Earth Bubbles - Teacher Notes

INTRODUCTION

Environmental issues are naturally engaging to children and they provide great opportunities to explore problems that students experience in their home communities. Well-mediated instruction on such issues will also promote students' ability to build their science knowledge in the relevant context of science-technology-society interaction. We have also found that students are more motivated to engage in thoughtful discussion when led into these topics with a demonstration or simulation. Such demonstrations can also serve to illustrate complex concepts - making them more accessible for children.

Earth Bubbles

The Earth's atmosphere has been called the precious envelope that consists of a relatively thin film of air, some 75 kilometers thick that swirls above our planet's surface, blocking cosmic rays and providing elements essential for the life on our planet. In some ways, our atmosphere is like a bubble. Both beautiful spheres are delicate and easily damaged. With respect to our planet, a critical equilibrium is found in the atmosphere where a balance of gases is necessary to maintain a relatively constant temperature on the earth. These gases, which include carbon dioxide, methane, nitrous oxides, and others, help keep the planet warm by trapping some of energy that would otherwise escape into space. Without this natural “greenhouse effect” the earth would be much colder than it is today. The key to a healthy climate is to maintain a relative balance in the concentration of these gases.

As you generate the Biosphere Bubbles, have your students observe the unusual properties and behavior of the gas. The “heaviness” of the CO_2 gas, and the bubble behavior of falling instead of floating, often leads to discussion of the blanket of greenhouse gases that surrounds our planet. We like to arrange students in cooperative learning groups of three or four and students and we start things out by providing questions written on the board. Once the student groups have adequate time to discuss their responses to the questions, we solicit responses from members of each group. In this way we are not putting individual students on the spot, but are allowing students to collaborate and generate the best thoughts of the group.

OBJECTIVES

The students will describe the how careful observations can help to produce new ideas.
The students will understand that each substance (material) has unique properties that help make it useful.

SCIENCE STANDARDS

National Science Standard: Unifying Concept
Nature is predictable and we can use evidence to explain and understand it.

Georgia Performance Standards:
Describe materials, what they are made of, and how they change. SKP1, S2P1, S5P2
Students will recognize the effects of pollution on humans and the environment. S3L2

SCIENCE REFRESHER

In this exercise, the teacher uses dry ice to generate unique bubbles that capture student interest and, most importantly, convey some foundational science principles in the process. Let's look at the concepts covered by this activity.

Carbon Dioxide: Physical Changes and Density

The "star" of this activity is carbon dioxide – a molecule comprised of a single carbon atom bonded to two oxygen atoms. Carbon dioxide is most familiar as the gas released by organisms during respiration and taken in by plants during photosynthesis. But carbon dioxide can also exist in a solid form when cooled to extremely low temperatures- what we call "**dry ice**". What makes dry ice "dry" is that when it warms, the molecules in the dry ice go directly from solid to gaseous form and do not form a liquid. This process of **sublimation** also occurs occasionally with water ice.

Physical Changes in Matter

When molecules or atoms combine to form new molecules, this is called a chemical change. While chemical changes are an important concept in science, but we will be examining **physical changes** in matter – when a molecule's atoms remain the same but their form changes. Water changing from ice to liquid water is an example of physical change. Atoms or molecules in solids are quite orderly arranged, liquids somewhat less orderly, and gases even less. This is what gives each of these physical states their particular characteristics. Water (H_2O) can exist as a solid (ice), liquid (liquid water), or a gas (water vapor), but it is always comprised of one oxygen atom and two hydrogen atoms. Physical changes are often related to temperature. When molecules are cold, they move very little and can form orderly structures like ice. But when temperatures increase, the molecules become more "active" and break the bonds that hold them together in solids, thereby forming liquids and gases.

When dry ice (carbon dioxide in solid form) warms, the carbon dioxide molecules break the bonds that held them together and escape into the atmosphere as a gas. Showing this physical change with carbon dioxide is an effective way to show students physical changes in matter, as it is quite unexpected given their experiences with water ice.

Density

When the teacher creates carbon dioxide bubbles in the activity, they display behaviors that are unusual for bubbles and so garner student interest. Perhaps the most striking difference between bubbles filled with carbon dioxide gas and bubbles filled with the normal complement of gases from the atmosphere is that the carbon dioxide bubbles do not float – they fall. This is because carbon dioxide is heavier than the nitrogen gas (N_2) and oxygen gas (O_2) that comprise the vast majority of the air around us. Carbon, nitrogen, and oxygen atoms have similar atomic weights, so it should not be surprising that a molecule with three atoms (CO_2) is heavier than those with only two (N_2 and O_2).

Density is calculated as mass divided by volume, so carbon dioxide gas is “more dense” than air due to its higher mass.

Carbon Dioxide and Climate Change

Carbon dioxide is one of the most abundant atoms on Earth and is an integral component of living things. Carbon forms the backbone of the molecules in our food (sugars, fats, proteins) and is released to the environment as carbon dioxide when organisms “burn” food to generate energy. Carbon dioxide cycles through the atmosphere and can be taken in by photosynthetic plants and used to create sugar through photosynthesis. Carbon dioxide is part of the larger carbon cycle which moves this important atom around our planet (Figure 1).

Carbon dioxide receives a great deal of attention in environmental science because it is a greenhouse gas. **Greenhouse gases** are gases that trap heat in Earth’s atmosphere. During the day, the sun warms the surface of the Earth and at night the heat is radiated off the surface and eventually out into space. As the heat makes its way up through the atmosphere, greenhouse gas molecules “grab hold” of it for an instant, slowing its journey. The collective actions of huge numbers of greenhouse gas molecules cause the atmosphere to trap heat around the Earth the same way a blanket traps the heat emanating from your body. The more greenhouse gas molecules in the atmosphere, the more heat that is trapped, and the higher the temperatures at Earth’s surface.

Carbon dioxide is released whenever a molecule containing carbon is burned or decomposes. We therefore release carbon dioxide when we burn coal to produce electricity, burn gasoline in our vehicles, or burn natural gas to heat our homes. Carbon dioxide is also released when wood burns or when we overcook a piece of meat on the grill. Since the mid 1800s, humans have been burning huge quantities of coal, oil (gasoline and diesel fuel are oil derivatives), and natural gas – collectively known as “fossil fuels”. Fossil fuels are the modified remains of ancient plants and marine organisms and so contain a great deal of carbon. When burned, that carbon is released to the atmosphere as carbon dioxide.

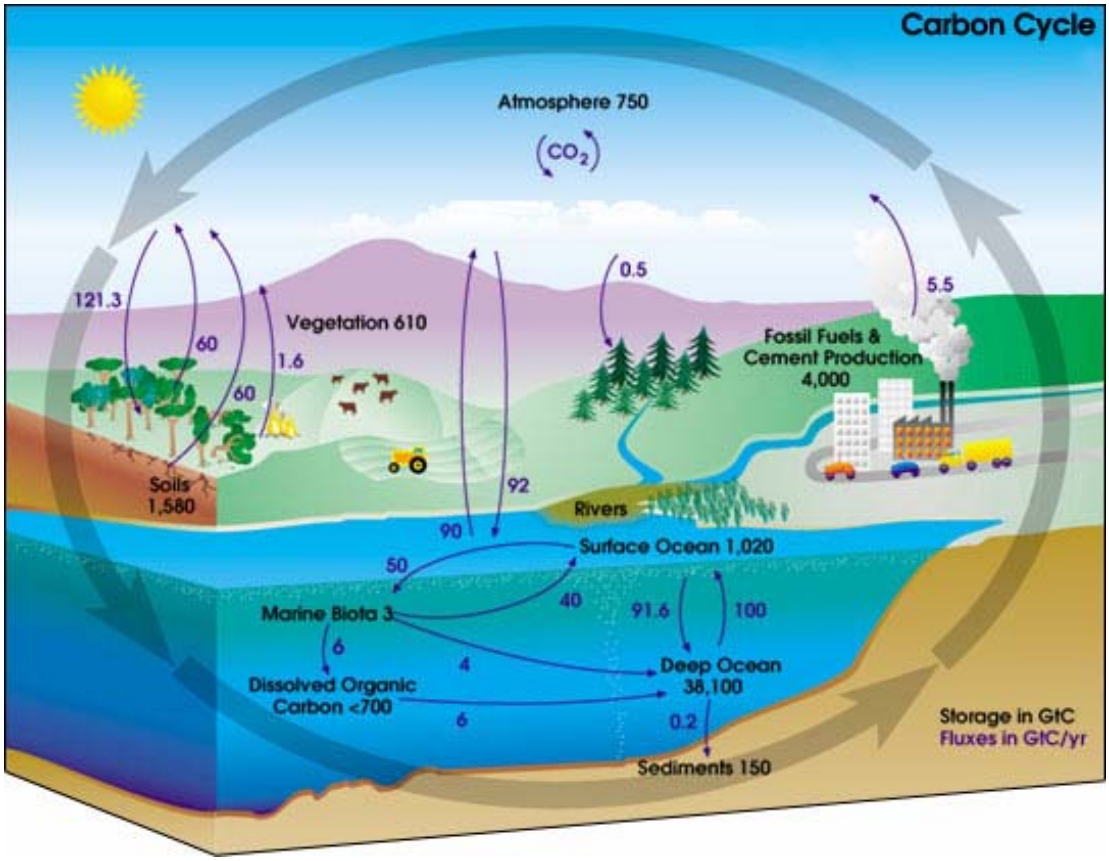

Figure 1. The carbon cycle. Carbon dioxide is an important part of the cycle.
[http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html]

Our combustion of fossil fuels, coupled with the destruction of forests that take up carbon dioxide, have resulted in ever-increasing concentrations of carbon dioxide in Earth's atmosphere. While carbon dioxide concentrations have been increasing, so has the average global temperature. In the last 100 years, Earth's average temperature has increased by about 1^{o} F (0.6^{o}C). While this may not seem like much, it is a much more rapid increase in temperature than that seen in Earth's past. Scientists have concluded that this warming of the planet, called "**global warming**" by some and "**human-induced climate change**" by others, is caused at least in part by humanity's releases of carbon dioxide from fossil fuel combustion. The warming of Earth's surface may lead to: accelerated melting of glaciers and ice caps; increased frequency and severity of hurricanes; more extreme temperatures in summer and winter; reduced crop yields in agriculture; rising sea levels; and impacts on plant and animal species.

To prevent such impacts, we need to conserve energy and reduce the amount of fossil fuels we burn. This can be accomplished by improving the efficiency of tasks that use energy (e.g., switching to a more fuel-efficient vehicle) and generating energy with non-carbon producing sources like solar power and wind power. Americans comprise less than 5% of the world's population but we consume 25% of the world's primary energy. Taking steps in this country to improve the sustainability of our energy needs could therefore go a long way. By providing students with a way to "see" carbon dioxide, this activity can make discussions of carbon dioxide's effects in the atmosphere more meaningful to students and help promote environmental awareness in the classroom. This activity can be used as a springing off point to talk about ways to conserve energy in the modern world such as walking/biking instead of driving, carpooling, using public

transportation, driving more fuel-efficient vehicles, using less electricity, turning the thermostat down in winter and up in summer, properly insulating and weatherstripping homes, and using energy-efficient appliances and electronics.

Surface Tension of Water

In the activity, students create “crystal ball” bubbles by stretching a thin film of soap liquid over the rim of a glass containing warm water and dry ice. As the carbon dioxide escapes from the water, it pulls the film upward into a dome well above the glass’ rim.

This is an effective way to demonstrate the **surface tension** of water. When water molecules in liquid form bond to one another, they create a flexible surface that can grow and constrict without breaking. This provides water with a higher value for surface tension that enables it to support the weight of objects on top of it and to stretch without fragmenting. This property allows insects like water striders to “walk” on the water’s surface without falling in (Figure 2). You can demonstrate water’s surface tension in your classroom by taking a small paper clip, rubbing it with oil (oil from your skin is usually sufficient), and gently placing it with a fork in glass of water. The metal paper clip will float on the liquid’s surface without sinking.

The reason the soap bubble is able to grow to such a large size without popping is due to the surface tension holding the water molecules together as the bubble grows. Only when the bubble reaches a sizable height will the force of the accumulated gas overpower the ability of the water to stretch further – causing it to pop.

Figure 2. A water strider demonstrating the high surface tension of water.
[http://www.newsday.com/media/photo/2003-08/9156437.jpg]

MATERIALS

Earth Bubble Activity:

Two clear 2-liter plastic bottles	
One piece PVC pipe, 2 cm (3/4in) diameter (50 cm long)	PVC can be found at local home improvement stores in electrical section.
Two pieces PVC pipe, 90 degree elbows, 2 cm (3/4in) diameter	Found in home improvement stores.
Two, PVC couplings, 2 cm (3/4in) diameter	Found in home improvement stores.
Paper towel	Bring a roll as many will be needed.
Soap solution	Dilute dishwashing detergent approximately 25-1 with water (one good squirt of detergent per cup of water)
Masking, duct, or electrical tape	To attach top of 2 liter bottle to bottom of ¾ inch PVC pipe
Several chunks of dry ice, 50-150 grams each	Can be purchased from local grocery stores. Should be handled with gloves and kept in cooler that allows for release of carbon dioxide gas
Plastic cup	
Water	Warm water works best. Water and/or dry ice should be replaced when bubble production slows down significantly.
Gloves	To handle the dry ice

Extension Activity:

A few chunks of dry ice (golf ball size chunks)	To place in plastic cup or small bowl with water.
Folded paper towels	To soak in bubble solution and then rub across of the top of the cup to produce a bubble film.
Soap solution (diluted 20 parts water/one part	
Flashlight (optional)	To shine at the crystal ball

EXPLORATION (Teacher-led):

Preparation

Safety Alert: Never allow students to touch dry ice without gloves, as it will quickly transfer heat away from the skin and damage tissue. Always wear safety goggles when carefully breaking dry ice into smaller pieces.

Earth Bubbles can be generated by collecting the CO_2 gas that is produced when dry ice is placed into water. The gas collects in a two liter bottle, passes up through a PVC pipe and down its curved end. By wrapping a paper towel that has been soaked in soap solution around the pipe opening, "earth bubbles" will form as the gas exits the tube. Since CO_2 is more dense than the surrounding air, the bubbles that form fall rapidly downward. Most students find these bubbles fascinating.

Construction

1. Carefully cut the top off of one of the bottles about 3 cm below the bottom of the cap. Keep the bottom portion. Carefully cut the second bottle about 5 cm farther down where the bottle reaches its widest point. Keep the top of this bottle.
2. Connect the three pipes and two elbow joints to construct the CO_2 cane (should look like a "shepherd's hook" or an upside-down "J").
3. Tape the top of the second bottle to the bottom of the CO_2 cane and secure it tightly.
4. Fold up the paper towel into 2-3 cm wide strip and wrap it around the mouth of the pipe. Trim off the extra towel and secure it with a rubber band.

Procedure

1. Fill the other bottle about half full of warm or room temperature water, then drop a few pieces of dry ice into the water. Place the bottom of the CO_2 cane over the top of the bottle so a seal is formed between the bottles.
2. Place the cup of dilute soap solution up to the mouth of the cane and wet the paper towel to establish a soap film across the opening. Repeat this as needed.
3. Observe as the unusual white bubbles fall quickly from the cane.
4. You can try to catch the bubbles in your hand or bounce them off the table if you cover them with a little bubble solution.
5. As the production of bubbles slows down, you can replace the water and add more dry ice.

Acknowledgment: Flinn Scientific Foundation (2001). Summer Chemistry Workshop. Batavia, IL.

Essential Questions

1. Why is carbon dioxide such an important gas in our atmosphere and why is important to have a proper amount of this gas?
2. Explain the changes in our environment that have led to a decrease in the amount of carbon dioxide that is used up and an increase in the amount of carbon dioxide that is produced.
3. Discuss actions that we can take to decrease the amount of carbon dioxide that each of us produces
4. Write a commercial, song, poem, or infomercial that you could use to convince people to reduce their production of carbon dioxide.

Safety and Disposal

Although Dry Ice is not toxic, you should avoid letting students touch it because if much colder than regular ice and it can cause frostbite quickly. You can dispose of it by leaving it out in a place where students cannot access it. It will sublimate into gas in a few hours. The water in which the dry ice was placed can be poured down the drain. It is not toxic.

Explanation (Concept Building)

Environmental issues provide great opportunities for kids to explore problems that they experience in their home communities. Our earth's atmosphere has been called the precious envelope that consists of a relatively thin film of air, some 75 kilometers thick that swirls above our planet's surface. The atmosphere functions to block harmful cosmic rays and provide elements essential for the life on our planet. In some ways, our atmosphere is like a bubble. Both beautiful spheres are delicate and easily damaged. With respect to our planet, a critical equilibrium is found in the atmosphere where a balance of gases is necessary to maintain a relatively constant temperature on the earth. These gases, which include carbon dioxide, methane, nitrous oxides, and others, help keep the planet warm by trapping some of energy that would otherwise escape into space. Without this natural “greenhouse effect” the earth would be much colder than it is today. The key to a healthy climate is to maintain a relative balance in the concentration of these gases.

Unfortunately, this balance is being disrupted because human activities are altering the composition of the atmosphere through an increased production of greenhouse gases. According to the Environmental Protection Agency, carbon dioxide concentrations have increased more than 30% since the industrial revolution while methane concentrations have more than doubled (EPA, 2002). These increases have enhanced the heat-trapping capabilities of our atmosphere. Of the greenhouse gases, carbon dioxide levels are thought to have the greatest impact on climate change. Though carbon dioxide is consumed through the process of photosynthesis, it is also a product of numerous chemical processes including the burning of fossil fuels such as gasoline, coal, and natural gas. We are adding carbon dioxide into the atmosphere much faster than it can be recycled. Not surprisingly, the United States is the world’s largest producer of carbon dioxide. Despite being just 5% of the earth's population, the United States produces over 20% of the this gas. The average U.S. citizen is responsible for six times as much carbon dioxide as the average Japanese citizen, and nearly 25 times the CO_2 produced by the average Australian. These data are humbling, even embarrassing, as we reflect on our global citizenship. To bring the concept of CO_2 emissions down to the level of the of an elementary student, we’ve adapted a chemistry demonstration using the sublimation of dry ice. We call these Earth Bubbles, and find the demonstration to be an effective means of focusing student attention on physical

properties and significant problem of greenhouse gases. Directions for generating Biosphere Bubbles and discussion questions are provided.

We like to arrange students in cooperative learning groups of three or four and students and we start things out by providing questions written on the board. Once the student groups have adequate time to discuss their responses to the questions, we solicit responses from members of each group. In this way we are not putting individual students on the spot, but are allowing students to collaborate and generate the best thoughts of the group. As they build their understanding of the role of carbon dioxide in our atmosphere, we hope that they will become active participants in working toward solutions to this problem.