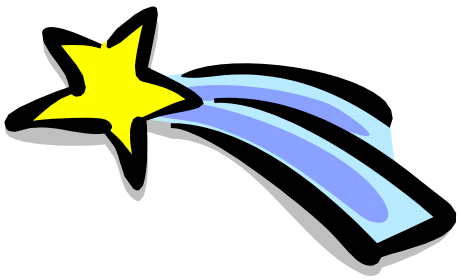
Section 4

Comets



Activity 16: Crazy Comets

Goal: Students learn the three main parts of a comet. They also discuss models and how they are used in science.

Materials:

Styrofoam ball (1 per student)
Cotton balls (2 - 3 per student)
Tissue paper
Elmer's glue
Overhead of comet with nucleus, coma, and tail
Optional: "Comets" worksheets (3)

Description:

1. Ask students to share what they think they know about comets. Have any seen a comet? What did it look like? Show the overhead of a comet.

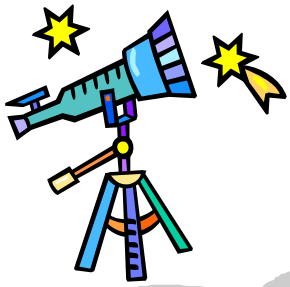
2. Tell students they will each make a model of a comet. A model of a comet will show some properties of comets, but not all. Ask students how they would model a comet. What properties would they want to show?

3. Explain that they will use a Styrofoam ball, tissue paper, and a cotton ball. Each of these things models a different part of a comet. Ask students to look at the overhead and guess which part each material will model. They don't need to know the names at this point.

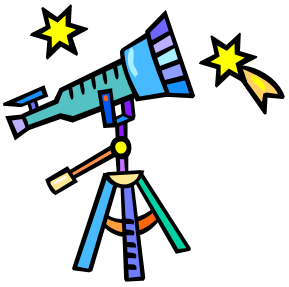
4. Distribute tissue paper, a Styrofoam ball, and a cotton ball to each student. Have students wrap the tissue paper (tail) around the Styrofoam ball (nucleus) and twist to tighten. Pull the cotton balls (coma) apart and then glue onto the tissue paper. As the students add each part, write the name on the board.

5. After the comets are finished, review the parts with the students. The comets can be hung from the ceiling, just beyond Neptune in the outer edges of the classroom solar system.

6. Optional: Allow students to begin the "Comets" worksheet by drawing their comet. You may choose to save the interesting facts section for later in the unit.



Comets



Comets can consist of three main parts:
a **nucleus**, a **coma** and a **tail**.
The frozen nucleus is the central permanent part of a comet. It is made of ice and dust.
The coma is a dusty cloud that forms around the frozen nucleus as the comet orbits closer to the sun and begins to heat up.
The comet's tail is formed when the **solar wind** forces the gas and dust of the coma away from the sun. The comet's gases may be blown behind the comet into tails that can be as long as 90 million miles.
Comets have two tails that flow behind the comet as it orbits around the sun, one made of gas and another made of dust.

1. What are the three main parts of a comet?

_____ _____ _____
_____, _____ and _____.

2. What is the nucleus of the comet made of?

_____
_____
_____

3. How is the comet tail formed?

_____
_____
_____

4. Can a comet have two tails?

_____
_____
_____

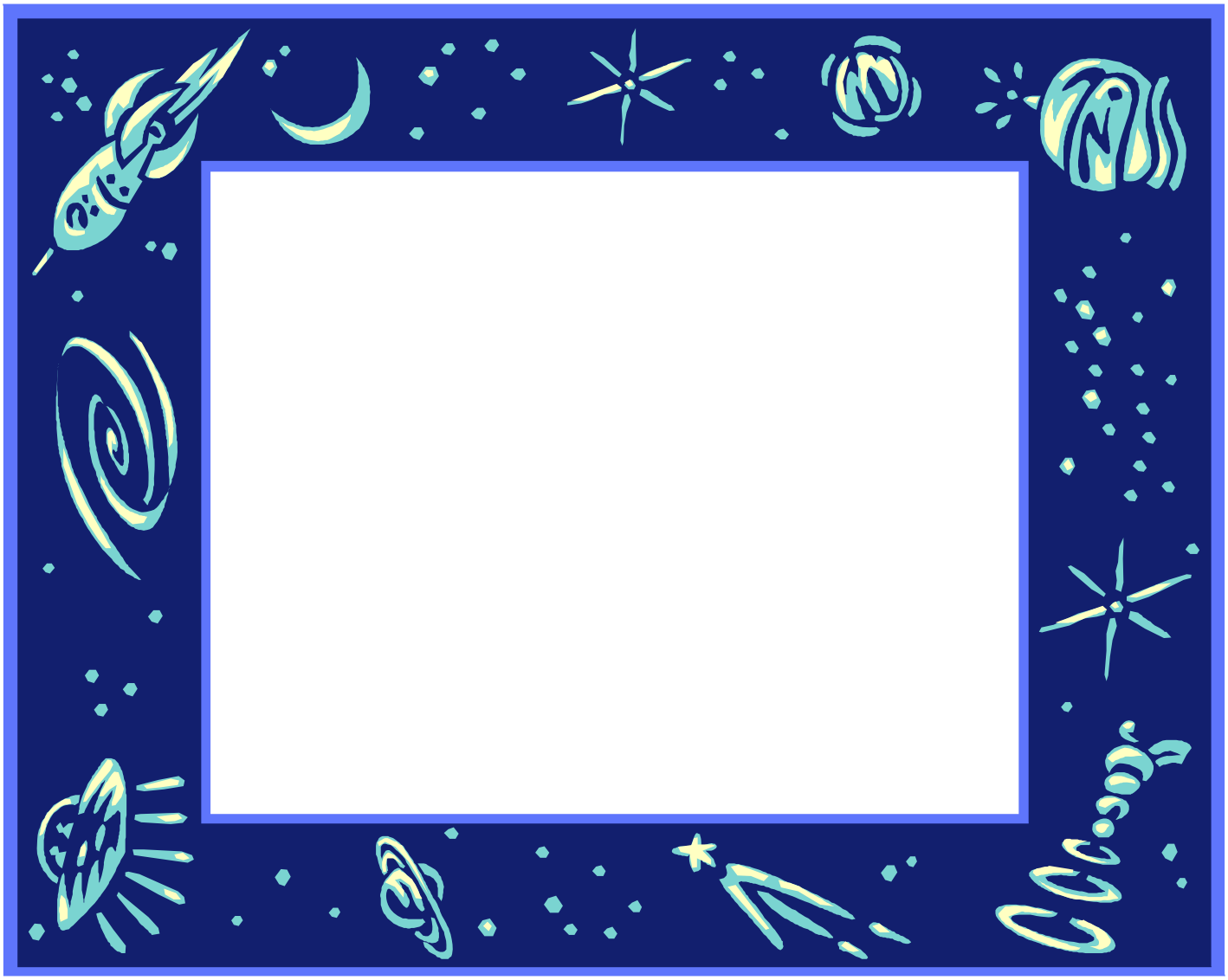
5. What are the two tails made of?

_____
_____
_____

Comets

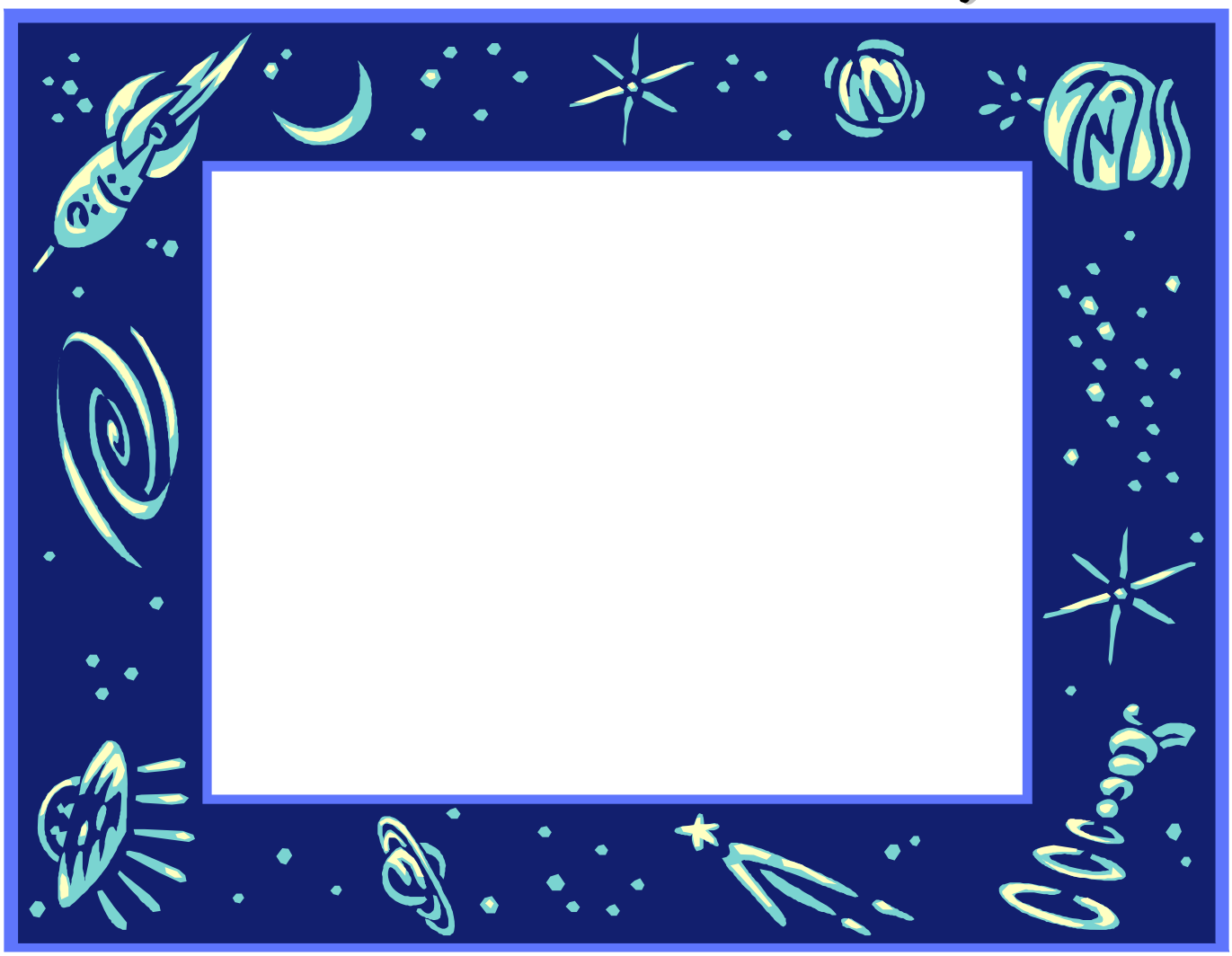
Draw a picture of a comet.
Label the three main parts.

Tail	Nucleus
Coma	



Comets

Draw a picture of a comet.
Label the three main parts.



What are three interesting facts you learned about comets?

Why are Comets Bright?

Activity 17: Why are comets bright?

Goal: Students learn that, unlike stars, comets do not produce their own light, but reflect light from the sun.

Materials:

**For each group of students (or you can do just one as a demonstration):
Flashlight
Shoebox
Hole punch or pencil (to punch holes in box)
Foil (enough to ball)
Yarn
Scotch tape

Description:

1. Ask students to describe how comets look in the sky. Are they dark or do they seem to glow? What makes them glow? Tell students they will make a model to show how comets appear to glow.

2. Pass out the shoeboxes. You may want to punch holes ahead of time, or allow students to punch them. They should both be on one end of the shoebox.

3. Pass out foil and have students create a ball about the size of a golf ball.

4. Students should tie some yarn around the aluminum foil ball and tape it in place. Then, tape the yarn to the top of the box so that the foil ball hangs in the shoebox about ½" from the bottom.

5. Cover one of the viewing holes with an index card. Have the students view the aluminum foil ball (comet) through the open hole of the shoebox. (Remind students to use their hands to cover around their eye so they don't get any classroom light in the viewing box.) Ask the students if they can see the comet.

6. Have the students take the index card off of the other opening and shine a flashlight in it. The students can take turns viewing the aluminum foil comet through the viewing hole. Have the students describe what they see. The comet should be illuminated by the light from the sun (flashlight).

7. Explain to the students that this activity models how comets seem to glow. They become visible in the night sky because they reflect the light of the sun. (Remember, though our part of the earth is turned away from the sun at night, the sun is still there and other objects receive its' light.)

Cooking up a Comet

Activity 18: Cooking up a Comet

* Adapted from NASA curriculum

Goal: Students gain content knowledge about the composition and physical properties of comets. They learn about the NASA STARDUST Mission and how scientists revise theories as they gain new information.

Materials:

Large, wide mixing bowl
Large wooden spoon for stirring
Blender
Heavy rubber gloves
Protective goggles
Cloth or paper towels
Overhead projector
Plexi-glass or cling wrap to cover overhead projector
Overhead of Comet Wild 2
Hair dryer (optional)
"Cooking up a Comet" worksheets (2) (optional)
"Comet Predictions" worksheet

Comet ingredients:
- 5lbs. **Dry ice pellets** (frozen carbon dioxide)
- 3 cups of water (comets contain lots of frozen water)
- A few squirts of windex (represents ammonia, which is frozen in comets)
- A handful of sand (represents rocky material, including grains collected by STARDUST)
- Soil (represents organic material, the building blocks for life)
- 1 can of soda (represents phosphorous; necessary for life as know it)

CAUTION

Dry ice is -79 degrees Celsius. Anything more than a brief exposure to the skin will cause burns. Anyone handling dry ice should wear protective heavy rubber gloves. Students shouldn't handle the dry ice. This is meant to be an observational lesson only! You should practice this lesson ahead of time to ensure a safe and accurate demonstration for the students.

Description:

1. Ask students if they have ever heard of the NASA STARDUST Mission. If so, what have they heard? Let them know the goal of the mission was to learn more about comets by flying by Comet Wild 2 (pronounced "Vilt 2"). Ask students what they would want to do to learn about a comet, if they were able to travel to one.

2. While you set up supplies, have students observe overhead of composite image of comet Wild 2 taken by the NASA STARDUST spacecraft. One of the things NASA scientists did was take pictures of the comet. Ask students to imagine they are the first scientists to see this image. How would they describe it?

Share with them some observations of NASA scientists:

- Hamburger shaped body about 4.5 km across
- Surface features unlike those seen on any other solar system body
- Tall pinnacles
- Flat topped mesas
- Sink-hole-like depressions with flat floors and vertical cliffs
- Crater like depressions surrounded by mysterious halos with over-hanging cliffs

3. Tell the students that they will make a comet model to compare with Wild 2, using ingredients really found in comets. Remind them that they already made a model of a comet. Ask them to observe how this model is different.

4. Once you are set up, begin to add ingredients. Discuss with students the significance of each ingredient. Add ingredients as follows:

Pour 2 ½ cups of water into the mixing bowl. Sprinkle in some sand, soil, and two squirts of ammonia (windex). Add the cola, mixing as you pour.

Put on the heavy rubber gloves and protective eye goggles. Use the blender to finely chop up the dry ice. Be careful not to freeze the blender by putting in too much at once. The dry ice should be the consistency of snow.

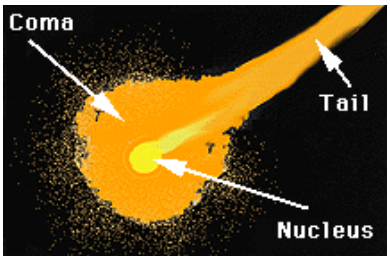
** Do not leave any dry ice in the blender as it will cause the blender to freeze up. If the blender freezes, use the hair dryer to thaw it.

Add 2 ½ cups of ground dry ice to the mixture. Stir carefully. Carbon dioxide gas will form as you stir (because the frozen carbon dioxide is warming up to room temperature). The mixture will get slushy. Keep stirring for a few seconds while it thickens.

Use the mixing spoon to push the slush off of the sides of the bowl and into the bottom. Reach in (with your gloved hands) and start packing the slush into a snowball. Keep packing and forming until you have a big lump. Add water to help it stick together.

5. Observe the behavior of your comet's nucleus. For the entire class to watch as the comet sublimes (turns from solid to gas without being a liquid) place some plexi-glass on top of an overhead projector. Place the comet onto the plexi-glass.

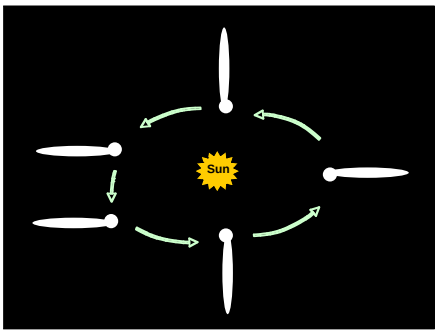
6. Have students observe the gases that sublime from the frozen nucleus to form a coma. Have students take turns blowing the coma to form a tail. Discuss the parts of a comet: nucleus, coma, and tail.



7. Remind students that the ingredients used to cook up this comet are representative of our current understanding of the components found in actual comets: frozen water, frozen carbon dioxide and other frozen gases, very small bits of rock, organic (carbon based) substances, and phosphorous. As the comet melts you can see little jets of gas coming off the comet. In space this is called "outgasing" and can actually affect the movement of the comet. Compare and contrast your model with the image of comet Wild 2.

8. If the comet is no longer subliming dramatically, blend up a little more dry ice and dump it on the plexi-glass around the nucleus.

9. Explain to students that their breath represents the solar wind, which streams from the sun in all direction at all times. When this wind hits the coma, it blows gas and dust away from the wind, like in the drawing below.



10. As you clean up, have students do one or more of the worksheets provided.

Cooking up a Comet

What did the comet look like?

What did you observe?

What happened to the comet as it warmed up?

How did the solar wind affect the comet?
What did you see because of it?

What have you learned about comets?

Cooking up a Comet

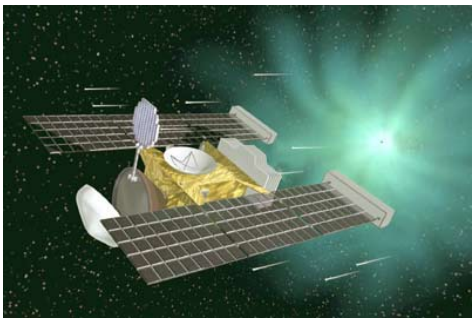
When we created our classroom comet we used items found at the store. What do these items represent in a real comet found in space?

Dish: _____ **Recipe** Serves: _____

1. Dry Ice	1. _____
2. Water	2. _____
3. Sand	3. _____
4. Cola	4. _____
5. Windex	5. _____
6. Soil	6. _____

What have you learned about comets and their ingredients?

Mission: STARDUST



Activity 19: Mission: STARDUST

Goal: Students use listening, reading and writing skills to learn more about the NASA STARDUST mission.

Materials:
Stardust Mission article
Comets (made in earlier the "Crazy Comets" activity)
Yarn
"STARDUST Mission" strips worksheet
Scissors
Scotch tape
Computer
Power Point Presentation: Our Solar System (slides 13-18)

Description:

1. Ask students to remember and share one piece of information about the NASA STARDUST Mission.

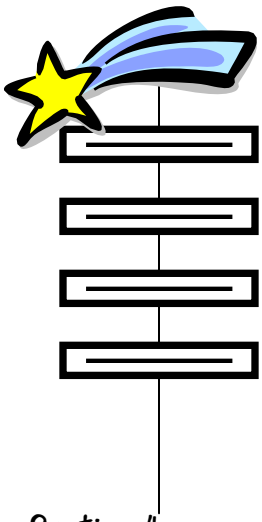
2. Tell students they will be making "Information Mobiles" with their "Crazy Comets" and "STARDUST Strips." Explain that they will cut out the 4 strips and record a piece of information on each of them. They will then attach these to a piece of yard and glue them to their "Crazy Comets."

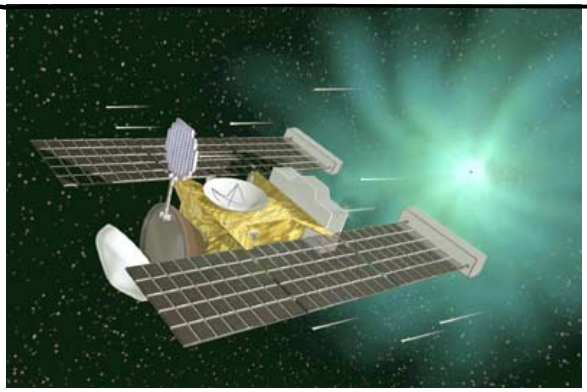
3. Pass out STARDUST Strips. Allow students to cut them out.

4. Play slides 13-18 of the DVD Power Point Presentation: Our Solar System. Ask students to listen for two pieces of information and record them on two strips.

5. Pass out the STARDUST article that fits the reading level of your students. Ask them or work together in groups of three to four to read the article. Have them choose two more pieces of information to record on their Stardust Mission strips.

6. Have them attach the strips to a piece of yarn with tape. They can then tape them to the Styrofoam comets made earlier in the unit. You may choose to hang these from the ceiling.





Stardust Mission

In 2004, the **NASA Stardust** spacecraft flew within 150 km of the nucleus of **Comet Wild 2**. It took pictures of the nucleus and captured dust samples to return to Earth for analysis. The primary goal of the mission was to learn more about comets.

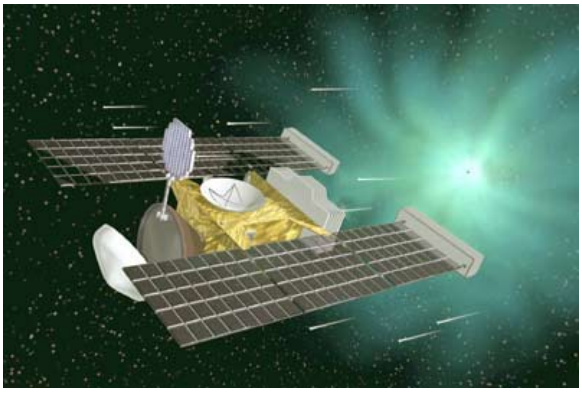
A comet is made of a frozen **nucleus** and sometimes a coma and a tail. When a comet comes close enough to the sun to be warmed, the frozen nucleus heats up and loses some of its material through the process of **sublimation.** This happens when a solid becomes a gas without first melting to a liquid. The escaping gases push the dust particles out of the solid nucleus. The dust and gas form a fuzzy cloud around the nucleus, called a **coma.**

The **solar wind** is made of charged particles streaming from the sun. When this "wind" reaches the coma of the comet, it pushes the gas and dust away from the nucleus to form **tails.** These tails sweep out into space, always pointing away from the sun. Some tails may be 100's of millions of kilometers long!

After about 1,000 trips past the sun, a comet loses most of these frozen materials and no longer forms a coma. Once this happens the comet no longer creates the long beautiful gas and dust tails that we can sometimes see in the night sky.

Unlike the planets, most comets have not changed very much since the formation of the solar system. Dust from comets may hold the key to our understanding of the early development of the solar system. Since Wild 2 has passed the sun only a few times, it still has most of its ancient dust and gases, making it an ideal choice for study. Scientists are just starting to learn about the dust grains returned by the Stardust spacecraft.

Information adapted from
Article Source: http://stardust.jpl.nasa.gov/science/wild2.html
http://www.windows.ucar.edu/tour/link=/space_missions/comets/stardust.html



Stardust Mission

A spacecraft named Stardust returned to Earth in January 2006 after a 7 year-long mission. Stardust flew past a comet and grabbed some pieces of dust from the comet. The spacecraft returned those dust particles to Earth. Scientists have started to study them. The scientists hope to learn about comets, and about the history of our solar system, from the comet dust.

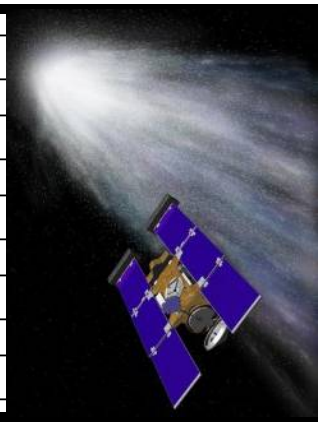
Stardust was launched in 1999 and flew by the comet in January 2004. It snapped the best pictures ever of the nucleus of a comet as it flew past Comet Wild 2. It also grabbed some dust from the coma of the comet using a high-tech material called aerogel.

On January 15, 2006 a capsule from the Stardust spacecraft brought the comet dust back to Earth. The capsule had a heat shield to protect it when it re-entered Earth's atmosphere. It also had parachutes that gently lowered it to the ground. The capsule landed in Utah at around 3 AM and crews in helicopters picked it up. They brought it to scientists who opened the capsule and got the dust particles out.

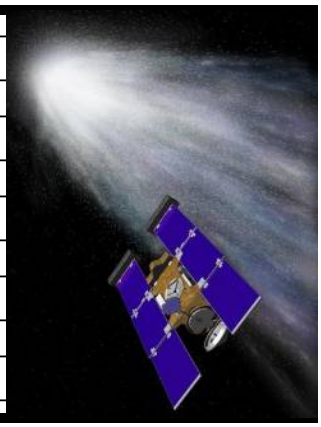
The scientists have started to study the dust to learn more about comets. They have already had a surprise. Comets are large balls of ice, but the samples Stardust brought back included some minerals that form at high temperatures! These minerals normally form near the Sun (or some other star). Scientists don't know how the minerals got out to the frozen edge of the solar system to become part of comets.

Information adapted from
Article Source: http://stardust.jpl.nasa.gov/science/wild2.html
http://www.windows.ucar.edu/tour/link=/space_missions/comets/stardust.html

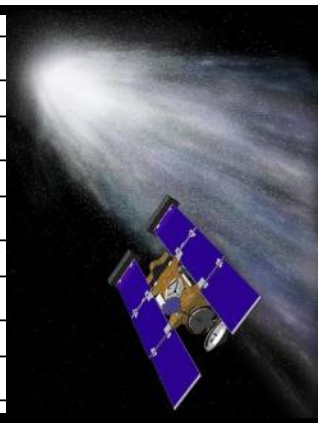
Stardust Mission



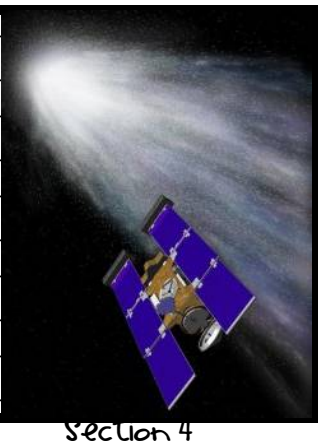
Stardust Mission



Stardust Mission



Stardust Mission



Searching for Stardust

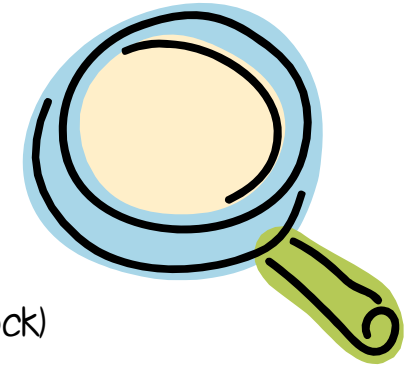
Activity 20: Searching for Stardust

Goal: Students will work as teams of scientists, extracting, observing, describing, and recording particles embedded in Jello. They will then compare their experiences to those of scientists working with NASA STARDUST material.

Materials:

For each group of students:

- 1 unrefrigerated Jello cup (with particles embedded)
- Pair of plastic tweezers
- Magnifying hand lens
- 2 pieces of yarn cut at 3"
- Tape
- Paper towel
- "STARDUST Team" packet (2-pages)
- Worksheet: Sampling a Comet



For whole class:

- Aluminum foil pieces (metal)
- Fish tank gravel of different colors (rock)
- Small beads of different colors (glass)
- Permanent marker
- Overhead with Aerogel pictures

Description:

1. Prepare the Jello cups ahead of time by removing the lid and placing an assortment of particles (aluminum foil, gravel, etc.) on each one. Push the particles into the Jello and replace the lid. Use a permanent marker to draw a line all the way around the middle of the cup, dividing the top from the bottom. Write an "A" on one side of the cup (so students can line up their cups to record items on their maps).

2. Explain to students that the Jello is a model for the Aerogel used in the NASA STARDUST mission. Let students know they will work as teams of scientists to explore particles in Jello. Place students in groups of four and assign roles: Extractor, Map Specialist, Recorder, and Reporter. The Extractor will use the tweezers to carefully extract one particle at a time. The Map Specialist will locate the position of the particle on the map and tape the particle in its appropriate place. The Recorder will write a description of the particle. The Reporter will participate in all parts of the process and present the information to the class.

3. Pass out the worksheets, tweezers, magnifying lenses, yard, tape, paper towels. Pass out Jello cups last. Show students how to tape yarn into an "X" on the top of Jello cup to divide it into quadrants. Help them position the cups so that they can easily find their place on their maps. Use an extra Jello cup to demonstrate the processes of extraction, mapping, and recording.

4. Let the students begin and circulate to help as needed.

5. After the students have recorded their findings allow Reporters to share results.

6. Show overhead pictures of Aerogel, used in the STARDUST mission to capture comet particles from Comet Wild 2. Aerogel is very lightweight, yet has excellent insulating capabilities and is able to support a large amount of weight. Particle tracks can be seen in Aerogel returned to Earth.

Teacher Resources

Video clips, Podcasts
and updated stardust mission
resources can be found at
http://stardust.jpl.nasa.gov/home/index.html

STARDUST Team

1. Write down the names of your team members.

Extractor _____

Map Specialist _____

Recorder _____

Reporter _____

2. Place your Aero-Jello so that the "A" on the cup is facing in the same direction as the "A" on the particle map.

3. Make sure you have taped your yarn on the top of the cup to make a grid.

4. Extractor: Take one particle from the top layer of your Aero-Jello.

   Map Specialist: Tape the particle in place on the map (use the "Top Layer" circle). Give it a number.

   Recorder: Write a description of the particle by its number.

   Reporter: Think about how you will report this particle.

5. Repeat step 4 until ALL particles are taken out of the top layer.

6. Do the same thing for all particles in the bottom layer. This time tape the particles in the "Bottom Layer" circle.

7. Prepare a report to share with the class.

Particle Map

A

Top Layer

A

Bottom Layer

Particle Descriptions:

Particle 1: _____

Particle 2: _____

Particle 3: _____

Particle 4: _____

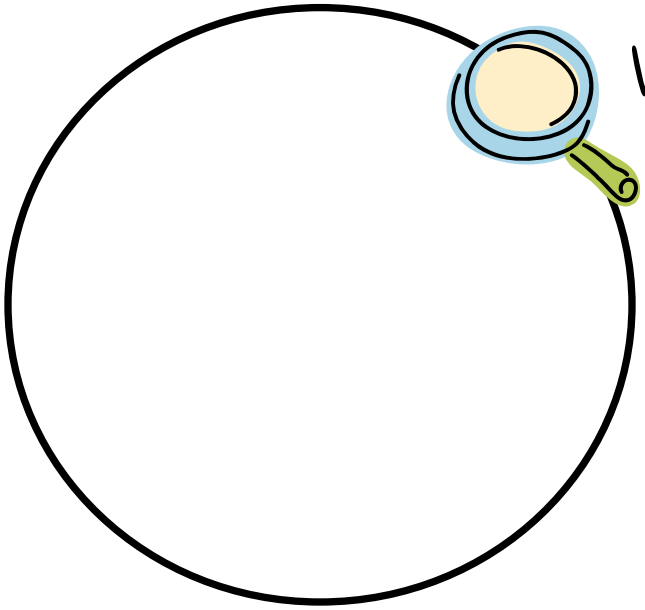
Particle 5: _____

Particle 6: _____

Particle 7: _____

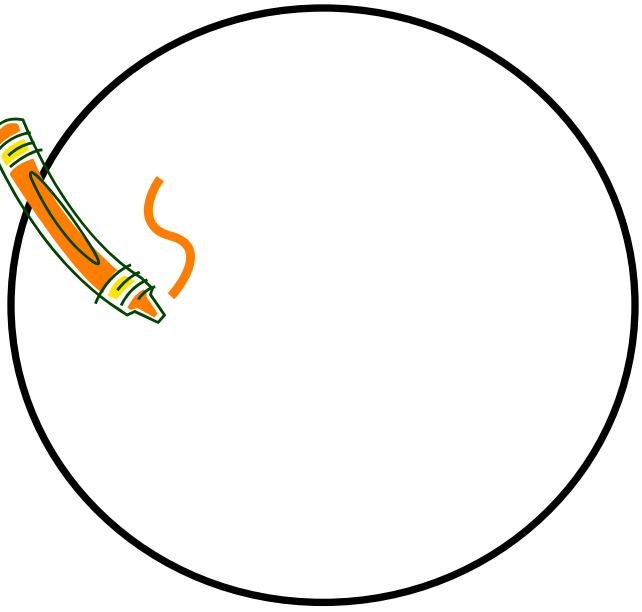
Particle 8: _____

Sampling a Comet



What do you see in your sample?

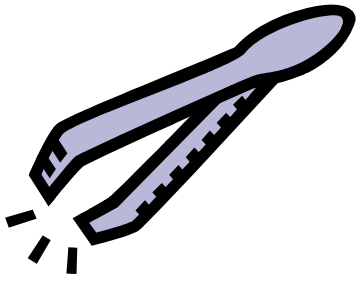
Draw and label each item you see.



Use your tweezers to extract the items from your comet sample.

What are the different particles you found in your sample?

Particle 1 _____
Particle 2 _____
Particle 3 _____
Particle 4 _____



Comet Craters

Activity 21: Comet Craters (2 days)

Materials:

For each student:
- "Comet Craters" worksheet (1 or 2)

For each group of students:
- 2-lb bag of flour
- Small bowl
- Water
- Large plastic container with lid (shallow containers work best)
- Enough modeling clay to make golf ball-sized "comet"
- Ruler with centimeters

For the whole class:
- 1 container of cocoa powder
- Food coloring (different colors)
- Small plastic animals, houses, Lego buildings, trees, cars, aliens
- Chart paper
- Computer
- Power Point Presentation: Our Solar System (slide 16 and 17)

Description:

Day 1

1. Ask students to imagine what it might be like on another planet. Will there be life? How will it compare to life on Earth?

2. Show students the materials they can use and tell them they will work in groups to design their own planet. Demonstrate what they will do. Using the flour as the base, fill the container 2-3 inches deep. Put a thin layer of cocoa over the flour to represent the top layer of soil. Show students how to add oceans or lakes by filling small plastic bowls with water and adding a drop of food coloring. Let them know they can add houses, trees, animals, people, or aliens.

3. Pass out materials (or have students go to already prepared stations) and let students begin. When their planet is complete put the lid on and save it for the next day.

Writing Extension

Have students write a letter to an alien or write a persuasive paragraph about whether or not there is life on other planets.

Day 2

1. Ask students why is it important to study comets. What do they think would happen if a comet hit a planet? Ask the students if they know how craters are formed.

2. Explain to them that they have created a model of a planet. Today they will be creating a model of what would happen if a comet struck that planet.

3. Give students rulers and various amounts of modeling clay (give some groups 2 - 3 sticks and other groups 5 - 7) to create a large ball (comet). Demonstrate how they will drop the clay onto their planet.

4. Allow them to see the crater that formed in your planet. Ask them what observations they might make about that crater. How might they measure it or describe its impacts? Hand out the "Comet Craters" worksheet and rulers. Explain to students how to measure the diameter of their clay comet and the diameter of the crater with a ruler (in cm). Demonstrate on the board how to measure the distance of rock scatter (how far out the flour shows up). Show them how to measure the distance of disturbance (how far they can see any effects of the impact- they may say it extends throughout the entire box).

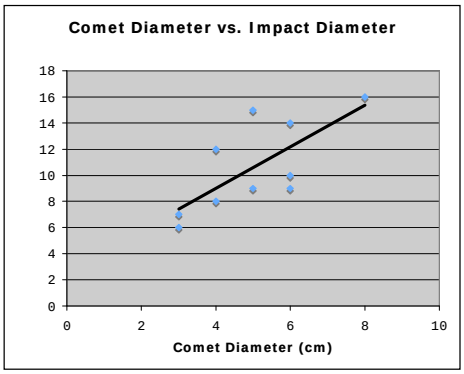
5. Once they have made their comet and measured its diameter allow them to get their planets from day 1.

6. Work with one group at a time to create their comet crater simulation. Choose one student to stand on a chair directly over their "planet". Have the other students stand around the planet ready to observe the comet's impact. Students should begin making measurements and observations on the "Comet Craters" worksheet immediately after impact.

7. When students finish, have them place the lid on their planets and collect them. (You may wish to have helpers separate and rinse out the parts later.)

8. Have the students record the diameter of their comet and of their impact on chart paper.

Group #	Diameter of comet (cm)	Diameter of impact (cm)



9. Help them make a scatter plot with this data. If possible, draw a trendline through the data points. If they recorded a relationship between comet size and impact size, discuss why a larger comet would make a bigger impact.

10. Discuss the impact the crater had on their planets. Talk about the environmental and physical effects of a comet impact. Some sample questions are: How might life be different for the animals? Will the air quality be different? How will life be different in the cities/ in the country? How will life be different for things that lived close to/ far away from the impact site?

11. Optional: Revisit the power point and focus on the comet impact section. (Slides 16 - 17).

sample Questions

How might life be different for the animals?
What about the air quality?
How will life be different in the cities or the towns?
How will life be different for people who lived close to/ far away from the impact site?

Science Connection

After completing the comet crater experiment have students relate what happened on their "planets" to what they think might have happened to the dinosaurs on planet Earth. Do they think a comet or an asteroid might have caused their extinction? Have a class debate. Support each side with facts from the comet craters experiment.
The Chicxulub crater is believed by scientists to be the missing evidence to support their findings that an impact led to the extinction of the dinosaurs.

For more information visit:
http://photojournal.jpl.nasa.gov/catalog/PIA03379

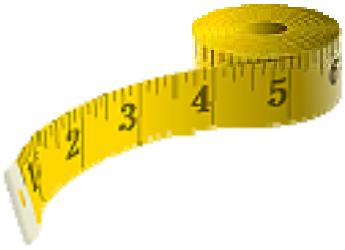
Comet Craters

1. Write the names of your group members.

_____
_____
_____
_____
_____

2. What is the diameter of your comet in cm?

_____cm



3. What is the diameter of your impact crater in cm?

_____cm

4. What is the distance of rock scatter (how far your flour went)?

_____cm

5. What is the farthest distance you can see any sign of damage?

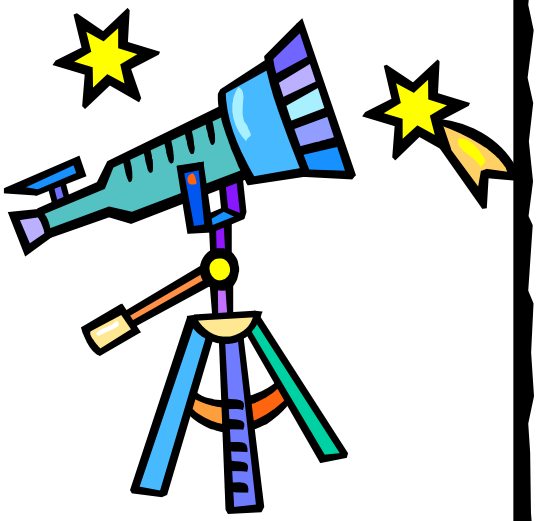
_____cm

Comet Craters

Draw a picture of your crater and the impact it had on your planet.

Describe what happened to your planet when the comet hit.

Comet Predictions



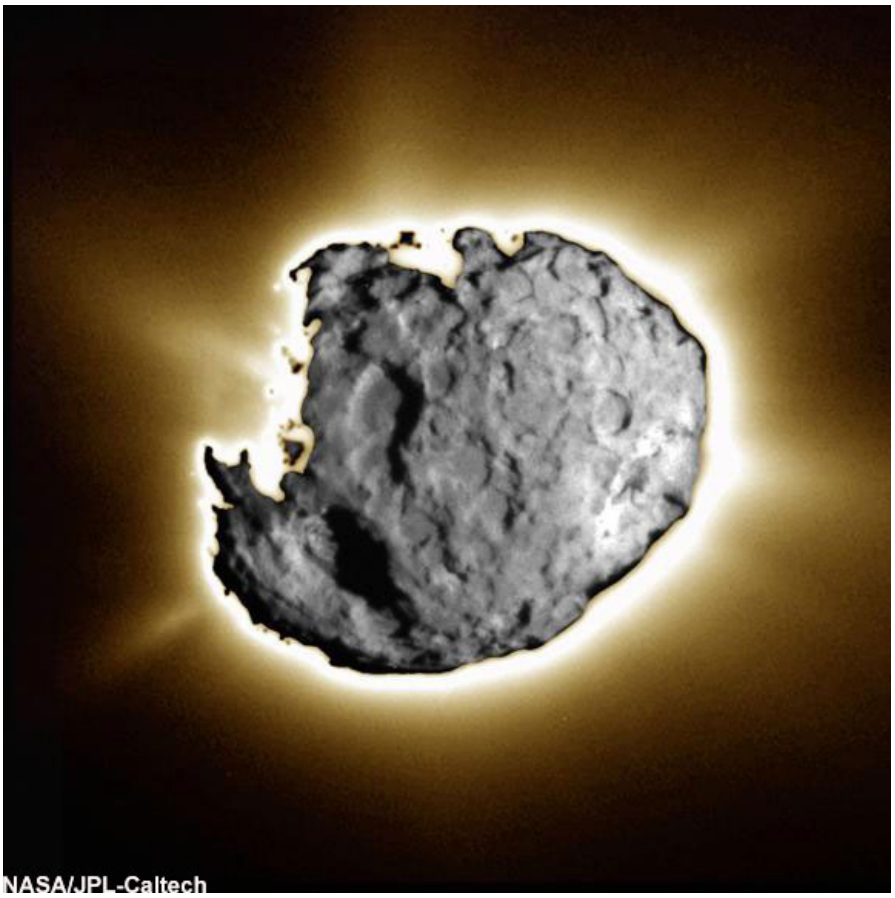
Activity 22: Comet Predictions

Goal: Students will apply the knowledge they have gained on comets, to observe and make predictions about them.

Materials: Images of Comet Wild 2
Worksheet "Comet Predictions"

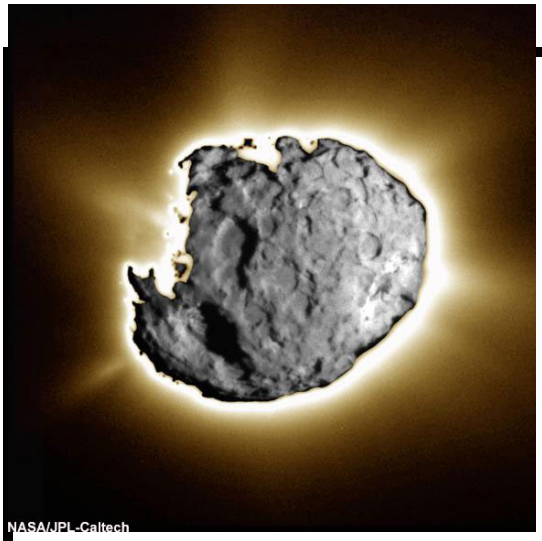
Description:

1. Ask the students to draw a picture of what they think Comet Wild 2 will look like the next time it passes the sun.
2. Did it get bigger? Smaller? Does it have a different shape? Ask students to explain their predictions.



Comet Predictions

The Wild 2 Comet orbits the sun once every 6.39 years. With each passing of the sun the comet loses a tiny bit of its mass. Draw a picture of what you think Comet Wild 2 will look like when it passes the sun again.



Describe what the comet will look like and why.