Science Unit: ***Climate Change***

Lesson 1: ***Greenhouse Effect: Pop Bottle Experiment***

School year:	2008/2009
Developed for:	Shaughnessy Elementary School, Vancouver School District
Developed by:	Tom-Pierre Frappé(scientist), Carol Church and Sharlene Steele (teachers)
Grade level:	Presented to grades 5 - 7; appropriate for grades 5 to 7 with age appropriate modifications.
Duration of lesson:	1 hour and 10 minutes
Notes:	This is lesson 1 of a 4 part series

Objectives

1. Describe how greenhouses work, and what factors affect their temperature.
2. Compare a simplified greenhouse to the greenhouse effect on Earth.
3. Gain experience using an analogous model to conduct experiments that cannot be conducted “in the real world”.
4. Explain how the temperature of the Earth depends on its energy budget, and explain how the temperature changes when influx and outflux of energy are not in balance. (This will be touched on only briefly in this lesson, but expanded on in the next three lessons).

Background Information

“Greenhouses are useful for growing and propagating plants because they both allow sunlight to enter and prevent heat from escaping. The transparent covering of the greenhouse allows visible light to enter unhindered, where it warms the interior as it is absorbed by the material within. The transparent covering also prevents the heat from leaving by reflecting the energy back into the interior and preventing outside winds from carrying it away.

Like the greenhouse covering, our atmosphere also serves to retain heat at the surface of the earth. Much of the sun's energy reaches earth as visible light. Of the visible light that enters the atmosphere, about 30% is reflected back out into space by clouds, snow and ice-covered land, sea surfaces, and atmospheric dust. The rest is absorbed by the liquids, solids, and gases that constitute our planet. The energy absorbed is eventually reemitted, but not as visible light (only very hot objects such as the sun can emit visible light). Instead, it's emitted as longer-wavelength light called ***infrared radiation****. This is also called "heat" radiation, because although we cannot see in infrared, we can feel its presence as heat. This is what you feel when you put your hand near the surface of a hot skillet. Certain gases in our atmosphere (known as "trace" gases because they make up only a tiny fraction of the atmosphere) can absorb this outgoing infrared radiation, in effect trapping the heat energy. This trapped heat energy makes the earth warmer than it would be without these trace gases.*

The ability of certain trace gases to be relatively transparent to incoming visible light from the sun yet opaque to the energy radiated from earth is one of the best-understood processes in atmospheric science. This phenomenon has been called the "greenhouse effect" because the trace gases trap heat similar to the way that a greenhouse's transparent covering traps heat. Without our atmospheric greenhouse effect, earth's surface temperature would be far below freezing. On the other hand, an increase in atmospheric trace gases could result in increased trapped heat and rising global temperatures.[1]"

Vocabulary

Words: Greenhouse, carbon dioxide, energy budget, inflow, outflow.

Materials for each team:

- 1 two-liter plastic soda bottle
- Scissors
- Portable reflector lamp
- Two thermometers
- 150-watt floodlight bulb
- Worksheets (see attached)
- Kitchen timer or stop-watches

Materials for teacher:

- Cordless drill with bits of the same diameter as the thermometers
- X-acto knife

In the Classroom

Introductory Discussion

1. Short description of 'hook' to capture student's attention.
   - Who has heard of global warming? OK - do you know what causes it? [should lead to cars, pollution, CO2, etc. maybe even greenhouse effect] Why is it that these things increase the temperature of the whole planet, even thought it's so big?
   - Do you know why it is called the greenhouse effect? Have you seen or been in a greenhouse? What happens when you open a car that was parked in the light in the summer?
2. Short description of other items to discuss or review.
   - What is our main source of energy? [the Sun] When it shines it sends 1370 W/m2 (like thirteen 100W light bulbs per m2). What happens with an oven if you leave the heat on ALL the time? [it gets hotter and hotter]. OK but the heat is on all the time on the planet, why is it that it's not getting so hot? Because the planet also looses energy, radiated back to space.
3. Briefly describe science experiment/activity.
4. Briefly describe the processes of science that the students will focus on (prediction/hypothesis, observations, recording results, conclusions.)

- Observation
- Recording result
- Using analogue models

5. Briefly describe safety guidelines.
   - Careful with scissors!
   - Lamp can get hot

Science Activity/Experiment

Experiment Title: The Pop-bottle greenhouse

Purpose of Experiment: illustrate how a greenhouse work. Initiate comparison with the Earth's atmosphere. Get students familiarized with this analogous model so they can conduct their own experiment in lesson 4.

Experimental Treatments: how is temperature in the bottle affected by the bottle?

Control treatment	Thermometer outside bottle, on a coat hanger
Test treatment	Closed bottle

Prediction or Hypothesis: What will happen to the temperature in the greenhouse when we turn on the lamp? What will happen to the temperature just outside the greenhouse? Which one will be hotter at the end?

Methods and Instructions:

Experimental chamber construction

For each chamber, you will need a two-liter plastic soda bottle (with cap).

1. Remove the bottle label by soaking it in warm water.

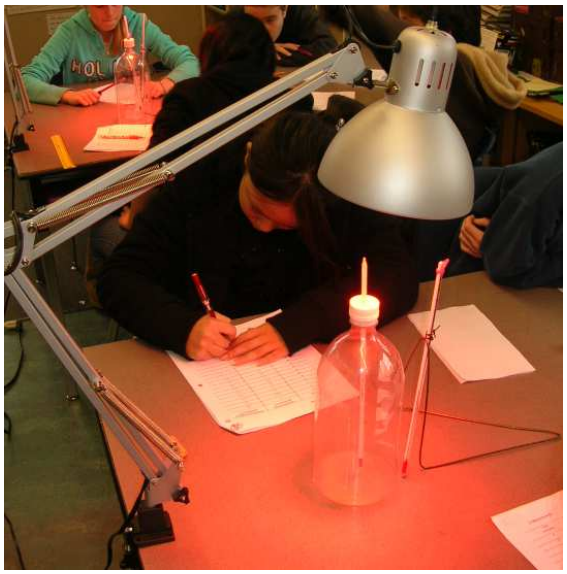
2. Cut off the end of the bottle approximately 2 inches from the bottom and discard the bottom piece. (best if the teacher starts the hole with the X-acto knife; the student can then finish off with scissors)

3. Drill a hole the same diameter than that of the thermometers in the cap of the pop-bottle. The hole can also be carved by hand with an X-acto knife pretty easily.

Experiment

1. Insert a thermometer in the hole in the pop-bottle cap. Attach the control thermometer to a coat hanger folded at 90 degree so that it is at the same height and same angle as the thermometer in the bottle. Make sure the bulbs of the thermometers are above the bottom of the chamber base. (See picture below).

2. Place both thermometers approximately six inches away from the lamp. Insure that they receive the same amount of light.



3. Inspect the setting of each team before they start. Then they can turn on their light and begin collecting data every 2 minutes for 20-26 minutes, until the temperature starts leveling. Students should divide up the work so that everyone is active: one can be time keeper, another reads the thermometer, another notes the results, etc. NOTE: to see some example of data obtained by students, see the spreadsheet included with lesson 3.

***"Cautionary Note:** The analogy between the plastic cover and the atmosphere is not a perfect one. Greenhouse covers prevent heat losses from convection (air movement carrying away the heat) as well as by radiation (direct transfer of heat energy). The atmosphere prevents only heat loss by radiation. The greenhouses used in this activity serve as a crude model of the actual atmospheric process and are only of limited use in understanding the nature and scope of the actual Greenhouse Effect.* [1]"

Closure Discussion [Here are some follow up question: I didn't use all of them]

- Students graph their results, and give the results to the teacher who will enter them in a spreadsheet, to be discussed in lesson 3.
- Compare and contrast the graphed data from the vented bottle and the intact bottle. What happened? How do you explain your observations?
- Why did the temperature increase? [the lamp provided heat/energy to the bottle]
- Why did it stop increasing? [harder question… heat comes in, heat leaves too. At first, more was coming in than leaving, so temperature increased. As the temperature rose, the bottle started to loose heat more quickly and the temperature remained constant. INFLOW = OUTFLOW]
- What could you do to increase the temperature in your bottle? [more powerful bulb, insulate lamp better (which lead to ask what happens if you block the light… like clouds do!), add reflectors on the sides, etc.]
- How could you "change" your greenhouse to now have a temperature range in between the two you tested?

- Compare and contrast your plastic greenhouse to the greenhouse effect on Earth. How does the Earth loose energy?... [This is also in the worksheet. I asked them to leave it blank for now, they will return to it after the next lesson: greenhouse effect simulation.]

References

1. University Corporation for Atmospheric Research, Project LEARN, retrieved February 2008 from <http://www.ucar.edu/learn/1_3_2_12t.htm>. See http://www.ucar.edu/learn/copyrite.htm for copyright info.

   Also of interest:

2. http://www.teachersdomain.org/resources/phy03/sci/phys/matter/greenhouse2/index.html
3. http://www.teachersdomain.org/resources/phy03/sci/ess/watcyc/co2/index.html

Extension of Lesson Plan

Climate Change science unit, Lesson 2: Use a computer simulation to visualize and what is actually happening in the atmosphere with greenhouse gases. Investigate other factors affecting the energy budget of the Earth.

Climate Change science unit, Lesson 3: Discuss results of this lab, and data analysis in general. Brainstorms ways that this analogous model can be used to investigate other factors affecting the energy budget of the Earth, more specifically the albedo, cloud cover, atmospheric CO2 concentration, and atmospheric water vapor concentration.

Climate Change science unit, Lesson 4: Student will test the effect of one of these factors using their own experimental design.