Science Unit: ***Climate Change***

Lesson 4: ***Earth Energy Budget Lab***

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 4 to 7 with age appropriate modifications.
Duration of lesson:	1 hour and 10 minutes
Notes:	This is lesson 4 of a 4 part series

Objectives

1. Describe how greenhouse 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 it's 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, Vocabulary

See Climate Change science unit, lessons 1 and 2, Scientist in Residence Program website http://www.scientistinresidence.ca).

Materials for each team:

- 2 two-liter plastic soda bottle
- Two 14- to 16-oz. plastic containers at least 4 1/2 inches in diameter at the top (sour cream, cottage cheese, or deli containers work well)
- Knife or scissors
- Two thermometers
- 150-watt floodlight bulb
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- Portable reflector lamp
- Graph paper or worksheets
- Kitchen timer or stop-watches
- Whatever the students need to create their test and control conditions…

In the Classroom

Introductory Discussion

1. Was done previous lesson.Jump right in.

2. Short description of other items to discuss or review.
    - Remind them that the lamps can get hot. They should have a data-table ready to compile their results.
3. Briefly describe science experiment/activity.
    - Each team of two students will have 2 pop-bottles, to test one of the factors affecting the energy balance of the Earth (CO2 concentration, H2O concentration, ground albedo, effect of clouds). They design the experiment: what the test bottle will be like, what the control bottle will be like, and what kind of measurements they will make.
4. Briefly describe the processes of science that the students will focus on (prediction/hypothesis, observations, recording results, conclusions.)
    - Experimental design, prediction/hypothesis, observations, recording results, conclusions
5. Briefly describe safety guidelines.
    - Careful with scissors!
    - Lamps can get hot.

Science Activity/Experiment

Experiment Title: The Pop-Bottle Earth

Purpose of Experiment: Test the effect of the factors affecting the energy balance of the Earth (O2 concentration, H2O concentration, ground albedo, effect of clouds), using pop-bottles as analogous models.

Experimental Treatments: how is temperature in each bottle affected by the treatment? This is designed by the students, and will be different for each team. However, here are a few possible examples:

Testing for effect of: CO2 concentration

Control treatment	Normal bottle closed
Test treatment	Bottle enriched with CO2

The CO2 can be produced by mixing sodium bicarbonate (baking soda) and vinegar, by mixing sugar yeast and warm water, or by collecting it from a car exhaust pipe (see http://www.ucar.edu/learn/1_4_2_17t.htm for instructions). Note that CO2 is heavier than air, so the bottle must be well sealed at the bottom (doesn't matter so much at the top).

Testing for effect of: water vapor

Control treatment	Normal bottle closed
Test treatment	Bottle enriched with water vapor (e.g. by adding a wet rag in the bottle)

Note that if students put hot water in their bottle, they add a source of heat and that will make the experiment ambiguous and inconclusive. I would let them do it, but bring it to their attention when they analyze their data.

Testing for effect of: ground albedo

treatment	Change the color of the bottom surface between the two bottles. One black one white. One dirt one sand. One normal one ice*. Etc.

*Note that if students put ice in their bottle, they add a sink of heat and will also likely increase the amount of water vapor in the bottle. This will make the experiment ambiguous and inconclusive. I would let them do it, but bring it to their attention when they analyze their data.

Testing for effect of: clouds

Control treatment	Normal bottle closed
Test treatment	Bottle with clouds pasted on top or inside. (cotton balls, rags, tinfoil, sunscreen (which blocks UVs!) etc.

Prediction or Hypothesis: In which of the two bottle will the temperature raise the fastest? Will the final temperature be the same?

Methods and Instructions:

Variable; see lesson 1 for basic idea.

Experiment

1. Students Place caps on both bottles, with thermometer passed thought a hole in the cap.
2. Place both bottles approximately six inches away from the lamp.
3. Turn on the light and begin collecting data every minute for 20 minutes. Students graph temperature change.
4. If required, keep one or two stations going for longer, so students can check if temperature stabilizes, and if so, if the final temperatures between the two bottles are different.

Closure Discussion

- For each of the four factors, get the teams that worked on that factor to quickly summarize: (1)what their setup was, and (2) the results they obtained (what was the "effect", ie the final temperature difference between the test and control bottle).
- Are the results consequent? What other factors could have affected the temperature?
- Finally, are the results comparable to what we expect on Earth? How are they different?

References

1. Inspired by: University Corporation for Atmospheric Research, Project LEARN, retrieved February 2008 from <http://www.ucar.edu/learn/1_3_2_13t.htm>. See http://www.ucar.edu/learn/copyrite.htm for copyright info.