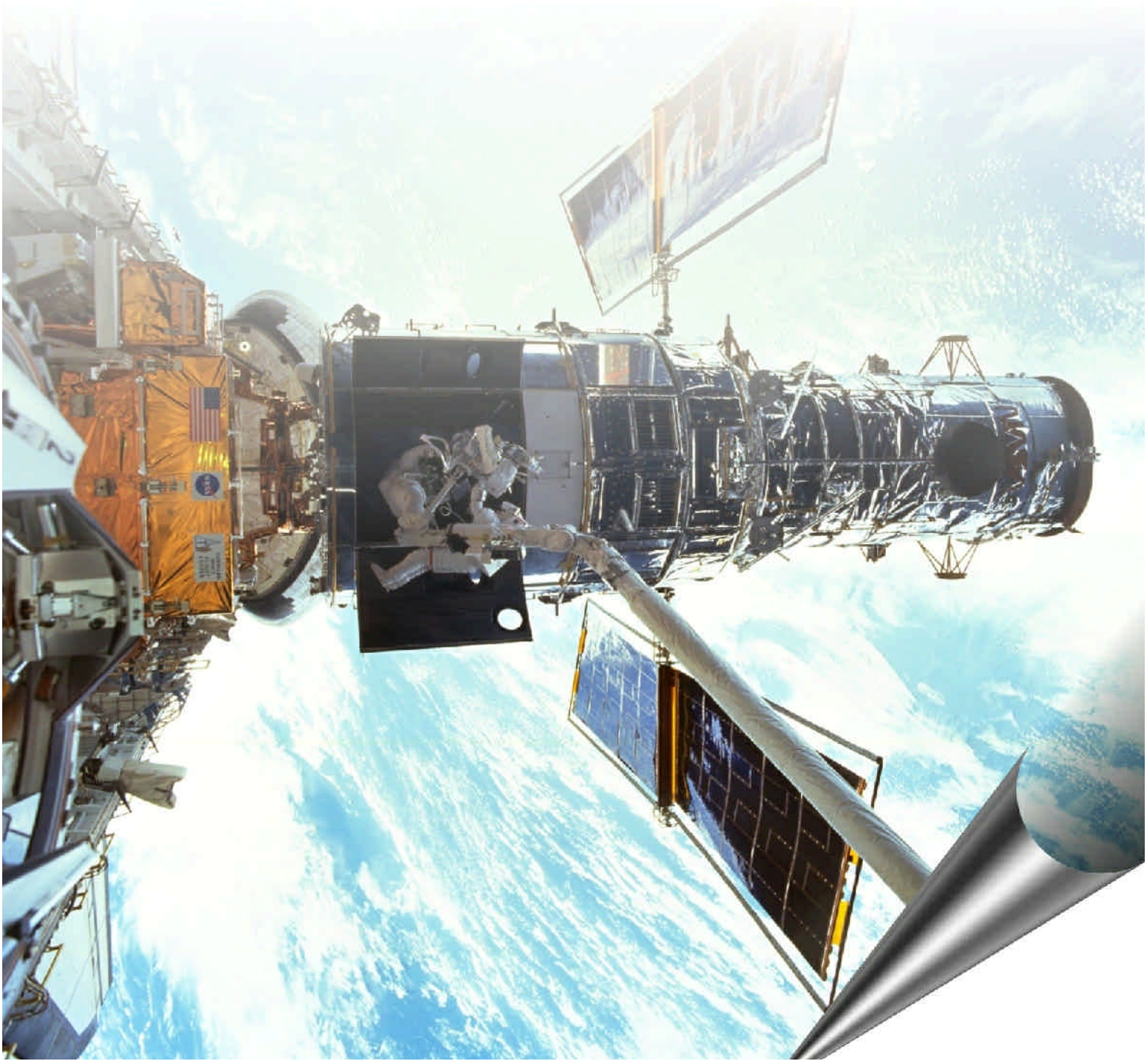
Preparations

FOR SPACEWALKING



Prebreath Activities

FOR SPACEWALKING

Objectives:

The learner will be able to:

- Describe what happens to the carbon dioxide in soda pop when it is exposed to reduced pressure.
- Construct a vacuum jar.
- Experiment with a vacuum jar to determine what happens when gases are exposed to a reduced pressure area.

Science Standards:

- Physical Science- Properties and changes of properties of matter.
- Life Science- Regulation and Behavior

Technology Standards:

- Technology productivity tools-
  Students will use technology tools to enhance learning, increase productivty, and promote creativity.

Materials:

(students will work in groups of 4)

Introductory Activity

- Pre-breath Observation Worksheet
- 1 liter soda pop bottle (unopened, filled with soda pop)

Construction Activity:

- Heavy-duty plastic canister with rubber seal and locking top (similar to canning jar) 1 for every group

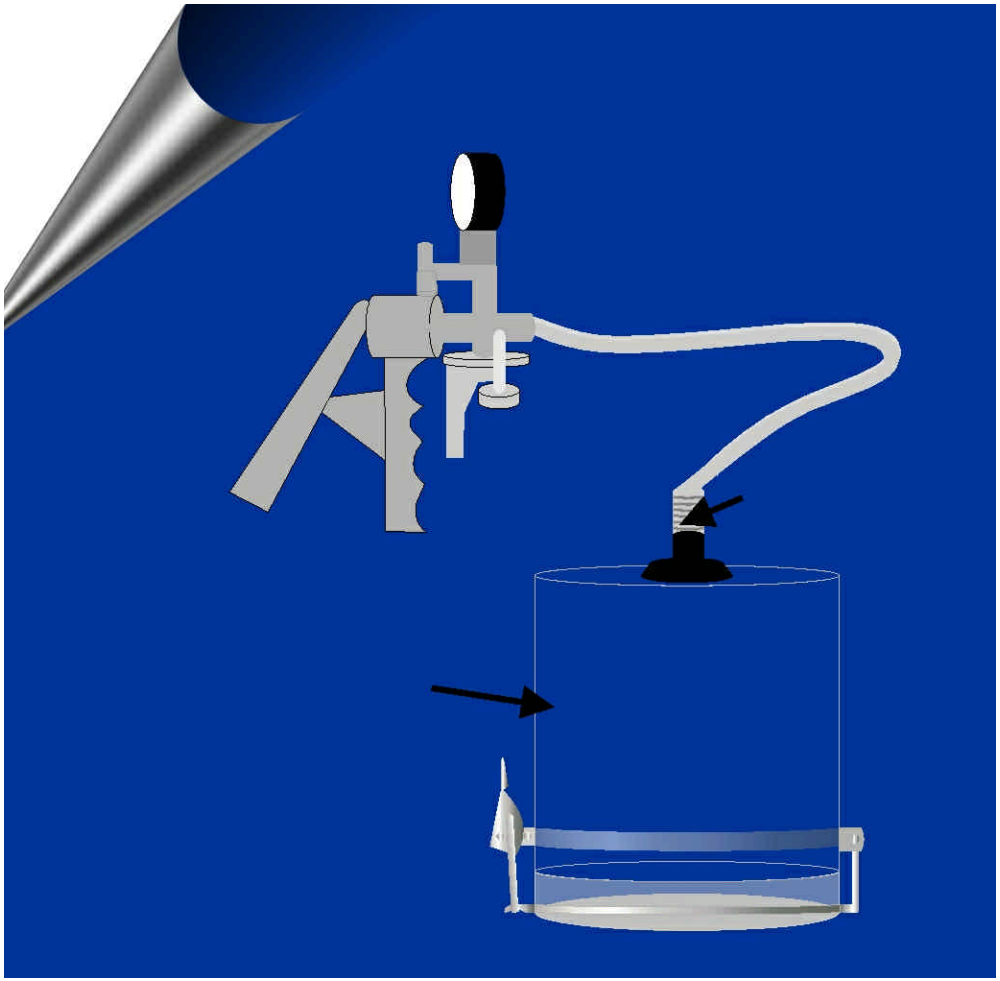
Astronauts Michael R. (Rich) Clifford and Linda M. Godwin, the assigned space-walking mission specialists for STS-76, go through a pre-breathing period on the Space Shuttle Atlantis mid-deck. This practice is normal procedure for space-walkers in preparation for their extravehicular activity (EVA) and the wearing of their Extravehicular Mobility Units (EMU).

- Drill with drill bit 9/16 (sharp not worn) - power or hand held
- Some sort of wood to protect table surface when drilling
- Tire valve (1 for every group)
- Hand vacuum pump (may be found in science catalogs)
- Eye protection is necessary

Teacher Note: You may want to pre-drill the holes. It is relatively easy to break the jar if you are not careful.

Vacuum Activity

- Marshmallows
- Toothpicks
- Balloons
- Shaving Cream
- Misc. items to test in vacuum canister



Background Information:

Human beings are forever on the quest to explore and live in space. In order to do this, an Earth-like atmosphere must be taken with them. Earth's atmosphere contains 20% oxygen and 80% nitrogen. The higher the altitude traveled the less atmosphere is available. At 5.5 kilometers (18,000 feet), the atmosphere is half as dense or thick as it is on the ground. At altitudes above 12.2 kilometers (40,000 feet), the air is so thin and the amount of oxygen so small that pressure oxygen masks can no longer do the job for which they were intended. Above 19.2 kilometers (63,000 feet) spacesuits must be worn in order to supply oxygen and maintain a pressure around the body to keep body fluids in the liquid state. At this altitude the total air pressure is no longer sufficient to keep body fluids from boiling. The pressurized Space Shuttle or Space Station breathing conditions are not unlike those here on Earth. Once the astronaut wants to go outside these pressurized havens, precautions need to be taken to ensure the astronauts' safety from the vacuum environment, radiation, and temperature extremes. The spacesuit will not do the job alone. Safeguards need to be taken before the astronaut even dons the suit.

While preparing for a spacewalk, astronauts participate in oxygen pre-breathing activities to remove the nitrogen gas from their bodies. On the Space Shuttle, the cabin pressure is first reduced to 10.2 psi (pounds per square inch.) This lowered pressure also helps the astronauts to purge the nitrogen gas from their bodies. After about a day at this pressure they

will also spend some time breathing pure oxygen. These activities help to ensure that they won't suffer from Decompression Sickness (DCS) sometimes called "the bends" by scuba divers.

What is Decompression Sickness (DCS)?

When you open a can of soda pop, what do you hear? Fizzing. A can of soda pop gets its fizz because it is supersaturated (more highly concentrated than is normally possible under given conditions of temperature and pressure) with carbon dioxide gas once it is opened. The pressure of the carbon dioxide dissolved in the liquid is greater than the pressure of the air surrounding it. This causes the carbon dioxide to move from the liquid to either the air in the can or to small bubbles in the liquid. Water molecules are attracted to each other more than to carbon dioxide so carbon dioxide gets forced out when the pressure is decreased.

This same sort of reaction can take place in the human body. However it is not carbon dioxide that forms the bubbles, but, rather it is nitrogen. Body tissues usually absorb nitrogen from the air we breath, but at lower pressures it can cause bubbles. Just like the soda a human body can also become supersaturated if the pressure of dissolved nitrogen ever exceeds the surrounding air pressure.

Decompression Sickness (DCS), also known as "the bends", can be caused by the effect of the growing bubbles on the body tissues and the body's response to the bubbles. There are several signs and symptoms of Decompression Sickness. The "bends" occur in the large joints of the body (elbows, shoulders, hip, wrists, knees, and ankles.) There is a localized deep pain. Movement seems to aggravate the pain and it may occur immediately or several hours after a lessening of pressure.

Neurological DCS affects the nervous system of the body and may affect the brain, spinal cord (in the back bone), or the nerves of the arms and legs. If the brain is affected, confusion or memory loss may occur (much like a stroke). Headaches, tunnel vision, extreme fatigue, behavior changes, seizures, vomiting and unconsciousness may occur. Back pain, progressive or growing weakness or paralysis, or a deep abdominal or chest pain accompany spinal cord neurological DCS. The peripheral nerve symptoms include muscle weakness and twitching, numbness (like your leg or arm "falling asleep"), burning, stinging, and tingling.

Astronaut James H. Newman works on wrap up tasks during the final of three space walks performed by the STS-88 crew during its twelve-day mission in Earth orbit.

The "chokes" is another form of DCS and it effects the lungs. It is caused when blood vessels to the lungs get too many nitrogen bubbles. A burning chest pain, pain with breathing, shortness of breath and a dry constant cough are symptoms of the chokes. The treatment for the chokes is immediate hyperbaric oxygen treatment. Hyperbaric oxygen treatment consists of breathing 100% oxygen in a high-pressure chamber. This also helps to eliminate the nitrogen bubbles in the body.
Cutaneous Decompression Sickness ("skin bends") is caused when bubbles form and accumulate underneath the skin. The skin bends are noticed when there is itching around the ears, face, neck, arms, and upper chest. It may

View of Astronaut Bruc McCandless during EVA.

feel like insects crawling beneath the surface of the skin. The skin may look as if it has red patches and swelling could be present. This is not life threatening but it feels like hundreds of mosquito bites and is usually an indication of more severe problems.

In order to prevent the onset of Decompression Sickness, the cabin pressure in the Space Shuttle orbiter is decreased. The astronauts also pre-breath 100% oxygen in order to purge their bodies of nitrogen. Because the spacesuits are pressurized to 4.3 psi, several hours of pre-breath time is needed.

Many studies have been performed over the years dating as far back as the early 1930's on Decompression Sickness. The United States Navy and Air Force established the guidelines used today to help prevent and treat DCS. Using the precautions set forth astronauts may leave the pressurized environment of the Space Shuttle or Space Station and not be fearful of experiencing Decompression Sickness. When astronauts are healthy they can continue to perform their duties and explore space so that we may better improve life here on Earth.

Introductory Activity:

The background information discusses the need for astronauts to wear special suits (spacesuits) while venturing out of the pressurized compartments of the Space Shuttle or Space Station. These suits are used to supply oxygen for breathing and to keep the pressure around their bodies constant so they will not suffer from Decompression Sickness or experience other problems caused by the vacuum of space. This introductory activity demonstrates how dissolved gases change to bubbles when the surrounding pressure is decreased.

Procedure:

Each team will observe (15 to 20 seconds) the action taking place in an unopened bottle of soda pop. The soda pop should rest undisturbed for several minutes before the observations begin. The students will write down at least three observations they made during that time period. After completing their observations the students will then open their soda bottle and observe any changes that are now occurring. Students should then describe what observations were made.

For the teacher: When sodas are bottled, high pressure is used to cause considerable amounts of carbon dioxide gas to dissolve in the soda

water. This gives a tartness of flavor in addition to the effervescence when the container is uncapped. When opened, the pressure immediately decreases and the carbon dioxide gas escapes to the surface. That is Spacesuits help prevent the dissolved gases in an astronauts blood from doing this same thing. Pre-breathing to purge the astronauts system of nitrogen gas is a precautionary action that also ensures safety from Decompression Sickness.

Discussion:

1. What happened to the pop and were there any changes?
2. Are there any dramatic changes taking place?
3. What caused the soda pop to bubble and fizz?
4. Is there any other product that you can think of that demonstrates this same action?

Assessment:

Student worksheet

Extension:

Special thanks to Dr. Michael Powell for his input and extension activity.

Materials needed:

- Soda pop (one quart or less) for each group
- Sugar crystals
- Bottle pump-used to help retain the fizz in bottles (can be found at grocery stores)

Procedure:

Each group will get a bottle (one quart or less) of soda pop and some sugar crystals (about two or three tablespoons full). The labels can be easily removed so not to impair viewing. The top should be removed without shaking the bottle and a teaspoon of sugar crystals added. The crystals carry

Astronaut Edward White during first EVA performed during Gemini 4 flight.

tiny microbubbles on their surface and cause the soda water to effervesce quite strongly for about one minute. When bubbling ceases, the process can be repeated—actually many times.

For the teacher: All of our bodies contain minute gas bubbles formed by the movement of fluids in our tissues. These microbubbles grow when

A closeup view of astronaut John M. Grunsfeld, with a cloud-covered part of Earth in the background, during the final of three extravehicular activities (EVA) on which he performed a variety of servicing tasks.

we are depressurized. Adding sugar crystals to soda pop is one way of introducing these microbubbles into the fluid—shaking the pop is another.

How long did the liquid bubble?

Now, add some more crystals and quickly screw the bottle pump onto the pop bottle.
How long did the liquid bubble this time?
Repeat and pump about six times: how long did it bubble?

For the teacher: The purpose of the prebreathe procedure at NASA is for the EVA astronauts to (1) washout dissolved nitrogen by breathing oxygen, (2) decrease the microbubbles in their tissues, and (3) repressurize (as with the pump on the soda pop bottle) if "the bends" develop.

Construction Activity

(Miniature Vacuum Chamber)
Special thanks to Dr. Gregory Vogt for his vacuum chamber design.

Equipment needed:

- Clear Plastic Canister approx. 6 1/2 inches tall by 4 1/2 inches wide
  (The canister needs to have a clasp-locking top that makes a tight seal when the canister is closed.)
- Tire valve
- Hand held vacuum pump with tubing
- Clear silicon cement (aquarium sealing cement)

Drill a hole (the same diameter as the tire valve) in the bottom. Turn the canister upside down making the bottom the top. Insert the tire valve with the intake section outside of the canister. Seal the valve to the canister using a rubber cement type of glue. This can be found at any building supply store. Let the cement dry overnight to ensure a good seal. Make sure the canister is sealed and attach the hand held pump to the tire valve. At this point you may insert a variety of objects into the vacuum pump and experiment.

Discussion:

1. Can you think of any other containers that would work to build a vacuum chamber?
2. During construction did you think of any other methods of design that could be used?

Extension:

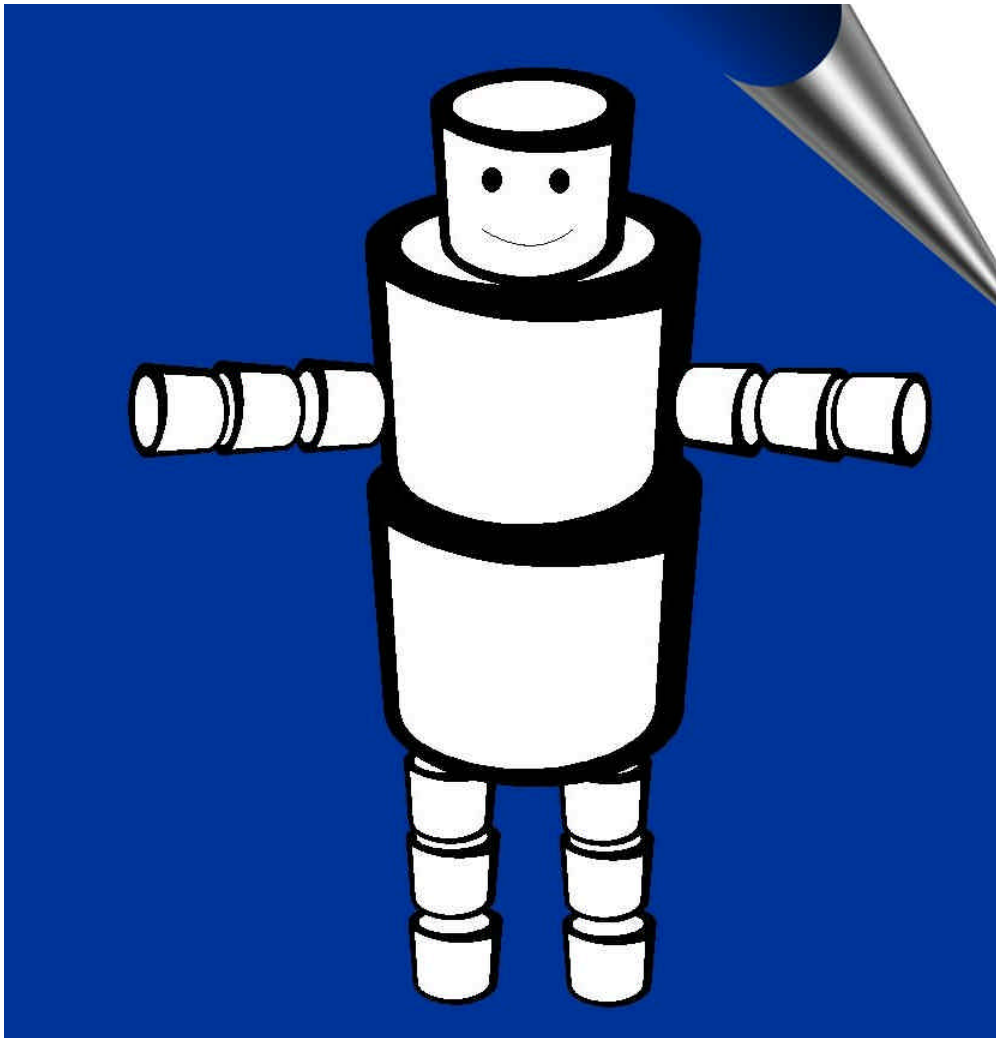
Marshmallow Astronaut

Supplies needed:

- Marshmallows (various sizes)
- Toothpicks
- Vacuum chamber (hand-made) or
- Purchased Vacuum chamber
- Using the vacuum chamber built in the previous activity it is now time to see what happens to objects when atmospheric pressure changes.

Construct an astronaut using the marshmallows and toothpicks.
Insert the astronaut into the vacuum chamber and lock top into place. Make sure that a good seal is made. Use the hand held pump to extract the air from the chamber. Be patient it may take a little while. Observe the changes to the marshmallow astronaut. Fill a balloon with shaving cream and experiment with the vacuum chamber. Shaving cream may be placed in a cup or beaker, but this can be messy.

Suggestion: Build an identical marshmallow astronaut that will remain outside the chamber. This astronaut can be used for size comparisons before, during and after the experiment.



Discussion:

1. What happened to the astronaut?
2. Why did these changes take place?

Name_____

Marshmallow Astronaut Activity Sheet

Measure the length and size of the marshmallow astronaut:

Before Vacuum Chamber:

Length_____ Height_____ Width_____

After Vacuum Chamber:

Length_____ Height_____ Width_____

Observations:

Draw a picture of your observations during the experiment:

Before During After

What observations were noted for other materials put into the vacuum chamber? (use the back of this sheet if more room is needed)

Name_____

Pre-breath Observation Worksheet

Unopened Soda Pop Bottle Observations	Opened Soda Pop Bottle Observations

Theory: What made the soda pop react the way it did?