Junior Climate Stewards

An Inquiry-Based Curriculum for Teaching Middle School Students About Climate Change

Foreword

This curriculum was developed by the University of Oregon Climate Leadership Initiative (CLI). The curriculum draws upon the success of CLI's Climate Master climate change outreach programs, which provide actionable community education on the physical science of climate change as well as strategies for individuals and businesses to reduce emissions and work with others to do the same.

We appreciate your field testing the curriculum and ask that you send us feedback on the individual lessons and curriculum as a whole. We will contact you periodically for feedback, or please provide input at your convenience by phone, mail or email to:

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Introduction

Climate change is one of the most pressing environmental and social issues facing the world today, and the Pacific Northwest is already feeling the effects of climate change on our economy, quality of life and environment through increased wildfires, decreased snowpack and rising temperatures and sea levels. Climate change could be the greatest public health threat of the century, while the poorest populations are the most vulnerable to climate impacts.[1] With temperature increases of 2.7 to 4.5 degrees Fahrenheit (°F)/1.5 to 2.5 degrees Celsius (°C), 20-30 percent of species are at risk of extinction.[2] Temperatures have already gone up 1.4°F in the last century and recent research points to likely increases of 6.3 to 13.3°F by the end of the century without massive and rapid action.[3] Such impacts to biodiversity have ramifications far beyond the individual species, as we rely on plants and animals to provide food, raw materials, flood protection and other "ecosystem services."

Today's youth should be poised to both prepare for the impacts of climate change and capture the opportunities that accompany a carbon constrained society, economy and environment. Understanding climate change and the connections between the issue and their own lives will allow students to make educated decisions around their actions that impact the climate.

Who should use the JCS curriculum?

Building climate literacy is an ongoing and interdisciplinary process. The symptoms of and solutions to climate change express themselves as a physical science phenomenon with economic and social ramifications. What remains constant in this rapidly expanding field of knowledge is the need for systems thinking and the ability to understand complex relationships.

As such, while the majority of this curriculum is designed for middle school science classes and meets national middle school science and social studies standards, many lessons meet standards in other subjects. Standards are provided at the beginning of each unit.

The lessons are designed so that everyone feels comfortable to use them regardless of their background with climate change. Although detailed lesson plans are provided, teachers who feel comfortable with the subject matter are welcome to be creative and adapt the lessons.

What are the objectives of the JCS curriculum?

Broadly, the purpose of the Junior Climate Stewards curriculum is to develop students' climate literacy and empower them to take action to reduce climate change and prepare for projected impacts. More specifically, after completing this curriculum, students should:[4]

- Understand the key principles of our climate system, including the relationship of humans to the climate,
- Think critically and use evidence in assessing information about climate change,
- Communicate clearly and meaningfully about climate change, and
- Be empowered to make informed and responsible decisions concerning actions that impact the climate.

1 Costello, A. et. al. "Managing the Health Effects of Climate Change." The Lancet, Volume 373, Issue 9676, Pages 1693 - 1733, 16 May 2009. *http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2809%2960935-1/fulltext*

2 IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Mannimg, Z. Chen, M. Marquis, K.B Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

3 MIT Joint Program on the Science and Policy of Global Change, "Policy vs. No Policy, Updated Estimates." *http://globalchange.mit.edu/resources/gamble/* Accessed 3 September 2009.

4 These objectives are based on those stated in "Climate Literacy: The Essential Principles of Climate Science." U.S. Global Change Research Program /Climate Change Science Program, *www.climatescience.gov*

In meeting those objectives, the curriculum engages students in scientific inquiry and includes content in physical, life, earth and space science, science and technology, and science in personal and social perspectives—six of the eight National Science Education content standards. While the lessons are presented at the middle school level, the activities and information can be tailored to meet the ability and skills of the students and grade level benchmarks.

This curriculum is also designed to be used in a 4-H setting, and as such, meets the 4-H Youth Development Essential Elements of belonging, mastery, independence and generosity.

How to use this curriculum

The four-week curriculum consists of six units that can be used in sequence or individually. The units begin with the physical science of climate change and continue with home and school energy; transportation; food; consumption and waste. The final unit leads students through a service-learning project designed to reduce emissions.

Within each unit, teachers will find the unit objectives, a unit overview and the physical science, social studies and related standards that the lessons meet. This is followed by background information for the teacher on the subject covered by the unit.

The lessons consist of:

- Lesson objectives and standards
- Suggested timeframe
- Material list
- Further background information for teachers
- Links to other resources
- Discussion outline
- Lesson procedure
- Student worksheets and materials (differentiated by tabs on upper right corner)
- Assessment
- Content quizzes
- Quiz Solutions
- Appendices for further research

Aside from allowing the teacher to assess the students' understanding of the content, quizzes have been shown to improve student learning. The effect comes in part from students' delayed re-exposure to information and is effective when correct answer feedback is provided.[5] This curriculum therefore contains "objective checks" to accompany each lesson, as well a quiz to conclude each unit. The objective checks can be posed as verbal questions or presented to students as a written quiz. These objective checks could be done individually or in small groups.

5 Institute of Education Sciences, "Organizing Instruction and Study to Improve Student Learning," September, 2007

Unit 1: Climate Change

Unit Objectives and Standards

At the end of this unit the students will be able to:

- Understand the structure of the climate system, particularly the concept of the greenhouse effect and the primary greenhouse gases
- Analyze information about the impacts of climate change to humans and other species
- Identify the difference between weather and climate **(Science Standard)**
- Based on observations and scientific concepts, form hypotheses that can be explored through scientific investigations **(Science Standard)**

Unit Background

Lesson 1A

Creating a Greenhouse Effect (2+ hours)

Lesson 1B

The Carbon Cycle (40-60 minutes)

Lesson 1C

It's Getting Hot in Here! (45-60 minutes)

Unit 1 Quiz

15 minutes

Unit 1 Appendices

Unit Background

Over time the Earth's climate has changed due to natural processes such as changes in the Earth's orbit. At some times the Earth's average temperature has been higher while at other times it has been cooler. In fact, there was a long-term period of low temperatures 20,000 years ago during the last glacial period that caused large glacier sheets to cover much of North America. However, the climate has been changing significantly since the mid-20th century and scientists agree that in contrast to previous climatic changes, these changes are due to human-induced increases in greenhouse gases.

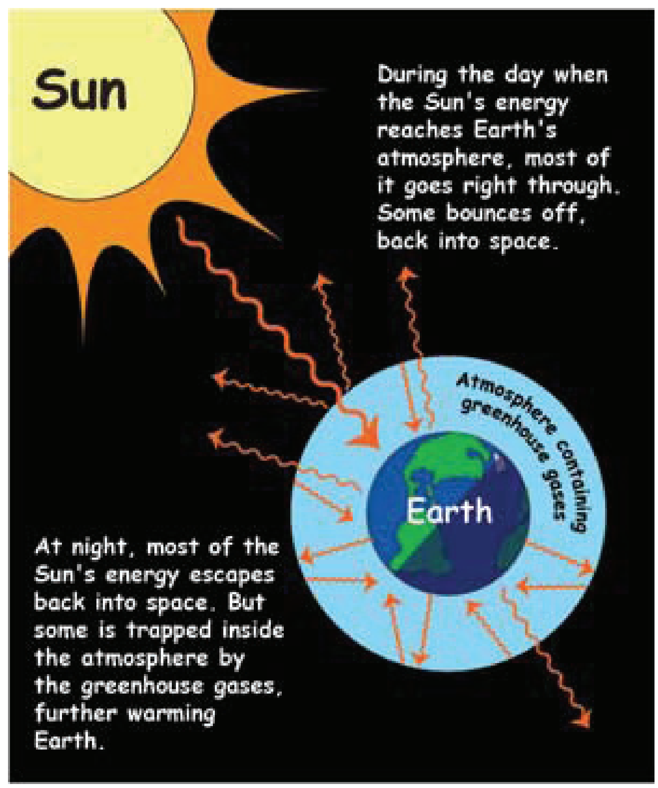
Carbon dioxide and other **greenhouse gases** (GHGs) absorb and radiate heat from the sun back to earth, acting like a heat trapping blanket or greenhouse. These gases make our planet habitable. Without them, the earth would be too cold for human life (like Mars). Too many of these gases in the atmosphere, however, would make our planet too hot for human life (like Venus) (see *http://spaceplace.nasa.gov/en/kids/goes/planets/index.shtml*). Burning fossil fuels and other human activities since the industrial revolution have resulted in increased concentrations of greenhouse gases like carbon dioxide, methane and nitrous oxide in the atmosphere, known as the **greenhouse effect.** This results in higher average temperatures on Earth and significantly changes the climate across the whole planet. This phenomenon is referred to as climate change, global warming, or global climate change.

Currently China, with its 1.3 billion people, produces more GHGs than any other country. However, the United States has contributed the most GHGs to the current problem and produces far more GHGs per capita than most other countries. US emissions amount to between a fifth and a quarter of the global total.

Weather is the state of the atmosphere at a particular place and time. Weather is described in many ways: temperature of the air, whether the sky is clear or cloudy, how hard the wind is blowing, or whether it is raining or snowing. The weather can be fair in some places while it rains or snows in another.

Climate is the pattern of weather over long time periods such as decades: how much sunlight and rainfall it gets over time, how windy it is, and so on. The world's weather is entirely powered by the sun. Since the Earth rotates on a tilted axis, different parts of our planet are heated by different amounts at different times of year, making some regions hotter than others and causing the seasons. The temperature variations between one part of the world and another cause differences in air pressure, producing winds, storms, and even hurricanes. The sun's heat also warms the seas unevenly, driving ocean currents—which, in some ways are like underwater winds—from one place to another.

For more information on the greenhouse effect for you or your students go to NASA's Space Place *http://spaceplace.nasa.gov/en/kids/tes/gases/index.shtml* or the Energy Information Administration at *http://www.eia.doe.gov/bookshelf/brochures/greenhouse/Chapter1.htm*



Source: NASA, The Space Place
http://spaceplace.nasa.gov/en/kids/tes/gases/index.shtml

Lesson 1A—Creating a Greenhouse Effect

Objectives

- Students will develop a basic understanding of the greenhouse effect and understand its relationship to the laboratory activity
- Students will identify a research question and develop a hypothesis
- Students will report data in a scientific manner

Materials

For each pair or small group of students:

- Three thermometers
- Two clear glass jars that will fit over the thermometers
- Sun lamp or sunny windowsill
- Paper towels
- Student Worksheet
- Graph paper
- Ruler/Straight edge
- One clock to be used by the entire group

Suggested Timeframe

(2+ hours)

- 10 minutes—introduce climate change
- 10 minutes—begin discussion (see outline above)
- 20 minutes—discuss and do pre laboratory written report
- 60 minutes—data collection (students may get bored during data collection without a concurrent assignment such as the word search in Appendix 2.)
- 20 minutes—data analysis (making the graph)
- 10 minutes—conclusion and evaluation

Teacher Information

Earth is surrounded by the **atmosphere,** which is made up of several layers of different gases. The sun is much hotter than the earth and it gives off high-energy **ultraviolet radiation** that travels through space to the earth. Oceans and land absorb most of this energy. Heat is then radiated outward as **infrared energy**. Some of this heat is absorbed by what are called greenhouse gases, which exist naturally in the atmosphere. Greenhouse gases include **carbon dioxide** (CO_2), **methane** (CH_4), **nitrous oxide** (N_2O) and **water vapor** (H_2O). The gases re-radiate the infrared back to the earth and it is reabsorbed, further warming the Earth. The greenhouse gases are often compared to a blanket around the earth, which keeps the Earth warm. Increased concentrations of CO_2 and other greenhouse gases due to human activities absorb more infrared energy, in essence creating a thicker blanket around the earth to keep heat inside. This, in turn, causes increases in the temperature of the atmosphere and Earth's surface.

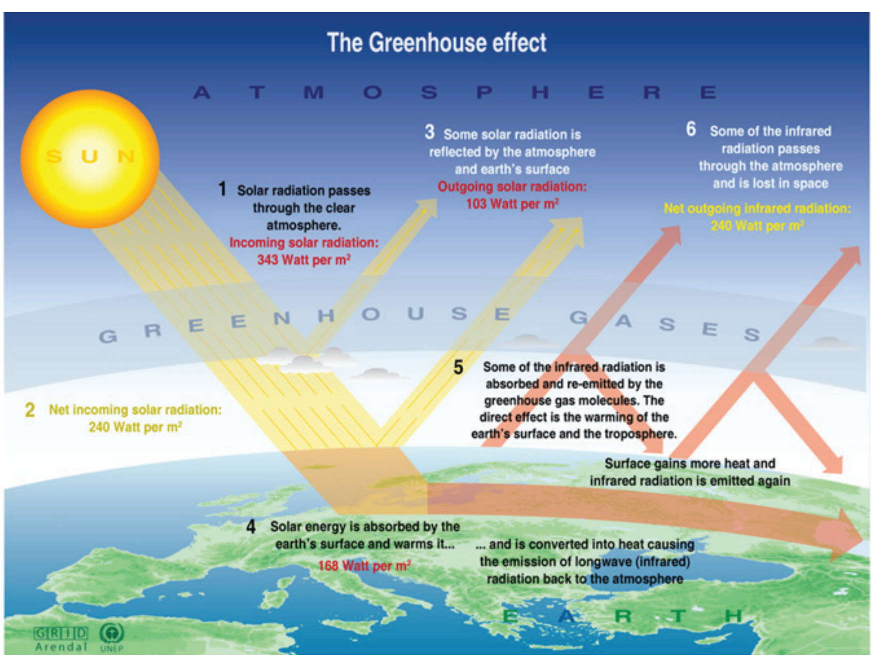
Human activity like burning fossil fuels directly results in increased emissions of CO_2, CH_4, and N_2O. Water vapor is different in that it is not directly increased through human activity. Rather, warm air can hold greater concentrations of water vapor than cooler air can, so as the atmosphere warms, the concentration of water vapor in the atmosphere increases. Such phenomenons in which warming trends lead to further warming are called positive feedbacks.

Discussion

This outline highlights the key points to be shared with students.

1. Explain the following terms found in the "Teacher Information" above.
   a. Atmosphere
   b. UV and IR radiation
   c. Greenhouse gases (including water vapor).
2. Describe the effect of greenhouse gases in the Earth's atmosphere.
   a. Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.
   b. When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.
   c. Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.
   d. Natural processes driving Earth's long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change. Future changes in climate may be rapid compared to historical changes.
   e. Natural processes that remove carbon dioxide from the atmosphere operate slowly when compared to the processes that are now adding it to the atmosphere. Thus, carbon dioxide introduced into the atmosphere today may remain there for a century or more. Other greenhouse gases, including some created by humans, may remain in the atmosphere for thousands of years.

   (Source: *http://climateliteracynow.org/files/Climate_Science_Literacy_Brochure_Final_v4.pdf)*
3. Describe the laboratory report process
   a. Defining the question and the variables
   b. Developing a hypothesis
   c. Understanding the procedure
   d. Data Collection
   e. Data Analysis
   f. Conclusion and evaluation



Source: Stop Global Warming, *http://www.stopglobalwarming.com.au/global_warming_greenhouse_effect_in_detail.html*

Lesson

1. Introduce the topic by using the "Discussion" section as a guide, or by creating your own lecture.
2. Distribute Student Worksheets. Have the students read through the Procedure section of the experiment. Explain to the students how to define a research question (use Lab Instruction for Teachers to help you with this step). Have the students work individually to write a research question.
3. Help the students to each develop a hypothesis.
4. Help the students define the variables as a class (this is difficult to do at times.)
5. Divide the students into small groups. Distribute the prepared materials to each group and have the groups follow the procedure. Check to see that groups are on task. Make sure students clean their lab stations when they are finished.
6. Once they have collected data, help the students with the graphing. Remember, they should not "connect the dots" but rather use a line of best fit. (For background information on scatter plots and drawing lines of best fit, see NASA Quest: *http://quest.nasa.gov/space/frontiers/activities/aeronautics/m.html*)
7. Assist the groups with writing a conclusion and evaluation.
8. Discuss with the class how their lab is connected to climate change (they have created a greenhouse effect in the jars similar to the greenhouse effect that takes place in the atmosphere.)
9. Collect laboratory reports before the students leave.

Laboratory Instructions for Teachers

Question: The question must be testable. A testable question is one that can be answered by performing an experiment. In this case the students should develop a question similar to "How will temperature vary between a wet jar, a dry jar and the room when an equal amount of sunlight hits each?"

Variables:
Manipulated: this is the variable that you change in the experiment. Also known as the independent or experimental variable. In this case the manipulated variable is moisture level.

Responding: this is the variable that changes because the experimenter made a change to the manipulated variable. Also known as the dependent variable. In this case the responding variable is temperature.

Controlled: these variables are the ones held constant throughout the experiment. In this case the controlled variables are amount of sunlight and time.

Hypothesis: The hypothesis is a prediction of what is going to happen. It's important to get the students to anticipate what may occur in the experiment. A hypothesis can be stated in a "if, then, because" format. *If* the manipulated variable is changed, *then* the responding variable will do this or that, *because* of some justification. In this case the students should have a statement similar to "If the amount of water in the jar increases, then the temperature will be higher, because the water vapor acts as a greenhouse gas and absorbs more heat than the air in the dry glass."

Data Collection: Accurate data collection is important. Note a couple of attributes of the data table: each column is labeled with appropriate headings and units and is made using a computer (or with a straight-edge when computers are not available.) Neatness and clarity are important in data tables.

Data Analysis: The students should graph their data on the provided graph. Note that the axis labels are provided. The students will need to add a title, an appropriate scale (try to use as much of the graph as possible), a key to denote each line (colored pencils or different shaped "points" work well) and the data points. They should make a line graph, not a bar graph.

Conclusion: The students should now write three sentences: the first sentence comparing their results to their hypothesis, the second listing possible mistakes they made, and the third explaining what they might do differently if they did it a second time. In this case the students should have something similar to: "Our results supported our hypothesis because the air in the jar with the wet paper towel had the highest temperature while the room temperature was the coolest. We did not measure all the thermometers at the same time and the wet paper towel dried out. Next time we would have three people reading the thermometers at the same time and make sure the paper towel was wetter."

Student Worksheet

Name: ______________________________

Pre-laboratory Report (do this before starting the experiment)

Question	
Variables	
Manipulated	
Responding	
Controlled	
Hypothesis	
If	
Then	
Because	

Student Worksheet

Name: ______________________________

Procedure

(Do not start until you finish the pre-lab portion of the lab.)

1. Place three thermometers within a few inches of each other on a sunny windowsill or under a sun lamp. Be sure that all three thermometers receive the same amount of light. Periodically check the thermometers until they are at exactly the same temperature. Once the thermometers are displaying the same temperature, record this information on the initial row on the data table.
2. Now cover two thermometers with glass jars, leaving one thermometer uncovered. Place a wet paper towel inside one of the two jars. Use water at room temperature to wet the paper towel. Check all three thermometers at five-minute intervals and record the temperature in the data table.
3. After one hour (or whatever time your teacher suggests) take your final temperature measurements. Analyze the data that you have collected by creating a graph to show how the temperature of the three thermometers changed throughout the experiment.

Time (min)	**Wet Jar (oC)**	**Dry Jar (oC)**	**Room (oC)**
0 (initial)			
5			
10			
15			
20			
25			
30			
35			
40			
45			
50			
55			
60			

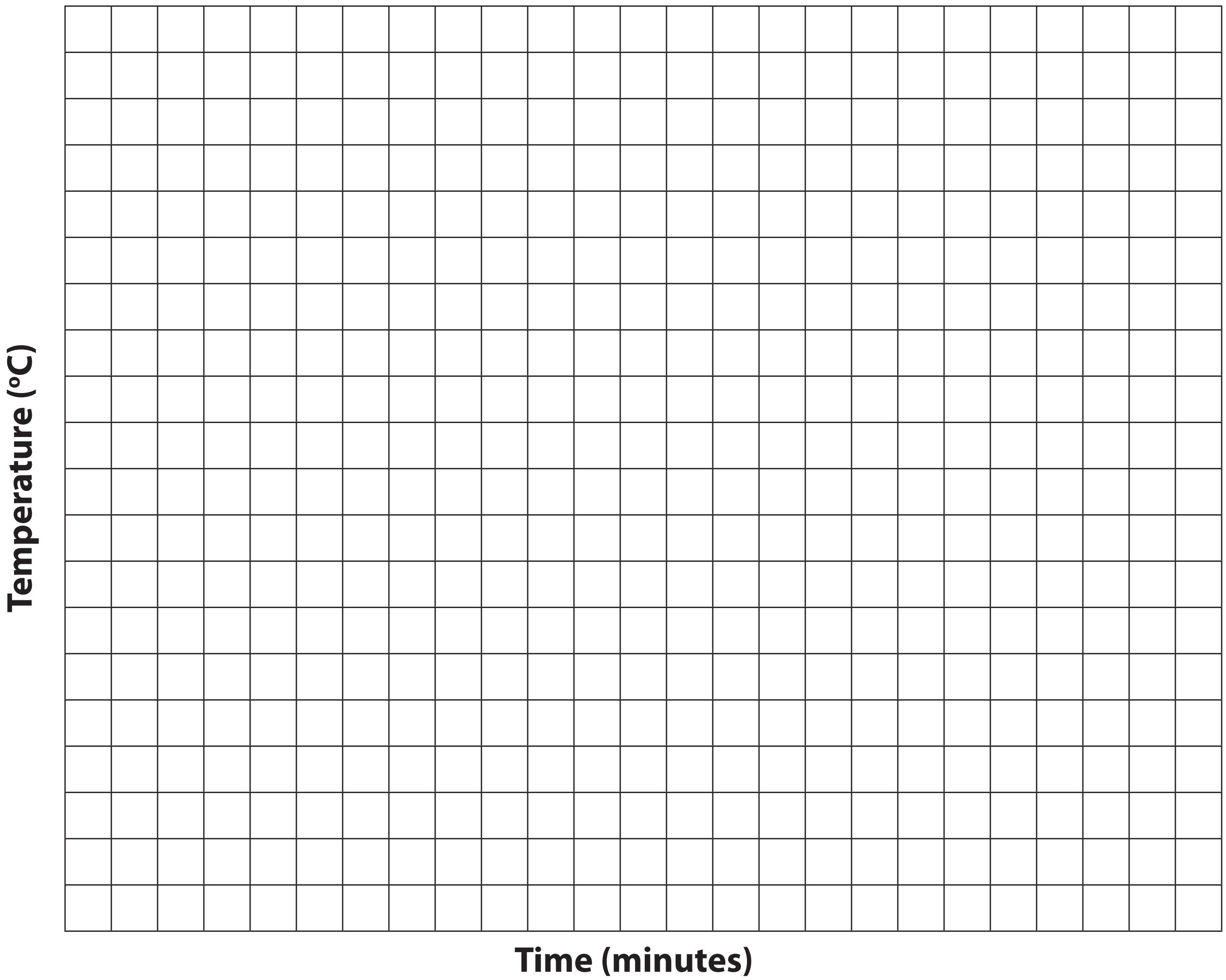
Unit 1

Title: ______________________________

Name: ______________________________

Key:
Wet =
Dry=
Room=

Data Analysis



Conclusion (one sentence for each)	
Results	
Mistakes	
Improvements	

Lesson 1A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Research Question	Asks a testable, clearly defined question.	Asks a testable, but not clearly defined question.	Question is stated but is not defined or is incomplete.	No question is stated.	
Variables	Correct variables are chosen and defined.	Some variables are chosen and defined.	Variables were attempted but incorrectly defined.	No variables were defined.	
Hypothesis	Hypothesis is directly related to the question and is explained.	Hypothesis is directly related to the question but is not explained.	Hypothesis is not related to the question nor is explained.	No hypothesis is stated.	
Follows Procedure	Follows procedure correctly without guidance.	Follows procedure correctly with some guidance.	Does not follow procedure without guidance.	Does not follow procedure and required a great deal of guidance.	
Data Collection	Raw data is recorded appropriately.	Some raw data is recorded.	The wrong raw data is recorded.	No raw data is recorded.	
Data Analysis	Raw data is converted into a graph with points correctly plotted, title clearly shown, and key filled in completely.	Some data is converted into a graph and title and key are complete.	Some data is converted into a graph but title or key are incomplete.	No attempt was made to create a graph.	
Conclusion	Results are summarized correctly, mistakes are acknowledged, and ideas for improvement are given.	One of the three (results, mistakes, or improvements) is not included or not clear.	Two of the three (results, mistakes, or improvements) are not included or not clear.	No attempt was made to write a conclusion.	
Teamwork	Collaborates with, seeks views of, and exchanges ideas with others in order to integrate them into the task.	Requires guidance to collaborate with others, acknowledges some views, and exchanges some ideas.	Requires guidance to collaborate with others, does not acknowledge others and does not exchange ideas.	Is unsuccessful when working with others, disregards the views of others and does not contribute.	
				Total Score	/32

Objective Check

1. What does the greenhouse effect do to the temperature of the Earth? (Raise it)
2. What part of the experiment serves the same function as greenhouse gases in the atmosphere? (The glass jar.)
3. What is a characteristic of a good research question? (Testable)

Lesson 1B—The Carbon Cycle

This lesson has been adapted from The California Academy of Sciences, *http://www.calacademy.org/teachers/resources/lessons/carbon-cycle-demonstration/*

Objectives

- Students will learn that there is a limited amount of carbon on earth.
- Students will learn how carbon cycles between abiotic and biotic components of the ecosystem in both the short term and the long-term carbon cycle.
- Students will discuss a few of the ways in which humans are changing the carbon cycle.

Materials

- Ping pong balls (at least 14)
- Permanent marker
- Carbon Cycle Demonstration Cards (1 set of 7 cards)
- Carbon Cycle Worksheets (1 per student)

Suggested Timeframe

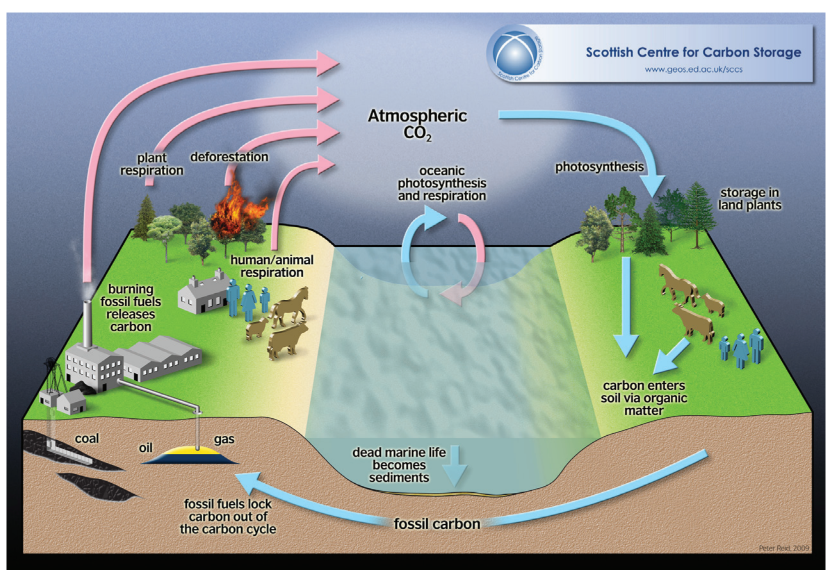
(40-60 minutes)

- 10 minutes—Introduction and discussion
- 20-30 minutes—Activity
- 10-20 minutes—Post-activity worksheet

Teacher Information

Carbon is a common element on Earth and the fourth most abundant element in the Universe. It is the building block of life. It is contained in the atmosphere, the crust, oceans and in living creatures. When students stop and think about all the things on Earth that contain carbon they are often amazed. It's almost harder to come up with things that do not contain carbon! It's the element that anchors all organic substances, from fossil fuels to DNA. On Earth, carbon cycles through the land, ocean, atmosphere, and the Earth's interior in a major biogeochemical cycle (the circulation of chemical components through the biosphere from or to the lithosphere, atmosphere, and hydrosphere). However, there is a limited amount of carbon on Earth, and the carbon contained in any one thing doesn't stay there forever.

Carbon atoms move from one thing to another in the carbon cycle. Parts of the carbon cycle happen very quickly, like when plants take in carbon dioxide from the atmosphere for photosynthesis. But other parts of the carbon cycle happen very slowly. These different parts of the cycle can be divided into two categories: the geological, which operates over large time scales (millions of years), and the biological/physical, which operates at shorter time scales (days to thousands of years). This demonstration will illustrate how carbon moves from one place to another.



In any given year, tens of billions of tons of carbon move between the atmosphere, hydrosphere, and geosphere. Human activities add about 5.5 billion tons per year of carbon dioxide to the atmosphere. (Illustration Source: Scottish Center for Carbon Storage, *http://www.geos.ed.ac.uk/sccs/public/teachers/Carbon-cycle-full.jpg)*

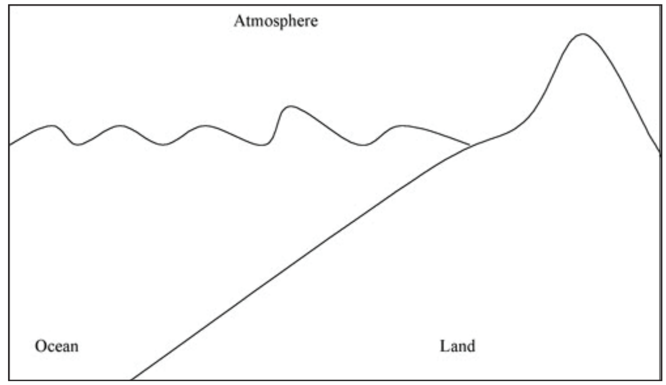
Discussion

This outline highlights the key points to be shared with students.

1. Carbon is a common element on Earth and fourth most common in the Universe.
2. Brainstorm some of the things in your daily life that contain carbon:
   c. The atmosphere
   d. The ground
   e. People
   f. Plants
   g. The ocean
   h. Any petroleum product (plastics, etc.)
   i. Organic materials
3. There is a limited amount of carbon on the Earth
   a. Carbon does not stay in one place. Carbon atoms move from place to place or item to item.
   b. This movement is known as the carbon cycle.
4. The carbon cycle on Earth can be broken into two categories
   a. The geological which occurs over millions of years
   b. The biological/physical, which occurs in days to thousands of years.

Preparation

- Collect 14-28 ping-pong balls.
- Write the chemical symbol for carbon (C) on each ping-pong ball with a permanent marker.
- Draw a picture of the three regions below on the board and then designate different areas of the classroom to represent the ocean, the land, and the atmosphere.



Lesson

1. Divide students evenly into 7 groups. Each group will be a team that will represent a certain part of the carbon cycle. The groups are listed in the table below. (Note: you can also simply choose 7 students to perform the demonstration for the rest of the class.)
2. Tell students to stand in the appropriate section of the classroom: atmosphere, land, or ocean.
3. Distribute the appropriate demonstration card to each group.
4. Distribute 2-4 ping-pong balls to each group and explain that these represent carbon atoms.
5. Tell students that they need to look at their card as a group to figure out their role and what they get to do in the demonstration.
6. Tell students that they need to decide as a group how they are going to move their carbon. Their options are listed in the "Options for carbon movement" section on their cards. You might want to conduct one round where students must give their carbon atoms to one other group and then conduct a second round where they can split their carbon between different groups.
7. Tell students that they need to keep one of their carbon atoms for themselves. This is to represent that carbon moves from one thing to another, but also remains in each of these different groups.
8. One at a time, ask each group to give their carbon to another group (or groups).
9. Tell students that as they move their carbon, they must explain the carbon movement that they have chosen. Students can either read the explanations for carbon movement directly from their cards or translate the explanations into their own words.
10. Run the demonstration a few times, telling students to make different choices about carbon movement each time.
11. Consider running the role-play one time with all the groups moving their carbon at the same time. To do this, have one person from each group be the deliverer of carbon and the other group members remain to receive carbon from other groups. Tell students that this is a more chaotic, but more realistic demonstration of the carbon cycle, since in the real world carbon moves between all these areas at the same time.

12. Tell students that this demonstration showed the carbon cycle without human involvement. But, humans greatly influence the carbon cycle with some of their activities. Pull a few students aside and have them be the humans. Ask them to move the carbon in the appropriate manner for each of the following human alterations. First have students guess what the movement will be and then help them make the appropriate movement.
    - Humans extract and burn fossil fuels for energy – carbon moves from the sediments and rocks where fossil fuels are buried into the atmosphere.
    - Humans cut and burn trees to use land for farming, ranching, or building – carbon moves from the land plants into the atmosphere.
13. Explain that burning fossil fuels takes carbon from sediments and rocks where fossil fuels are buried and puts it into the atmosphere because when fossil fuels are burned they release carbon-containing gases. Explain that cutting and burning trees takes carbon from the land plants and puts it into the atmosphere because when trees are burned, the carbon that was stored in their structures is released as carbon-containing gases. **Explain that humans have not created more carbon on earth, but that we move carbon from one place to another more quickly than would naturally happen and that this has consequences for the climate of the planet.**
14. After completing the rounds, pass out the student worksheet. Answers can be found in the table below:

Name of Group	Options for Carbon Flows	Explanation for each Carbon Flow
Atmosphere	1. Water 2. Land plants	1. Carbon dioxide from the atmosphere diffuses and dissolves into water. 2. Carbon is taken up by land plants to perform photosynthesis.
Water	1. Aquatic plants 2. Aquatic animals 3. Atmosphere	1. Aquatic plants use carbon dioxide from the water to perform photosynthesis. 2. Some marine organisms take carbon from the water to build their skeletons and shells. 3. Carbon dioxide can diffuse from the water back into the atmosphere.
Aquatic Plants	1. Water 2. Sediments and rocks 3. Aquatic animals	1. Cellular respiration and decomposition put carbon back into the water. Carbon from dead plants can be incorporated into sediments. 2. Animals consume aquatic plants and use carbon for energy or store it in their tissues.
Aquatic Animals	1. Water 2. Sediments and rocks	1. Respiration and decomposition put carbon back into the water. 2. Carbon from dead animals can be incorporated into sediments on the ocean floor and can eventually become sedimentary and metamorphic rocks.
Sediments and Rocks	1. Water 2. Volcano to atmosphere	1. Weathering and erosion of rocks deposits carbon in rivers and oceans. 2. Volcanic eruptions spew carbon-containing gases into the atmosphere.
Land Plants	1. Atmosphere 2. Sediments and rocks 3. Land animals	1. Cellular respiration and decomposition put carbon back into the atmosphere. 2. Carbon from dead trees can be buried and incorporated into sediments. 3. Plants are consumed by animals that use carbon for energy or store it in their tissues.
Land Animals	1. Atmosphere 2. Sediments and rocks	1. Respiration and the decomposition of dead animals put carbon back into the atmosphere. 2. Carbon from dead animals can be buried and incorporated into sediments.

Atmosphere

Card 1

Description:
You are the atmosphere, the gases that surround our planet. You have carbon in the form of carbon dioxide and methane gases. These are greenhouse gases, which help to maintain the temperature of the planet.

Options for carbon movement:

1. Water
2. Land plants

Explanation for carbon movement:

1. Carbon dioxide from the atmosphere diffuses and dissolves into water.
2. Carbon is taken up by land plants to perform photosynthesis.

Water

Card 2

Description:
You are the water on our planet. Carbon dioxide gas dissolves in water and allows aquatic plants to perform photosynthesis. Carbon in water also helps certain aquatic animals make their skeletons and shells.

Options for carbon movement:

1. Aquatic plants
2. Aquatic animals
3. Atmosphere

Explanation for carbon movement:

1. Aquatic plants use carbon dioxide from the water to perform photosynthesis.
2. Some marine organisms take carbon from the water to build their skeletons and shells.
3. Carbon dioxide can diffuse from the water back into the atmosphere.

Aquatic Plants

Card 3

Description:
You are aquatic plants. You get carbon dioxide from the water around you to perform photosynthesis.

Options for carbon movement:

1. Water
2. Sediments and rocks
3. Aquatic animals

Explanation for carbon movement:

1. Cellular respiration and decomposition put carbon back into the water.
2. Carbon from dead plants can be incorporated into sediments.
3. Animals consume aquatic plants and use carbon for energy or store it in their tissues.

Aquatic Animals

Card 4

Description:
You are aquatic animals, such as coral and snails. You feed on aquatic plants and use carbon from the water around you to build your skeletons and shells.

Options for carbon movement:

1. Water
2. Sediments and rocks

Explanation for carbon movement:

1. Respiration and decomposition put carbon back into the water.
2. Carbon from dead animals can be incorporated into sediments on the ocean floor and can eventually become sedimentary and metamorphic rocks.

Sediments and Rocks

Card 5

Description:
You are the sediments and rocks on our planet. Many rocks and sediments contain carbon from dead animals and plants or from chemical reactions.

Options for carbon movement:

1. Water
2. Atmosphere

Explanation for carbon movement:

1. Weathering and erosion of rocks deposits carbon in rivers and oceans.
2. Volcanic eruptions spew carbon-containing gases into the atmosphere.

Land Plants

Card 6

Description:
You are the land plants on our planet. You use carbon dioxide from the atmosphere to perform photosynthesis.

Options for carbon movement:

1. Atmosphere
2. Sediments and rocks
3. Land animals

Explanation for carbon movement:

1. Cellular respiration and decomposition put carbon back into the atmosphere.
2. Carbon from dead trees can be buried and incorporated into sediments.
3. Plants are consumed by animals that use carbon for energy or store it in their tissues.

Land Animals

Card 7

Description:
You are land animals. You have carbon in your bodies, which you get from eating carbon-rich foods.

Options for carbon movement:

1. Atmosphere
2. Sediments and rocks

Explanation for carbon movement:

1. Respiration and the decomposition of dead animals put carbon back into the atmosphere.
2. Carbon from dead animals can be buried and incorporated into sediments.

Student Worksheet

Name:______________________________

Carbon Movement	Explanation for this Movement
Atmosphere → Water	
Atmosphere → Land Plants	
Water → Aquatic Plants	
Water → Aquatic Animals	
Water → Atmosphere	
Aquatic Plants → Water	
Aquatic Plants → Sediments and Rocks	
Aquatic Plants → Aquatic Animals	

Student Worksheet

Name:______________________________

Carbon Movement	Explanation for this Movement
Aquatic Animals → Water	
Aquatic Animals → Sediments and Rocks	
Land Plants → Sediments and Rocks	
Land Plants → Atmosphere	
Land Plants → Land Animals	
Land Animals → Atmosphere	
Land Animals → Sediments and Rocks	
Sediments and Rocks → Water	
Sediments and Rocks → Atmosphere	

Student Worksheet

Name:______________________________

Carbon Movement	Explanation for this Movement
Aquatic Animals → Water	
Aquatic Animals → Sediments and Rocks	
Land Plants → Sediments and Rocks	
Land Plants → Atmosphere	
Land Plants → Land Animals	
Land Animals → Atmosphere	
Land Animals → Sediments and Rocks	
Sediments and Rocks → Water	
Sediments and Rocks → Atmosphere	

Student Worksheet

Name:______________________

Lesson 1B Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Participation	Actively engages in carbon activity. Discusses options with teammates and thoughtfully passes ping-pong ball.	Is somewhat engaged in carbon cycle activity. At times participates in decision-making.	Rarely engages in activity.	Shows no engagement in activity, refuses to participate.	
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
				Total Score	**/8**

Objective Check

1. Create a three-step carbon cycle: list each step of where a single atom of carbon can go. (Many acceptable answers, ex. Atmosphere to plants, plants to animals, animals to atmosphere.)
2. What is the difference between a geological and a biological/physical carbon cycle? (Geological are longer term than biological/physical)
3. Name two ways in which humans are changing the carbon cycle. (Burning fossil fuels takes carbon from sediments and rocks where fossil fuels are buried and puts it into the atmosphere. Cutting and burning trees takes carbon from the land plants and puts it into the atmosphere.)

Lesson 1C—It's Getting Hot in Here!

Objectives

- Students will project local consequences to global climate change.
- Students will become familiar with projections made by scientists on the impacts of global climate change

Materials

- Chalkboard, whiteboard, or poster paper
- Markers
- Computer with Internet access
- Paper
- Pencils
- Rulers

Suggested Timeframe

(45-60 minutes)

- 15 minutes—Discussion
- 15 minutes—Student Worksheet
- 15-30 minutes—Post-worksheet discussion

Teacher Information

The following pages have background information for you and your students. Look over the lesson and see what the students will need to learn, and then read through the information provided. The first section is specific to the Willamette Valley; the second section is a global overview. It is recommended that you read through the information and become familiar with the projections. You may also wish to photocopy some of the sections for your students to read.

If you live outside the Willamette Valley in Oregon, find projections for climate impacts in your region by checking out the site http://www.globalchange.gov/. This resource provides a comprehensive guide to impacts in different regions of the United States.

Local Information

The following information is from the Preparing for Climate Change in the Upper Willamette River Basin of Western Oregon Executive Summary at

http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/UppWill%20Exec%20Sum%20FINALv2.pdf

In the fall of 2008, the University of Oregon's Climate Leadership Initiative (CLI) and the National Center for Conservation Science & Policy (NCCSP), in partnership with the Mapped Atmosphere-Plant-Soil-System (MAPSS) Team at the U.S. Forest Service Pacific Northwest Research Station, initiated a project to assess the likely consequences of climate change for the Upper Willamette River Basin. The Basin is defined as the region from the confluence of the McKenzie and Willamette rivers south and east to the headwaters of the South Fork Willamette, Middle Fork Willamette, and McKenzie rivers. Conditions in the Upper Willamette River Basin are projected to change substantially during the coming century due to changing global climate conditions. Some of the key projections include:

Temperature: average summer temperatures are likely to increase by 8 to 14° F by 2080. This equates to an average high temperature of 96°F for Eugene. This would be like living in the middle of the Mohave Desert in Palm Springs, CA.

Precipitation: overall precipitation may not change but more will fall during the winter months in the form of rain rather than snow. This means less skiing and more flooding!

Snowpack: the Pacific Northwest's snowpack is likely to decline by 80-90% by 2095 from current levels. Melting will occur earlier, leading to less storage for towns, cities, and farmers and increased flooding.

Storms and Flooding: storm events could increase in intensity resulting in more flooding.

Wildfire: potential increase in the frequency of wildfires with hotter, dryer summers and increased pests and diseases that kill off trees. This would lead to even more wildfires.

Vegetation change: current coastal spruce and fir may be replaced with mixed pine, hardwoods and oaks. The eastern portion may best support ponderosa pine and Douglas fir. Plant and wildlife communities are expected to take decades or centuries to adjust.

Aquatic Systems: changes are likely to be detrimental to reproduction and survival of many native fish and amphibians. This means a decline of the Chinook salmon, steelhead, and Oregon chub. Due to higher water temperatures, Chinook are likely to have the most problems. There will also be a potential for seasonal water shortages for Eugene.

Terrestrial Systems: Warmer temperatures and drought stressed vegetation are likely to provide more favorable conditions for disease, pests, and invasive species. For example, invasive species such as blackberry and bullfrogs will become more common across the landscape. The goods and services humans gain from natural ecosystems are likely to be negatively impacted and degraded.

Some of the key recommendations include:
Prioritize areas for protection from development and degradation; increase early detection and rapid response efforts to identify; manage, and control invasive species; base resource management decisions on a thorough understanding of the entire ecological system, climate change projections for the area, and careful consideration of the outcome of alternative management actions; adopt new conservation priorities; update methods for resource monitoring and evaluation; direct planners and managers to work across jurisdictions; replace the 'multiple use approach' to federal lands policy with a 'whole systems' approach.

More details can be found at:

http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/UppWill%20Exec%20Sum%20FINALv2.pdf

Global Information

Human Health

Climate change may affect people's health both directly and indirectly. For example, heat stress and other heat related health problems are caused directly by very warm temperatures and high humidity. Untreated, heat stress can be a very serious medical problem. In many places climate change is projected to increase the number of very hot days that occur during the year. More hot days increase the possibility of heat related health problems. Additionally, tropical diseases, such as malaria and dengue, might spread to larger regions.

Indirectly, ecological disturbances, air pollution, changes in food and water supplies, and coastal flooding are all examples of possible impacts that might affect human health. How people and nature adapt to climate change will determine how seriously it impacts human health. Some people and places are likely to be affected more than others. Generally, poor people and poor countries are less likely to have the money and resources they need to cope with preventing and treating health problems. Very young children and the elderly adults will also run the highest risks.

Source:
NASA, http://www.nasa.gov/worldbook/global warming_worldbook.html

Ecological Systems

Climate change may alter the world's habitats and ecosystems. Many of these habitats depend on a delicate balance of rainfall, temperature, and soil type. A rapid change in climate could upset this balance and seriously endanger many living things. Most past climate changes occurred slowly, allowing plants and animals to adapt to the new environment or move somewhere else. However, if future climate changes occur as rapidly as most scientists predict (and thanks to fragmented habitats), plants and animals may not be able to react quickly enough to survive. The ocean's ecosystems also could be affected in the same manner with further negative impacts resulting from ocean acidification. Acidification occurs due to absorption of excessive CO_2 in the atmosphere and leads to a lower level of reef building and survival of many marine species.

Sources:
NASA, http://www.nasa.gov/worldbook/global_warming_worldbook.html

NOAA, http://www.pmel.noaa.gov/co2/OA/Ocean_Acidification%20FINAL.pdf

Sea Levels

Climate change is causing sea levels to rise. Warmer weather makes glaciers melt and the resulting run-off flows to the ocean. Warmer temperatures also make water expand. When water expands in the ocean, it takes up more space and the level of the sea rises. Recent studies have shown that sea levels are rising much faster than earlier thought and could rise as much as three feet during the next century. This will affect both natural systems and manmade structures along coastlines. Coastal flooding is already causing saltwater to flow into areas where salt is harmful, threatening plants, animals and fresh water supplies in those areas.

For example, an increase in the salt content of the Delaware and Chesapeake bays is thought to have decreased the number of oysters able to live in those waters, impacting not just wildlife but also local economies. Oceanfront property would be affected by flooding, and beach erosion could leave structures even more vulnerable to storm waves. Some communities living on Pacific islands and coastal Alaska have had to relocate entirely. Rising sea levels will result in fierce winter storms and mammoth waves that the state's fragile shoreline can't rebuff. Riprap and seawalls already line parts of the coast to ward off strong wave action, but they tend to shift the energy elsewhere and scour the beach in front of the structures of sand. State geologists estimate that the beaches of Oregon could erode between 33 and 66 feet due to rising sea levels alone. Whether we move back from the water or build barricades in the face of a rising sea, it could cost billions of dollars to adapt to such change, making poorer communities disproportionately vulnerable to such impacts.

Sources:

NASA, http://earthobservatory.nasa.gov/IOTD/view.php?id=6638

NOAA, http://www.cop.noaa.gov/stressors/climatechange/current/sea_level_rise.html

Neils Bohr Institute, http://www.nbi.ku.dk/english/news/sea_level_rise_of_one_meter/

The Register Guard, http://www.registerguard.com/csp/cms/sites/web/news/sevendays/18135021-35/story.csp

Crops and Food Supply

Global warming may make the Earth warmer in cold places. People living in these places may have a chance to grow crops in new areas. But climate change also might bring droughts to other places where we grow crops. Additionally, climate change is predicted to bring extreme rain events, which will lead to flooding of prime agricultural land, resulting in crop loss. In some parts of the world, people may not have enough to eat because they cannot grow the food that they need. Malnutrition due to crop losses could be one of the greatest impacts that climate change poses public health.

Sources:

Kid's Newsroom, http://www.kidsnewsroom.org/climatechange/bigdeal.html

NASA, http://www.gsfc.nasa.gov/topstory/20021022cropdamage.html

The Lancet, http://www.thelancet.com/climate-change

For more information go to NASA's Global Climate Change webpage: *http://climate.jpl.nasa.gov*

Discussion

This outline highlights the key points to be shared with students.

1. Review the greenhouse effect.
2. Climate and Weather
   c. Define "climate." (Describes the total of all weather occurring over a period of years in a given place. This includes average weather conditions, regular weather sequences (like winter, spring, summer, and fall), and special weather events (like tornadoes and floods).
   d. Define "weather." (Describes whatever is happening outdoors in a given place at a given time. Weather is what happens from minute to minute.)
3. Introduce projected climate impacts.
   a. Average temperatures
   b. Annual precipitation
   c. Snow pack
   d. Extreme weather events

Lesson

1. As a review or introduction, write the word **climate** on the board and ask students to try to define it. Write down their suggestions on the board. Once the list is complete, help students synthesize their ideas into a class definition. For example, one definition might be: "Climate is how weather acts over a large area over many years." Have the students name different types of climate areas on Earth (for example, polar, deserts, Pacific Northwest, etc.)

   Use the following information to prepare for this lesson:

   - ***Weather*** describes whatever is happening outdoors in a given place at a given time. Weather is what happens from minute to minute. The weather can change a lot within a very short time. For example, it may rain for an hour and then become sunny and clear. Weather is what we hear about on the television news every night. Weather includes daily changes in precipitation, barometric pressure, temperature, and wind conditions in a given location.
   - ***Climate*** describes the total of all weather occurring over a period of years in a given place. This includes average weather conditions, regular weather sequences (like winter, spring, summer, and fall), and special weather events (like tornadoes and floods). Climate tells us what it's usually like in the place where you live. San Diego is known as having a mild climate, New Orleans a humid climate; Buffalo a snowy climate, and Seattle a rainy climate.

For more information on the differences between climate and weather see NASA's Education Site: *http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html*

2. Ask students to think about the term **global climate**. Ask them how global climate might differ from regional or local climate. Discuss with students that the term global climate describes Earth's overall climate variability — such as average temperature, average precipitation, average intensity of winds, and other conditions of Earth's overall atmosphere and at its surface — separate from any specific weather events or local climate conditions.
3. Ask the students some basic questions about extreme climate.
   a. What would "extreme" conditions look like in your area? (Tornados in the Midwest, extreme winter storms in the west, droughts in the southwest, etc.)
   b. Now that you have discussed as a group what extreme climate change might look like in your local area, watch this 15-minute video to see some effects of climate change across the globe: *http://www.teachers.tv/video/24992* (alternative: *http://www.youtube.com/watch?v=VH0TYRnlVVY*)
4. Distribute a copy of the **Student Worksheet** to each participant to be completed individually or in pairs.
5. When students have completed the worksheet do one or more of the following activities:
   a. Distribute the projections provided in the background section and have the students compare their projections with the scientists.
   b. Have the students get into small groups and discuss their projections
   c. Lead the whole class in a **discussion** of their projections. Look for any common themes and introduce the students to the scientist's projections.

Student Worksheet

Name:________________________________

Climate change is already beginning to happen in parts of the world. If you live in a chilly place like Alaska or Greenland, you might think a bit of **global warming** sounds like a great idea. But climate change doesn't necessarily mean things will get hotter. Some places will be hotter some of the time, but most places will simply see more **erratic** and **extreme weather**. That could mean more frequent intense storm events, more precipitation falling as rain instead of snow, longer periods of drought, more storms and hurricanes, and more frequent heat waves.

Think about your own community. How would things be different if there were extreme conditions of climate change?

Climate Change Impact	**How could it affect my family and me?**	**How could it affect animals?**	**How could it affect plants?**
Hotter summer days and nights			
Higher average temperatures			
Drier summers			
Less snow pack (more precipitation falling as rain, earlier snowmelt in spring)			
More intense storms			
Spread of tropical diseases and other heat related health issues			

Lesson 1C Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Communication	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
				Total Score	**/8**

Objective Check:

1. Name a projected local impact of global climate change on the following areas:
   b. Snow pack
   c. Annual precipitation
   d. Annual average temperature
   e. Plant life

(Answers will vary depending on your location, see information above.)

2. How will the world's human population be affected by the projected climate changes? (Increase in tropical diseases, food insecurity, higher temperatures which could lead to lower quality of life, changes in precipitation that will effect farmers, etc.)

Unit 1: Climate Change Quiz

Name:________________________

Multiple Choice: Read all possible responses and select the best answer.

1. **Climate is:**
    a. If it is raining or not today.
    b. The pattern of weather in a particular place.
    c. How sunny it is in California this week.
    d. All of the above.

2. **What is the difference between climate and weather?**
    a. There is no difference.
    b. Climate refers to weather conditions for a region over a period of time.
    c. Weather refers to climatic conditions for a region over a period of time.
    d. Climate is the location of the weather conditions at a particular time.

3. **Temperatures are projected to rise because**
    a. The sun is getting hotter.
    b. The moon is getting closer.
    c. Concentrations of heat-trapping greenhouse gases is increasing.
    d. Greater population numbers generate more body heat.

4. **Which of the following gases is not considered a major greenhouse gas?**
    a. Methane
    b. Water vapor
    c. Phosphorus trioxide
    d. Carbon dioxide

5. **Which of the following changes is not associated with increasing global temperatures?**
    a. Decrease in sea levels
    b. Increase in tropical diseases such as malaria and dengue
    c. Reduction in sea ice cover
    d. Increase in agricultural growing season in some parts of the world

6. **All of the carbon in existence is continually recycled in the carbon cycle.**
    a. True
    b. False

7. Where does the carbon come from that plants use?

a. Animals
b. Water
c. Air

8. What do humans do that leads to greenhouse gas emissions?

a. Drive cars.
b. Use electricity.
c. Produce food.
d. All of the above.

9. What are some projected impacts to human health from climate change?

a. Average life spans will increase
b. Malnutrition from impacts to agriculture
c. Fewer cases of cancer will appear
d. More brittle bone related injuries would occur

10. How do humans affect the carbon cycle?

a. Humans cut down trees and burn it causing stored carbon to be released to the atmosphere.
b. Humans eat plants and then release carbon during respiration.
c. Humans pump oil from the ground and burn it, pushing carbon into the atmosphere.
d. All of the above.

Short Answer

11. Name the three primary greenhouse gases:

1.

2.

3.

12. Name three of the projected local impacts due to higher concentrations of greenhouse gases:

1.

2.

3.

Climate Change Appendix 1

Resources

For more activities dealing with climate and weather, see NASA's Spaceplace: *http://spaceplace.nasa.gov/en/kids/tes/gases/index.shtml*

For additional information on the Carbon Cycle check out NASA's Earth Observatory: *http://earthobservatory.nasa.gov/Features/CarbonCycle/carbon_cycle.php*

For more information on the differences between climate and weather see NASA's Education Site: *http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html*

For more information on climate change, go to NASA's Jet Propulsion Laboratory page: *http://climate.jpl.nasa.gov*

To see how the Willamette Valley's climate will change in the next century check out: for changes in the Rogue River Valley see projections for California can be found at: *http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/sites/aaaweb5.uoregon.edu/files/reports/ExSumROGUE%20FINAL.pdf*

For general information about climate change, global warming and the effects of the increased presence of greenhouse gases, see the following NASA pages: *http://www.nasa.gov/worldbook/global_warming_worldbook.html*, *http://earthobservatory.nasa.gov/IOTD/view.php?id=6638*, and *http://www.gsfc.nasa.gov/topstory/20021022cropdamage.html*.

Additionally check out NOAA's *http://www.pmel.noaa.gov/co2/OA/Ocean_Acidification%20FINAL.pdf*, the Neils Bohr Institute, *http://www.nbi.ku.dk/english/news/sea_level_rise_of_one_meter/*, the Kid's Newsroom *http://www.kidsnewsroom.org/climatechange/bigdeal.html*, and the Lancet *http://www.thelancet.com/climate-change*

Is Climate Change for real? Some students will pose questions they have heard from other sources. Prepare yourself for these arguments by checking out these two sites, the first from the University of Oregon's Climate Leadership Institute: and the second from the US EPA *http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/Setting_record_Straight.pdf*

Climate Change Appendix 2

Word Search

Climate Change

Find the words in the grid.
Words can go horizontally, vertically and diagonally - backwards or forwards.

Z	N	G	L	W	B	V	R	R	D	R	O	U	G	H	T
T	A	E	H	C	L	Z	E	R	K	N	U	S	Y	E	B
L	L	C	G	N	K	T	G	D	G	H	B	K	R	L	G
L	L	X	P	M	A	H	R	B	K	P	D	U	A	N	T
A	A	T	T	W	M	H	G	N	M	W	T	N	I	W	T
B	F	K	B	C	D	K	E	P	V	A	K	D	Q	G	E
O	N	K	G	K	N	G	R	A	R	E	O	G	R	F	R
L	I	J	L	N	P	F	R	E	T	O	Z	L	E	T	E
G	A	D	R	T	I	P	P	E	L	W	Z	N	H	M	H
D	R	I	S	E	P	M	L	F	E	L	A	N	T	N	P
R	H	Z	C	N	E	E	R	R	M	N	N	V	A	F	S
Y	K	T	M	T	V	G	L	A	N	P	H	Z	E	P	O
N	M	Y	R	E	L	A	M	Y	W	L	V	O	W	M	M
E	C	J	L	A	L	S	N	Q	C	M	K	R	U	L	T
S	N	M	B	C	E	G	F	D	E	S	E	R	T	S	A
S	N	Y	L	L	F	F	M	C	X	C	N	D	R	N	**G**

This puzzle was made by K. Beke for learn-english-today.com, using 1-2-3 Word Search Maker™

atmosphere	earth	heat	sun
blanket	flooding	heatwave	temperature
desert	gas	level	warming
drought	global	rainfall	water
dryness	greenhouse	rise	weather

Climate Change Appendix 3

Word Search Key

Climate Change

Z	N	G	L	W	B	V	R	R	D	R	O	U	G	H	T
T	A	E	H	C	L	Z	E	R	K	N	U	S	Y	E	B
L	L	C	G	N	K	T	G	D	G	H	B	K	R	L	G
L	L	X	P	M	A	H	R	B	K	P	D	U	A	N	T
A	A	T	T	W	M	H	G	N	M	W	T	N	I	W	T
B	F	K	B	C	D	K	E	P	V	A	K	D	Q	G	E
O	N	K	G	K	N	G	R	A	R	E	O	G	R	F	R
L	I	J	L	N	P	F	R	E	T	O	Z	L	E	T	E
G	A	D	R	T	I	P	P	E	L	W	Z	N	H	M	H
D	R	I	S	E	P	M	L	F	E	L	A	N	T	N	P
R	H	Z	C	N	E	E	R	R	M	N	N	V	A	F	S
Y	K	T	M	T	V	G	L	A	N	P	H	Z	E	P	O
N	M	Y	R	E	L	A	M	Y	W	L	V	O	W	M	M
E	C	J	L	A	L	S	N	Q	C	M	K	R	U	L	T
S	N	M	B	C	E	G	F	D	E	S	E	R	T	S	A
S	N	Y	L	L	F	F	M	C	X	C	N	D	R	N	E

Unit 2: Home and School Energy

Unit Objectives and Standards

At the end of this unit the students will be able to:

- Know that energy from the sun (and derivatives like wind and hydropower) is available indefinitely and that other sources don't renew or renew slowly.
- Know that electrical energy can be produced from a variety of energy sources.
- Understand that different forms of energy have different environmental and climate-related consequences.
- Understand strategies for reducing home and school energy related climate impacts.
- Collect, organize and display sufficient data to support analysis. **(Science Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. **(Social Studies Standard)**
- Examine the various characteristics, causes, and effects of an event, issue, or problem. **(Social Studies Standard)**

Unit Background

Lesson 2A

Understanding Energy (60 minutes)

Lesson 2B

School Lighting Audit (75 minutes + possible extension)

Lesson 2C

What is Renewable Energy? (60-75 minutes)

Unit 2 Quiz

(15 minutes)

Unit 2 Appendix

Unit Background

In the last unit we learned about the role of greenhouse gases in climate change. We also began to look at the sources of the three main greenhouse gases: carbon dioxide (CO_2), nitrous oxide (NO_2) and methane (CH_4). In the next four units we will explore how we individually and collectively contribute to the increased concentration of these gases in the atmosphere. We will also look at an array of actions we can take to reduce their emission. This unit will focus on our home and energy use and how it is related to greenhouse gas (GHG) emissions.

After transportation, which accounts for approximately 33% of emissions, household emissions rank second at about 17% of total U.S. green house gas emissions. According to the United States Environmental Protection Agency, approximately 4 metric tons of carbon dioxide equivalent (CO_2e), almost 9,000 pounds per person per year are emitted from people's homes. Conserving energy by turning off lights, appliances, hot water, heaters, and air conditioning when you're not using them is one excellent way to reduce your greenhouse gas emissions. Although low or no-emissions energy supplies, like wind, solar or hydropower, may provide the cleanest supply of electricity, minimizing the energy we need is still an important first step.

The lessons in the unit will cover the following in greater detail:

- Electricity is a secondary energy source, the majority of which is generated by burning fossil fuels.
- Even if your energy source is "clean," like hydropower, utility providers buy electricity off the "grid" during peak energy times. This power is often fossil fuel generated.
- Fossil fuels are non-renewable and produce GHG emissions.
- There are many simple ways to reduce your consumption of electricity at home and in school.
- Renewable energy sources provide GHG-free electricity and are becoming less expensive and more commonly available.
- Home and school energy reduction will help mitigate GHG emissions but ultimately a larger effort will be needed in order to reduce the nation's total emissions.

Lesson 2A—Understanding Energy

Objectives

- Students will understand the basic concepts and vocabulary of electricity generation.
- Students will begin to understand the connection between electricity use and greenhouse gases.
- Students will develop an understanding of what appliances are using energy.
- Students will learn ways to reduce electricity use in their home.

Materials

- A small electrical appliance such as a microwave, toaster or hair dryer
- Pencil
- Classroom set of the Student Worksheet
- Calculator

Suggested Timeframe

(60 minutes)

- 10 minutes—Introduction to unit
- 15 minutes—Lesson discussion and demonstration
- 15 minutes—Student worksheet
- 20 minutes—Post-worksheet discussion

Teacher Information

When you drive to the store, take a shower or turn on a computer, you're using energy. Electricity is the most common form of energy we use at home and at school. It is a secondary energy source, which means that we get it by converting other sources of energy, such as coal, oil, natural gas, uranium (for nuclear energy), biomass, water, wind or sunlight into electricity.

To produce electricity, power plants use a primary energy source for heating water to produce steam. Then the steam turns a series of blades on a turbine connected to a generator. As the turbine rotates, spinning bundles of copper wire in the generator create a magnetic field that causes electrons to move from atom to atom. This movement of electrons makes an electric current.

While electricity is itself a clean source of energy, the majority of electricity in the United States is generated from power plants that burn fossil fuels (coal, natural gas, and less frequently, oil). These power plants emit large amounts of carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, and other emissions that affect air quality and/or the climate. Fossil fuels are referred to as non-renewable sources of energy because they cannot be quickly replenished. Fossil fuels formed from the fossilized remains of plants and animals that lived millions of years ago. Uranium, an ore, is also nonrenewable, but is not a fossil fuel and does not result in greenhouse gas emissions when converted into electricity. However, power plants using uranium produce radioactive wastes that will be dangerous for 300,000 years.

Electricity is measured in units of power called watts. The amount of electricity we use over a period of time is measured in kilowatt-hours (kWh). A kWh is the energy of 1000 watts acting for one hour. For example, if you use a 100-watt light bulb for ten hours, you use 1000 watt-hours of energy, or 1 kilowatt-hour. Likewise, if you use ten 100-watt light bulbs for one hour, you use 1 kilowatt-hour.

Energy conservation means reducing unnecessary energy use. Consuming less energy reduces the amount of carbon dioxide and other pollutants released into the atmosphere when that energy comes from fossil fuels. There are many simple ways that students and their families can conserve energy at home and at school, including using energy efficient appliances and electronics, adjusting the heating or air conditioning thermostat, using compact fluorescent bulbs or natural light when possible, caulking doors and windows to minimize drafts, lowering the temperature setting of the water heater, and turning off lights and appliances that are not in use. Finally, purchasing renewable power from your local utility can minimize the impact of the energy that you do use. Find out whether your utility offers a renewable energy program and share with students how their families can sign up for it.

Discussion

This outline highlights the key points to be shared with students.

1. Electricity is a secondary energy source.
2. The majority of electricity in the US is generated from power plants that burn fossil fuels.
   a. These fossil fuels are non-renewable
   b. Burning fossil fuels produces carbon dioxide and nitrogen oxides, both major greenhouse gases.
3. Unless you are using a renewable energy source such as solar, hydro, or wind power, every time you consume electricity you are adding greenhouse gases to the atmosphere.
4. Basic electricity vocabulary
   a. Kilowatt (kW)
   b. Kilowatt-hour (kWh)
5. Conserving energy not only reduces the amount of greenhouse gas emissions, but saves money as well.

Lesson

1. Use an electrical appliance to complete a task. Examples include microwaving a bag of popcorn, toasting a piece of bread or using a hair dryer to blow-dry a wet spot on a cotton shirt.
2. Describe what appliance you will be using to the class. Ask the students what they think is needed in order to complete the task; make sure that "energy" is included in the list.
3. Explain that electrical consumption is stated in kilowatt-hours. Most electrical devices list power consumption in watts. Define kilowatt (kW), kilowatt-hour (kWh), and if you choose to, ampere (or "amps") and volt:
   a. Kilowatt (kW) - One thousand watts. A watt is a measure of power that an appliance uses. It is calculated by multiplying the voltage by the current.
   b. Kilowatt-hour (kWh) – A measure of electrical energy calculated by multiplying the number of kilowatts an appliance uses by the time in hours an appliance is used.
   c. Ampere – The measure of the flow of electricity through an appliance.
   d. Volt – The amount of "push" being applied through an appliance. The standard voltage in the US is 110 or 120 V.
4. Find out the cost of a kWh from your local electricity provider (a rough approximation is $0.10). (See the graphic in Teacher Information for an explanation.)
5. Ask the students what information would be needed in order to determine the cost of energy used. (Answer: the amount of time the appliance is used, wattage of appliance and the cost per kilowatt-hour used)
6. Have students guess how much the energy needed to complete the task will cost.
7. Have a student examine the appliance and locate its power consumption information in watts.
8. Distribute Student Worksheet then pop the popcorn, toast some bread, or use the hair drier to dry something. As a class, use the calculation on the worksheet to determine what the cost of the demonstration was.
9. Now ask the students to fill out the Home Appliance List and, using the Appliance and Energy Use Table as a reference, determine the amount of energy some common household appliances use and how much it costs to operate these appliances. Students should list what appliances they have in their home and estimate the time of use. Some students may ignore items like water heaters; you may have to prompt them and help them determine the amount of time these "unseen" appliances are used.
10. Go through a sample calculation with the students. Use the plasma TV example or do one of your own. Check for understanding to ensure that the students are doing their math correctly.

Discussion Questions

Check results with the students and discuss the comparisons among the energy costs for each activity. Ask some or all of the following questions:

- How are electricity costs related to greenhouse gases?
- How are greenhouse gases related to climate change?
- What are some obvious ways you could reduce your energy costs (and therefore your GHG emissions)?
- Who do you think is responsible for reducing energy use in your home? Why?
- How does home energy consumption relate to global climate change?

Example 1: Use one 100-Watt light bulb for 10 hours:

100 Watts x 10 hours = 1000 Watt-hours = 1 kilowatt-hour = 1 kWh

Example 2: Use ten 100-Watt light bulbs for 1 hour:

10 bulbs x 100 Watts each = 1000 Watts. 1000 Watts x 1 hour = 1000 Watt-hours = 1 kWh

Source: *Dan Morehouse, Eugene Water and Electric Board, http://www.eweb.org/Public/documents/energy/Energy_Smart_Operations_Tips.pdf*

Brainstorm

Now that you know where energy is being used and how much it costs, come up with other ways that students and their families could reduce energy use in their homes. Possible answers might include:

- Lowering the temperature by two degrees when present and ten degrees at night or if the house is empty
- Turning down the water heater to 120 degrees
- Turning off computers when not in use
- Turning off lights when not in use
- Hanging out washing to dry in the summer
- Washing clothes with cold water
- Taking shorter showers
- Keeping the fridge door closed
- Waiting until the dishwasher is full before running it on a short cycle
- Bigger changes, like adding insulation to the walls and roof and sealing drafts

Optional Extra Credit

What changes do you plan to make? Try to be as specific as possible. Assign the students to work with their family to create an energy-reduction action-plan. The students could bring in a list of three concrete steps they and their family pledge to do. Have their parents or guardians sign the plan as proof to their commitment.

Supplementary Information on Energy Production

In this discussion, make sure the students understand how electricity is produced in their community, and that burning coal or natural gas to produce electricity means that every time you use electricity, you are emitting GHGs. Even if your community uses primarily hydro electricity, at peak times the electrical utility is probably supplementing it with electricity generated using coal or natural gas. Likewise, the use of natural gas for cooking, heating, and hot water heating, while more efficient than converting that gas into electricity and the using it, is a fossil fuel and still results in the release of GHGs. The result is that your home energy use is likely to increase GHG emissions unless you are using 100% renewable energy.

Student Worksheet Name:______________________________

Use the following calculations to determine the amount of energy used during the demonstration.

Calculation:

STEP 1

(______ X ______) /1,000= ______ kWh (energy used)
Watts Ave X Daily use (hrs)

STEP 2

(____________ X .10) = $______ Daily cost
kWh (from step one) X cost per kW

STEP 3

(_____________ X 365) = $ ______ Annual cost
Daily cost (from step two) X days in a year

Now try to calculate how much it costs to run all of the appliances in your home over the course of a year.

1. Start by listing all of the appliances that you know are used in your home using the Appliance and Energy Use Table provided. If your appliance is not on the list and you have access to a computer, use this link to look it up: *http://www.eere.energy.gov/consumer/your_home/appliances/index.cfm/mytopic=10040.*
2. Use the calculations above to estimate how much it costs to run each of these annually. Fill in the Home Appliance List with this information. Then, add up the annual cost for each item to get a total annual cost.
3. For some helpful advice on reducing your energy costs visit: *http://www.consumersenergy.com/apps/pdf/More-100-ways-save-on-bill12-06.pdf.*

Home Appliance List

Appliance	Watts	kWh (Watts x hours of use ÷1000)	Daily Cost (kWh x0.10) $	Annual Cost (Daily cost x 365) $
Example: TV (Plasma)	340w	340w x 3h ÷1000 = 1.02kWh	1.02 kWh x $0.10 = $.102	$.102 x 365 = $37.23

Appliance and Energy Use Table

How Much Energy Used in an Hour?

Item	Average Watts	Item	Average Watts
Clothes dryer	5060	Electric kettle	1500
Electric Oven	4400	Older fridge (pre-1994)	460
Wall Heater	1500	Newer fridge	250
Electric Furnace	6250	Coffee Maker	900
Clothes washer	1400	Range burner	800
A/C (window, medium sized)	1000	Clock Radio	4
Box fan	100	Microwave	1350
Ceiling fan	75	Toaster	1200
Hair dryer	1300	Dishwasher (no water heater)	900
Iron	1200	Dishwasher (with water heater)	3600
Halogen floodlight	300	Computer/printer	215
Regular (incandescent) light bulb	100	Laptop	45
Compact Fluorescent bulb	20	Cell Phone Charger	2
Nightlight	5	HD Cable Box	45
TV (CRT)	89	Xbox 360	185
TV (Plasma)	340	PS2	30
TV (LCD)	210	Nintendo Wii	18

Source: *http://michaelbluejay.com/electricity/howmuch.html*

Lesson 2A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Communication/ Brainstorming Session	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
				Total Score	/8

Objective Check:

1. What is a kilowatt-hour? (the amount of power in watts x the time used)
2. How does home electricity use relate to greenhouse gas emissions? (electricity is a secondary source of energy, which is often generated by burning greenhouse gas emitting fossil fuels.)
3. Name three ways you can reduce the amount of energy consumed in your home: (Answers will vary. Ex. Turn off lights when you leave a room, lower your thermostat, unplug appliances when not in use…)
4. What are three high-energy use appliances found in your home? (Answers will vary. Refrigerator, freezer, furnace, water heater, dryer, etc.)

Lesson 2B—School Lighting Audit

This lesson has been adapted from Benchmark Guide for An Integrated Sustainable Energy Education, by Managenergy, *http://www.managenergy.net/tg_education.html*

Objectives

- Students will learn one way that schools use energy and the associated costs.
- Students will learn problem-solving skills in addressing ways the school can reduce its lighting use.

Suggested Timeframe

(75 minutes)

- 15 minutes—Discussion
- 30 minutes—Data collection
- 30 minutes—Data analysis/discussion

Materials

- Pencil
- Paper
- Calculator

Teacher Information

School activities need appropriate lighting. Lighting accounts for 20-25% of schools' total energy use, with a cost of thousands of dollars per year. Yet schools typically operate during daylight hours and many classrooms have large windows that could offer sufficient lighting (daylighting).

The analysis of lighting in the school can be broken down into the following categories:

- Classrooms (general lighting and specific task lighting).
- Corridors and passageways.
- Special purpose areas such as toilets, the library, cafeteria, the gym, shops and the office.
- Indoor and outdoor security lighting.

Discussion:

This outline highlights the key points to be shared with students

1. Review: Electricity use and GHG emissions.
2. School lighting accounts for 20-25% of total school energy use.
   c. Costs thousands of dollars a year.
   d. Classrooms often have windows that make electric lighting excessive.
5. School Lighting
   a. Classrooms
   f. Corridors
   g. Special purpose areas
   h. Indoor and outdoor lighting
4. Ideas for reducing lighting in the school

Preparation

- Photocopy a class set of Student Table—School Lighting Audit worksheets.
- Prepare a way of recording and presenting class data (poster, overhead, computer projector—class data form).

Lesson

1. Evaluate lighting in the school by assigning groups to different rooms in the school. The students should complete the Student Table—School Lighting Audit for as many classrooms, hallways, and other locations in the school. (*Alternatively, if this is not practical, choose a typical classroom and multiply by the number of similar classrooms in the school.)* **Record the:**
   - Number of light bulbs or tubes.
   - Type of lights (incandescent or fluorescent).
   - Size of lights (number of watts). Most lights in the school are a single wattage. Find out from the custodian a typical fluorescent tube's wattage in order to help the students.
   - Type and size of curtains (if present at windows).
   - Estimate the daily hours of usage of lights.

- Try to observe the rooms:
  1. Before school.
  2. During morning classes.
  3. At recesses and lunchtimes.
  4. During afternoon classes.
  5. After school.
  6. Night time (for optional extra-credit: find a volunteer to stop by the school after hours in order to count the number of rooms with lights still on).

  Ask the janitor how long lights are on during cleaning and whether they are turned off afterwards.

  An example of the calculations is given on the first line.

2. When the students are finished with their audit, have them return to the classroom and record their data on the class data form.
3. Determine how much the school spends on lighting for a day, a week, and a school year. (The $0.10 cost for kWh is an estimate, so contact your local utility provider to get a more accurate figure).

Discussion Questions

Discuss some or all of the following questions:

- Is there enough natural light to turn off the lights during part of the day?
- Are all the lights in a room necessary to keep the room sufficiently illuminated?
- Are there incandescent lights that could be replaced by fluorescent lights?
- What plan could be implemented to ensure that the lights are turned off when not in use? If lights are left on at night for security, could fewer be left on?
- What uses of technology could be justified to reduce lighting bills? (Are motion detectors worth the investment? Note: They typically are worthwhile in public buildings.)
- How would the school benefit from reduced lighting?
- What steps would we have to take to make these changes in our school?
- What other uses of energy in your school could be audited in this way?
- How does reducing electricity costs relate to GHGs?

Optional Activity: Get Involved In Your School Community!

This activity should be looked as supplementary to the core climate change curriculum. The process can be long and at times, frustrating. However, the payouts could be tremendous and the students will learn a great deal about local politics.

Many school districts are looking for ways to cut costs and making ends meet. Budget experts have determined that American schools spend more money on heating and lighting than they do on textbooks. In the 1990s, German schools had come to the same conclusion and they started the 50/50 program. (For more information see: *http://tve.org/ho/series1/reports_13-18/5050_Germany.html*). For schools that embarked upon energy conservation initiatives, this program returned half of the savings back to the general fund for each participating school. This gave the schools an incentive for imaginative ways of cutting electrical consumption and therefore GHGs.

Have the students develop a plan to develop a similar program in your school. Have them discuss the steps that would be necessary to start a pilot program. Keep in mind that the students would have to contact the school district, petition the school board, and get broad community support for their program. They would need to explain to the decision-making body that there would be some initial investment in energy monitoring equipment but those costs would be offset in the long run.

Student Worksheet—School Lighting Audit

Name:________________________

Room	Number of lights (N)	Light Wattage (w)	Total Watts Used (N x W)	Kilowatts (total Watts + 1000)	Operating time/day (hrs)	Daily Consumption (kWh)
Total						

Total kW*hr x $0.10 (cost/kW*hr) = **Total Cost=**

Lesson 2B Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Data Collection	Raw data is recorded appropriately.	Some raw data is recorded.	The wrong raw data is recorded.	No raw data is recorded.	
Communication/ Discussion of results	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
Get Involved/ Participation	Active engagement in discussion on energy reduction plan. Contributes regularly.	Engagement in discussion on energy reduction plan. Contributes occasionally.	Attempts to contribute to discussion but lacks engagement.	Does not participate in discussion. Not engaged.	
				Total Score	/12

Objective Check:

1. What ways could your school reduce its lighting costs? (Answers will vary. Examples include turning off the lights when not in use, decreasing the number of lights used for security, changing incandescent lights to fluorescent)
2. How would you try to encourage others to reduce the amount of money the school pays on lighting? (Answers will vary. Examples include writing letters to your principal or school board, asking parents to write letters, create a petition to be signed by other students, etc.)
3. Name two positive consequences to reducing lighting use at school (lower GHG emissions, saves school money that can be used for more needed purposes).

Lesson 2C—What is Renewable Energy?

Objectives

- Students will learn about the different types of renewable energy sources.
- Students will learn the advantages and disadvantages of these energy sources.

Suggested Timeframe

(60-90 minutes)

- 10 minutes—Discussion
- 15 minutes—Students work on their summaries
- 10 minutes—Students present information
- 15-30 minutes—Energy in the Round Game
- 10 minutes—Unit Summary

Materials

- Computer with PowerPoint
- Renewable Energy Sources Handout
- Butcher paper or easels with chart paper.
- Markers

Teacher Information

Individuals are looking for ways to lower energy costs for their businesses, homes, schools, and transportation. Our primary energy sources today are fossil fuels, which result in GHG emissions and other forms of pollution both in combustion and extraction. Another concern is the depletion of fossil fuels. According to researchers at the University of Michigan, if consumption continues at the current rate, the fossil fuel supply could be gone before the end of the century. (Source: *http://www.umich.edu/~gs265/society/fossilfuels.htm*) Finally, because many of our fossil fuels are imported from politically unstable countries, there are socio-political risks associated with our use of fossil fuels. In short, we are at a crossroads. Americans must use and develop alternate forms of energy to help us power our homes, automobiles, and businesses into the future without destroying the earth's environment for ourselves, future generations and other species. Exploring the use of renewable and alternative energies is a necessity in today's world.

Use of renewable energy is an important step towards becoming independent from fossil fuels and decreasing our dependency on energy sources from outside our borders. However, it is important to remind the student that the most significant and cost-effective step they can take is to reduce their own consumption of energy. Reduce first, and then use renewable energy for the power we cannot currently do without. Keep in mind that even if your energy source is "clean," like hydropower, the utility provider needs to buy electricity off the "grid" during peak energy times. This electricity is often fossil fuel generated. The bottom line is that every kind of energy, no matter how clean, has some impact on the environment.

Discussion

This outline highlights the key points to be shared with students.

1. Burning fossil fuels to produce electricity results in GHG emissions.
2. Fossil fuel supplies could be gone before the end of the century (non-renewable)
3. Conservation/efficiency paired with the use of renewable or alternative energy sources allow us to become independent from fossil fuel sources.
4. Types of renewable energy sources
    a. Hydropower
    b. Biomass/Bioenergy
    c. Geothermal Energy
    d. Wind Energy
    e. Photovoltaic Cells/Solar
    f. Unit summary

Preparation

- Photocopy a class set of the Renewable Energy Sources Handout.
- Set up five easels with one title on each: Hydropower, Biomass/Bioenergy, Geothermal Energy, Wind Energy, and Photovoltaic (PV) Cells/Solar.
- Make cards for the Energy In the Round game.

Lesson

1. Write the five categories of renewable energy on different charts. You will need one chart per type of energy. Divide the students into groups representing each energy source: Hydropower, Biomass/Bioenergy, Geothermal Energy, Wind Energy, and Photovoltaic (PV) Cells/Solar.
2. Give the groups 15 minutes to read the section of the handout on their renewable energy source and summarize their findings on the chart paper for all to see:
   a. An explanation of the energy source.
   b. Examples of the energy source.
   c. A cost per kWh (if available).
   d. Examples of how this renewable energy source could be used in their home or school (if applicable).

   (If there is time and access to a computer, allow the students more time to find additional information.)
3. Have a spokesperson for each group take 1-2 minutes to present their information to the class, highlighting the important facts.
4. After all groups have had the opportunity to discuss their charts start the Energy In the Round Game. See 2C—Energy In The Round Game for instructions.

Student Handout— Renewable Energy Sources

Hydropower

Hydropower (or hydroelectricity) is currently the most widely used renewable source of energy in the world. Worldwide hydropower represents 19% of total electricity production. The US is the fourth largest producer of hydroelectricity in the world and it accounted for 7.1% of the nation's electricity production in 2006. In 2008, there were 78,000 Megawatts of hydroelectricity being produced, enough to meet the residential needs of more than 14 million people.

Converting flowing water into usable energy produces hydropower. Most of this water comes from rivers and is released through turbines to produce energy. Although this power source does not release pollution or greenhouse gases, it is expensive and time consuming to build, is rain dependent, can harm fish and wildlife, displace people, and alter the quality of water. Finally, the die-off of plants and organic matter beneath the water surface results in methane emissions, a potent greenhouse gas. The impact of these emissions is under debate.

Sources:

USGS, http://ga.water.usgs.gov/edu/wuhy.html

US Energy Information Administration, http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table3.html

Bureau of Reclamation, http://www.usbr.gov/power/edu/pamphlet.pdf

Biomass/Bioenergy

Biomass energy is derived from three distinct energy sources: wood, waste, and alcohol fuels. Wood energy is derived both from direct use of harvested wood as a fuel and from wood waste streams. The largest source of energy from wood is pulping liquor or "black liquor," a waste product from processes of the pulp, paper and paperboard industry. Waste energy is the second-largest source of biomass energy. The main contributors of waste energy are municipal solid waste (MSW), manufacturing waste, and landfill gas. Biomass alcohol fuel, or ethanol, is derived almost exclusively from corn.

Waste from paper mill operations is the main source of fuel for biomass energy production in the United States. Alternatively, Europe draws its main source of fuel for biomass energy from wood and wood waste. Finally, developing nations make timber their main source of fuel for biomass energy.

In 2008, biomass produced about 11,000 Megawatts of renewable electricity in the United States (approximately 1.1% of the electricity generated in the US.) Worldwide, according to statistics from the International Energy Agency, 11% of energy (but not electricity) generated is from biomass.

Sources:

US Energy Information Administration, http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table4.html

European Biomass Industry Association, http://www.eubia.org/about_biomass.0.html

Geothermal Energy

Geothermal energy is contained in underground reservoirs of steam, hot water, and hot dry rocks. In electric generating facilities, hot water or steam extracted from geothermal reservoirs in the Earth's crust is supplied to steam turbines at electric utilities that drive generators to produce electricity. Moderate-to-low temperature geothermal resources are used for direct-use applications such as district and space heating. Lower temperature, shallow ground geothermal resources are used for geothermal heat pumps to heat and cool buildings.

In 2008, geothermal energy's electricity capacity in the US is about 2,244 Megawatts (approximately 0.23 percent of electricity generated in the US.)

Sources:

US Energy Information Administration, http://www.eia.doe.gov/cneaf/solar.renewables/page/geothermal/geothermal.html

http://tonto.eia.doe.gov/energy_in_brief/renewable_energy.cfm

Wind Energy

The sun's uneven heating of the atmosphere, irregularities of the Earth's surface, and the rotation of the Earth create winds. As a result, winds are strongly influenced and modified by local terrain, bodies of water, weather patterns, vegetative cover, and other factors. Wind turbines use two or three long blades to collect the energy in the wind and convert it to electricity. The blades spin when the wind blows over them. The energy of motion contained in the wind is then converted into electricity as the spinning turbine blades turn a generator. To create enough electricity for a town or city, several wind turbine towers need to be placed together in groups or rows to create a "wind farm." Wind-based electricity generating capacity has increased markedly in the United States since 1970, although it remains a small fraction of total electric capacity. (24,000 Megawatts in 2008 or 1.6 percent of total US electrical generation).

Areas with the best wind resources include portions of the following states: North Dakota, Texas, Kansas, South Dakota, Montana, Nebraska, Wyoming, Oklahoma, Minnesota, Iowa, Colorado, New Mexico, California, Wisconsin, and Oregon. In general, wind is consistent and strong enough in the Great Plains states and mountain passes in the various mountain ranges throughout the United States to generate electricity using wind turbines. The Rocky Mountain and Great Plains states have sufficient wind resources to meet 10 to 25 percent of the electric power requirements of these states.

Sources:
US EPA, http://www.epa.gov/RDEE/energy-and-you/affect/non-hydro.html#wind

US Energy Information Administration, http://www.eia.doe.gov/cneaf/solar.renewables/page/wind/wind.html

Photovoltaic (PV) Cells (Solar Power)
Photovoltaic devices use semi-conducting materials to convert sunlight directly into electricity. Solar radiation, which is nearly constant outside the Earth's atmosphere, varies with changing atmospheric conditions (clouds and dust) and the changing position of the Earth relative to the sun.

Solar resources are available everywhere in the United States, although some areas receive less sunlight than others, depending on the climate and seasons. The greatest solar resources are located in the Southwestern states, where sufficient solar energy falls on an area of 100 miles by 100 miles to provide all of the nation's electricity requirements.

In 2008 the US generated 514 Megawatts of electricity using Solar Power (approximately 0.04 percent of electricity generated in the US).

Sources:
US EPA, http://www.epa.gov/RDEE/energy-and-you/affect/non-hydro.html#wind

US Energy Information Administration, http://www.eia.doe.gov/cneaf/solar.renewables/page/solarphotv/solarpv.html

Energy in the Round Game

(Adapted from the "Energy in the Round" game developed by The National Energy Education and Development Project; *www.need.org)*

Energy in the Round is a quick, fun game to reinforce information about energy sources, forms of energy, and general energy information.

1. Copy one set of the Energy in the Round cards onto card stock and cut into individual cards.
2. Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
3. Have the students look at the bold words at the top of their cards.
4. Choose a student to begin and give the following instructions:
5. Read Question 1 on your card: The student with the correct answer will stand up and read the bolded answer, "I have _____."
6. That student will then read Question 1 on his/her card, and the round will continue until the first student stands up and answers a question, signaling the end of the round.
7. Continue the game with Rounds 2 and 3.
8. If there is a disagreement about the correct answer, have the students listen to the question carefully (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.
9. More topics and cards can be found on the website at *www.need.org*.

I HAVE PROPANE.

1. Who has the energy source converted directly into electricity using PV cells?
2. Who has the sector of the economy that uses about 36 percent of the nation's energy?
3. Who has the processes of surface, deep, underground, room-and-pillar, and longwall?

I HAVE BIOMASS.

1. Who has the energy sources that are replenished in a short time?
2. Who has the transportation fuel that can be made from biomass?
3. Who has the group of nonrenewable energy sources used most in the U.S.?

I HAVE SOLAR.

1. Who has an energy concept based on efficiency and conservation?
2. Who has the process during which precipitation replenishes oceans, rivers, and lakes?
3. Who has the alcohol made by adding yeast to biomass?

I HAVE RENEWABLE.

1. Who has the energy source that generates more than half of the nation's electricity?
2. Who has the number one state for producing natural gas?
3. Who has the gas that becomes a liquid under moderate pressure or when cooled?

I HAVE LIGHT.

1. Who has the sector of the economy that makes the goods and materials we use every day?
2. Who has the energy source two-thirds of which is imported from other countries?
3. Who has the energy carrier that may become a significant transportation fuel in the future?

I HAVE COAL.

1. Who has a renewable fuel often made from corn that costs more than gasoline, but burns cleaner?
2. Who has what can use many different fuels to produce most of the electricity in the U.S.?
3. Who has the type of bulb that includes compact fluorescents?

I HAVE ENERGY SUSTAINABILITY.

1. Who has the energy source transported by one million miles of underground pipeline?
2. Who has the resource that fuel cells use to generate electricity?
3. Who has the energy source that produces volcanoes and hot springs?

I HAVE ETHANOL.

1. Who has another word that describes thermal energy?
2. Who has what can be changed into other forms, but cannot be created or destroyed?
3. Who has the process in which atoms are split apart, releasing energy as heat and radiation?

I HAVE NATURAL GAS.

1. Who has the energy source that makes renewable methane gas?
2. Who has a secondary source of energy defined as moving electrons?
3. Who has the state that is number five in coal production?

I HAVE HEAT.

1. Who has the energy source caused by uneven heating of the earth's surface?
2. Who has the process in which water, carbon dioxide and sunlight are turned into glucose and oxygen?
3. Who has the energy source that requires the earth's gravity to work?

I HAVE URANIUM.

1. Who has the resources that can be categorized as either renewable or nonrenewable?
2. Who has the type of energy sources used mainly to make electricity?
3. Who has the energy source that consists mostly of methane?

I HAVE ENERGY SOURCES.

1. Who has the production facility where electricity is generated?
2. Who has the portable energy source used in barbecue grills and hot air balloons?
3. Who has the energy sources whose supplies are limited?

I HAVE NUCLEAR FISSION.

1. Who has another word for radiant energy from the sun?
2. Who has the effect that traps heat in the atmosphere?
3. Who has the renewable energy source that produces most of its electricity in California?

I HAVE TEXAS.

1. Who has the process of evaporation, condensation, and precipitation?
2. Who has the energy source that is produced in the Ring of Fire in the Pacific Ocean?
3. Who has the nuclear combining process that gives off radiant energy?

I HAVE ENERGY.

1. Who has the process green plants use to change radiant energy into chemical energy?
2. Who has the process nuclear power plants use to produce electricity?
3. Who has the energy source of which most is refined into gasoline?

I HAVE THE WATER CYCLE.

1. Who has the process used to reach energy sources buried underground?
2. Who has the type of energy sources in which fossil fuels are grouped?
3. Who has the sector of the economy that uses natural gas and propane the most?

I HAVE PHOTOSYNTHESIS.

1. Who has the number one petroleum producing state?
2. Who has the form of energy plants transform and store in their leaves and roots?
3. Who has the energy source whose waste products will soon be stored in Nevada?

I HAVE MINING.

1. Who has the energy source Dr. Walter Snelling discovered in 1911?
2. Who has the process in which helium atoms are made by combining hydrogen atoms?
3. Who has the gases that are more than 97 percent water vapor?

I HAVE POWER PLANT.

1. Who has the energy source that comes from the earth's core?
2. Who has the belief that every generation should meet their energy needs without compromising the energy needs of future generations?
3. Who has another word for thermal energy?

I HAVE INDUSTRY.

1. Who has the ability to do work or make a change?
2. Who has the energy source that is transported chiefly by train?
3. Who has the type of energy source that includes biomass, solar, geothermal, hydropower, and wind?

PAGE 50 Games and Icebreakers

Lesson 2C Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Chart/ Explanation of the Energy Source	Clearly communicates what the energy source is and how it works.	Shows a basic understanding of the energy source and how it works	Struggles to show a basic understanding of the energy source.	Shows no understanding.	
Chart/Examples	Clearly communicates examples	Shows basic understanding of examples.	Struggles to show examples.	No examples are given.	
Chart/Cost per kWh	Has the correct cost per kWh	Has a reasonably close cost per kWh	Has the incorrect cost.	No cost given.	
Chart/Examples of use in home or school.	Gives multiple uses for home and school.	Gives some uses for home and school.	Gives one use for home or school.	Gives no use for home or school.	
Game/Energy in the Round	Actively participates in the game. Shows understanding of the rules.	Some participation of the game. Does not show a clear understanding of the rules.	Does not understand the game nor participate without guidance.	Does not participate.	
				Total Score	**/12**

Objective Check

1. Name four types of renewable energy. (Answers will include hydropower, biomass/bioenergy, geothermal energy, wind energy, and photovoltaic (PV) cells/solar)
2. Choose one type of renewable energy and list one advantage and one disadvantage of using this energy. (Answers will vary. Example: Solar, advantage: unlimited clean energy source, disadvantage: high cost.)

Unit 2: Home and School Energy Quiz

Name:________________________

Multiple Choice: Read all possible responses and select the best answer.

1. **Which of the following sources produces the most electricity in the US?**
   a. Hydro
   b. Biomass
   c. Solar
   d. Wind

2. **What steps can you take to help reduce energy costs around the house?**
   a. Locate and seal up drafts around doors, windows, and baseboards with caulk or weather-stripping
   b. Add insulation to the attic and walls
   c. Turn off heating and air conditioning system when you're away
   d. All of the above

3. **True or false; the capacity of electrical generation from renewable sources is increasing.**
   a. True
   b. False

4. **Making your home more energy-efficient will have which of the following environmental benefits?**
   a. Reduce water pollution
   b. Help protect endangered species
   c. Lower greenhouse-gas emissions
   d. All of the above

5. **On average, which is the "cleaner fuel" in terms of emissions of the greenhouse gas CO_2?**
   a. Electricity from a coal-fired power plant
   b. Natural gas
   c. Electricity from a hydroelectric power plant
   d. Wood

6. **Energy efficient appliances are often more expensive than non-efficient ones. How can you justify spending more on the efficient ones?**
   a. You cannot justify buying the more expensive one.
   b. Your electricity bills will be smaller and eventually your savings will be greater than the difference in costs.
   c. The more expensive one is probably a better brand.
   d. Simply on looks.

7. **What is an action your school could take to reduce its electricity bills?**
   a. Install motion detectors in hallways so lights go off when no one is in the hall.
   b. Instruct custodians to turn off all unnecessary lights after school hours.
   c. Do a lighting audit to make sure there are not too many lights in a single room.
   d. All of the above.

8. **Which of the following items consume the most electricity?**
   a. Clothes dryer
   b. Oven
   c. c. Light bulb
   d. Old fridge

9. **Which of the following actions will save the most electricity over time?**
   a. Hang your laundry on a clothesline instead of using a clothes dryer
   b. Use a microwave oven instead of a regular oven
   c. Replace a regular light bulb with a compact fluorescent bulb
   d. Replace an old fridge with a brand new one

10. **Which of the following is NOT a renewable source of energy source?**
   a. Solar
   b. Wind
   c. Coal
   d. Biomass

Short Answer

11. Name a form of renewable energy:

12. What is an advantage to using that energy source?

13. What is a disadvantage of using that energy source?

14. Name four strategies that you can do to reduce your home-related greenhouse gas emissions:

1.
2.
3.
4.

Unit 2 Quiz Key

1. A
2. D
3. A
4. D
5. C
6. B
7. D
8. A
9. A
10. C
11. Answers will vary
12. Answers will vary
13. Answers will vary
14. Answers will vary but could include:
    - Turn off lights when not in use
    - Turn down the thermostat
    - Turn down the water heater
    - Air-dry clothes.Unit Quiz Key

Home and School Energy Appendix

1. For a number of energy-based activities, readings and games see the National Energy Education Development Project's website: *http://need.org/*

2. Another nice collection of energy-based lesson plans are provided by the Bonneville Power Administration's Energy Smarts Team Training Manual *http://www.bpa.gov/corporate/kr/ed/energysmarts/homepage.htm*

3. The Institution of Energy and Technology's Faraday program has an interesting role-playing lesson plan built around debating renewable energy sources. *http://faraday09.theiet.org/teachers/sb/Renewable-energy-role-play.pdf?type=pdf*

4. The American Forest Foundation has a lesson plan designed to identify ways to save energy in our daily lives and understand how that will reduce air pollution. Waste Watchers can be found at (permission required for reproductions): *http://apps1.eere.energy.gov/education/lessonplans/pdfs/efficiency_wastewatchers.pdf*

5. The Earthday Network and Redefining Progress have a lesson plan focused on the history of energy use and renewable energy sources. They provide suggestions for a discussion/debate regarding renewable sources. *http://www.earthday.net/lesson%20plans/Renewable%20Energy.pdf*

Unit 3: Transportation

Unit Objectives

At the end of this unit the students will be able to:

- Understand that different modes of transportation and different transportation fuels have varied impacts on the climate.
- Describe how daily (transportation) choices of individuals, taken together, affect global resource cycles, ecosystems and natural resource supplies.
- State a clear proposal in support of a position.
- Listen critically and respond appropriately.
- Understand strategies for reducing transportation related greenhouse gas emissions.
- Identify how technological advances have changed our use of energy. (**Science Standard)**
- Collect, organize and display sufficient data to support analysis. (**Science Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. (**Social Studies Standard)**
- Examine the various characteristics, causes, and effects of an event, issue, or problem. (**Social Studies Standard)**
- Examine a controversial event, issue, or problem from more than one perspective. (**Social Studies Standard)**

Unit Background

In the last unit we looked at practical ways of reducing our home and school energy use. By reducing electricity use we can reduce the greenhouse gas (GHG) pollution we emit. Now we are going to shift our reduction focus to the fastest growing sector of GHG emissions: transportation.

According to the US Environmental Protection Agency (EPA), the transportation sector made up 29 percent of the nation's GHG emissions in 2006. Emissions are increasing more rapidly in this sector than in any other, and account for nearly half of the net increase in total US emissions since 1990. Transportation is the greatest end-use source of the most prevalent greenhouse gas, CO_2. These figures do not account for emissions associated with the lifecycle processes of fuel extraction and refining, vehicle manufacturing, and road construction and maintenance – all of which result in significant GHG pollution.

Individual transportation emissions can be significantly reduced through a number of strategies. These include:

- The use of alternative modes of transportation like walking, biking, carpooling and public transportation whenever possible.
- Avoiding unnecessary trips and practicing "trip chaining," or combining trips, to decrease the number of miles driven.
- Keeping up with vehicle maintenance. Well-maintained vehicles achieve greater mileage, with an average improvement of four percent and as much as 40 percent for major repairs. Properly inflating tires improves vehicle efficiency by an average of 3.3 percent.
- Leaving heavy items at home. Miles per gallon decreases by two percent for every extra 100 pounds. A loaded roof rack decreases efficiency by five percent.
- Smart driving:
  - Avoiding aggressive driving (rapid acceleration and braking as well as speeding), which can lower highway mileage by 33 percent and in-town mileage by five percent. Cruise control can help maintain constant speeds and usually saves gas.
  - Idling for more than thirty seconds uses more gas than turning off the car and restarting it. Although many drivers idle to warm up their vehicle, the best thing for modern vehicles is to drive off slowly to warm up the catalytic converter and other moving parts.
- When driving is necessary and when vehicle options are available, using the least emissions-intensive vehicle available. This might be a vehicle that achieves high mileage per gallon like a hybrid; an all electric vehicle; or one that can substitute biofuels like non-food crop based ethanol or biodiesel for gasoline and diesel respectively. Biofuels are discussed in more detail in the introduction to lesson 3A on transportation fuels.
- Considering mode of travel (bus, train, airplane, passenger vehicle) for long-distance and vacation travel. A new report on greenhouse gas emissions and long distance travel from the Union of Concerned Scientists has some surprises about the efficiency of airplanes and car travel, amongst other interesting information. Check out the report at: *http://www.ucsusa.org/assets/documents/clean_vehicles/greentravel_slick_opt_web.pdf*
- Finally, supporting policies and programs that build and maintain the infrastructure for these modes of transportation can lead to substantial collective emission reductions.

If you are a resident of Lane County, Oregon contact CLI at ***climlead@uoregon.edu*** for Lesson S5, Getting to School Efficiently. This lesson highlights some of the transportation resources available to Lane County residents.

Sources:

US Environmental Protection Agency, "Transportation and Climate," http://www.epa.gov/oms/climate/ Retrieved 22 September, 2009.

US Department of Energy, fueleconomy.gov http://www.fueleconomy.gov/feg/drive.shtml Retrieved 22 September, 2009.

Lesson 3A—Transportation Fuels Debate Game

(Adapted from the "Transportation Fuels Debate Game" developed by The National Energy Education and Development Project; *www.need.org)*

Objectives

- Students will become familiar with the different types of fuels available for transportation, and the advantages and disadvantages of each.

Suggested Timeframe

(60-80 minutes)

- 10 minutes—Introduce the unit
- 10 minutes—Introduce the game
- 20-30 minutes—Game
- 10-20 minutes—Post-game discussion

Materials

- A set of Transportation Fuels Debate Sheets for each team
- A set of Yes/No cards for the judges
- A transparency of the Game Board

Teacher Information

Student teams will learn about transportation fuels and then will be assigned to represent the different fuels. Working cooperatively, the students develop arguments and debate the merits of their type of fuel over the others.

Nearly all of the energy used for transportation in the United States is petroleum-based. More than half of the fuel is gasoline, used in automobiles and other highway vehicles. The remainder comes from other fuel uses, like diesel for freight trucks and jet fuel for airplanes.

New information on the connections between GHGs and transportation is constantly being published. The game cards will provide you with information on various fuel sources, and you will find greater detail on biofuels below.

Biofuels are made from renewable biomass sources. Ethanol is a replacement for gasoline, while biodiesel is a replacement for diesel. Biofuels produce fewer GHG emissions at the tailpipe than their fossil fuel based counterparts. However, a look at the full lifecycle emissions of the fuels (often called a well to wheel analysis) that includes producing the feedstock, the manufacturing process, as well as land use changes from growing the feedstock provides a more robust picture of the emissions associated with all fuels. Research published by the California Environmental Protection Agency Air Resources Board reveals that when land use changes are included in the analysis, our current corn-based ethanol actually results in slightly higher emissions than gasoline. However, non-food crop based ethanol results in much lower emissions than gasoline, even when accounting for land-use changes.

Take a look at their website for the most up to date information: http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Source:
United States Environmental Protection Agency, "2009 US Greenhouse Gas Inventory Report." http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Discussion:

This outline highlights the key points to be shared with students.

1. Transportation accounts for approximately 29% of the GHG emissions in the US.
   b. Transportation emissions are increasing every year.
   c. Transportation emissions would be even greater than 29% if lifecycle emissions, like those from fuel extraction and vehicle manufacture, were included in the count.
2. Many different types of fuel are available (brainstorm a list).
   a. Gasoline
   b. Diesel
   c. Ethanol
   d. Hybrid Electric
   e. Compressed or liquefied natural gas (CNG/LNG)
   f. Electricity
   g. Biodiesel
   h. Hydrogen
3. All sources have advantages and disadvantages (purpose of the game).

Preparation

- Decide which fuels you will be using for the debate depending upon the number of students in the class or group. You need a minimum of three students in each group.
- Make a copy of the Debate Sheets you will be using for each group.
- Make a transparency of the game board for the debate. Write in the fuels you have chosen for the debate in the blocks at the top of the board. The teacher can mark teams' progress on the game board, erasing past moves.
- Make sets of Yes/No cards for the judges.
- Divide the class into each of the fuel groups.

Lesson

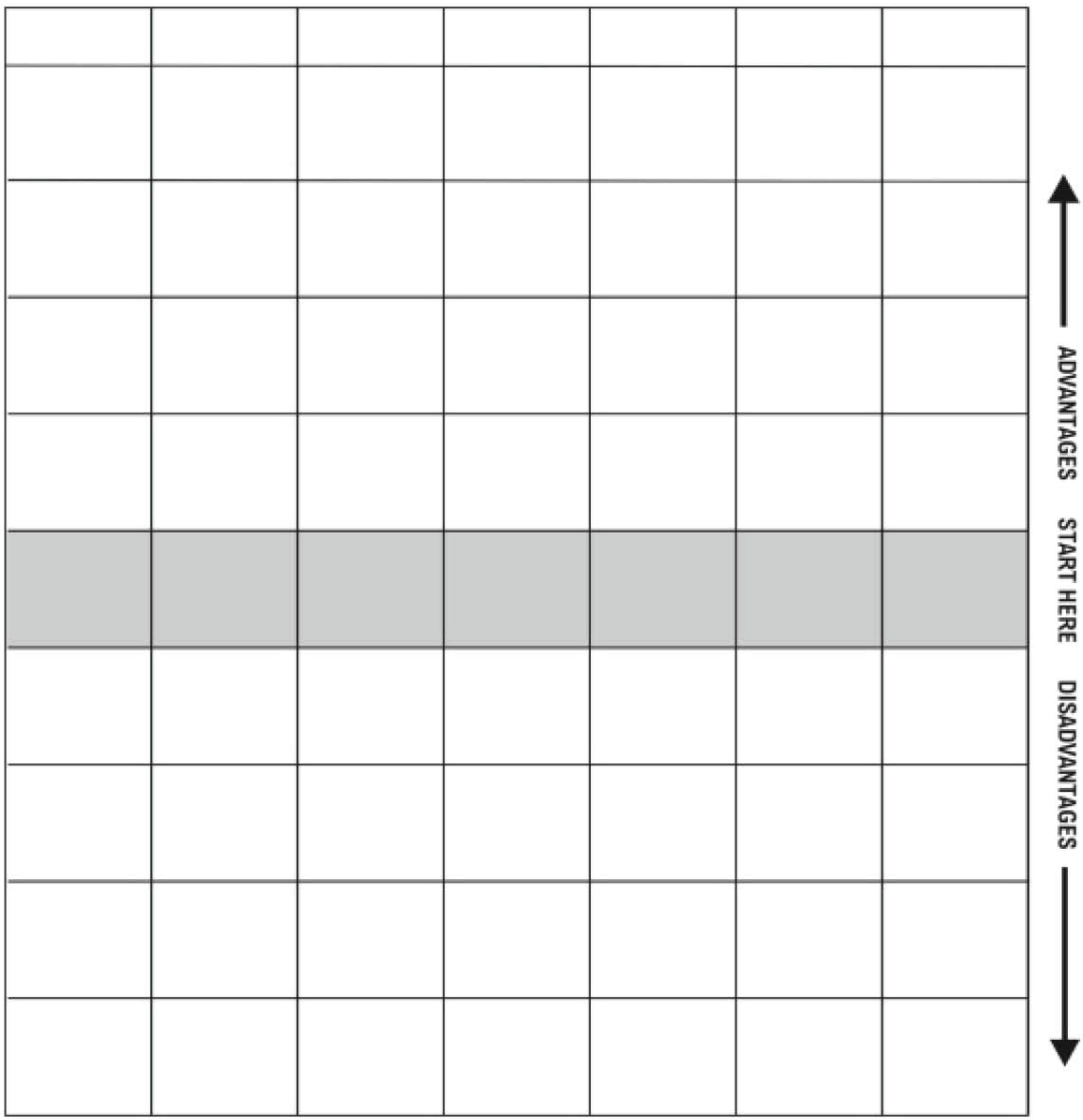
1. Introduce the game to the class and assign a fuel to each group.
2. Have the groups complete the sheets for all fuels.
3. Begin the game by sharing the goal of the game: to reach the top of the game board. Teams have two choices when it is their turn. They can present an advantage of their fuel, so as to advance their own team. Or, they can present a disadvantage of another team's fuel to move that team backwards on the game board.
4. Ask the first team to present an advantage of their fuel to initiate the game.
5. Each succeeding team decides whether to present an advantage or disadvantage.
6. An advanced version of the game would include allowing teams to contest an advantage or disadvantage posed by another team. If playing the game in this way, you may want to appoint judges or serve as a judge.
7. Action continues until one team reaches the top line.
8. If the game goes quickly, you may have time to play again, reassigning fuels or allowing a different team to start the game.

Discussion Questions

Discuss all or a few of the following questions after the game:

- Did all fuels have advantages and disadvantages?
- Was the winner the best fuel (in terms of GHG emissions or other factors)?
- If the game continued, would the results change? Why or why not?
- What are some other factors that we need to consider in our choice of transportation fuels?
- What fuel do you think would be the best for a personal vehicle and why?
- If all fuels have some drawbacks, how can we lessen our fuel use? (e.g., walk or carpool when possible, trip chain, avoid trips, maintain vehicles, etc.)
- Why do we use transportation fuels that have negative impacts on the environment? (This question could lead to a broader discussion of cost, infrastructure, and the history of transportation and our current mobility needs.

TRANSPORTATION FUELS DEBATE GAME BOARD



Gasoline

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Gasoline is a petroleum-based fossil fuel made of hydrogen and carbon.			
2. The chemical formula for gasoline is $C_8H_{15\text{-}18}$.			
3. Petroleum is a nonrenewable source of energy.			
4. Forty-five percent of crude oil is refined into gasoline in the U.S.			
5. The octane rating for gasoline is 86 to 94.			
6. Gasoline has a high energy content of 114,000 Btu/gallon and produces 19.6 lbs/gal of CO_2.			
7. More than 95 percent of the vehicles in the U.S. use petroleum-based fuels.			
8. The U.S. has a vast infrastructure of refineries, pipelines, and filling stations to distribute gasoline efficiently and conveniently.			
9. The U.S. imports about two-thirds of the crude oil it uses from other countries.			
10. There are about 170,000 gasoline fueling stations in the U.S.			
11. There are about 200 million cars in the U.S. that use gasoline.			
12. The average gasoline-powered vehicles travels 12,000 miles per year.			
13. Vehicles that use petroleum-based fuels emit air pollutants.			
14. In the last 50 years, gasoline-powered vehicle emissions have decreased an average of 95 percent.			
15. In many metropolitan areas, vehicles contribute about half of the air pollution.			
16. Almost half of the people in the U.S. live in areas that do not meet air quality standards.			

DIESEL

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Diesel is a petroleum-based fossil fuel made of hydrogen and carbon.			
2. The chemical formula for diesel is $C_{16}H_{34}$.			
3. Petroleum is a nonrenewable source of energy.			
4. Diesel has a very high energy content; it contains 18-20 percent more energy per gallon than gasoline, and produces 22.4 lbs/gal of CO2.			
5. About ten gallons of diesel are produced from every 42-gallon barrel of crude oil.			
6. Diesel is used in internal combustion engines designed specifically for diesel fuel.			
7. Diesel is used in more than two-thirds of all farm equipment because it can power demanding work.			
8. Ninety-four percent of the goods in the U.S. are moved by diesel-powered vehicles.			
9. The U.S. has a vast infrastructure of refineries, pipelines, and filling stations to distribute diesel efficiently and conveniently.			
10. The construction industry uses diesel-powered vehicles to perform heavy-duty jobs.			
11. Vehicles that use petroleum-based fuels emit air pollutants.			
12. In the last 50 years, petroleum-fueled vehicle emissions have decreased an average of 95 percent per vehicle.			
13. Today, there are approximately seven million commercial trucks and 700,000 buses on U.S. roads that use diesel.			
14. Diesel vehicles built today are eight times cleaner than those built 15 years ago.			
15. Using low sulfur diesel fuel and advanced exhaust control systems can reduce particulate emissions by 90 percent and nitrogen compounds by 25-50 percent.			
16. Almost half of the people in the U.S. live in areas that do not meet air quality standards.			

Unit 3

Propane (LPG)

	It's a Fact	Relevant: Advantage	Relevant: Disadvantage
1. Propane is a fossil fuel, sometimes called liquefied petroleum gas or LPG.			
2. The chemical formula for propane is C_3H_8; propane is a hydrocarbon.			
3. Propane is a by-product of petroleum refining and natural gas processing.			
4. Propane is a nonrenewable source of energy.			
5. Under normal pressure and temperature, propane is a gas. Under moderate pressure or lower temperature, propane can be converted into a liquid and stored in pressurized tanks.			
6. As a liquid, propane is 270 times more compact than as a gas.			
7. There is an infrastructure of pipelines and distribution terminals in the U.S. to transport propane.			
8. There are about 2,300 propane vehicle fueling stations in the U.S.			
9. Propane has been used as a transportation fuel for more than 75 years.			
10. About three percent of propane consumption is for transportation.			
11. After petroleum-based fuels, propane is the most widely used and accessible transportation fuel.			
12. Today, about 270,000 vehicles, mostly fleet vehicles such as mail trucks, use propane fuel.			
13. For fleet vehicles, the cost of using propane is five to 30 percent less than gasoline.			
14. Propane is cleaner burning than gasoline and produces less air pollution.			
15. The octane rating for propane (104) is equal to or higher than that of gasoline.			
16. It costs about $2,500 to convert a conventional automobile engine to use propane fuel.			

ETHANOL

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Ethanol is an alcohol fuel made by fermenting the sugars in grains and other plants.			
2. The chemical formula for ethanol is C_2H_5OH.			
3. The most commonly used processes today use yeast to ferment the sugars to produce ethanol.			
4. A new process being developed uses enzymes to break down the cellulose in woody fibers, making it possible to produce ethanol from trees, grasses, and crop residues.			
5. Ethanol is made from renewable sources of energy.			
6. The use of ethanol provides new markets for U.S. agriculture.			
7. Since ethanol contains oxygen, adding it to gasoline reduces ozone-forming and carbon monoxide emissions.			
8. Gasoline containing 10 percent ethanol--E10--is used in many urban areas that fail to meet air quality standards for carbon monoxide and ozone.			
9. Vehicles can use E10 without any changes to their engines.			
10. The Federal government provides incentives to use ethanol.			
11. E-85 is a mixture of 85% ethanol and 15% gasoline—but only specially designed vehicles can use it.			
12. Flexible fuel vehicles (FFVs) are manufactured to use any combination of ethanol and gasoline up to E85.			
13. Today there are about 7 million FFVs that can use E85.			
14. The octane rating for ethanol is 100, slightly higher than that of gasoline.			
15. The energy content of E-85 is about 27% less than that of gasoline, but ethanol produces 19-52% less CO_2 per gallon than gasoline, depending on the feedstock.			
16. There are more than 2,200 E85 fueling stations in the U.S., mainly in the Midwest and South.			

Unit 3

CNG/LNG

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Natural gas can be used as a vehicle fuel when it is compressed (CNG) or liquefied (LNG) by lowering its temperature to -259ºF.			
2. The formula for natural gas is CH_4.			
3. Natural gas is a nonrenewable fossil fuel.			
4. Natural gas is a clean-burning fuel. It emits 25% less CO_2 and up to 99% less particulate emissions than gasoline.			
5. Methane--the main ingredient in natural gas--can be produced from biomass, a renewable energy source.			
6. When compressed, natural gas has less energy per gallon than gasoline, so vehicle range is shorter unless additional tanks are added, which reduces payload capacity.			
7. CNG has an octane rating of 120+, which provides good power and acceleration to vehicles.			
8. Today, there are about 140,000 vehicles in the U.S. that run on CNG.			
9. Conventional vehicle engines can be converted to use CNG at a cost of $2,000 - $3,000, depending on the number of pressurized tanks installed.			
10. The production and distribution systems for natural gas are in place, but the delivery system of fueling stations is not extensive.			
11. CNG vehicles are well suited for fleets that have their own refueling stations.			
12. There are about 3,100 vehicles in the U.S. that run on LNG.			
13. LNG takes up much less space than CNG, so the tanks are much smaller.			
14. LNG tanks must be kept cold, which uses energy.			
15. CNG and LNG tanks are designed to be safe in case of accidents.			
16. There are about 1100 natural gas refueling stations in the U.S.			
17. There are significant emissions released in processing and transporting CNG, much of this comes from the process of liquefying the gas for transport in LNG tankers.			

ELECTRICITY

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Electricity can be produced by many sources of energy.			
2. Electric vehicles must have batteries that can be discharged and recharged repeatedly.			
3. Most batteries cannot store large amounts of electricity, so electric vehicles must carry several batteries.			
4. In some electric vehicles, the batteries constitute half the weight of the vehicle.			
5. The batteries in electric vehicles must be replaced every three–six years.			
6. A typical electric vehicle can travel 50 - 130 miles between charges.			
7. Weather conditions, terrain, and accessory use can reduce the range of an electric vehicle.			
8. Electric vehicles are best suited for neighborhood vehicle use, for consumers going short distances at 30 mph or less.			
9. Extensive research is ongoing to develop longer-lived batteries that will also extend the range of electric vehicles.			
10. Electric vehicles produce no tailpipe emissions.			
11. Some power plants that generate electricity, such as coal-fired plants, produce air pollution and GHGs.			
12. It is easier to control the emissions from power plants than from vehicles.			
13. Electric vehicles are low maintenance; they require no tune-ups, oil changes, water pumps, radiators, injectors, or tailpipes.			
14. Electric vehicles can be recharged at home at night when electricity rates and demand are low.			
15. There are about 440 electricity refueling stations, mostly in California and Arkansas.			
16. Consumers who drive electric vehicles receive tax incentives.			

Unit 3

Hybrid Electric

	It's a Fact	Relevant: Advantage	Relevant: Disadvantage
1. Hybrid vehicles have two power sources––an energy conversion unit (such as an internal combustion engine) and an energy storage device (such as a battery).			
2. The typical hybrid on the market today has a gasoline-powered engine and an electric motor with a battery.			
3. Hybrid electric vehicles (HEVs) can have either a series or parallel design.			
4. In a parallel design, the engine and motor are connected directly to the vehicle's wheels. The primary engine is used for highway driving; the electric motor provides added power during periods of high demand.			
5. In a series design, the primary engine is connected to a generator that produces electricity. The electricity charges the batteries and drives a motor that powers the wheels.			
6. HEVs can function as purely electric vehicles for short trips, using the internal combustion engine only when longer range or more power is required.			
7. HEVs can get twice the fuel economy of comparable conventional vehicles.			
8. HEVs have generators powered by the internal combustion engines to recharge the batteries when they are low.			
9. HEVs have regenerative braking systems that capture excess energy when the brakes are engaged; this recovered energy is also used to recharge the batteries.			
10. HEVs still produce 19.6 lbs CO_2/gal of gasoline burned but reduce air pollutants over gasoline powered vehicle due to better fuel economy.			
11. HEVs have a higher purchase price than comparable gasoline-powered vehicles.			
12. Tax incentives and superior fuel economy produce savings over the life of the vehicles to make them competitive with gasoline-powered vehicles.			
13. Today, there are several hybrids available to consumers, including the Toyota Prius, Honda Insight and Civic, and Ford Escape SUV.			
14. HEVs on the market today average 40-60 mpg and can travel 500-700 miles on one tank of gasoline.			
15. Within the next few years, there will be many models of HEVs to meet consumer needs, including trucks and SUVs.			
16. Hybrids use established gasoline fueling stations.			

BIODIESEL

	It's a Fact	Relevant: Advantage	Relevant: Disadvantage
1. Biodiesel is a fuel made by chemically reacting alcohol with organic fats, oil, or grease. Most biodiesel is made from soybeans.			
2. Biodiesel is a renewable fuel.			
3. Biodiesel is usually blended with diesel fuel in different percentages, such as B20, which is 20 percent biodiesel.			
4. Neat (or pure) biodiesel (B100) can also be used as a transportation fuel.			
5. Biodiesel fuels can be used in regular diesel engines without modifications.			
6. Biodiesel fuel can be used in the existing fuel infrastructure.			
7. Biodiesel is the fastest growing alternative transportation fuel.			
8. Biodiesel contains no sulfur and can reduce the amount of sulfur in the nation's diesel fuel supply.			
9. Adding biodiesel in small amounts to regular diesel fuel improves the lubrication qualities of diesel fuel without sulfur.			
10. Biodiesel can improve the smell of diesel fuel.			
11. Biodiesel emits 75% less CO2 than diesel and reduces air pollutants such as particulates, carbon monoxide, hydrocarbons and air toxics compared to regular diesel.			
12. Using biodiesel slightly increases the emissions of nitrogen oxides.			
13. There are approximately 1600 biofuel fueling stations in the nation.			
14. Biodiesel is well suited for fleets with their own refueling stations.			
15. Biodiesel fuel is more expensive than regular diesel fuel.			
16. Using biodiesel can reduce maintenance cost because of its good lubricating characteristics.			

Unit 3

METHANOL

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Methanol, or wood alcohol, is a simple alcohol fuel.			
2. Methanol (CH_3OH) is made by replacing one hydrogen atom of methane with a hydroxyl radical (OH).			
3. Methanol can be produced from natural gas, coal, oil, or biomass.			
4. Today, most methanol is made from natural gas.			
5. Most methanol plants are located in conjunction with ammonia plants, since both use the same gas in the production process.			
6. Methanol was widely used to produce MTBE, a gasoline additive in declining use because of concerns about ground water pollution.			
7. Methanol can be used in its pure form (M100) or blended with 15 percent gasoline (M85).			
8. No major auto manufacturers offer methanol-compatible vehicles at this time.			
9. The cost of M85 is equal to or slightly higher than premium gasolines.			
10. There is no distribution infrastructure for methanol today.			
11. With an octane rating of 105, methanol can provide superior power to vehicles and is used in several racing classes.			
12. Methanol is a cleaner burning fuel than gasoline, producing fewer hydrocarbon emissions.			
13. Methanol produces more formaldehyde emissions than gasoline.			
14. Today, there are about 4,600 vehicles in the U.S. that use M85.			
15. M85 has lower energy content than gasoline, so vehicle mileage is reduced.			
16. Vehicles that use methanol must use a special, expensive lubricant.			

HYDROGEN

	IT'S A FACT	RELEVANT: ADVANTAGE	RELEVANT: DISADVANTAGE
1. Hydrogen is the most abundant element in the universe.			
2. Pure hydrogen does not exist on Earth; it is only found in molecules with other elements.			
3. Hydrogen is a gas at normal temperature and pressure.			
4. Hydrogen can be produced from water by electrolysis, a process in which water molecules are separated into hydrogen and oxygen using electricity. The generation of electricity typically produces GHGs.			
5. Today, it takes more electricity to electrolyze water than is produced by the hydrogen fuel.			
6. Hydrogen can be produced from natural gas, coal, or biomass.			
7. Today, most hydrogen comes from the steam reforming of natural gas, a nonrenewable energy source.			
8. Fuel cells use hydrogen and oxygen to produce electricity without harmful emissions; water is the main by-product.			
9. No hydrogen production or distribution infrastructure exists at this time.			
10. Hydrogen gas takes up six times as much space as gasoline per energy equivalent.			
11. The production of hydrogen is very expensive today.			
12. Fuel cells are an expensive method of producing electricity today.			
13. Hydrogen is the fuel used in the space shuttles.			
14. There no hydrogen fuel cell vehicles on the market today and only 35 fueling stations for test vehicles.			
15. There is ongoing research into hydrogen fuel cell technology.			
16. The Bush administration has launched a hydrogen fuel cell initiative to support research and development of new technologies.			

Lesson 3A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	**Score**
Rules of the game	Follows rules correctly without guidance.	Follows rules correctly with some guidance.	Does not follow rules without guidance.	Does not follow rules and required a great deal of guidance.	
Knowledge of the purpose of the game.	Understands the purpose of the game without significant guidance.	Has a general understanding of the purpose with some guidance.	Has very little understanding of the purpose of the game even with guidance.	Does not try to understand the purpose of the game even with guidance.	
Participation in the game	Participates fully in the game without guidance.	Participates in the game with some guidance.	Participates with a great deal of guidance.	Does not participate in the game.	
Game/ Teamwork	Collaborates with, seeks views of, and exchanges ideas with others in order to integrate them into the task.	Requires guidance to collaborate with others, acknowledges some views, and exchanges some ideas.	Requires guidance to collaborate with others, does not acknowledge others and does not exchange ideas.	Is unsuccessful when working with others, disregards the views of others and does not contribute.	
	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
				Total Score	**/20**

Objective Check

1. Name four of the different types of transportation fuels that are available. (Answers will vary but should include gasoline, diesel, ethanol, hybrid electric, CNG/LNG, electricity, biodiesel, hydrogen)
2. Choose one of the types of fuel and list two advantages and two disadvantages of using this fuel. (Answers will vary. Example: Hydrogen advantages—low CO_2 emissions, great abundance, disadvantages—expensive technology, difficult to carry.)

Lesson 3B—Lowering Our Transportation Emissions

Objectives

- Students will develop an understanding of the impact of their transportation choices on CO_2 emissions.
- Students will be introduced to the term "CO_2 footprint" and will consider how to reduce their footprint size.

Suggested Timeframe

- 10 minutes—Discussion
- 30 minutes—Activity
- 20 minutes—Post-activity discussion

Materials

- Computer with Internet access
- School population data (how many students attend your school?)
- Pencil

Teacher Information

According to the US EPA, passenger cars and light trucks account for more than half of all transportation emissions. Therefore, the way we get to and from school can affect our personal and collective greenhouse gas emissions.

Another factor to consider is cost; the average US vehicle that is driven 10,000 miles per year costs $0.70 per mile, or over $7,000 per year. These costs, however, do not account for the social and environmental impacts of driving. Each mile of driving an average passenger vehicle emits about a pound of CO_2, but it's extremely difficult to calculate the direct and indirect costs that pound of CO_2 has on individuals, communities and ecosystems.

By analyzing the mode of transportation they use to get to and from school students can identify ways to reduce their GHG emissions, save money and even improve their health (if they choose to use a human powered mode of transportation.)

Sources:

American Automobile Association "Your Driving Costs" (2009) http://www.aaaexchange.com/Assets/Files/200948913570.DrivingCosts2009.pdf

United States Environmental Protection Agency, "2009 US Greenhouse Gas Inventory Report." http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Discussion:

This outline highlights the key points to be shared with students.

1. Review the fact that nearly 30% of US GHG emissions come from transportation.
   a. Fastest growing sector for GHG emissions
   b. More than half those transportation emissions are from passenger cars and light trucks.
   c. In communities using low-emissions sources of home energy, transportation can play a greater role in the overall GHG emissions profile.
2. Many modes of transportation produce a lower per capita emission than a solo car trip
   a. Bus
   b. Light rail
   c. Carpooling
3. Human powered modes produce no GHG emissions outside of those associated with the production of the bike, skateboard, etc.
4. Students may not currently have the ability or option to travel by a low-emissions mode, due to where they live, their family's comfort level with alternative modes, physical disabilities, or other reasons. However, as their life circumstances change, so might their transportation options.
5. Introduce Activity

Sources:

EPA http://www.epa.gov/ttn/chief/conference/ei16/session5/davies_pres.pdf

Sightline http://www.sightline.org/maps/charts/Climate-EmBySector Data from 2003

Preparation

1. Photocopy a class set of the Student Worksheets.
2. Make a copy of the section choices (different modes of transportation) and write/post it so all students can see it.
3. Write the address of the school where all students can see it.
4. Create a poster, overhead or other way of displaying the **Class Data Summary** so that students may add their data.

Lesson

1. Distribute the Student Worksheets.
2. Ask the students to think about the response to the following question: How do you typically get to and from school?
3. Refer them to the four stacks of worksheets based on the transportation modes (below) and have them select and fill out the Student Worksheet: Transportation Emissions that corresponds with the way they typically get to school.

If you get to and from school by:
Answer the following worksheet:

Car, alone (with driver)
Worksheet A

Carpool – with other students, or
dropped off by a parent/guardian/other
Worksheet B
on the way to work or elsewhere

Walk, bike or other zero-emission mode
Worksheet C

Bus – public or school bus
Worksheet D

4. Once students are finished, have them anonymously record their data on the appropriate Class Data Summary, depending on their mode of transportation. Responding anonymously will decrease the chance of students feeling singled out because of their transportation choices.
5. The teacher then discusses the results of the four Class Data Summary sheets. See discussion questions listed.

Discussion Questions

Once every student has completed the data summary, discuss results. Some suggested questions:

- Looking at the Class Data Summary, what is the most common way students in your class get to and from school? Why do you think this is the case?
- Which mode of transportation generates the most CO_2 per person in your class?
- Which mode of transportation generates the most CO_2 as a category in your class?
- How many students generated "zero" pounds of CO_2 from their commute?
- If the rest of the school is like your class, what would the school's commuting emissions be? (Multiply the class total by the number of classes in the school.)
- If the rest of the district/state is like your school, what would the district/state's commuting emissions be? (Multiply the school total by the number of schools in the district/state).
- What are some of the obstacles to using alternative transportation and how can they be overcome?
- Does your school or community offer incentives to students who carpool, ride the bus, bike or walk? What are these incentives and how effective are they?
- What are some other ways to encourage alternative modes of transportation?
- List the benefits of using alternative transportation.
- How might your class/school/district/state decrease its transportation CO_2 footprint?

Student Worksheet A: Name:____________________________

Car/driving alone

Answer

1. **How many miles do you drive to school each day?** Find out the round trip distance from your home to school. You can do this by going to either *www.mapquest.com* or *http://maps.google.com/* and put in the address of your home and school to calculate the distance. __________**miles**

2. **How many miles per gallon does your vehicle get?** Determine the average fuel economy of the vehicle being used in miles per gallon by checking *www.fueleconomy.gov* __________**mpg**

3. **Estimate gallons of gas consumed each day** getting to and from school by dividing the miles driven by the miles per gallon (miles driven/miles per gallon = gallons of fuel consumed). __________**gallons**

4. **Calculate the CO_2 emissions each day** of your round trip commute. Each gallon of gasoline burned emits about 20 lbs of CO_2. __________**lbs CO_2**

5. **Estimate your annual CO_2 emissions each year** getting to and from school. Multiply your total from #4 above by 180 school days. Record the answer anonymously in the Class Data Summary. __________**lbs CO_2**

6. **Estimate the CO_2 footprint of your school from transportation.** What if every student at your school produced the same amount of CO_2 as you in their commute to and from school? What would your school's CO_2 footprint from transportation be? Multiply your answer from #5 by the number of students at your school. __________**lbs CO_2**

Student Worksheet B: Name:________________________

Carpool

Answer

1. **How many miles do you drive to school each day?**
   Find out the round trip distance from your home to school. You can do this by going to either *www.mapquest.com* or *http://maps.google.com/* and put in the address of your home and school to calculate the distance. ____________**miles**

2. **How many miles per gallon does your vehicle get?**
   Determine the average fuel economy of the vehicle being used in miles per gallon by checking *www.fueleconomy.gov* ____________**mpg**

3. **Estimate gallons of gas consumed each day getting to and from school** by dividing the miles driven by the miles per gallon (miles driven/miles per gallon = gallons of fuel consumed). ____________**gallons**

4. **Calculate the CO_2 emissions each day of your round trip** commute. Each gallon of gasoline burned emits about 20 lbs of CO_2. ___________**lbs CO_2**

5. **Estimate your annual CO_2 emissions each year** getting to and from school. Multiply your total from #4 above by 180 school days. __________**lbs CO_2**

6. **Calculate your individual impact.** How many people shared your ride? Divide your total from #5 by the number of people in your carpool (include yourself!) to calculate the individual CO_2 emissions of each person in the carpool. (Remember, your driver does not count as a member of your carpool if he/she does not stay at school with you!) Record the answer anonymously in the Class Data Summary. __________**lbs CO_2**

7. **Estimate the CO_2 footprint of your school from transportation.** What if every student at your school produced the same amount of CO_2 as you, just from their commute? What would your school's transportation CO_2 footprint be? Multiply your answer from #6 by the number of students at your school. __________**lbs CO_2**

Student Worksheet C: Name:________________________________

Bus (public or school bus)

Answer

1. **Estimate the amount of fuel used by the bus.** The average bus drives 40 miles round trip. Buses get about 5 miles per gallon. Calculate the gallons of diesel used by your bus per trip. ____________ **gallons**

2. **Calculate the CO_2 emissions of your commute.** Each gallon of diesel burned creates 22 pounds (lbs) of CO_2. Calculate the amount of CO_2 generated by the bus for each roundtrip journey. ___________**lbs CO_2**

3. **Calculate the CO_2 emissions per passenger.** How many people shared your ride? Estimate the number of students who rode the bus with you today and divide the lbs CO_2 from #2 by the number of students on the bus. ___________**lbs CO_2**

4. **Estimate your annual CO_2 emissions from** getting to and from school. Multiply the total from #3 by 180 school days per year and record your answer anonymously in "Class Data Summary." ___________**lbs CO_2**

5. **Estimate the CO_2 footprint of your school from transportation**. What if every student at your school produced the same amount of CO_2 as you, just by getting to and from school? What would your school's CO_2 footprint from transportation be? Multiply your answer from #4 by the number of students at your school. ___________**lbs CO_2**

Student Worksheet D: Name:______________________________

Walk, bike, skateboard, or other human-powered mode of transportation

Your CO_2 footprint from your travel each day equals zero!

Record a "0" in the Class Transportation Data Summary.

If everyone in your school traveled as you typically do, this part of the CO_2 school footprint would be zero!

Pick one of the other modes of transportation and calculate what your emissions would be if you used that mode. Congratulations for avoiding those emissions!

Class Data Summary

Record each student's data in the table below and add up the CO_2 emissions for the entire class.

Student	Miles (round-trip)	Mode of Travel	Pounds CO_2 per year
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
Class Total:			

Lesson adapted from: *http://www.coolschoolchallenge.org*

Lesson 3B Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Individual Transportation Data	Individual data is recorded appropriately.	Some individual data is recorded.	The wrong data is recorded.	No data is recorded.	
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
Post Worksheet Communication	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
				Total Score	**/12**

Objective Check

1. How does driving in a car differ from taking the bus in terms of CO_2 footprint? (A bus may produce more GHGs but a car produces more PER PERSON.)
2. What advantage is there to take alternative modes (walking, biking, carpooling, busing) to school? (Answers will vary. Less GHG emissions, healthier, saving money.)

Transportation Quiz

Name:______________________

Multiple Choice: Read all possible responses and select the best answer.

1. **In the United States, the transportation sector produces what percent of the annual greenhouse gas emission?**
   a. 10%
   b. 15%
   c. 30%
   d. 50%
2. **Biofuels come from all of the following sources EXCEPT?**
   a. Corn
   b. Soybeans
   c. Petroleum
   d. Used vegetable oils
3. **Which of the following statements about fuels is true?**
   a. Biofuels have no disadvantages
   b. Buying a fuel-efficient car is the only way to reduce fuel consumption
   c. It does not matter what source of fuels you choose to use
   d. There are advantages and disadvantages to all sources of fuels
4. **Which of the following activities reduces GHG emissions compared to riding in a car?**
   a. Walking
   b. Biking
   c. Taking public transportation
   d. All of the above
5. **Which of the following transportation modes usually produces the most GHG emissions per person?**
   a. Riding in your car alone
   b. Carpooling with fellow students/friends
   c. Biking
   d. Taking public transportation
6. **True or false: transportation is the fastest growing source of GHG emissions in the United States?**
   a. True
   b. False

7. **Which of the following transportation modes produces the fewest GHG emissions PER PERSON?**
   a. Riding in your car alone
   b. Carpooling with fellow students/friends
   c. Biking
   d. Taking public transportation

8. **What is NOT usually a benefit of walking to school over driving to school?**
   a. Decreased GHGs
   b. Time savings
   c. Improved health
   d. Get to know the neighborhood

9. **Most of the GHG emissions from transportation are caused by:**
   a. Organic materials decomposing
   b. Burning fossil fuels
   c. Generating electricity
   d. Burning biofuels

10. **Public transportation can be useful for**
   a. Getting to the mall
   b. Getting to school
   c. Getting to your friend's house
   d. All of the above

Short Answer

11. **List four ways of getting to school that does not include riding alone in a passenger car:**
   1.
   2.
   3.
   4.

12. **Name four types of fuel used for transportation:**
   1.
   2.
   3.
   4.

Unit 3 Quiz Key

1. C
2. C
3. D
4. D
5. A
6. A
7. C
8. B
9. B
10. D
11. Answers will vary but might include:

- Biking
- Walking
- Skateboarding
- Car pooling
- Busing

12. Answers will vary but might include:

- Gas
- Diesel
- CNG/LNG
- Hydrogen
- Biodiesel

Transportation Appendix 1

New information on the connections between GHGs and transportation is constantly being researched and published. The California Environmental Protection Agency shares their latest research at: *http://www.arb.ca.gov/fuels/lcfs/lcfs.htm*

A new report on emissions and long distance travel from the Union of Concerned Scientists: *http://www.ucsusa.org/assets/documents/clean_vehicles/greentravel_slick_opt_web.pdf*

The EPA has a page filled with tips for decreasing your emissions of GHGs. Go to their On the Road page to find out for yourself: *http://www.epa.gov/climatechange/wycd/road.html*

Fuel our Future Now, from the US Department of Energy, has a list of lesson plans that will challenge your students at: *http://fuelourfuturenow.com/resources-9-12.cfm*

Unit 4: Food

Unit Objectives

At the end of this unit the students will be able to:

- Describe the sources of greenhouse gas emissions in the food system
- Identify ways to reduce emissions in individuals' diets and the food system as a whole
- Demonstrate understanding and develop an interpretation of grade level informational text **(Science Standard)**
- Evaluate the significance and accuracy of information **(Science Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. **(Social Studies Standard)**
- Gather, interpret, use, and document information from multiple sources, distinguishing facts from opinions and recognizing points of view. **(Social Studies Standard)**
- Examine a controversial event, issue, or problem from more than one perspective. **(Social Studies Standard)**
- Examine the various characteristics, causes, and effects of an event, issue, or problem. **(Social Studies Standard)**

Unit Background

The average U.S. household is responsible for about eight tons of carbon dioxide equivalent (CO_2e) emissions annually related to their food consumption. Fortunately, these emissions are very flexible, as we can change the carbon footprint of our diet with every meal choice.

Modern agriculture relies on large expenditures of fossil fuels at all levels of food production and distribution, from plowing and fertilizing fields, to transporting crops to storage, to processing and packaging products, to the final trip to the consumer's home (where further energy is used to store and prepare food). Moreover, at every stage of this process, food is wasted and thrown away.

When looking at the full life-cycle of the food system, including production, transportation and distribution of food, the vast majority of food-related emissions, 83%, derive from the production phase, with transportation accounting for just 11%. The growing body of research on the food system's carbon footprint shows that cutting down on red meat and dairy are a surefire way to trim emissions. Eating locally, while important for food security and the local economy, plays only a minor role in reducing food emissions. Other strategies for reducing food emissions, like eating unprocessed and organic foods and avoiding food waste also play a part in reducing emissions.

Animal Products

According to the Food and Agriculture Organization of the United Nations, livestock uses 30% of the world's surface land area and accounts for a whopping 18% of CO_2e emissions, including those from land use changes, fertilizers for feed, and energy use. The Environmental Protection Agency's 2007 Greenhouse Gas Emissions Inventory shows that livestock is responsible for about half of the emissions from the agricultural sector.

For the other components of our personal climate footprint, such as energy use and transportation, CO_2 is the major offender. In the case of food-related emissions, half are in the form of methane and nitrous oxide. The vast majority of these methane and nitrous oxide emissions are related to livestock.

The methane in our food system largely results from enteric fermentation, or the digestive process of ruminants like cows and goats. Cows and other ruminants raised for dairy and meat actually burp methane (which has twenty-one times the warming potential of carbon dioxide) as their four stomachs digest fibrous grass that makes up their diet. Cows raised on corn belch even more methane than grass-fed cows. According to the Environmental Protection Agency, globally, this methane makes up 28% of all methane released by human-related activities!

Nitrous oxide (N_2O) is produced naturally through the microbial nitrification and denitrification processes in soils. However, adding nitrogen to the soil through chemical and organic fertilizers, manure, nitrogen fixing crops and other means increase the soil's production of N_2O. Livestock use 78% of all agricultural land and 33% of cropland globally for grazing and for feed production. As a result, 65% of global N_2O emissions are related to raising livestock, according to the UN Food and Agriculture Association.

Carbon dioxide emissions from livestock come from land use changes and energy use. Feedlots (a type of confined-animal feeding operation) rely on antibiotics and grain production to increase meat yields, the production of which requires energy inputs. Much large-scale meat production occurs in areas that have been recently deforested for production of animal products or their feed. The total cost to the atmosphere of meat production embodies the loss of forests that fix, or sequester, CO_2—many of them in tropical areas where plants are able to photosynthesize year-round, so that loss can be huge.

Researchers at Carnegie Mellon found that switching from red meat or dairy to another protein source one day a week has the same impact on emissions as eating a pure "local" diet that includes red meat and dairy. A University of Chicago study compared the average American diet, which includes red meat, to the emissions produced by a Chevrolet Suburban; the lacto-ovo vegetarian diet (which includes dairy and eggs) was much closer to the emissions of a Toyota Prius, a low-carbon emissions car.

This study also found that a diet rich in fish nearly equaled the emissions associated with a red-meat diet. Deep-sea fishing requires large amounts of fossil fuel in catching, storing, and transporting fish from sea to market. Because many of the world's fisheries have collapsed due to over-fishing, fishing methods have become increasingly invasive and destructive on marine ecosystems.

Comprehensive research prioritizing various dietary choices is recent and continues to emerge.

Whole Foods

Processing and packaging foods is an energy-intensive practice—and we're surrounded by a multitude of these products. Of the total amount of energy used in the United States, about 16% is consumed by the food production system. Of that 16%, nearly a third is used for processing, 10% for transportation, and 17.5% for agriculture. On-farm energy use accounts for 1% of the US total energy related CO_2 emissions, with a third of that going to electricity use and nearly half going to diesel. Therefore, buying unprocessed foods with less or no packaging is typically far less impactful than buying processed and heavily packaged foods.

Waste

Americans throw away about a quarter of the food we prepare, at a cost of a billion dollars a year, according to the Environmental Protection Agency (EPA). Food scraps made up 12.5% of the solid waste generated by American households in 2007. This uneaten food causes emissions upstream, before the food reaches its intended point of use, and downstream, in the landfill. Upstream emissions are from growing, transporting and processing the food, while downstream emissions are the methane released from organic material decomposing anaerobically (without oxygen) in the landfill. Clearly, doing your best to gauge food purchases and preparation can cut down on the emissions associated with the lifecycle of wasted food.

Transporting Food

Despite the recent focus on transportation from farm to store, these so-called "food miles" account for only 4% of our food-related emissions, with transportation as a whole making up 11% of food-related emissions. However, disruptions to the food supply are one projected impact of climate change due to changes in weather, water supplies, and distribution systems. Eating local foods could help protect your community against these risks by building a more resilient local food system.

"Eating with the seasons" can increase the chances of finding food produced locally, in-season, and more efficiently. Food grown locally, but out of season, can require additional energy for production in heated greenhouses. For example, a study in the UK found that the energy used to grow hothouse tomatoes in winter

Retrieved from: *http://www.nytimes.com/imagepages/2008/05/18/weekinreview/18martin-popup.html* in England (for heating or lighting) is greater than the energy needed to grow and import tomatoes from Spain shipped by truck.

The trip from supermarket to home can contribute among the largest expenditures of energy in the foods' travels. Consider that a truck carrying tomatoes will be packed to the brim, using one engine to carry pounds and pounds of tomatoes. We might carry just two bags of groceries home in our otherwise empty vehicle. Most of the fossil fuels burned in that journey home are being used to move the hulking body of the vehicle, rather than to move our groceries. Ways to lessen food transportation emissions are a) grow a portion of your own food; b) bike, walk, or use public transportation to do your shopping; c) plan ahead to make fewer trips to the store.

Organic

Modern conventional agriculture relies heavily on fossil fuel, and therefore results in greenhouse-gas emissions, in almost every aspect of production, including:

- Fuels burned in machinery.
- Fertilizers, pesticides, herbicides, and fungicides used in farming are made from fossil fuels, release nitrous oxide (a greenhouse gas), and require energy for transportation and production. Synthesizing nitrogen for fertilizers requires massive amounts of energy.
- Embodied emissions—those produced in the manufacture and maintenance of a product, to its point of use—in machinery used for plowing, harvesting, and irrigation.

Organic farming methods typically require less fossil fuel use because they do not rely on chemical fertilizers; organic farms are also limited in the amount and types of pesticides that can be used. A 22-year study from the Rodale Institute demonstrated that conventional farming methods require 3.7 barrels of oil per hectare of crop production, while organic farming methods needed only 2.5 barrels of oil to produce the same crop yield. Organic farmers rely less on machinery and more on labor-intensive practices to weed and harvest fields. The same study concluded that fields farmed organically stored at least twice, and up to three times, as much carbon than fields farmed using conventional methods. Eating more organic foods can decrease your own and your farmers' exposure to chemicals, while also lessening your impact on global warming.

Sources:

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Lesson 4A—Food-Related Greenhouse Gas Emissions

Objectives

- Students will become familiar with food-related GHG emissions.
- Students will learn which dietary choices result in the lowest GHG emissions.

Suggested Timing

(50-60 minutes)

- 10 minutes—Introduction to Unit
- 5 minutes—Introduction to Lesson
- 20-30 minutes—Activity
- 15 minutes—Post-Activity discussion

Materials

- Computers with internet access
- Copies of Student Worksheet 4A
- Pencils

Teacher Information

Food production accounts for one-third of global greenhouse gas (GHG) production. Luckily, with every meal we eat we have the opportunity to reduce our food-related emissions and therefore our contributions to global climate change. We can reduce our GHG levels with each meal, as described broadly below, and in the unit introduction in detail.

1. *Reduce the amount of beef and/or dairy that you consume*. According to the United Nations, raising cattle produces more GHGs than driving cars. If every American reduced their consumption of cheeseburgers by one a week it would be equivalent to taking approximately 6.5 million SUVs off the road for a year! *http://openthefuture.com/cheeseburger_CF.html*
2. *Decrease food waste*. According to the EPA, Americans waste 27% of food available for consumption and 40-50% of food produced is never consumed. This accounts for over 30 million tons of food waste every year. All of that food production results in the emission of GHGs that could have been avoided.
3. *Eat more whole and unpackaged food*. Whole-foods are not processed and therefore do not produce the GHGs associated with the energy of processing. Producing packaging requires energy and as a result produces GHGs.
4. *Eat organically-grown food.* These foods are produced using non-fossil fuel-based fertilizers. Soil that has been farmed organically results in a buildup of organic matter, and therefore is better at storing carbon and serving as a "carbon sink" than the soil at conventional farms.
5. *Eat local food, particularly in-season.* "Food-miles" produce approximately 4% of total food-related GHG emissions (the transportation of food from the farm to the grocery store). By buying local food you are not only supporting local farmers and therefore the local economy but also reducing your GHG emissions.

Discussion

This outline highlights the key points to be shared with students.

1. Discuss sources of food-related emissions – methane, nitrous oxide and carbon dioxide.
    a. CO_2 and N_2O associated with growing food
        i. On-farm energy use leads to CO_2 emissions (but only 1% of US total energy use)
            1. Electricity amounts to 30% of agricultural energy use
            2. Diesel for tractors, etc. accounts for 46% of agricultural energy use
        ii. Fertilizer application leads to N_2O emissions. Discuss the nitrogen cycle in greater detail here if desired.
    b. NH_4 and N_2O emissions associated with raising cattle/other animals
        i. Nitrous oxide from land used for growing feed.
        ii. Methane produced by cows (yes, cow burps.)
    c. CO_2 emissions associated processing and packaging food.
    d. CO_2 emissions from other food-related energy use:
        i. Transportation to store, and transporting from store to home.
        ii. Energy used by retailers.
        iii. Energy used for food storage (refrigerators and freezers) and cooking.
2. Discuss the importance of consumer choices, as well as the various factors like religion, allergies and personal preference that play into our dietary choices. These points should be covered in the discussion that follows the activity. Strategies for emission reduction include:
    a. Reduce consumption of meat/dairy products.
    b. Decrease food waste.
    c. Eat more whole or unpackaged foods.
    d. Eat organically grown food.
    e. Eat local food.
3. Emphasize that a student does not need to radically change their diet to decrease food-related GHG emissions; small changes can make big differences.

Lesson

1. Pass out copies of the Student Worksheet and explain how they will be trying to find the foods with the lowest and highest emissions. The object of the game is to create the meals with the lowest and highest GHG emissions.
2. Have the students go to *http://www.eatlowcarbon.org/* and explain how they look up the greenhouse gas emissions of each food or menu item in an allotted time period (otherwise students might spend hours here). You might want them to start by clicking on "Getting Started."
3. Make sure that the students pay particular attention to portions so that their meals are realistic. (i.e., they can't put one ounce of meat and count it as a full portion!)
4. Ask the students for the total emissions from their lowest and highest meals. This exercise can be done in teams.

Discussion Questions

Discuss the results with the class; consider a few or all of these questions:

- Does reducing your GHG emissions mean that you cannot eat meat?
- What change has a bigger impact, a person who reduces their meat consumption from three to two times a week, or a person who consumed meat once a week becoming a vegetarian? In other words, do you have to become a vegetarian to make a difference?
- What foods surprised you with their CO_2 output? Were they higher or lower in GHG emissions than you thought?
- How could you apply what you learned today into your everyday life? Is there one pledge you could make (e.g., I will consume less soda and more water, or I will consume one less meal with beef/dairy per week)?
- How would planting your own vegetable garden be helpful in terms of GHG emissions and climate change?

How can we view reducing our food GHG emissions as an opportunity? Is there information you learned that could save you and your family money? Would there be other benefits to making those changes? What might some of the challenges be?

Student Worksheet

Name: ______________________________

List the food you chose for each item. Aim for a well-balanced meal that someone would actually eat (includes proteins, carbohydrates and fats. Not too big, not too small).

Breakfast	**Highest CO_2e Food Item**	**CO_2e Emissions**	**Lowest CO_2e Food Item**	**CO_2e Emissions**
Item 1				
Item 2				
Beverage				
Total				
Lunch				
Item 1				
Item 2				
Item 3				
Beverage				
Total				
Dinner				
Item 1				
Item 2				
Item 3				
Item 4				
Beverage				
Total				
Daily Total				

Lesson 4A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Participation in research	Participates fully in research without guidance.	Participates in research with some guidance.	Participates with a great deal of guidance.	Does not participate in research.	
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
Post Worksheet Communication	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
				Total Score	**/12**

Objective Check

1. Name three sources of food-related GHG emissions: (Answers will vary but may include methane from cows, transportation related emissions, nitrous oxide from fertilizer.)
2. What is one simple activity you plan to do to reduce your food-related GHG emissions? (Answers will vary but may include decreasing meat or dairy consumption, eating local, wasting less food, eating organic, eating whole foods.)

Lesson 4B—Meat Consumption Debate

Objectives

- Students will become familiar with two sides of a debate about cutting meat consumption.
- Students will attempt to analyze these positions to distinguish fact from opinion.
- Students will express their own opinions on the subject of meat consumption.

Suggested Timing

(30-60 minutes)

- 15 minutes—Introduction to lesson
- 20-30 minutes—Reading (in-class or homework)
- 15 minutes—Post-reading discussion

Materials

- Class set of *The Meat of the Problem* and *A Flawed Look at the Meat Industry* from The Washington Post.
- Class set of *Meat, Climate Change and Industry Tripe* from Grist.com.

Information

The Washington Post's economic policy blogger Ezra Klein sparked a debate with his article on cutting back on beef consumption. People defended their right to eat as much beef as they cared too, others accused Mr. Klein of not going far enough in his calls for reduced meat consumption, and some defended the beef industry.

This lesson has the students critically reading a blog article and the rebuttal from the representative of J. Patrick Boyle, the President and Chief Executive of the American Meat Institute in Washington. The students may do this as individuals or as a class. The students will then either write or discuss their opinions.

After responding to the original two articles, students continue by reading a follow-up fact check of the two authors printed at Grist.com by Tom Philpott.

Read *http://news.bbc.co.uk/2/hi/science/nature/7600005.stm* for more information on meat consumption or see the resources listed in the unit introduction.

Discussion

This outline highlights the key points to be shared with students.

1. Review food-related GHG emissions from eating meat.
   a. Eating beef produces a greater amount of GHG than other meats due to the high level of methane emissions from enteric fermentation.
   b. All meats must convert grains/plants into meat, which is less efficient than eating the grains/plants directly.
3. Discuss the two articles that the students will be reading.
   a. Ezra Klein—The Meat of the Problem
      i. An opinion piece in the Washington Post
      ii. Ezra Klein is the Economic Blogger for the Washington Post
   c. J. Patrick Boyle—A Flawed Look at the Meat Industry
      i. A rebuttal letter to the Washington Post
      ii. J. Patrick Boyle is the President and Chief Executive of the American Meat Institute in Washington.
3. Introduce the Critical Thinking Questions
   a. Opinion questions
      i. Asking viewpoints
      ii. Synthesizing ideas
   c. Analytical questions
      i. Reading to verify facts
      ii. Analyzing the quality of arguments/points

Preparation

- Photocopy the articles.
- Choose several or all of the questions from the "Critical Thinking Questions." Either distribute them to the students or post them on the board *before* the students read the articles.

Lesson

1. Before handing out the reading, introduce the critical thinking questions. These can be assigned as written reflections or for a class discussion.
2. Hand out the reading. The articles can be read in class as a group or individually. Alternatively, the reading can be assigned as homework. If you choose to do this, make sure the students have a copy of the critical thinking questions.
3. Have the students work on the questions individually or discuss them as a group.
4. Much of the analytical work requires the student to know which of the "facts" given by the two authors are supported by scientific research. The Philpott article breaks down the debate and lets the reader know veracity of the authors' statements. Photocopy the article and distribute after the students have had time to do some critical thinking. Ask the students if the Philpott article changes their minds at all.

Critical thinking questions

Consider a few or all of these questions:

1. What is your general reaction to Ezra Klein's suggestion of cutting down on meat consumption?
2. Who do you tend to believe more, Ezra Klein or J. Patrick Boyle? Why? What might motivate the authors to write their respective pieces?
3. Do you think your belief can be affected by your personal opinions on the topic? In other words, do you think a vegetarian would be more likely to believe Mr. Klein because he supports his opinions, while a meat eater might be inclined towards Mr. Boyle's position?
4. What do you think of the PBJ project? Would you be willing to try it?
5. If you had to do one thing to cut down your food-related GHG emissions, what would it be?
6. What do you think is more motivating about eating less red-meat (if any): saving money, being healthy or reducing your GHG emissions? Why?

The Meat of the Problem

By Ezra Klein

Wednesday, July 29, 2009

The debate over climate change has reached a rarefied level of policy abstraction in recent months. Carbon tax or cap-and-trade? Upstream or downstream? Should we auction permits? Head-scratching is, at this point, permitted. But at base, these policies aim to do a simple thing, in a simple way: persuade us to undertake fewer activities that are bad for the atmosphere by making those activities more expensive. Driving an SUV would become pricier. So would heating a giant house with coal and buying electricity from an inefficient power plant. But there's one activity that's not on the list and should be: eating a hamburger.

If it's any consolation, I didn't like writing that sentence any more than you liked reading it. But the evidence is strong. It's not simply that meat is a contributor to global warming; it's that it is a huge contributor. Larger, by a significant margin, than the global transportation sector.

According to a 2006 United Nations report, livestock accounts for 18 percent of worldwide greenhouse gas emissions. Some of meat's contribution to climate change is intuitive. It's more energy efficient to grow grain and feed it to people than it is to grow grain and turn it into feed that we give to calves until they become adults that we then slaughter to feed to people. Some of the contribution is gross. "Manure lagoons," for instance, is the oddly evocative name for the acres of animal excrement that sit in the sun steaming nitrous oxide into the atmosphere. And some of it would make Bart Simpson chuckle. Cow gas—interestingly, it's mainly burps, not farts—is a real player.

But the result isn't funny at all: Two researchers at the University of Chicago estimated that switching to a vegan diet would have a bigger impact than trading in your gas guzzler for a Prius. A study out of Carnegie Mellon University found that the average American would do less for the planet by switching to a totally local diet than by going vegetarian one day a week. That prompted Rajendra Pachauri, the head of the United Nations Intergovernmental Panel on Climate Change, to recommend that people give up meat one day a week to take pressure off the atmosphere. The response was quick and vicious. "How convenient for him," was the inexplicable reply from a columnist at the Pittsburgh Tribune Review. "He's a vegetarian."

The visceral reaction against anyone questioning our God-given right to bathe in bacon has been enough to scare many in the environmental movement away from this issue. The National Resources Defense Council has a long page of suggestions for how you, too, can "fight global warming." As you'd expect, "Drive Less" is in bold letters. There's also an endorsement for "high-mileage cars such as hybrids and plug-in hybrids." They advise that you weatherize your home, upgrade to more efficient appliances and even buy carbon offsets. The word "meat" is nowhere to be found.

That's not an oversight. Telling people to give up burgers doesn't poll well. Ben Adler, an urban policy writer, explored that in a December 2008 article for the American Prospect. He called environmental groups and asked them for their policy on meat consumption. "The Sierra Club isn't opposed to eating meat," was the clipped reply from a Sierra Club spokesman. "So that's sort of the long and short of it." And without pressure to address the costs of meat, politicians predictably are whiffing on the issue. The Waxman-Markey cap-and-trade bill, for instance, does nothing to address the emissions from livestock.

The pity of it is that compared with cars or appliances or heating your house, eating pasta on a night when you'd otherwise have made fajitas is easy. It doesn't require a long commute on the bus or the disposable income to trade up to a Prius. It doesn't mean you have to scrounge for change to buy a carbon offset. In fact, it saves money. It's healthful. And it can be done immediately. A Montanan who drives 40 miles to work might not have the option to take public transportation. But he or she can probably pull off a veggie stew. A cash-strapped family might not be able buy a new dishwasher. But it might be able to replace meatballs with mac-and-cheese. That is the whole point behind the cheery

PB&J Campaign, which reminds that "you can fight global warming by having a PB&J for lunch." Given that PB&J is delicious, it's not the world's most onerous commitment.

It's also worth saying that this is not a call for asceticism. It's not a value judgment on anyone's choices. Going vegetarian might not be as effective as going vegan, but it's better than eating meat, and eating meat less is better than eating meat more. It would be a whole lot better for the planet if everyone eliminated one meat meal a week than if a small core of die-hards developed perfectly virtuous diets.

I've not had the willpower to eliminate bacon from my life entirely, and so I eliminated it from breakfast and lunch, and when that grew easier, pulled back further to allow myself five meat-based meals a month. And believe me, I enjoy the hell out of those five meals. But if we're going to take global warming seriously, if we're going to make crude oil more expensive and tank-size cars less practical, there's no reason to ignore the impact of what we put on our plates.

A Flawed Look at the Meat Industry

Monday, August 3, 2009

Ezra Klein's commentary "The Meat of the Problem" [Food, July 29] was inaccurate and not scientifically based. The U.N. report "Livestock's Long Shadow," the foundation for Mr. Klein's commentary, asserted that the livestock sector is responsible for 18 percent of greenhouse gas emissions worldwide.

The Environmental Protection Agency concluded that in 2007, only 2.8 percent of U.S. greenhouse gas emissions came from animal agriculture.

Livestock production systems in the United States differ notably from livestock practices worldwide in genetic selection, feeding practices and other technologies. Assigning a percentage of global emissions to the U.S. system is misleading because the vast majority of global greenhouse gas emissions attributed to livestock production result from deforestation and the conversion of rain forests and other lands to crop or pasture land, which does not occur in the United States.

Since 1990, greenhouse gas emissions from the U.S. animal agriculture industry have remained nearly constant while meat production increased by almost 50 percent, milk production by 16 percent and egg production by almost 33 percent. Today's American farmer feeds about 144 people worldwide and often does so by using land that is not tillable or that cannot be used for other non-agrarian practices.

The animal protein sector in the United States is environmentally and socially responsible, and we strive to provide the safest, most abundant and most wholesome product to consumers domestically and worldwide.

J. PATRICK BOYLE
President and Chief Executive
American Meat Institute
Washington

Meat, climate change, and industry tripe

Posted 8:50 AM on 5 Aug 2009
by Tom Philpott
http://www.grist.org/article/2009-08-05-meat-climate-nonsense/

Washington Post food-politics columnist Ezra Klein has taken a stand: people should eat less meat, because of its vast greenhouse gas footprint. To make his case, Ezra cited the FAO's landmark "Livestock's Long Shadow" report, which found that global meat production is responsible for 18 percent of total greenhouse gas emissions.

To be honest, when I read Ezra's column, I thought, "yeah, and?" Of course we should eat less meat. But how far will individual choice take us? Shouldn't we focus on forcing the meat industry to pay up for its massive externalities, including its contribution to climate change? Yet this eat-less-meat plea ended up generating more controversy than I thought possible.

In a letter to the editor published Monday, J. Patrick Boyle, president of the American Meat institute, fired back, declaring Klein's take on meat "inaccurate and not scientifically based." How so? According to Boyle:

The Environmental Protection Agency concluded that in 2007, only 2.8 percent of U.S. greenhouse gas emissions came from animal agriculture.

He concludes: "The animal protein sector in the United States is environmentally and socially responsible, and we strive to provide the safest, most abundant and most wholesome product to consumers domestically and worldwide."

Oh, really?

Boyle is a veteran fighter for the big-meat cause. The AMI lobbies on behalf of meat packers like Tyson, Cargill, and Smithfield. According to his bio, Boyle has led AMI since 1990. He had prepped himself for a career as a top lobbyist the traditional way—by working for the agency he would later lobby. His bio declares:

From 1986-89, Boyle was administrator of the Agricultural Marketing Service (AMS) at the U.S. Department of Agriculture (USDA). At AMS, he oversaw such programs as federal meat grading and the national beef and pork checkoff programs. He was responsible for administering 37 federal statutes affecting food quality, safety, research and marketing of meat, poultry, milk, fruits, vegetables, cotton and tobacco.

Indeed, the AMI is a popular stop for those who swing through the revolving door between government jobs and plumb lobbying positions. Click around its staff page and you'll find plenty of former USDA and Congressional-staff apparatchiks.

So what of Boyle's claim that Klein way overstated the GHG footprint of U.S. meat—that meat, in fact, contributes just 2.8 percent of total U.S. GHG emissions as compared to the FAO's global estimate of 18 percent?

First, it should be noted that Klein and Boyle are talking about different things: Klein used global numbers, while Boyle pointed to strictly U.S. numbers.

And as Ralph Loglisci of The Center for a Livable Future at Johns Hopkins University points out in a recent blog post, the U.S. number will certainly be lower than the global one, for the simple reason that the U.S. spews out so much more greenhouse gases from all sources than the rest of the world.

We're the globe's largest per-capita emitter of greenhouse gas (and a close second to China in overall emissions). Here, the meat industry exists alongside a 211 million-strong fleet of generally low-mileage cars (propped up by a low-functioning mass-transit system), a network of coal-fired power plants that supply half of our electricity, and a built environment characterized by low-density sprawl.

In short, comparing meat's share of greenhouse gas emissions domestically and globally, the denominator—total emissions—is relatively much higher domestically. To use that truism to excuse the carbon footprint of the U.S. meat industry is ridiculous—a form of vulgar relativism. Just because they're surrounded by an abundance of SUVs and coal-fired power plants doesn't make our meat factories any more benign.

Next, it must be acknowledged that the FAO study Klein cites and Boyle's EPA source were measuring different things. As Loglisci points out, the FAO sought to calculate meat's total GHG footprint—not only methane from cows and nitrous oxide from manure, but also emissions related to growing and hauling feed grains and moving processed meat to market. The EPA numbers cited by Boyle, by contrast, measure only methane from livestock and nitrous oxide from manure. Emissions related to feed are accounted for elsewhere, as is carbon released in the process of ventilating massive confinement houses, and moving meat from production centers like North Carolina and Iowa to far-flung markets.

Perhaps most egregiously of all, Boyle's cherry-picked stat thus wrongly absolves the meat industry from nitrous oxide emissions associated with growing corn—a massive source of greenhouse gas.

How massive? According to the National Corn Growers Association (PDF), 44 percent of U.S. corn becomes domestic animal feed, and another 10 percent ends up in feed rations as the ethanol byproduct distillers grains. That means more than half of U.S. corn—our nation's largest farm crop—ends up on feedlots.

And farmers use more nitrogen fertilizer on corn than any other crop by a wide margin. Using data from the charts on this USDA page, I estimate corn sucks in about 44% of nitrogen fertilizer applied in U.S. agriculture. So based on its reliance on corn, U.S. feedlot agriculture is responsible for nearly a quarter of total U.S. nitrous oxide emissions. And Boyle's number conveniently omits that.

The omission is not trivial. In the agriculture section (PDF) of its "Inventory of U.S. Greenhouse Gas Emissions, 1990-2007," the EPA credits "agriculture soil management"—i.e., nitrous oxide from fertilizer application—with about half of ag-related GHG emissions. And guess what? The EPA may be seriously underestimating here. A 2007 study by the Dutch Nobel laureate Paul Crutzen, an atmospheric chemist, concluded (PDF) that the accepted estimates for how much nitrogen fertilizer ends up in the air as NO2 could be off by a factor of as much as five.

So if Boyle's 2.8% figure is off the mark, what percentage of U.S. greenhouse gas emissions does actually stem from meat production? Loglisci of The Center for a Livable Future says it's hard to pinpoint. "As far as I know, no one has crunched the numbers to determine a comparable GHG emissions number for U.S. livestock," he writes.

Working with a Johns Hopkins researcher, Loglisci compiled some rough numbers and came out with an estimate of about 9%—half of the global FAO number cited by Klein, but three times the figure pushed by Boyle. "And in real numbers, not percentages, U.S. livestock production's GHG contribution could still be the largest in the world," Loglisci writes.

So, yes, Ezra Klein was right—there's a strong case for eating less meat.

Lesson 4B Assessment 1

(Use this rubric if the writing assignment was assigned.)

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Written Report/ Ideas	Paper is clear and focused. It holds the reader's attention.	The writer is beginning to define the topic, even though development is still basic or general.	The paper has no clear sense of purpose or central theme.	The paper did not address the assignment	
Written Report/ Organization	Organization enhances and showcases the central idea. The order, structure or presentation of information is compelling.	Organizational structure is strong enough to move the reader through the text without too much confusion.	Writing lacks a clear sense of direction. Ideas and details seem strung together in a loose or random fashion.	The paper is not organized.	
Written Report/ Voice	Writer speaks directly to the reader in a way that is individual, compelling, and engaging.	Writer seems sincere, but not fully engaged or involved. Writing has discernable purpose, but is not compelling.	Writer seems indifferent to the topic and the content. Writing lacks purpose and audience engagement.	The paper lacks a voice.	
Written Report/ Conventions (spelling, punctuation, capitalization, grammar, usage, paragraphing)	Writer demonstrates a good grasp of standard writing conventions and uses conventions effectively to enhance readability.	Writer shows reasonable control over a limited range of standard writing conventions.	Errors in conventions repeatedly distract the reader and make the text difficult to read.	Conventions are ignored.	
Information Analysis	Both sides of the debate were read and understood. Writing related a strong analysis of both sides.	Both sides of the debate were somewhat understood. Writing analysis is generalized.	Argument not really understood. Writing does not show any analysis.	Little or no attempt at analysis.	
				Total Score	**/20**

Lesson 4B Assessment 2

(Use this rubric if the classroom discussion is chosen.)

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Reading	Reading is thoroughly completed without guidance.	Reading is completed with some guidance.	Reading is partially completed; guidance is needed.	Reading is not attempted.	
Information Analysis	Both sides of the debate were read and understood. Discussion relates a strong analysis of both sides.	Both sides of the debate were somewhat understood. Discussion analysis is generalized.	Argument not really understood. Discussion does not show any analysis.	Little or no attempt at analysis.	
Communication/ Critical Thinking Questions	Clearly communicates subject understanding during class discussion.	Clearly communicates some subject understanding during class discussion.	Communicates minimal subject understanding and needed to be called upon during class discussion.	Shows no subject understanding and did not participate in class discussion.	
				Total Score	**/12**

Objective Check

1. What are the two sides to the meat consumption debate? (Eat less meat because it is good for the environment vs. meat production is cast in a negative light and the statistics related to greenhouse gases are misrepresented.)
2. How did the authors use opinions and facts to support their arguments? (Authors used specific statistics that supported their own argument while ignoring other statistics that did not.)
3. What is your opinion on the meat consumption debate? (Answers will vary.)

Unit 4: Food Quiz

Name:_______________________

Multiple Choice: Read all possible responses and select the best answer.

1. **Eating organically grown food can reduce greenhouse gas emissions.**
   a. True
   b. False

2. **What is the greatest advantage to the climate (in terms of GHGs) to purchasing locally grown food from a neighborhood farmer's market?**
   a. The food has traveled fewer "food miles."
   b. The money spent stays in the local economy.
   c. There is no advantage.
   d. The food is more nutritious.

3. **Which of the following foods produces the most GHGs?**
   a. Vegetables.
   b. Chicken
   c. Beans
   d. Beef

4. **Which of the following activities decreases the GHG emissions of food consumption?**
   a. Reduce the amount of red meat and dairy you consume.
   b. Decrease food waste.
   c. Eat more unpackaged and unprocessed food.
   d. All of the above.

5. **What is the advantage to eating whole foods when considering greenhouse gas emissions?**
   a. Processing and packaging foods is an energy-intensive practice.
   b. Whole foods are more available in grocery stores.
   c. Whole foods are healthier than processed foods.
   d. Whole foods do not provide any advantage.

6. **How should you cut down on waste from cooking?**
   a. Actually eat leftovers.
   b. Don't cook more than you'll eat.
   c. Recycle packaging from food products.
   d. d. All of the above.

7. **True or False? Food miles are the most effective way to reduce the GHG emissions associated with food.**
   a. True
   b. False

8. **Reducing your GHG emissions means you cannot eat meat.**
   a. True
   b. False

9. **Meat and dairy production has become more efficient in terms of GHG in the past 20 years.**
   a. True
   b. False

10. **Why does eating organic food reduce GHG emissions?**
   a. The food travels fewer miles to get to your plate.
   b. Organic farming methods costs less.
   c. Organic farming results in more carbon sequestration in the soil.
   d. Organic farming is healthier for your body.

Short Answer

11. **Name three steps you can take to reduce your food related emissions:**

    1.
    2.
    3.

12. **Name three sources of greenhouse gas emissions associated with producing food and getting it to your plate:**

    1.
    2.
    3.

Unit 4 Quiz Key

1. a
2. c
3. d
4. d
5. a
6. d
7. b
8. b
9. a
10. c
11. Answers will vary but may include decreasing meat or dairy consumption, eating local, wasting less food, eating organic, eating whole foods.
12. Answers will vary but may include meat or dairy consumption, food mile, food waste, packaged foods, fertilizers.

Food Appendix

The EPA publishes a guide for food service providers to putting surplus food to use at:

http://www.epa.gov/osw/conserve/materials/organics/pubs/food-guide.pdf

This article does a good job laying out the basic facts relating food, "food miles" and production processes to greenhouse gases:

http://news.mongabay.com/2008/0602-ucsc_liaw_food_miles.html

A number of quizzes can be found at National Geographic's Green Guide. There are quizzes on food safety, food crisis, organic food, seasonal fruit, and a number of other important issues: *http://www.thegreenguide.com/quizzes*

Unit 5: Consumption and Waste

Unit Objectives

At the end of this unit the students will be able to:

- Understand the concept of embodied energy and emissions
- Define lifecycle, upstream and downstream emissions
- Understand the hierarchy for reducing embodied emissions
- Identify ways in which various resources can be recycled and reused. **(Science Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. **(Social Studies Standard)**

Unit Background

Lesson 5A

Waste Audit (60 minutes)

Lesson 5B

Life Cycle Analysis (45 minutes)

Unit 5 Quiz

15 minutes

Unit 5 Appendix

Unit Background

Greenhouse gas emissions are associated with material goods at nearly every phase of their life cycle, from extraction to production to use (in some cases), and all the way through to the methane released from decomposition in the landfill. US residents generated an average of 4.6 pounds waste per person per day in 2006, for a grand total of 251.3 million tons before recycling. If we're tossing that much away, think of all we're consuming. Knowing that the production and disposal of a ream of nonrecycled content paper is responsible for 35.7 pounds of carbon dioxide emissions makes it easier to conceive of all the embodied energy and emissions associated with the goods we consume and throw away.

The US EPA estimates that residential waste makes up 55 to 65 percent of the nation's total waste stream, but even industrial and construction waste exist because of demand by individuals. According to the United Nations Systemwide Earthwatch initiative, those of us in industrialized countries account for only 20 percent of the world population, but consume 86% of aluminum, 81% of paper, 80% of iron and steel, and 76% of timber produced globally. In the average American's lifetime, he or she will consume 540 tons of construction materials, 18 tons of paper, 23 tons of wood, 16 tons of metals, and 32 tons of organic chemicals. Although we are recycling a higher percentage of our waste than in the past, we create more total waste per capita each year. In 1960, Americans averaged 2.68 pounds per person per day, but this jumped to 4.4 pounds of waste per person per day by 1997 (landfill + recycled). Today, it is very easy to find one-time use items created for convenience, which only increases the amount of waste produced.

How would a decrease in consumption and the resulting waste production relate to climate change? According to research by the EPA described in Reducing Waste Can Make A Difference, waste prevention is generally the best management option in terms of climate benefits. Recycling is the next best approach. The EPA found that by cutting the amount of waste we generate back to 1990 levels, we could reduce greenhouse gas emissions by 18 million metric tons of carbon equivalent (MMTCE is the basic unit of measure for greenhouse gases). This reduction in emissions was due to two main factors: 1) avoided methane released from landfills when organic matter decomposes anaerobically, and 2) avoided upstream emissions from energy used in resource extraction, production and transportation all along the way.

In terms of recycling, the EPA estimates that by increasing our national recycling rate from 2000 levels of 30 percent up to 35 percent, we would reduce greenhouse gas emissions by another 10 MMTCE, compared to landfilling the same material. Together, achieving these levels of waste prevention and recycling would be comparable to eliminating annual emissions from the electricity consumption of nearly 4.9 million households.

Every little bit helps! For example, by recycling all of its office paper waste for one year, an office building of 7,000 workers could reduce greenhouse gas emissions by 570 metric tons of carbon equivalent (MTCE), when compared to landfilling. This is the equivalent of taking about 370 cars off the road that year. If an average family of four were to recycle all of its mixed plastic waste, nearly 340 pounds of carbon equivalent emissions could be reduced each year.

Sources:

United States Environmental Protection Agency, "Municipal Solid Waste" www.epa.gov/msw/facts-text.htm

United States Environmental Protection Agency, "Municipal Solid Waste Charts." http://www.epa.gov/waste/facts-text.htm

United States Environmental Protection Agency, "Climate Change and Waste." http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf

Source: *US EPA http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf*

Lesson 5A—Waste Audit

This lesson has been adapted from the Oregon Green Schools *http://www.oregongreenschools.org/waste_audits.cfm*

Objectives

- Students will be introduced to the concepts of embodied energy and upstream and downstream emissions.
- Students will learn what exactly is being thrown away by their school and what alternatives there are to landfilling.

Suggested Timeframe

(65 minutes)

- 15 minutes—Discussion
- 30 minutes—Audit
- 20 minutes—Create a Plan

Materials

- Materials
- Rubber gloves
- Large tarp or plastic drop cloth
- Extra garbage bags
- Scale
- Several five-gallon buckets
- Waste category signs
- Waste audit forms

Teacher Information

A waste audit is a way to see what your school's garbage is made up of so that you can make a plan for reducing, reusing and recycling. It seems like a yucky, dirty task, but believe it or not, kids and adults usually have fun with it. The results of a waste audit can help your school determine what areas need work and how best to start your waste reduction program. (As a bonus, you can use the data you collect for real-world math lessons on weight and volume and creating graphs and charts.)

Discussion

This outline highlights the key points to be shared with students.

1. Consumerism and waste in America
   a. On average, Americans landfill approximately 4.6 pounds of waste daily.
   b. 55-65% of waste produced is from residential sources.
   c. Every year we recycle more but we also send more to the landfill.
   d. Despite representing a small percentage of the world's population, the US consumes a large percentage of the earth's natural resources.
2. Embodied Energy
   a. This includes the energy used throughout the product's entire life cycle, from production to disposal, including fuel for machinery used in production and transportation, energy required to make chemical pesticides and fertilizers, not to mention processing and packaging. You may want to bring in an example of a packaged, processed food.
   b. For every product purchased, embodied energy is a factor.
   c. The more embodied energy in a product, the greater the GHG emissions.
3. Emissions
   a. Upstream: emissions associated with resource extraction, production and transportation. Much of this is CO_2 from energy use.
   b. Point of use: emissions associated with use of the product, largely energy related.
   c. Downstream: emissions associated with the disposal of the product. These emissions are largely CO_2 from transportation to the landfill and methane from waste decomposing anaerobically in the landfill.

4. Reducing GHG emissions associated with consumption.
   a. Purchasing less new goods is the most important step.
   b. Buy only what you need.
   c. Create a strategy, like waiting a week before making major purchases, to decrease impulse buying.
   d. Reusing products is the second most important step.
   e. Choose goods with recycled content when buying new items.
   f. Finally, recycle and compost to avoid "downstream" emissions from landfills.
5. Waste in schools.
   a. Many items thrown away could be reused.
   b. Other items can be recycled or composted.

Preparation

- Obtain permission to conduct the audit in the cafeteria, gym, or in a covered area outdoors and work with your custodian to save or collect cafeteria and/or classroom and office garbage from previous day.
- Photocopy Waste Audit Form: *http://www.oregongreenschools.org/pdf/SchoolWasteSortForm.pdf*
- Print out signs for sorting: *http://www.oregongreenschools.org/pdf/WasteAuditSigns.pdf*
- Safety considerations:
  - Please do not sort bathroom or health room waste.
  - Ask students to wear closed-toe shoes and rubber gloves throughout activity.

Audit

1. Using the waste audit form, record where the waste was collected from (Classrooms, cafeteria, etc.).
2. Put on gloves and estimate the total volume and weight of the waste to be audited. Record on form.
   a. Weight: Weigh the unopened bags of garbage. (With a bathroom-type scale, have a student hold the bag while standing on the scale, and then subtract the student's weight).
   b. Volume: Compare volume to the 5-gallon buckets.
3. Empty the contents of the bag on tarp and sort into waste categories listed on the form.
4. Record the weight and estimate the volume for each of the categories.
   a. Weight: put in buckets and weigh, subtract weight of bucket.
   b. Volume: estimate volume by measuring how much of the bucket is full
5. Make notes about items that you find a lot of in the trash – types of food, pop cans, etc., or other interesting things you observe.
6. Clean up!
   a. Return non-recyclables to garbage cans and sort recyclables into recycling bins.
   b. Wash tarp and buckets, sweep floor.

Create a Plan

1. Complete calculations on the waste audit form. Use these numbers to chart or graph your school's waste by weight and volume.
2. Create a plan to reduce waste based on your findings. Questions to think about:
   a. What were the main components of the school's waste?
   b. Would the results be different if the sort was done at a different time in the school year?
   c. What were some of the items that could have been reused, composted, or recycled instead of thrown away?

Discussion Questions

- How could students reduce how much was thrown away some of the items?
- Discuss the connection between waste and greenhouse gases (GHGs). How can decreasing use, reusing, composting and recycling reduce GHGs?

Extension Activities (optional)

1. Share the results and the plan with the rest of the school.
2. Put your plan into action!

Lesson 5A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Teamwork	Worked well as a team.	Worked well with some guidance.	Worked as a team with a great deal of guidance.	Did not work well together.	
Participation in Activity	Participates fully during activity	Participates somewhat during activity	Demonstrates minimal participation during activity	Does not participate in activity	
Waste Audit Sheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
Post Audit Discussion	Participates fully during class discussion.	Participates somewhat during class discussion.	Demonstrates minimal contribution during class discussion.	Does not participate in class discussion.	
				Total Score	**/16**

Objective Check

1. What does it mean to say that a product has embodied energy? (Embodied energy is the energy used throughout the product's entire life cycle, from production to disposal, including fuel for machinery used in production and transportation, energy required to make chemical pesticides and fertilizers, not to mention processing and packaging.
2. What are upstream emissions? (These are associated with resource extraction, production and transportation.)
3. What are three alternatives to throwing something away? (Sell or give away the object, reuse for another purpose and recycle.)

Lesson 5B—Life Cycle Analysis for a CD or DVD

Objectives

- Students will be introduced to the concept of life cycle analysis.
- Students will learn more about the embodied energy that is associated with consumption.

Suggested Timeframe

(45 minutes)

- 10 minutes—Discussion
- 20 minutes—Poster making
- 15 minutes—Poster presentations and discussion

Materials

- Easels with chart paper or butcher paper
- Markers

Teacher Information

The term "life cycle" refers to the major activities in the course of a product's life-span from resource extraction, manufacture, use, and maintenance, to the product's final disposal. Life cycle assessment (LCA) is a tool used to evaluate the potential environmental impact of a product, process or activity throughout its entire life cycle by quantifying the use of resources ("inputs" such as energy, raw materials, water, labor) and environmental emissions ("outputs" to air, water and soil) associated with the system that is being evaluated. There are two types of LCA: cradle to gate and cradle to grave. "To gate" refers to manufacturers getting the product to the store while "to grave" includes every step until disposal. A newer movement, called "cradle to cradle" goes one step further by aiming to create product systems that create zero waste. For example, all extra materials used during manufacturing could be used for another function or composted. The product itself would also be reusable or compostable, like greeting cards with seeds embedded in them that can be planted upon receipt. The US EPA hosts annual Cradle to Cradle contests for companies and individuals that can come up with an innovative design. This is how they define the movement:

- Cradle to Cradle Design is a system of thinking based on the belief that human design can approach the effectiveness and elegance of natural systems by learning from nature and incorporating its patterns. Industry can be transformed into a sustaining enterprise—one that creates economic, ecological, and social value—through thoughtful and intentional design that mirrors the safe, regenerative productivity of nature and eliminates the concept of waste.
- The application of cradle-to-cradle principles to industry creates cyclical material flows (cradle-to-cradle rather than cradle-to-grave) that, like the earth's nutrient cycles, eliminate the concept of waste. Each material in a product is designed to be safe and effective, and to provide high quality resources for subsequent generations of products. All materials are conceived as nutrients, circulating safely and productively in one of two "metabolisms"—the biological metabolism and the technical metabolism.

Graphic Source: *http://www.scienceinthebox.com/en_UK/programs/pic/lca.gif*

Concerns about increasing quantities of waste and the associated GHG emissions have become more serious due to the short life cycles and heavy packaging of more and more goods. For years there has been a push for Americans to develop policies that make manufacturers more responsible for their product from cradle to grave and now cradle to cradle. Many people feel that products should be made more durably (rather than "planned obsolescence"); made easier to dismantle for repair, reuse or recycling; and made with fewer toxic and landfill-bound materials. Not only would this reduce the amount of landfilled material, but it would also decrease the amount of GHGs that are released from manufacturing new products. Generally, the fewer products we consume, particularly those made from virgin materials, the fewer GHGs are released into our atmosphere.

Waste issues can be better understood by examining the life cycle of the materials that compose it, from extraction to final disposal. On the surface many products seem to have a simple life cycle. However, as you begin to dig a little deeper and conduct a LCA on a product, you can find it is quite complicated.

In this lesson students will attempt to develop a map of the life cycle of a CD or DVD. Keep in mind that the primary steps that will be analyzed are materials acquisition, materials processing, manufacturing, packaging, distribution, use, reuse/recycling and disposal.

Sources:
United States Environmental Protection Agency, "Cradle to Cradle Design Award." http://www.mbdc.com/challenge/cradle-to-cradle.shtml

Discussion

1. Life cycle analysis (LCA)
   a. Definition— see above
   b. Cradle to gate—from materials acquisition to point of purchase
   c. Cradle to grave—from materials acquisition to disposal
   d. Cradle to cradle—life cycle with no waste products being produced
2. Steps in LCA
   a. Materials acquisition
   b. Materials processing
   c. Manufacturing
   d. Packaging
   e. Transportation/distribution
   f. Useful Life
   g. Reusing, recycling or disposal
3. Problems with consumerism
   a. Planned obsolescence—giving a product a certain life span
   b. Lack of durability – could make products easier to repair
4. Toxic and landfill bound materials

Preparation

Create a poster, slide or overhead of the following pdf: *http://www.epa.gov/osw/education/pdfs/finalposter.pdf* but do not show it to the class until they are finished with their life cycles.

Lesson

1. Break the class into small groups of 3-5 and distribute one piece of chart paper and marker to each group.
2. Tell the students to come up with a life cycle of a CD or DVD. Give them as much guidance as you feel necessary. You may want to tell them to try to think of all the steps that go into the process of manufacturing to disposal of a CD or give them the following information:
   a. CDs and DVDs are made from plastic and aluminum foil.
   b. The steps in a life cycle analysis are: materials acquisition, materials processing, manufacturing, packaging, transportation/distribution, useful life, and reuse/recycle/disposal. Keep in mind that the more guidance you give them, the more similar their LCA will be to the EPA's.
3. They can sketch their rough draft on a piece of scratch paper first if you like. When they are satisfied with their life cycle, have them transfer it to the chart paper so they can share it with the class.
4. Note that the students' and the EPA's LCAs could be very different, depending on the boundaries that the students use. If you would like the students' LCAs to match the EPA's more closely, you may want to start out with a class discussion of how far back they should go for each step of the process. For example, if you wanted to draw very broad boundaries when discussing resource extraction, you could include things like the fuel needed to transport workers to the oil fields.
5. Once every group is finished, display all of the posters in front of the room. Have each group stand by their posters, and go around the room having each group answer one or two questions from students in other groups.
6. Show the students the life cycle poster developed by the US EPA.

Discussion Questions

Lead a class discussion asking all or some of the following questions:

- How was your life cycle analysis (LCA) different from the EPA's?
- What did you forget to add?
- What did you choose not to add? Why did you make this choice?
- What did the EPA not have on their LCA that you had on your LCA? Why do you think the EPA chose not to include it?
- Did you include the energy that it took to make the trucks that transported the DVDs? Why not? (This is referred to as defining the "scope" of the product.)
- Which steps in your LCA produced GHGs?
- How does the change to digital downloads and MP3 players help in decreasing GHGs? How do they contribute to more GHGs? (For example, by disposing of CD players and buying new MP3 players, by using more energy in spending more time online.)

Lesson 5B Assessment (for group)

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Chart Presentation: Content	Content shows thoughtfulness and creativity. Includes most of the lifecycle.	Content shows some thoughtfulness but lacks several parts of the lifecycle.	Content shows little thoughtfulness. Major parts of the lifecycle are missing.	Content does not relate to the assignment.	
Chart Presentation: Oral	Presentation is clear and is easy to understand. Tone is conversational or informational.	Presentation is good but sometimes difficult to follow.	Presentation is difficult to follow. Tone is not appropriate.	Presentation does not relate to the assignment.	
Chart Presentation: Written	Clearly readable text of the lifecycle and uses drawings to help communicate ideas.	Text is generally readable. Limited drawings are used.	Text is barely legible. No drawings are used.	Poster is not completed.	
Teamwork	Worked well as a team.	Worked well with some guidance.	Worked as a team with a great deal of guidance.	Did not work well together.	
Post Chart Presentation Discussion	Participates fully during class discussion.	Participates somewhat during class discussion.	Demonstrates minimal contribution during class discussion.	Does not participate in class discussion.	
				Total Score	**/20**

Objective Check

1. What is the difference between "cradle to gate" and "cradle to grave" life cycle analysis? ("To gate" refers to analyzing a product from its resource extraction to the store, whereas "to grave" refers to analyzing it until the object is disposed of or recycled.)
2. For which steps of a life cycle analysis is there no embodied energy added? (In every step there is energy added. From resource extraction to reuse every step requires some new energy to be inputted.)

Consumption and Waste Quiz

Name ______________________

Multiple Choice: Read all possible responses and select the best answer.

1. **What is the best approach to managing waste?**
   a. Recycling
   b. Prevention
   c. Incineration
   d. Landfilling

2. **What is the best way, in terms of GHGs, to dispose of food waste?**
   a. Recycling
   b. Composting
   c. Incinerating
   d. All of the above

3. **How much waste does the average American generate per day?**
   a. 7.8 pounds/day
   b. 4.6 pounds/day
   c. 3.4 pounds/day
   d. 2.5 pounds/day

4. **The amount of stuff we produce as a society affects how much GHG we emit because:**
   a. Carbon dioxide is released in the process of making each product.
   b. Carbon dioxide is emitted in packaging and transporting each item.
   c. Greenhouse gases are produced in the disposal of garbage.
   d. All of the above.

5. **Which of the following trash can be composted?**
   a. Glass bottle
   b. Plastic bottle
   c. Orange peel
   d. All of the above

6. **Which of the following items can be reused?**
   a. A glass jar
   b. A plastic jar
   c. A cardboard box
   d. All of the above

7. **Which production processes are included in a life cycle analysis?**
   a. Raw material collection
   b. Transportation
   c. Manufacturing
   d. All of the above

8. **What type of life cycle analysis includes every step until disposal?**
   a. Cradle to gate
   b. Cradle to grave
   c. Gate to grave
   d. None of the above

9. **Consumers who are concerned with life cycle analysis feel products should be made so they are**
   a. More durable
   b. Easier to dismantle and repair
   c. Have fewer toxic materials
   d. All of the above

10. **The largest component of our school's waste stream is:**
   a. Paper
   b. Food
   c. Bottles and cans
   d. Glass

Short Answer

11. **Distinguish between cradle to grave and cradle to cradle life cycle analysis.**

12. **What does embodied energy have to do with greenhouse gas emissions?**

13. **What is the difference between upstream and downstream emissions?**

Quiz Answer Key

1. b
2. b
3. b
4. d
5. c
6. d
7. d
8. b
9. d

1. Answer depends on your waste audit.
2. Cradle to grave refers to analysis to disposal/recycling whereas cradle to cradle refers to an analysis that includes reusing the product or materials used to make the product (zero environmental impact.)
3. Every step of a products life adds embodied energy; this energy must be produced, and therefore releases GHGs.
4. Upstream emissions occur before consumption of the product, downstream emissions occur from consumption onwards.

Consumption and Waste Appendix

Climate Change and Waste from the US EPA. An excellent overview of the waste/Climate Change relationship: *http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf*

A Waste and Climate Change game from the EPA. It is aimed at "Junior High and Middle Schools." This could be done in one 45 minute period. The EPA will also mail you copies if you plan far enough ahead: *http://www.epa.gov/waste/education/pdfs/4-6.pdf*

The Story of Stuff online video chronicles the social and environmental impacts of our production and consumption patterns at: *http://www.storyofstuff.com/*

Unit 6: Service Learning Project

Unit Objectives

At the end of this unit the students will be able to:

- Evaluate natural processes and human activities that affect global environmental change and suggest and evaluate possible solutions to problems. **(Science Standard)**
- Define a problem that addresses a need and identify constraints that may be related to possible solutions. **(Science Standard)**
- Identify and give examples of how groups and organizations can influence the actions of government. **(Social Studies Standard)**
- Understand how citizens can make their voices heard in the political process. **(Social Studies Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. **(Social Studies Standard)**
- Consider two or more outcomes, responses, or solutions, identify their strengths and weaknesses, then conclude and justify which is the best. **(Social Studies Standard)**

Unit Background

Lesson 6A

Project Development (time frame is variable depending on your resources and the amount of available time.)

Unit Background

This final unit provides an opportunity for students to work with classmates on a service learning project intended to culminate in real world emission reductions. The project serves as an authentic assessment of students' new-found knowledge about the causes of and solutions to climate change and tests their ability to apply concepts learned in the classroom to their community. Another value of the unit is that it provides students with the tangible experience of making a difference on an issue so vast that it often leaves us feeling helpless.

Service learning projects engage students in active learning that has been shown to positively influence their motivation, attendance, academic learning, interpersonal and personal development, sense of civic and social responsibility, lifestyle choices, appreciation for cultural diversity, and career aspirations. Research also shows service learning to enhance students' leadership and moral development and problem solving skills.

Learning through experiential experiences can be enhanced by reflection on the process, successes and challenges throughout. Evaluating the experience based on multiple criteria enhances opportunities for success along the way. Consider whether you will allow your students to fail in any realms and, if so, how to deal with those failures.

Sources:

Bilig, Shelley H, 2000. "Research on K-12 School-Based Service-Learning: The Evidence Builds." Phi Delta Kappan, v81 n9 p658-64

Lester, Scott et Al, 2005. "Does Service Learning add Value? Examining Perspectives of Multiple Stakeholders." Academy of Management Learning & Education, Vol. 4, No. 3, 278 –294.

Eugene C. Roehlkepartain, 2007. Learn and Serve Clearninghouse. "Benefits of Community Based Service Learning," http://www.servicelearning.org/instant_info/fact_sheets/cb_facts/benefits_cbosl/

Lesson 6A—Project Development

Objectives

- Students will practice engaging in solutions to climate change.
- Students will be empowered to address a global problem on a local scale.
- Students will learn new skills like project development, implementation and evaluation

Suggested Timeframe

- 10 minutes—Introduce the project
- 20 minutes—Lesson (Part 1)
- 30-60 minutes—Lesson (Part 2)
- 1-3 days—Lesson (Part 3) and Evaluation

Materials

- Materials will vary depending on the project

Teacher Information

The intent of this lesson is for the students to plan and implement a project that, if successful, will lead to actual emission reductions. The project is designed to introduce the students to the challenges and rewards of taking action. Not only will the students put their newly learned climate change knowledge to use, but they will also recognize the steps necessary to plan, implement, and evaluate a project. The aim is not to merely inform by transmission of information, but to engage both students and the audience in activities that promote understanding of climate change, (its causes, effects and solutions) and that lead to actual emission reductions.

In small groups, students will go through the process of planning a project. They will choose **what** the goals will be, **who** will be involved (audience), **when** the goals will be met, **where** the project will occur and **how** to evaluate and sustain the project. Each group will present their proposal to the class and the class will choose one project to pursue. (Concentrating on just one class-wide project will be more manageable for the teacher and will increase the sustainability of the project.) At this point the class (or you) will choose project coordinators and finalize the plans. Next, the plan will be implemented with the cooperation of the entire class. Finally, the plan will be evaluated for its impact on climate change and the possibilities of sustaining the project in the future.

As the teacher you will be called upon to guide the students, so it is important that you can anticipate obstacles they will encounter. Appendix 2 has an extensive list of projects students have done in other schools. Use this as a resource for any students who may be struggling for ideas.

It may be possible that you do not have time to run a complete project or go through the brainstorming session. If not, we have included a pre-designed project to do a food waste audit for your school. The directions are highly structured and will work on a fixed schedule (60-90 minutes.) See Supplemental Lesson, S9, for these instructions.

Discussion

1. Purpose of project
   a. Practice engaging in solutions to climate change.
   b. Empowerment to address a global problem on a local scale.
   c. Learn new skills like project development, implementation and evaluation.
2. Process planning
   a. What
   b. Who
   c. When
   d. Where
   e. How
3. Evaluation
   a. Process evaluation—how did the process go?
   b. Product evaluation—Did the project reach the expected results?
   c. Prepare the students for the possibility of frustration and even failure. This process can be difficult, but oftentimes goals are met only after overcoming obstacles.

Lesson (Part 1)

1. This lesson has wide parameters and is open to interpretations by you and your students.
2. Take a few minutes and review the main topics covered in the Climate Change Curriculum (see Appendix 1).
3. Ask students to brainstorm their concerns about climate change and record these concerns on the board.
4. Ask students, either working in groups or as an entire class, to express their vision of a future where human impact on climate is no longer an issue. This vision should include the types of energy we would use, how we would care for the environment, how we would conserve and so on. They might suggest things like:
   - Creating ways to use cleaner, renewable sources of energy
   - Driving less, using more public transportation
   - Using more electric vehicles
   - Lowering idling in school parking lots
   - Reducing consumption of materials which are non-recyclable or non-reusable etc.
5. The students' ideas can be recorded on the board as a brainstorming activity or visually as an art or mixed-media exercise (combining words and pictures).
6. To bridge the gap between the students' visualization of an ideal future and what needs to be done to create this vision, it is necessary to **take action**. Students need to know that being passive will not bring about the future that that they desire.
7. Ask the students what can be done to move closer to that ideal future (with the understanding that it will take many positive actions over time to reach that ideal), and try to encourage realistic responses while emphasizing a proactive approach.
8. Break the class up into small groups so they can brainstorm what type of projects they could organize and implement in their school, community, or homes.
9. Some suggestions are:

- Tree planting
   - Starting or improving a recycling or composting program
   - A no-idling campaign
   - A carpooling signup
   - A biking and walking campaign
   - Compact fluorescent lights/lights out at the end of the day campaigns
   - Other campaigns
   - Meetings with and/or writing letters to leaders to encourage climate solutions

10. Ask students to conduct Internet searches to discover what other students around the world have done as similar projects. Each student (or small group) should find and record at least three different projects.
11. As a large group, share their findings and create one master list of possible projects.

Lesson (Part 2)

1. As students begin deciding on their own possible projects, gather the group together and discuss these criteria with the entire class:
   a. Who is your audience? Is this achievable?
   b. What will be the goals of your project? What will your audience do?
   c. When will you hold your event?
   d. Where will this take place?
   e. How will you achieve your goals? What resources will you need? How might could the project be sustained over time?
   f. What impact will the successful completion of your project have? This could include not only fewer GHGs, but also more school or community awareness, providing an example or pilot that could be expanded, etc.
2. Students will return to their small group and complete Student Worksheet: Project Details.
3. When students have completed their worksheet, they will present it to their teacher for approval.
4. Once all student projects have been approved, the small groups should present their proposal to the class.
5. During this process, the class will decide on one project to begin as an entire class. At this point, the class or teacher should choose project coordinators to act in a leadership role.
6. With teacher assistance, the project coordinators should stand before the class and expand their project detail worksheet to include every member of the class:
   a. What? Define 2-3 achievable goals for your project (If needed, visit http://www.goal-setting-guide.com/smart-goals.html to learn about "SMART" goal setting)
   b. Who? Define a role for everyone in the class (can be done last).
   c. Who? Define your audience.
   d. When? Define a timeline for the goals you set.
   e. Where? Define the location of your project.
   f. How? Define a plan to achieve your goals.
   g. How? Define the resources needed to achieve your goals.
   h. How? Define a plan to sustain your project over time, if desired.
7. When step #6 is complete, the project plan should be typed up for review.
8. Once the plan is approved by the class, all students should sign the plan to show their commitment to the project.
9. Evaluation—the students will need to develop criteria with which to evaluate their project. Some suggestions include:
   a. Did the project stay on the timeline proposed by the class?
   b. Did the project reach the intended audience?
   c. Did the project achieve its goals?
   d. Were GHG emissions reduced?
   e. Was the location appropriate?
   f. Is the project sustainable? Can it be carried out in the future? Is it a one-time event?

Lesson (Part 3)

1. Implement the project. Keep in mind your criteria for success as you follow through with the project.
2. Project Evaluation—the students will need to determine ways of collecting data for evaluating their project. Suggestions include:
   a. Record when the project started and when it ended and the number of hours spent carrying out the project.
   b. Count the number of people involved in the project.
      i. Record the number of students.
      ii. Record the number of staff/teachers.
      iii. Record the number of parents or community members.
   c. Take photographs to record and share.
   d. Other means of evaluating the impacts depending on the project:
      i. Count—the amount of trash recycled/composted or number of trees planted
      ii. Survey—participants in an anti-idling campaign
      iii. Interview—people impacted by the project
      iv. Test—subjects from an educational project
   e. Estimate reductions in GHG emissions.
      i. Look back to past lessons for quantifications of GHG emissions of particular actions, like using an incandescent as compared to a compact fluorescent light.
      ii. Using the data collected on actions taken and the emission reductions from those actions, calculate the GHG emissions avoided as a result of the project.

Optional Activity—Secure Funding

You may choose to register your project with SOLV, receive free materials, and apply for a $100 grant to assist you meet your goals. Visit SOLV at: *http://www.solv.org/programs/k16_education.asp*.

Apply for a grant and download a planning guide from Project Learning Tree "Green Works!" at: *http://www.plt.org/cms/pages/21_22_18.html*

Student Worksheet: Project Details

As your small group discusses the details of your project, complete this worksheet. When it is completed, present it to your teacher for approval.

Name of the project: ______________________________

Group members: ____________________ Role: ____________________

____________________ Role: ____________________

____________________ Role: ____________________

____________________ Role: ____________________

Project Details:

WHAT?	
WHO?	
WHEN?	
WHERE?	
HOW?	

Teacher suggestions/comments:

Teacher Approval: ______________________________ Date: __________

Assessment

(Includes blanks to fill in depending on the chosen subject.)

Aspect	**Expert (4)**	**Practitioner (3)**	**Apprentice (2)**	**Novice (1)**	**Score**
Worksheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
Presentation: Content	Content shows thoughtfulness and creativity.	Content shows some thoughtfulness but lacks some creativity.	Content shows little thoughtfulness and lacks creativity.	Presentation lacks content.	
Presentation: Oral	Presentation is clear and is easy to understand. Tone is conversational or informational.	Presentation is good but sometimes difficult to follow.	Presentation is difficult to follow. Tone is not appropriate.	Presentation completely misses the assignment.	
Teamwork	Worked well as a team.	Worked well with some guidance.	Worked as a team with a great deal of guidance.	Did not work well together.	
Post Presentation Discussion	Participates fully during class discussion.	Participates somewhat during class discussion.	Demonstrates minimal contribution during class discussion.	Does not participate in class discussion.	
Optional Grading Aspect 1					
2					
3					
4					
5					
				Total Score	/

Climate Change Action Appendix 1

Unit Highlights

Unit 1 Highlights

- Human made carbon dioxide, methane, and nitrous oxide are all considered greenhouse gases (GHGs) because they contribute to the greenhouse effect.
- The changing climate due to the greenhouse effect is referred to as climate change, global warming, or global climate change.
- The concentrations of GHGs in the atmosphere are increasing due to fossil fuel use in homes, industry, agriculture, and transportation, deforestation, and fertilizer use.
- GHGs absorb and radiate heat back to the earth.
- The temperature of the earth has risen 1.4 degrees Fahrenheit over the last century.
- GHGs are emitted by all countries, with China and the United States producing the most.
- In the US, a sector by sector look at GHG emissions is as follows: Industry (30%), transportation (28%), commercial (17%), residential (17%) and agriculture (8%)

Unit 2 Highlights

- Electricity is the most common form of energy we use at home and at school.
- Most power plants convert mechanical energy into electrical energy. This can be done by heating water and creating stream to turn a turbine or using water or wind to turn the turbine.
- Many times the energy used to heat the water comes from burning fossil fuels and therefore produces GHGs.
- A region's energy profile dictates how many GHGs are emitted. In Oregon, with its abundance of hydroelectricity production, electricity generation accounts for fewer emissions than other, more fossil fuel dependent, states.
- Americans produce almost 9000 pounds of CO_2e per person per year in their homes (from energy use).
- Conserving energy is an excellent way to reduce your GHG emissions.
- Lighting accounts for 20 to 25% of the total energy use in a school.
- There are several sources of renewable or alternative energy: hydro, solar (PV), wind, geothermal, and biomass.

Unit 3 Highlights

- Transportation accounts for approximately 29 percent of total US GHG emissions.
- Transportation is the fastest-growing source of US GHGs.
- There are many alternative fuels to gasoline; however all result in GHG emissions.
- Transportation choices include zero emission methods like walking and biking, mass-transit such as buses and light rail, low emission solutions such as car-pooling and higher emission choices like driving in your car alone.

Unit 4 Highlights

- Food production accounts for one-third of global GHG production.
- There are five important actions we can take to reduce our contribution to GHG emissions:
  - Reduce the amount of beef and/or dairy that you consume.
  - Decrease food waste.
  - Eat more whole and unpackaged food.
  - Eat organically-grown food.
  - Eat local and in-season food.

Unit 5 Highlights

- GHG emissions are associated with material goods at nearly every phase of their life cycle.
- US residents generated an average of 4.6 pounds of waste per person per day in 2006.
- Although we are recycling more than we have in the past, we are producing even more total waste than previously.
- Waste prevention is the best option to reducing GHGs. After buying and throwing away less, reusing and recycling and composting are important steps in reducing GHGs.
- Life Cycle Analysis (LCA) is a tool used to evaluate the potential environmental impact of a product.
- There are two types of LCA, cradle to gate and cradle to grave.
- Cradle to cradle refers to the idea that materials from one product become the raw material for another product, or in some way are regenerative for the Earth.
- Proposed policy changes would make some producers responsible for their products throughout its life cycle, from raw material extraction to disposal of the product.

Climate Change Action Appendix 2

Student Project Examples

Below is a list of links to example projects and Oregon resources. A review of these projects will be helpful as you steer students toward success.

Climate Change

- Reduce school emissions with the Cool School Challenge toolkit: *http://www.coolschoolchallenge.org/resources.aspx*
- Get support in Lane County from Partners for Sustainable Schools at *iseesustains@live.com*
- "Climate Change: Youth Guide to Action" for policy engagement: *http://www.tigweb.org/action/guide/*

Waste

- Recycling, zero waste and composting links: *http://www.kidsrecycle.org/kids_links.php*
- Detailed overview of school composting project: *http://www.mansfieldct.org/schools/mms/compost/index.htm*
- Oregon Green Schools provides funding, technical assistance and resources: *http://www.oregongreenschools.org/*

Energy

- Local lightbulb exchange project: *http://lightitforward.org*
- Energy tracking project: *http://web3.unt.edu/news/story.cfm?story=11476*

Transportation

- "No Idling" campaign project: *http://www.ikecoalition.org/Schools/Smart_Schools/Index.htm*

Varied

- List of varied environment and climate projects: *http://servicewire.org/content/20090416/nsb/Young-Heroes/Featured-GYSD-Projects-Environment-Climate-Change*

Climate Change Action Appendix 3

Resource List

Basics of Climate Change

- Fourth Assessment Report of the Intergovernmental Panel on Climate Change *http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm*
- The Climate Leadership Initiative's site featuring our research, programs and curriculum. *http://climlead.uoregon.edu/*
- Pacific Northwest focused climate change research from the Climate Impact Group at the University of Washington. *http://cses.washington.edu/cig/*
- The EPA's fact filled site on climate change. *http://www.epa.gov/climatechange/*
- Climate science blog from climate scientists. *http://www.realclimate.org/*
- NASA's eyes on Earth. *http://climate.nasa.gov/*
- The Pew Center on Climate Change with national and global factsheets, policy briefs, and more. *http://www.pewclimate.org/*

Climate Change Newsfeeds

- Comprehensive climate change website and newsfeed from Environmental Health Sciences. *http://dailyclimate.org/*
- Policy focused climate change news from the Environmental and Energy Study Institute *http://www.eesi.ccn/*

Dealing with Climate Skeptics

- Responses to common challenges to climate science *http://climlead.uoregon.edu/pdfs/Setting_record_Straight.pdf*
- This article is has a step-by-step set of instructions for dealing with a climate skeptic. *http://www.grist.org/article/series/skeptics/*

CLI
CLIMATE LEADERSHIP INITIATIVE
http://climlead.uoregon.edu

The Climate Leadership Initiative is a research collaborative between The Resource Innovation Group, a 501(c)(3) nonprofit, and the University of Oregon's Institute for a Sustainable Environment.

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