VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

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Comets

Fall 2018 VINSE/VSVS Rural

Goal: To teach students the importance and composition of comets.
Fits Tennessee standards:

GLE 0607.6.1 Analyze information about the major components of the universe.

Lesson Outline

1. **What are Comets?**
2. **Where are Comets Found?**
3. **What is a Comet Made Of?**
4. **Making a Comet**
   Students simulate a comet by combining dry ice, water, charcoal, ammonia and dirt.
5. **Observing the "Comet"**
   Students watch their comet as it gives off gas. It can be broken with a hammer to observe the inner part of the comet.
6. **Observing the Tail**
   Dry ice is used to simulate the tail of the comet.
7. **Comparing Comets with Asteroids and Meteorites**
8. **Clean-Up**

Materials

1 quart water
1 Styrofoam cup of powdered dry ice
1 Styrofoam cup of whole pieces of dry ice
16 spoons
16 containers of dirt
1 containers of carbon (ground up charcoal)
1 dropper bottles of ammonia
32 pairs gloves
16 sandwich bags
32 3.5 oz cups (16 for water, 16 for powdered dry ice)
16 1 oz cups for whole dry ice
16 aluminum pie pans
9 meteorites
9 magnets
1 hammer
1 scoop
1 aluminum pan (large)
1 binder containing:
16 thermometer diagrams showing temperature of dry ice and water ice
16 Instruction sheets
16 Diagrams of the orbits of comets and asteroids

Lesson set-up:

Put the powdered dry ice into 16 3.5 oz cups (fill).
Pour water into 16 3.5oz cups to the 50 mL mark.
Put whole pieces of dry ice into 16 1 oz cups.

I. What are Comets?

Comets are left over debris from the period of the early formation of our solar system.
Comets may have brought water and carbon-based molecules to earth. These are the molecules that make up living things.
Most comets are too small to be seen without a telescope.

II. Where are Comets Found?

Pass out Instruction sheets to pairs of students.

- Comets are part of our solar system. They orbit the sun.
  Tell students to look at the diagram (bottom image) of the solar system. Show them where the **asteroid belt** is and where **comets** can be found.
- Comets spend most of their time out past Pluto in the Oort cloud or in the Kuiper cloud near Neptune.
- Gravity can pull a comet closer to the sun.
  Have students trace the typical orbit of a comet (top image) (It is very long and oval shaped.)
- Planets have a more circular orbit, so comets can sometimes cross the planetary orbits and collide with planets and their satellites.
- They have not been easy to study since they orbit the sun with long periods of rotation around it.
- It is rare to see one come close to earth, but it does happen. In 1986 the first picture of the interior of a comet was taken by the Giotto spacecraft. It was found that a comet's surface is not smooth, but very rough, full of holes, and lumpy.

III. What is a Comet Made of?

1. A comet is a dirty ball of ice!

2. The comet has a small **nucleus** in the center– this may be only 1-10 miles across.
   The nucleus is the solid center, 50% is ice, and 50% dust and rock.
   80% of the ice is made of frozen water. Another 15% is frozen carbon monoxide.
   The rest of the ice is frozen ammonia, carbon dioxide, and methane.

3. The nucleus is surrounded by a **coma –** this is formed when the comet gets close to the inner solar system.

4. The heat from the sun warms up the ices on the surface of the comet and creates gas and dust.

5. The comet may have 1 or 2 tails, depending on how close it is to the sun.
   a) The **dust tail** is produced as the ices evaporate and drag dust particles off the surface of the comet. They are pushed into a tail by radiation from the sun.
   b) The **ion tail** is produced by the solar wind which converts some of the comet's gases into electrically charged particles called ions.
   We see comets because the gas and dust reflect sunlight.

Tell the students that they will make a model of a comet using common materials.

- Water is present in comets as ice.

Your Notes:

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- Other ices include dry ice, which is frozen carbon dioxide, or CO_2.
- Ammonia or NH_3 is added as a liquid and gets frozen in the dry ice.
- Other frozen gases such as carbon monoxide and methane cannot be represented in this model.
- Sand or dirt represents the rock and dust.
- Charcoal (ground up) represents the carbon.

IV. Making a Comet.

All students must wear safety goggles and wear gloves.

Materials for demonstration:

1 plastic bag containing materials for VSVS members to use for demonstration:
- 1 spoon
- 4 pairs of gloves
- 1 sandwich bag
- 1 3.5 oz cup powdered dry ice
- 1 3.5 oz cup with water filled to 50 mL level
- 1 plate
- 1 container sand/dirt
- 1 container charcoal
- 1 dropper bottle ammonia

Demonstrate the procedure.

1. Add 50 ml of water to the sandwich bag
   Tell students this will become ice water, which is present in comets.
2. Add 2 tsp of non-organic material (dirt) to the water. Stir well until the water, and dirt are well blended to a muddy substance. Dirt represents the rock and dust in comets.
3. Add 1 spoon of ground charcoal. Stir well. Charcoal represents the carbon-based material.
4. Add a small squirt of NH_3 (ammonia). Continue to mix carefully.
5. Put on the thick working gloves.
6. Add the powdered dry ice to the bag and place bag on a pie pan. Agitate gently.
7. Wait until the mixture is almost frozen (it will stop bubbling).
8. Lift the bag up and shape it into a snow ball by holding the bag tightly until the comet is able to hold its own shape. If necessary, add more water.
9. Unwrap the comet and display the result.

Divide the class into pairs.

Review safety procedures:

All students must wear goggles and gloves.
Make sure that each group is supervised by a VSVS volunteer. If discipline is a problem, divide the class into as many groups as there are VSVS members, so that each group is supervised by one VSVS member.
Tell students that they must NOT touch dry ice with bare hands.
Make sure that the teacher is available for help, if needed.
Tell students they must NOT seal the plastic bag.

Your Notes:

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Distribute materials to each group of <u>2 pairs</u>.

1 spoon
4 pairs gloves
2 sandwich bags
2 3.5 oz cup powdered dry ice
2 3.5 oz cup with water filled to 50 mL level
2 plates
1 container sand/dirt

Make sure that all groups keep a plate under the bag.

Tell students to:

1. Put on goggles and gloves.
2. Pour the 50 mL of water into the plastic bag.
3. Add 2 spoons of dirt/sand.
4. VSVSers will add a small spoon of ground charcoal. Mix gently but well with spoon.
5. A VSVS member will add a squirt of ammonia.
6. Add the dry ice and wait until it starts to freeze (when it stops bubbling).
7. Form a ball by squeezing the bag tight. Do not mix. At some point the material will hold its own shape. Add more dry ice or water if needed.

Make sure that the students do not close the bag completely. Remind them that the carbon dioxide is subliming and the gas needs to dissipate, and the only way out at this point is out the top though the open hole in the bag.

What is happening?

- The CO_2 freezes the water, and all the other ingredients.
- Tell students to look at the thermometer diagram and note where the temperature of dry ice is compared to the freezing point of water.
- Point out to students that the temperature of outer space is −270 °C (−454 °F).
- The water ice acts as the glue that holds everything together.

V. Observing the "Comets"

- Have students take the comet out of the bag by turning it upside down, and place it on the aluminum pie pan. Watch for a few minutes.
- Their "dirty snow ball" contains some dry ice that is subliming and spouting off CO_2 gas. Some dry ice may "explode" out.
- As time passes they will find that the comets will have craters. These craters come from the **<u>sublimation</u>** of the carbon dioxide. These pockets can be observed in real comets
- The ejection of CO_2 gas can change the trajectory of the comets.

At the end of the lesson a VSVS member will break the comets with the hammer.
Students can observe holes in the middle of the comet, where the dry ice gas has sublimed.
Tell students that some comets are actually the size of the one they have made. These ones fall apart when they get close to the sun.
Other comets can be as big as earth. These are the ones that can survive several orbits around the sun.

Your Notes:

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Sublimation Information: Write the different states on the board and the phase change that occurs between each state.

Solid ***melts*** **→Liquid** ***vaporizes*** **→Gas**

Gas ***condenses*** **→Liquid** ***freezes*** **→Solid**

Solid ***sublimes*** **→Gas**

Gas ***deposits*** **→Solid**

- Most substances have three states of matter that are observable at normal conditions (1 atmosphere of pressure and 20°C).
- Ask students what the 3 states of water are? *Ice (solid), liquid, and water vapor (gas).*
- Tell students that carbon dioxide also has 3 states, but that only 2 exist at normal conditions: a solid (called dry ice) and gas.
- Substances change their states of matter by **physical processes**.
- There are 6 changes of state: **freezing, melting, vaporization, condensation**, **deposition a**nd **sublimation.**
- Liquids can change to solids by **freezing**.
- Solids can change to liquids by **melting**.
- A liquid changes to a gas by **vaporization** (boiling).
- A gas changes to a liquid via **condensation**.
- **Sublimation** occurs when a solid changes state to a gas without going through a liquid phase. Dry Ice (solid CO_2), undergoes sublimation at normal conditions. Dry Ice sublimes at -78°C or -108°F.
- **Deposition** is the change from gas to solid. (One example is snow that forms in clouds. Water vapor changes directly to ice without first becoming a liquid.)

VI. Seeing the Tails

This can be done as a demonstration if needed.

Give each group a few whole pieces of dry ice in a 1 oz cup. Add a little water to the cup to produce a cloud.

Tell one member of the group to hold the cup and move it in the air. Students should notice a tail behind the piece. This would represent the dust/gas cloud that is always behind the comet body.

Tell another student in the group to represent the sun and to blow gently across the path of the dry ice pieces. Students should see another cloud in a different direction. This represents the ion cloud that can be seen when comets get nearer the sun.

Your Notes:

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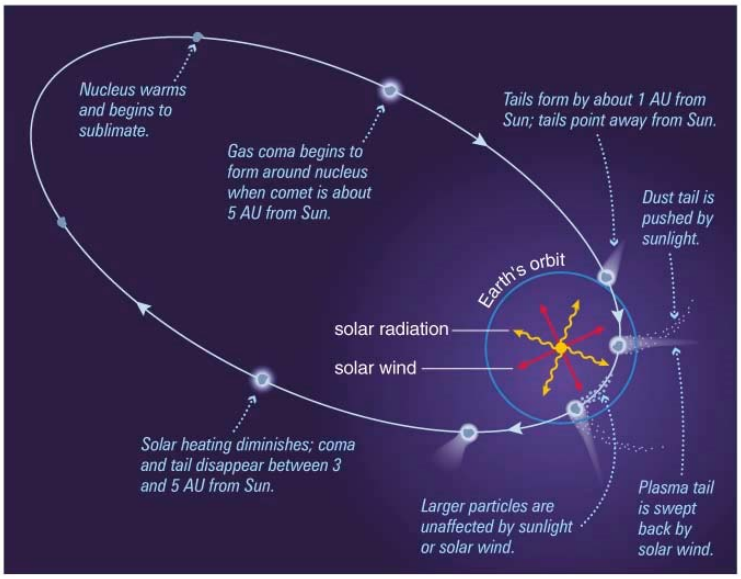
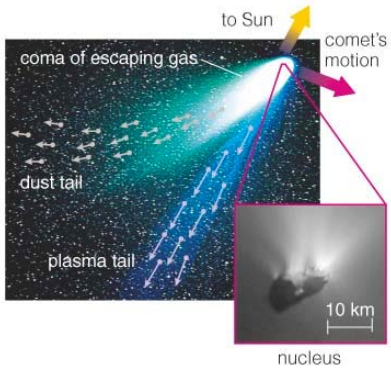
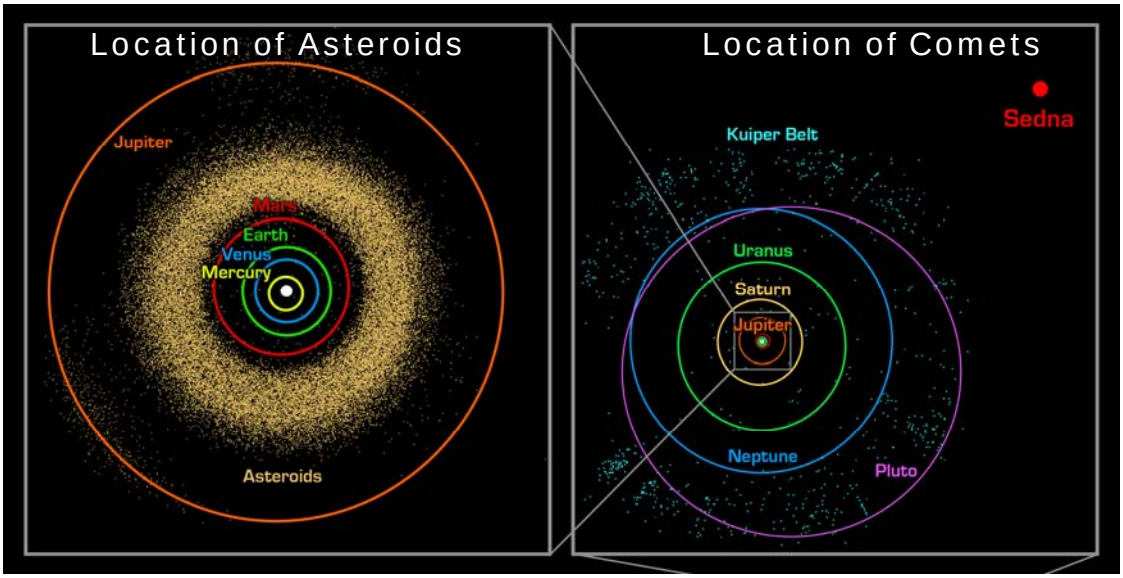




b (Above) Anatomy of a comet. The larger image shows a ground based photo of comet Hale-Bopp. The inset shows the nucleus of Halley's comet photographed by the *Giotto* spacecraft.

a (Left) This diagram shows the changes that occur when a comet's orbit takes it on a passage into the inner solar system. (Not to scale.)

VII. Comparing Comets with Asteroids and Meteorites



Asteroids and meteoroids are small rocky bodies.

Asteroids do not have much ice and do not have tails.

Meteoroids are similar to asteroids but much smaller. They are probably pieces of asteroids.

Tell students to trace the orbit of the asteroid belt.

Point out that it is between Mars and Jupiter. Asteroid orbits can cross the path of Earth.

A meteorite is a meteoroid that has entered the earth's atmosphere.

Show the students the meteorite samples and tell them that it was found in Odessa, Texas.

Make sure all the meteorite samples are counted before leaving the classroom

Your Notes:

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VIII. Clean-up

1. Collect all dirty comets and place in trash bag.
2. Tie the bag and then poke a few holes in the top. This should prevent the bag from exploding.
3. Please take it out of the VSVS kit when you get back to the lab and hand it to a VSVS lab assistant.
4. Place all cups in another trash bag and return to the lab. They will be reused.

Lesson materials adapted from NASA web site. Lesson written by:
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Your Notes:

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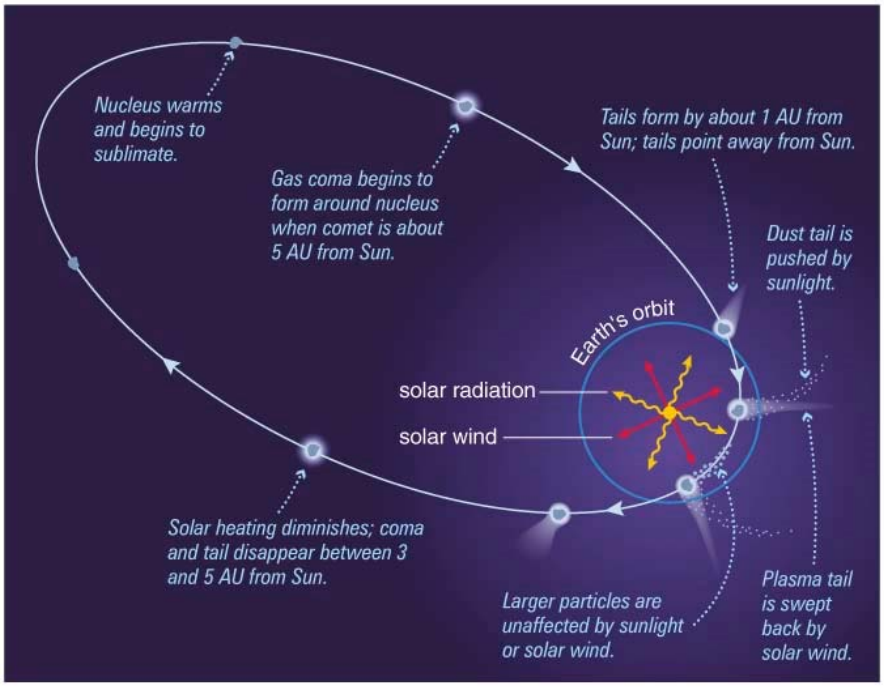
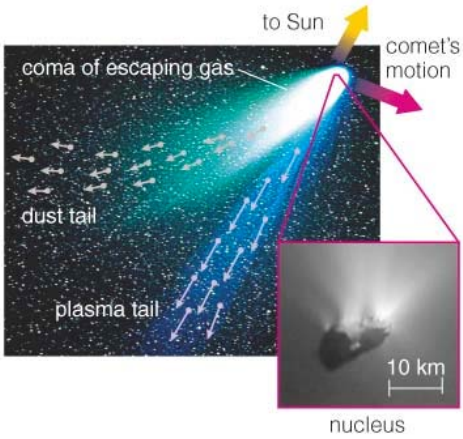
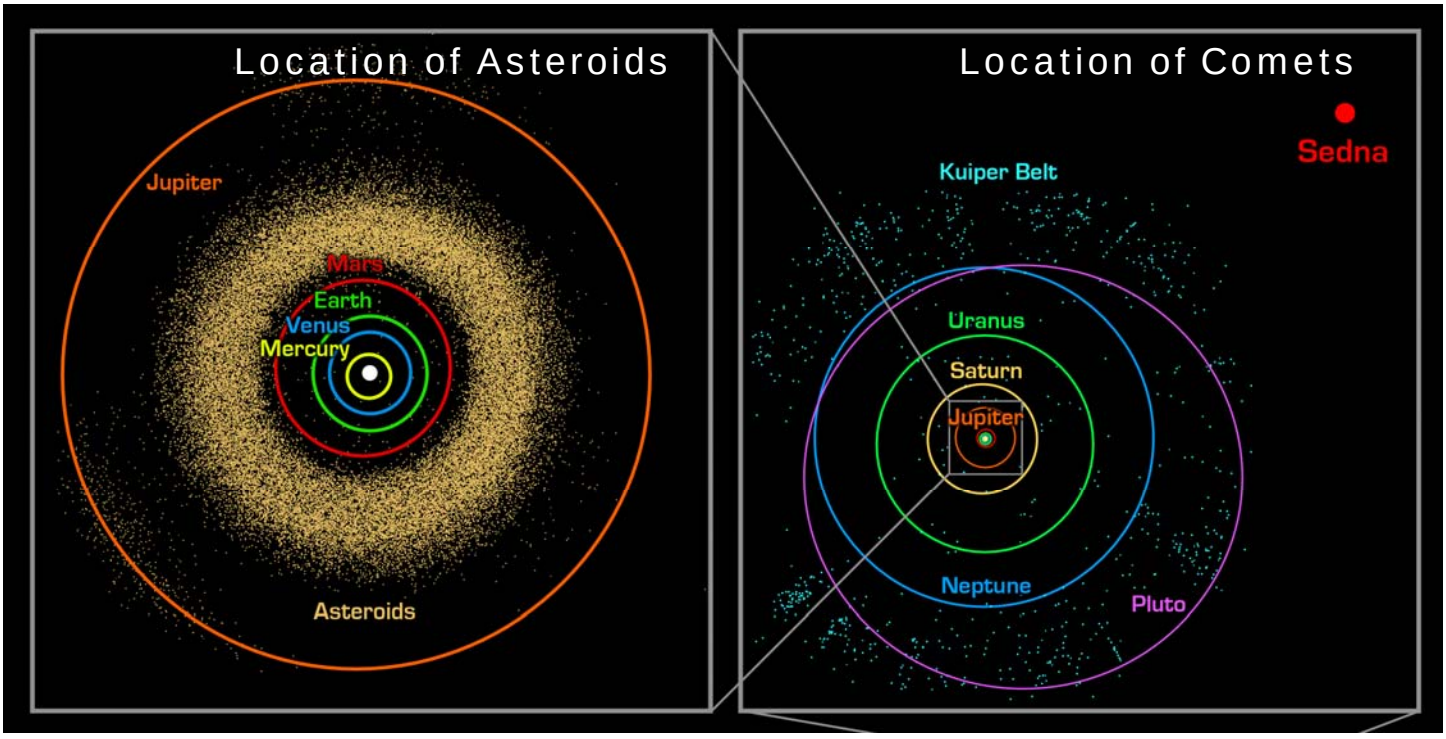




b (Above) Anatomy of a comet. The larger image shows a ground based photo of comet Hale-Bopp. The inset shows the nucleus of Halley's comet photographed by the *Giotto* spacecraft.

a (Left) This diagram shows the changes that occur when a comet's orbit takes it on a passage into the inner solar system. (Not to scale.)



Comets Worksheet

Name _____

1. What are comets? _____

   _____

2. Where are comets found? _____

   _____

   _____

3. What is a comet made of? _____

   _____

   _____

4. What is holding together the comet you made? _____

   _____

   _____

5. What is the temperature of outer space? _____

6. What caused the craters to form in your comet? _____

   _____

   _____

7. What does the trail behind the piece of dry ice represent? _____

   _____

8. What happens when someone blows on the dry ice while it is moving?

   _____

9. What does this represent? _____

10. How are asteroids and meteoroids different from comets? _____

    _____

Comets Worksheet - ANSWERS

1. What are comets?
   Comets are left over debris from the early formation of our solar system.

2. Where are comets found?
   Comets are typically found near Neptune (in the Kuiper cloud) or out past Pluto (in the Oort cloud). Gravity can pull a comet closer to the Sun.

3. What is a comet made of?
   Comets are dirty balls of ice. They are mainly made of frozen water, frozen carbon monoxide, dust, and rock. (There is also some frozen ammonia, carbon dioxide, and methane.)

4. What is holding together the comet you made?
   The liquid water holds the comet together when it is frozen by the dry ice. The dry ice is cold enough (< -78°C) to freeze the water.

5. What is the temperature of outer space?
   -270 °C (-454 °F)

6. What caused the craters to form in your comet?
   The sublimation of dry ice. The carbon dioxide from the dry ice goes from solid to gas form. When the gas escapes, holes (craters) are left where there was once solid carbon dioxide.

7. What does the trail behind the piece of dry ice represent?
   It represents the dust/gas cloud that is always behind the comet body.

8. What happens when someone blows on the dry ice while it is moving?
   Another dust/gas cloud forms in a different direction.

9. What does this represent?
   The ion cloud that can be seen when comets get nearer to the sun.

10. How are asteroids and meteoroids different from comets?
    They do not have much ice and do not have tails. Meteoroids are smaller versions of asteroids. Asteroids have orbits much closer to Earth than comets.

Comets Instruction Sheet

II. Where are Comets Found?

1. Look at the diagram (bottom image) of the solar system. Find the **asteroid belt** and the Oort cloud and the Kuiper cloud near Neptune.
2. Trace the typical orbit of a comet (top image). It is very long and oval shaped.

III. What is a Comet Made of?

Discuss what comets are made of.

IV. Making a Comet. - All students must wear safety goggles and wear gloves.

VSVS members will demonstrate the procedure then students will make their own comets.

1. Add 50 ml of water to a sandwich bag. This will become ice water.
2. Add 2 tsp of non-organic material (sand and dirt) to the water. Sand represents the rock and dust in comets.
3. A VSVS member will add 1 spoon of ground charcoal. Stir well. Charcoal represents the carbon-based material.
4. A VSVS member will add a small squirt of NH_3 (ammonia).
5. Place bag on the plate and add the powdered dry ice to the bag plate. Agitate gently.

Do not close the bag completely. Dry ice (carbon dioxide) is subliming and the gas needs to dissipate. The only way out at this point is out the top through the open hole in the bag.

6. Wait until the mixture is almost frozen (it will stop bubbling).
7. Lift the bag up and shape it into a snow ball by holding the bag tightly until the comet is able to hold its own shape. If necessary, add more water.
8. Unwrap the comet and put on the plate.

What is happening?

Look at the thermometer diagram and note where the temperature of dry ice is compared to the freezing point of water. What is the temperature of outer space?

V. Observing the "Comets".

Watch the comet for a few minutes. Some dry ice may "explode" out.
As time passes, the comets will have craters.
At the end of the lesson a VSVS member will break the comets with the hammer -observe the holes in the middle of the comet, where the dry ice gas has sublimed.

VI. Seeing the Tails.

A VSVS member will give each group a few whole pieces of dry ice in a 1 oz cup with a little water added.

1. One member of the group will hold the cup and move it in the air. You should notice a trail behind the piece. This would represent the dust/gas cloud that is always behind the comet body.
2. Another student will represent the sun and blow gently across the path of the dry ice pieces. You should see another cloud in a different direction. This represents the ion cloud that can be seen when comets get nearer the sun.

VII. Comparing Comets with Asteroids and Meteorites.

Discuss differences between asteroids, meteoroids and comets.
Trace the orbit of the asteroid belt (it is between Mars and Jupiter)
Look at the meteorite sample.

Thermometer Diagram