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Hands-on

Tested & Approved STEM Activities

Recipe for a Comet

Activity Guide

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Recipe for a Comet

Activity Time

15 minutes for constructing the comet model, followed by 5 to 10 minute interactions. As a station, this activity could continue for two hours until the dry ice is gone.

Intended Audience

Families or other mixed-age groups, including children as young as 5 years old *with assistance from an older child, teen, or adult*
School-aged children ages 5 and up
Tweens
Teens
Adults

Overview

Create a "comet" using dry ice and household ingredients and use (optional) tools to observe how it models the features of a real comet.

This activity is revised from "Making a Comet in the Classroom" by Dennis Schatz.

Type of Program

- ☑ **Facilitated hands-on experience for teens and/or children under close supervision**
- ☑ **Station, presented in combination with related activities**
- ☐ Passive program
- ☑ **Demonstration by facilitator**

What's The Point?

- **Comets are made of many different materials or "ingredients" — including complex organic molecules necessary for life.**
- **The icy materials in comets spray gas and dust as they heat up.**
- **Models can be used to answer questions about the solar system.**

Materials

Facility needs:

- ☐ A freezer and cooler to keep the dry ice cool before use (it will still sublimate, turning from a solid into a gas, but at a slower rate)

CAUTION:
This activity uses dry ice (frozen carbon dioxide). This substance is extremely cold—never touch dry ice with bare hands. Facilitators need to use caution while handling the material, and ensure that participants who are handling the ice use thick work gloves or insulated rubber gloves.

For each demonstration or each facilitated group:

- ☐ 5 pounds of dry ice (purchased the day of or the day before the activity and stored well-wrapped in a freezer before use)
- ☐ Mallet
- ☐ Eye protection
- ☐ Thick work gloves or insulated rubber gloves
- ☐ Plastic bowl (large)
- ☐ Paper or cloth grocery bag
- ☐ 13 gallon garbage bag
- ☐ Pie pan or flat tray
- ☐ 1 liter (34 ounces) of water
- ☐ 1 cup of sand or soil
- ☐ Dash of ammonia
- ☐ Dash of organic materials, such as rubbing alcohol or corn syrup
- ☐ Strong flashlight
- ☐ (Optional) a printed image of a comet
- ☐ (Optional) tools for making additional observations, such as magnifying glasses, cameras, scales, an ear thermometer, or infrared thermal cameras that work with smartphones and tablets (such as a Seek Thermal Compact camera).

Photos and information about comets are at the NASA Solar System Exploration website. You may want to print copies of "Comets vs. Asteroids!", a colorful comet factsheet for tweens and teens.

Preparation

The day before the activity

- Purchase the dry ice, wrap it in thick insulation (such as dense cloth or paper) and place it in the freezer.
- Set up the demonstration table in a well-lit area.

Is a comet currently visible in your night sky? Use the Night Sky Planner to see which objects are bright, and In the Sky to check out all of the comets! This demonstration is helpful for explaining why comets have tails as they approach the Sun.

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already know each other).
- Show the participants a picture of a comet, and frame the activity with the main message: Comets contain ingredients that may have been crucial for early life on Earth.
- Explain that they will be building a model of a comet, using different ingredients.
  - Invite the participants to describe the different types of models that they have made or seen.
  - Can participants describe of other models that are smaller than the original? (For example, they might mention toy cars.)
  - Can participants describe of other models that behave like the original? (They might mention a toy helicopter or a paper airplane that flies, for instance.)
  - Share that this model is not only much smaller than a real comet, but that it isn't using exactly the same materials from a real comet; you will be substituting some of the ingredients. But it will behave like a comet.
- Share that some of the ingredients in comets are important for life!

As much as possible, encourage the participants to offer their own ideas as well as questions, and to share their ideas in response to others' questions. This model can be used to answer questions such as:
- What shape is a comet?
- Where do we see comets?
- What ingredients might be in a comet?
- It's cold in space far from the Sun - what would the temperatures do to the ingredients of a comet?

Activity (continued)

2. **Make the comet's nucleus.** This is the icy core that heats up as the comet approaches the Sun.

If this activity is being done as a facilitated, hands-on experience, take precautions that the participants are safe while handling the materials. Dry ice is extremely cold—participants who are handling the ice should use thick work gloves or insulated rubber gloves.

Dry ice is frozen carbon dioxide. When the dry ice warms up, the carbon dioxide changes directly from a solid (the dry ice) into a gas (the carbon dioxide). This process is called "sublimation." Dry ice and frozen water are key ingredients in comets.

a. Crush the dry ice. Facilitators should either select a mature participant to crush the dry ice, or do so themselves. (If done ahead of time, be aware that crushed dry ice will sublimate faster.)
   - Ask the participants to describe dry ice; have they seen it before, and do they know what it is?
   - Why is dry ice more common in the outer solar system than it is on Earth? (It is much colder in the outer solar system, because of the Sun's greater distance, and dry ice forms at very cold temperatures.)
   - The selected participant or the facilitator should put on safety glasses and gloves, place the dry ice inside the paper or cloth grocery bag, and use the mallet to crush it to a fine-grained consistency. (The finer the texture, the better.)

b. Line the large plastic bowl with the plastic garbage bag.

c. Invite participants to pour the following liquid ingredients into the garbage bag: half of the water, ammonia (warn the children about the strong smell!), the organic material (syrup or cornstarch or alcohol), and the sand or soil. Explain that each of the materials mixed into the model represents the actual ingredients of comets.

Comets are made of rock and dust and various frozen gases: water, carbon monoxide, carbon dioxide, methane, and ammonia. Scientists have also found complex organic molecules, including ethyl alcohol and a type of sugar, in comets.

- What does the water represent? (Regular water; there is plenty of water in our outer solar system.)
- What does the sand represent? (Rock or dust; comets are mostly ice but do have rock and dust grains.)
- What does the syrup (or cornstarch or alcohol, if used) represent? (This represents organic molecules found in comets—these are the ingredients that living things are made of.)
- Share that we have found organic molecules in comets, and invite the participants to share why this might be important.

Activity (continued)

Life is not required to make organic molecules, but life is made up of organic molecules. Most scientists do not think that comets have any forms of life. However, comets could have been a source for the building blocks of life, and could have delivered them to Earth through impacts early in the history of our planet.

d. Carefully add in half of the crushed dry ice and select a mature participant to mix it well with other ingredients by kneading the outside of the garbage bag, using the gloves and taking care not to touch any leaks. The dry ice will create a cool, cloudy vapor that is safe to touch.
   - *What is the cloud made of?* (It's made of water vapor, coming from the water in the comet nucleus.)
   - *What does the cloud represent?* (It represents the gases coming out of the comet.)
   - Invite the participants to share their ideas about the gases coming out of the comet nucleus—why this happens, when it happens, and what it causes. (The comets outgas as they heat up, as they approach the Sun. The gases are pushed away from the Sun by the solar wind, forming a tail.)

e. Add in the rest of the dry ice and again invite a mature participant to again mix it well by kneading the outside of the garbage bag.

f. Invite participants to add in the rest of the water. The water/dry ice slush will start to thicken as the dry ice freezes the water.

g. Invite a mature participant to close the garbage bag around the comet and shape it into a ball. It may be necessary to add a bit more water if the comet ball does not stick together. If participants have a hard time creating a solid comet, suggest that they form it like a snowball. They shouldn't press too lightly, or too hard.

h. Invite questions and additional ideas from participants:
   - *How is the model of the comet nucleus like a real comet nucleus?* (It's made of similar materials, gives off gas, and is similar in shape.)
   - *How stable is the comet nucleus—will it last a long time, like a rock, or a short time, like an ice cube?* (Comets can stay frozen if they stay far from the Sun, but if they approach the Sun they will start to fall apart.)

Optional: Comet behavior--Outgassing.
This part of the demonstration can be repeated with new participants up to two hours after the comet nucleus has been created.

a. Holding the flashlight, carefully blow on or fan the comet model from about a foot away. Turn out the lights to create a more dramatic visual effect.

Carbon dioxide is colorless and invisible. The bubbles and jets are water vapor that has condensed into a small cloud due to the cold of the dry ice.

Activity (continued)

b. Invite the participants to share what they see, and what they think is causing it.

c. Share that as comets approach the Sun, they are heated, and that particles from the Sun will also blow on the comet, pushing the gases and dust away from the Sun into a tail.

Optional: Invite participants to use tools to investigate the comet nucleus.

Note: After the comet nucleus has been adequately mixed and formed, the dry ice is much safer to handle; however, ***participants interacting with the model should still wear gloves as a safety precaution.***

- If magnifying glasses or cameras are available, demonstrate how they can be used to make observations, and if participants are old enough, allow them to use them (with supervision).
- Demonstrate how a scale can be used to measure the weight of the nucleus, and measure it periodically to determine whether it changes as the comet outgasses.
- Demonstrate how thermometers or infrared "thermal" cameras can be used to measure temperatures of the different parts of the nucleus, and if participants are old enough, allow them to use these tools with supervision. (*See Background Information for further tips on some of these tools.*)

3. Conclude.

Draw on the participants' observations and reflections to share the important role of comets:

- What are comets made of?
- What happens to comets as they get closer to the Sun?
- Where else do we find water and organic materials in our Solar System?
- What role do water and organic materials play for life on Earth?

Planetary scientists are still examining the role comets have played in Earth's formation and history, and in the formation of life. While some have suggested that comets are the source of water on Earth, recent research suggests that Earth's water formed with the planet rather than being delivered later by comets. But the impacts of comets and asteroids have played a significant role in Earth's history, and may have delivered complex organic molecules, the ingredients for life, to our planet.

Correlations to the Next Generation Science Standards

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

PS1.B Chemical Reactions

- Heating and cooling substances cause changes that are sometimes reversible and sometimes not.

Science and Engineering Practices

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

Developing and Using Models

- Develop and/or use models to describe and/or predict phenomena.
- Evaluate limitations of a model for a proposed object or tool.
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

Analyzing and Interpreting Data

- Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.

Constructing Explanations and Designing Solutions

- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

Engaging in Argument from Evidence

- Support an argument with evidence, data, or a model.

Correlations to the Next Generation Science Standards

Crosscutting Concepts

Structure and Function

- Students observe the shape and stability of structures of natural and designed objects are related to their function(s).

Cause and effect: Mechanism and explanation

- Students routinely identify and test causal relationships and use these relationships to explain change.

Stability and Change

- Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.

The Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Scientists use drawings, sketches, and models as a way to communicate ideas.
- Scientists search for cause and effect relationships to explain natural events.

Facilitator Background Information

Tips for Using Tools

Different tools will be appropriate for different participant ages.

Note: After the comet nucleus has been adequately mixed and formed, the dry ice is much safer to handle; however, ***participants interacting with the model should still wear gloves as a safety precaution.***

- Children under 7 may be too young to interact directly with the comet model but can add some of the ingredients and observe it after it's formed.
- Children ages 8 to 12 can be shown how to use scales and thermometers.
- Participants older than 12 may enjoy determining how to use the technology for themselves, with supervision.

The Seek thermal infrared camera

This camera and app have a variety of modes. Setting the app to "Hi/Lo Mode" will automatically provide the highest and lowest temperatures in the camera frame, which may be the most useful mode for this activity.

Participants should be allowed to view objects other than the comet nucleus first (such as ice cubes, a cup of warm water, or their faces) to learn the significance of the colors and how the camera works.

For participants younger than 10, program facilitators may want to use the camera themselves in real time, taking pictures of different objects based on the participants' requests and then showing or even printing the images for the participants.

Depending on the size of the group, older participants might be able to use the camera responsibly; facilitators should use common sense with this, as with any technology, and monitor the camera's use.