It's Hot in Here

Grade: 5

Subject Areas: Life Science, Physical Science, Social Science

Skills: modeling, observing, describing, predicting, interpreting

Duration: 1-2 hours

Connections: physics, chemistry, earth science, energy, atmosphere, fossil fuels, natural resources

Vocabulary

weather
climate
atmosphere
ozone layer
radiant energy
albedo
greenhouse gases
greenhouse effect
carbon dioxide
fossil fuels
global warming

Objective:

Students will learn about the greenhouse effect and how it relates to climate change.

Materials

- 2 identical glass jars per group
- 2cups cold water per group
- 10 ice cubes per group (ice chest or freezer)
- one plastic bag or a sheet of saran wrap per group
- rubber bands
- 2 thermometers per group
- blank paper for labeling purposes
- a sunny window or infrared lamps
- science journal or paper to record observations
- 12 oz. plastic water bottles or other plastic bottles
- medium sized balloons to fit over the mouth of bottles
- plastic balloons
- baking soda
- apple cider vinegar
- limestone chips
- science journal or paper to record observations

Standards

Strands: Excellence in Environmental Education Guidelines

Strand 1 —B) Designing investigations: Learners are able to design environmental investigations to answer particular questions—often their own questions. **F) Working with models and simulations:** Learners understand many of the uses and limitations of models.
Strand 2 —2.1 The Earth as a Physical System: B) Changes in Matter: Learners understand that the properties of the substances that make up objects or materials found in the environment.
Strand 2 —2.3 Humans and Their Societies: D) Global connections: Learners become familiar with ways in which the world's environmental, social, economic, cultural, and political systems are linked. **E) Change and Conflict:** Learners understand that human systems change over time and that conflicts sometimes arise over differing and changing viewpoints about the environment.
Strand 2 —2.4 Environment and Society: E) Environmental issues: Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that people in other places around the world share many of the issues they are concerned about locally.

California State Educational Standards:

Physical Sciences: 1g. Students know properties of solid, liquid, and gaseous substances, such as sugar, water, helium, oxygen, nitrogen, and carbon dioxide. **1h.** Students know living organisms and most materials are composed of just a few elements.
Life Sciences: 2a. Students know many multicellular organisms have specialized structures to support the transport of materials.
Earth Sciences: 4ca. Students know the cause and effects to different types of severe weather.
I and E: 6d. Students will identify the dependent and controlled variables in an investigation.

Background

Changing Planet

Climate change is nothing new. Evidence shows that the Saharan desert use to be covered by a shallow sea. There are fossilized trees in the frozen landscape of Antarctica. North America has experienced periodic ice ages for the last 70 million years. A mere 15,000 years ago the northern states and Canada were in the depths of an ice age. Today, our planet is experiencing another episode of climatic change. This time the planet isn't getting colder; it is getting warmer.

The difference between weather and climate is a matter of time. **Weather** is the condition of the atmosphere over a short period of time. **Climate** is the atmospheric conditions of an area over a long period. Climate is much more complex. Both are influenced by the amount of energy received by the sun, wind, ocean and the structure of the landscape or topography.

An **atmosphere** is the layer of gases that surrounds a planet or a moon. Some planets have atmospheres thousands of miles thick such as Jupiter. Generally, small planets don't have enough mass to hold onto an atmosphere. Mercury and Mars are an example of these. The atmosphere on Earth extends about 500 miles from the surface to the reaches of space. Our atmosphere is a mixture of gases composed of approximately 78% nitrogen, 21% oxygen, and 1% argon. Carbon dioxide, water, methane, and other rare gases make up a small fraction of the air.

Earth's lower atmosphere is where all weather occurs. It is called the troposphere. Above the troposphere are the stratosphere, mesosphere and thermosphere. Atop the stratosphere lies the **ozone layer**. This layer protects us from harmful UV (ultraviolet) radiation that is constantly striking the Earth from space.

As **radiant energy** or light from the sun strikes a surface some of it is reflected back into space and some of it is absorbed. The amount absorbed depends mostly on the gas mixture that makes up the atmosphere and albedo. **Albedo** is the amount of light reflected off a surface based on its surface coloration. Light colors tend to reflect light while dark colors absorb light. White clouds for instance will reflect a lot of light back into space, whereas dark colored surfaces, such as dark rock, will absorb a lot of light. Absorbed light is re-radiated from surfaces as heat.

Greenhouse Effect

Certain gases are called **greenhouse gases** because they absorb heat. Our atmosphere acts like a big blanket and holds in radiated heat. One analogy of

Local Connection

What can you do?
There are many things people can do to combat climate change.

Here are few of them:

- **Wait until you have a lot of clothes to wash before using the washing machine. Don't use the machine for one item just because it's your favorite shirt**
- **Turn off the lights when you leave a room. Use fluorescent bulbs in your room.**
- **Turn off your computer or the TV when you're not using it.**
- **Unplug chargers when not in use.**
- **Close the blinds on a hot day if the sun is shining in.**
- **Dress lightly instead of turning up the air conditioning. Or use a fan.**
- **Dress warmly inside your house when it's cold, instead of turning up the heat.**
- **Bike or walk short distances instead of asking for a ride in a car.**
- **Plant a tree.**
- **Take shorter showers. Heating water uses energy.**
- **Buy only what you need and use what you buy.**
- **Use solar energy for electrical needs.**
- **Practice the three R's: reduce, reuse, recycle**
- **Write letters to your representatives to encourage them to support efforts in alternative energy and resource conservation.**

heat being trapped in the atmosphere is like a car getting hot when all of its windows are closed. Earth is a closed system similar to a greenhouse. This overall phenomenon of gases trapping heat within Earth's atmosphere is called the "**greenhouse effect**". Without the greenhouse effect, our planet would be too cold to support life. It would become a frozen wasteland. Too much greenhouse gas, however, may heat the planet up so much that it could have catastrophic consequences for life.

The main greenhouse gas is **carbon dioxide** or CO_2. Other greenhouse gases include nitrous oxides, methane and water vapor. The amount of CO_2 in the atmosphere is a growing concern today because levels are increasing. Scientific evidence reveals that the burning of fossil fuels is the main cause for this increase. **Fossil fuels** are oil, natural gas, and coal. These resources are here on a temporary basis because they take tens of millions of years to produce. Because of their temporary nature, they are referred to as non-renewable resources. The reason why people use so much of them is because they are cheap and convenient sources of energy.

Unnatural Changes

Industry took off in the early 1800's after the Industrial Revolution. Oil was burned in lamps and coal was burned to fuel factories and trains. Now days, coal is still burned in power plants, and trains, cars and trucks have switched to burning diesel or gas. Factories, homes, and businesses use electrical power for their energy needs. Most electricity used in the U.S. comes from the burning of coal, natural gas and to a lesser degree, biomass. CO_2 levels are the highest they have been in over 600,000 years. Increased greenhouse gases are raising the average temperature of Earth causing **global warming**.

Carbon is an element found in carbon dioxide. Before the Industrial Revolution, the levels of CO_2 in the atmosphere was in rough balance with what could be stored on Earth in carbon sinks. Carbons sinks are those areas that absorb huge amounts of carbon dioxide, such as large areas of forests and the ocean. Now, the levels of CO_2 are surpassing what these "sinks" can absorb. Forests have been describe as the lungs of the planet because they exchange abundant amounts of carbon dioxide and oxygen on a planetary scale. During photosynthesis CO_2 is absorbed and oxygen (O_2) is released. Plants absorb CO_2 during growth and release CO_2 when they decompose. Because of this, carbon dioxide levels increase any time you remove living trees or other vegetation.

The larger the plant, the more carbon dioxide it absorbs. The King Range National Conservation Area (NCA) has many trees of mixed ages. The dominant tree growing in many places here is Douglas fir. Other trees include black oak and tanoak. Because Douglas fir is the number one choice for lumber in many parts of the world, almost all of the original Doug fir forests have been cut. Now the King Range NCA is protect, however, forests are being cut down elsewhere. Tropical forests have desirable hardwoods which are commonly turned into products like lumber, wood carvings, furniture and picture frames and are being cut at a rapid rate. Because trees absorb so much carbon, a reduction in forests increases CO_2 levels.

As mentioned earlier, the ocean absorbs a lot of carbon dioxide too. Algae, including a host of different seaweeds, absorb large amounts of CO_2. Many small microorganisms use CO_2 to make their shells, converting the carbon to calcium carbonate . If the ocean absorbs too much CO_2, the water turns more acidic and the little microorganism can't grow their shells. In addition, global warming is increasing ocean temperatures. Warmer temperatures are killing corals having a devastating affect on coral reefs worldwide. These problems along with other impacts are complex.

The impacts of global warming are being felt everywhere. Sea level is rising and severe weather patterns are being observed. Places low in elevation, like wetlands and coastal beaches, are at risk of flooding. Many major cities have been built near sea level making them vulnerable. Other areas are experiencing severe droughts on a regular basis. Severe and unpredictable weather causes crop damage adding up to a net loss of billions of dollars. The list goes on. People are not the only beings that are adjusting to these changes. Many plants and animals are having a difficult time adjusting to sudden climatic change as well.

People's desire for inexpensive products and cheap energy is now changing the atmosphere and making it hotter. In addition, the burning of fossil fuels has been responsible for other environmental problems like smog, acid rain, and indirectly, oil spills. Today, as people become more aware of the growing problems of climate change, there is an increasing demand for cleaner renewable energy alternatives such as wind, hydroelectric and solar power. There are many things people can do to help combat global warming including planting trees, avoiding products made of tropical hardwoods, buying less and conserving energy. By learning about the greenhouse effect, people can begin to make changes to combat climate change and work towards a cleaner, healthier and better future for all living beings.

Activity 1: Modeling the Greenhouse Effect

Preparation

This activity will take an hour before the final results can be observed. If infrared lamps are used, be very careful—they get very hot and can easily melt plastic if they are too close. Having students work in pairs works great for this activity, however for a large class, students may work in groups of 3-4. If graphing results is desired, have the students check the temperatures of both jars every 5 minutes. They should make a data table for recording their data. This activity can be done outside as well, as long as it is 75°F or hotter. It is recommended, that you practice this activity before presenting it to find out how well it works.

Materials

- 2 identical glass jars per group
- 2cups cold water per group
- 10 ice cubes per group (ice chest or freezer)
- one plastic bag or a sheet of saran wrap per group
- rubber bands
- 2 thermometers per group
- blank paper for labeling purposes
- a sunny window or infrared lamps
- science journal or paper to record observations

Procedure

1. Begin by asking the class questions about the greenhouse effect and climate change. Write main ideas and some key vocabulary words on the board for viewing.

2. Explain to the students that they will be trying to model the greenhouse effect using a plastic bag to act as greenhouse gases or a piece of greenhouse glass. Draw a thermometer on the board and make sure the students know how to read one accurately before they begin the activity. See if they can predict why two identical glass jars are needed. Next, have them predict what will happen to the ice in the covered jar versus the ice in the uncovered jar. Which will melt faster? Have an example set up for them to see. They should write down their predictions and their results on a worksheet? .

3. Next, break the students up into groups. Explain to them the importance of keeping all variables the same except for one; the variable they are changing. This will reduce error and make a more reliable experiment. Have each group place 5 ice cubes into each jar; jar A and B. Add 1 cup of water to each jar. Some of the ice should be above the water line. Have them place a thermometer into each jar facing out so that it can be easily read. The depths of the thermometers in each jar should be the same. You may want to have them tape

- *Has anyone ever heard of the greenhouse effect?*
- *What do you think the greenhouse effect is?*
- *Has earth always had a greenhouse effect? (no) Is the greenhouse effect important for our survival? (yes)*
- *What kinds of things have you heard about the greenhouse effect?*
- *How is a greenhouse similar to the greenhouse effect?*
- *Have you heard of global warming?*
- *Do most scientists agree that evidence suggest global warming is real? (yes, but controversial in politics)*
- *What does CO2 stand for?*
- *What kinds of activities emit CO2 (burning, breathing, decomposition)? What is the relationship between plants and CO2? Why are increasing CO2 levels a concern today? What are some effects of global warming? How can people help reduce global warming?*

Activity 1: Modeling the Greenhouse Effect (cont.)

each thermometer to the inside of the jar. Next, have the students securely wrap one of the jars in a plastic bag or place saran wrap over the top. Have them make it as air tight as possible by using a rubber band. The sealed jar, should not be opened until the very end. It is important that the glass jars be placed in a sunny window or under heat lamps in order for them to warm up sufficiently.

4. When setup is complete, have the student find the beginning temperatures of both jars A and B. The levels of water can be compared as well. Both jars should be side by side on a piece of labeled paper for each group. After at least one hour, have them compare the two jars and record their results. It is important to have them write a conclusion. Did the model work? How does this simple model compare to the greenhouse effect?

5. Several modifications can be done with this experiment. On a different day, instead of closing one bottle up, you can have the students cover one jar with black paper and keep the other see-through. After 30 minutes have them record the temperatures of both jars.

Activity 2: Making Carbon Dioxide

Preparation

Vinegar can be stinky, but also be part of the fun. Apple cider vinegar tends to be a good replacement to white vinegar. Each group will need 1 balloon, 2 T vinegar, 1 tsp. baking soda, 2 plastic spoons and a plastic bottle. It is suggested that you measure out the vinegar and baking soda in advance. Students should set up Activity 1 first and perform this activity while they wait for their jars to heat up.

Materials

- **12 oz. plastic water bottles or other plastic bottles**
- **medium sized balloons to fit over the mouth of bottles**
- **plastic balloons**
- **baking soda**
- **apple cider vinegar**
- **limestone chips**
- **science journal or paper to record observations**

Procedure

1. The purpose of this activity is for the students to observe a reaction where carbon dioxide and other gases are created. Explain to the students that during this reaction, one of the products produced is carbon dioxide, the main greenhouse gas. Vinegar is a solution called acetic acid ($HC_2H_3O_2$). Baking soda ($NaHCO_3$) is a powder also called sodium bicarbonate. It is basic (versus acidic) and reacts with vinegar to make water, carbon dioxide and sodium acetate ($NaC_2H_3O_2$). Vinegar will also react with materials made of calcium carbonate like chalk and sea shells, which are optional to use for demonstration purposes. The demonstration suggested here is to use limestone chips. The reaction happens much slower than the above reaction. To demonstrate, add 10-12 limestone chips to a see through glass jar. Add twice the volume of vinegar to it. The reaction is immediate and long lasting. You should see small bubbles. Pass the jar around for students to observe. Ask: How do we know a gas is being formed?

2. Next, have the students make a reaction. Every student should get a plastic bottle, a balloon, baking soda and vinegar. This reaction happens very quickly and can get messy. It is suggested that you have the students use a balloon first and then have them repeat the experiment without a balloon. If

they do not put a balloon over the top, be sure to have them perform the experiment over paper or a sink for easy clean up.

3. Each student should wrap their baking soda into a small piece of paper. Have them quickly drop it into their bottle. It should sit on the bottom of the bottle. If it gets stuck in the neck of the bottle, have them tap on the side gently to force it down. Next, they should add 2 tablespoons (3 tsp) of vinegar to the plastic bottle and quickly cover the opening with a balloon to capture the gases. The tricky part is to get the balloon securely over the mouth of the bottle in time. Have students make observations and write them down. Observations can include bubbles, an odor, a temperature change, etc. Depending on the age group, you may want to write out the chemical equation and have the students write it down.

4. Review how carbon dioxide relates to the greenhouse effect. Have them make connections between the gases in our atmosphere and carbon sinks. What are some ways carbon dioxide levels can increase? What are some ways carbon dioxide levels can be reduced?

Extensions

- Have the students research the effects of global warming using the Internet.
- Have the students make posters about renewable clean energy alternatives. The posters can be advertisements or informational.
- Invite someone from the Redwood Coast Energy Authority to come to the school and perform an energy audit.
- Plant trees or other plants in the local community.
- Calculate how much energy the classroom uses during one hour based on the number of lights, computers, and other electronic devices there are.
- Use environmental concepts to write poetry.
- Introduce a period of history by describing the methods of obtaining energy during that time.

References

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Global Warming: Facts and our Future, http://www.koshland-science-museum.org/exhibitgcc/impacts01.jsp, 2011
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Kid's Corner, http://www.pewclimate.org/global-warming-basics/kidspage.cfm, 2011
Recreating the Greenhouse Effect Activity, http://www.reachoutmichigan.org, 2011
The Basis of Global Warming, Environmental Defense Fund, http://www.edf.org/, 2011
The difference between weather and climate, http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html, 2011

FOSS Connection

Grades 5-6: Scientific Reasoning and Technology
Models and Designs
Grades 5-6: Alternative Module
Living Systems