. But when you hold an ice cube, the exterior, in contact with air and your hand is $+32^o$ F, cold water. Clean, pure water cannot be a liquid below $+32^o$ F. It becomes ice.

B. Salt Mysteries- The mixture of salt and water can be liquid below $+32^o$ F. It can be a liquid down to -20^o F. So adding salt does not "melt ice". It makes a mixture of water and salt that has a low temperature… "Salt gives water permission to freeze at a lower temperature".

C. The very cold salt water surrounds the baggie with the milk (which is 30% water) and "steals" heat from the milk. The temperature of the milk becomes so cold that the water in the milk begins to form tiny ice crystals. The butterfat does not form crystals. The shaking keeps the milk from forming one big ice cube.

D. What is a comet - ice cube or ice cream? Deep Impact will help us find out. The data from Deep Impact will tell us a little about how the comet formed…blob of water or snowball of crystals that came together.

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