WHO LEFT CARBON FOOTPRINTS IN MY GREENHOUSE?

Overview:

Students gain climate literacy through exploration of common climate-change terms and calculate their own potential carbon dioxide contributions.

Objectives:

The student will:

- explain the role of greenhouse gases in climate stability;
- calculate their carbon footprint; and
- describe how science integrates with personal cultural values.

Targeted Alaska Performance Measures Tested on the High School Graduation Qualifying Exam

Reading

R4.2 Summarize information or ideas from text and make connections between summarized information or sets of ideas and related topics or information.

Math

M6.3.2 Interpret and analyze information found in newspapers, magazines and graphical displays.
M6.3.4 Make projections based on available data and evaluate whether or not inferences can be made given the parameters of the data.
M10.3.1 Apply mathematical skills and processes to science and humanities.

Targeted Alaska Grade Level Expectations

Science

[11] SA1.1 The student develops an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating.
[11]SC3.1 The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by relating the carbon cycle to global climate change.
[11]SD3.1 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by describing causes, effects, preventions, and mitigations of human impact on climate.

Vocabulary

anthropogenic – of, relating to, or resulting from the influence of human beings on nature
atmosphere – the mixture of gases that surround Earth of some other celestial body; held by the force of gravity, it forms various layers at different heights, including the troposphere, stratosphere, mesosphere, thermosphere, and exosphere
carbon – a naturally abundant, non-metallic element that occurs in all organic compounds and can be found in all plants and animals; diamonds and graphite are pure forms, and carbon is a major part of coal, petroleum, and natural gas; symbol is C on the periodic table of elements
carbon cycle – the continuous process by which carbon is exchanged between organisms and the environment; carbon dioxide is absorbed from the atmosphere by plants and algae and converted to carbohydrates, passed into the food chain and returned to the atmosphere by respiration and decay; the burning of fossil fuels also releases carbon dioxide into the atmosphere
carbon dioxide – a colorless, odorless gas that is present in the atmosphere and is formed when any fuel containing carbon is burned; it is exhaled animals' lungs during respiration, produced by the decay of organic matter and used by plants in photosynthesis

climate – the 30-year average weather conditions of a certain region, including temperature, rainfall, and wind
greenhouse effect – the trapping of the sun's radiation in Earth's atmosphere due to the presence of greenhouse gases
greenhouse gas – any of the atmospheric gases that contribute to the greenhouse effect; includes carbon dioxide, water vapor, methane, and nitrous oxide
methane – a colorless, odorless, flammable gas that is the simplest of the hydrocarbons, having the formula CH_4; it is the major constituent of natural gas and is released during the decomposition of plants or other organic compounds in anaerobic environments such as marshes
water vapor – water in its gaseous state, especially in the atmosphere and at a temperature below the boiling point

Whole Picture:

Carbon

Carbon is a naturally occurring element that is found in all organic compounds. It is a major part of coal, petroleum, and natural gas—referred to as fossil fuels. That is why such fuels release carbon into the atmosphere when burned.

Carbon Cycle

The carbon cycle is the continuous process by which carbon is exchanged between organisms and the environment. Plants combine carbon dioxide from the air, water and sunlight to create a new compound called carbohydrates. When the plant dies, decomposers break down the plant and respire the carbon as carbon dioxide back into the air for other plants to absorb. If the plant is instead eaten by a herbivore, the plant is broken down with some of the carbon used for energy releasing carbon dioxide and the parts of the plant are used to by the animal to build new cells. It will also respire some of the carbon back into the air. If a carnivore then eats that herbivore, the carbon compounds will be reused and some of those will also be respired back into the air. When an animal dies decomposers break down the remaining organic material, and the carbon will be respired back into the air. Each time carbon is respired into the air it again becomes available for photosynthesis. Under certain conditions decomposers are unable to fully decompose of an organism, geologic processes bury the organic material, and carbon will accumulate in reservoirs. Fossil fuel is one type of carbon reservoir, when this fuel is burned the stored carbon is released into the air.

Greenhouse gases

There are atmospheric gases, often referred to as greenhouse gases that affect the radiant heat cycle of the planet. Such gases play a vital role in regulating the temperature of the planet. Some greenhouse gases include water vapor, carbon dioxide, methane, and nitrous oxide.

Solar radiation penetrates Earth's atmosphere and reaches the surface. Some of that heat is radiated back through the atmosphere and into space. Greenhouse gases absorb some of that reflected energy and act as a barrier to this process, trapping the heat next to the planet. If the concentration of greenhouse gasses increase more heat is trapped, and the temperature of the planet goes up.

Carbon dioxide

Plants and animals give off carbon dioxide when they extract energy from their food during cellular respiration. Carbon dioxide bubbles out of the earth in soda springs, explodes out of volcanoes, and is released when organic matter burns (such as during forest fires).

Anything that releases carbon dioxide into the atmosphere (living, dead, or non-living) is considered a source. Anything that absorbs and holds carbon dioxide from the air or water is considered a sink. Over geologic time, sources and sinks are generally in balance. Currently however carbon dioxide concentrations are increasing. This increase is dramatic and easily measurable, providing evidence that sources are increase faster than sinks. Burning of fossil fuels by humans is thought to be primarily responsible for the observed increases.

Composition of the atmosphere

The air we breathe consists mostly of nitrogen (78 percent), oxygen (21 percent) and argon (0.9 percent). Other gases present in such small quantities that they are referred to as traces gases. All the gases that are greenhouse gases are trace gases. Carbon dioxide represents 0.04 percent, methane 0.0002 percent, and nitrous oxide just 0.00003 percent.

WHO LEFT CARBON FOOTPRINTS IN MY GREENHOUSE?

Materials:

- Bucket
- 36 soft foam balls (1 ¾ to 4 inch)
- Masking tape
- Blank sheets of paper
- Chart paper
- Marker
- MULTIMEDIA: "Climate Change in the Arctic: Greenhouse Gases" available on the UNITE US website (uniteusforclimate.org)
- DIGITAL LECTURE: "Volcanoes Leave a Giant Carbon Footprint" by Professor Jon Dehn, available on the UNITE US website (uniteusforclimate.org)
- VISUAL AID: "Global Carbon Dioxide Transport from AIRS Data"
- VISUAL AID: "Carbon Emissions, CO_2 Concentrations and Temperature"
- STUDENT INFORMATION SHEET: "Carbon, Footprints and Green Houses"
- STUDENT WORKSHEET: "Carbon, Footprints and Green Houses"
- STUDENT WORKSHEET: "Carbon Footprint – Bringing it Home"

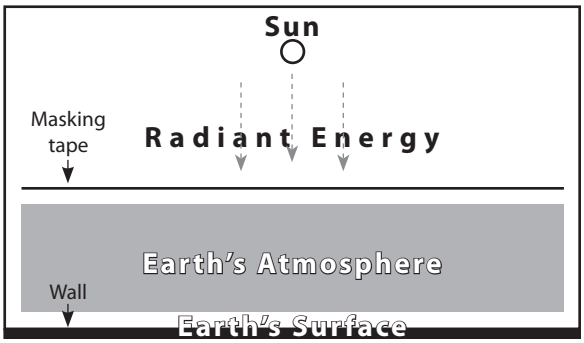
Activity Preparation:

1. Place all the materials students will need for "Greenhouse Gas Lab" in a central location.
2. Instruct students to navigate to the UNITE US website (uniteusforclimate.org) to access the MULTIMEDIA: "Climate Change in the Arctic: Greenhouse Gases."
3. Arrange time for the class to be in an open space (ideally a gym) for a game included in the lesson. Review the game (see Activity Procedure 4). Draw the following data collection chart on a piece of chart paper to transport to the game area, or write it on the board.

Game	Greenhouse Effect (a)	Enhanced Greenhouse Effect (b)
1		
2		
3		

Activity Procedure:

1. Pass out STUDENT INFORMATION SHEET: "Carbon, Footprints and Green Houses," and STUDENT WORKSHEET: "Carbon, Footprints and Green Houses." Explain students will be reviewing some familiar terms about climate change. Ask students to read through the questions on the worksheet to know what information they are listening for in the mentor lecture and multimedia.
2. As a class view the DIGITAL LECTURE: "Volcanoes Leave a Giant Carbon Footprint." Discuss. Remind students one gigaton (Gt) is equal to one billion tons.
   Scientists believe the human contribution of CO_2 is about 30 billion tons per year compared to the 1.5 Gt from volcanoes as they de-gas and erupt.
3. Ask students to go to student computers and access the MULTIMEDIA: "Climate Change in the Arctic: Greenhouse Gases" and review all the content.
4. Ask students to review the STUDENT INFORMATION SHEET: "Carbon, Footprints and Green Houses," then complete the STUDENT WORKSHEET: "Carbon, Footprints and Green Houses."



5. Play the Greenhouse Gases Game in an open space, such as a gym. Set up the as shown in the diagram.

   Explain students will model the greenhouse effect. In this model, one student will represent the sun. Foam balls in a bucket will represent the sun's radiation (heat). The sun will throw the balls at Earth's surface (a wall). Students will represent some of the gas molecule present in the atmosphere: Carbon dioxide (CO_2), water vapor (H_2O), nitrogen (N_2), and oxygen (O_2). Label blank pieces of paper with a marker and have students tape them to their shirts. The gas molecules mill about (NO Running) in the atmosphere, a defined space between the wall and masking tape on the floor. After the balls (heat) bounce or "reflect" off of the wall (Earth's surface), the molecules can catch the balls. If a greenhouse gas like water vapor (H_2O) or carbon dioxide (CO_2) catches a ball they hold onto it. If a non-greenhouse gas like nitrogen (N_2) or oxygen (O_2) catches a ball, they toss it back to the bucket. Assign a person to be a record the ratio of balls caught by the greenhouse gases to the total number of balls for three rounds of each following scenario (a and b).

   Following the game, return to class and discuss the results, referring to chart.

   Teacher Note: Greenhouse gases are trace gases, therefore the ratio in the atmosphere is very small. (See Whole Picture.) Explain and model this to students before increasing the amount of greenhouse gases to complete the activity. In fact, there would have to be 1,950 molecules of nitrogen, 525 molecules of oxygen and one molecule of carbon dioxide for the ratio to be correct. Nitrogen and oxygen, however, do not absorb heat. It is the increase in greenhouse gases that is of concern.

6. Display OVERHEAD: "Global Carbon Dioxide Transport from AIRS Data." Ask students: "What does this graphic point to as large contributors to the concentrations of CO_2 shown?"
7. Hand out STUDENT WORKSHEET: "Carbon Footprints – Bringing it Home." Ask students to complete the worksheet.
8. Display OVERHEAD: "Carbon Emissions, CO_2 Concentrations and Temperature." Explain it shows a model of what some scientist think may happen in the future. Ask students the following critical thinking questions:
   a. Based on historical temperature and CO_2-level records, do you feel the model is a fair representation? Why or why not?
   b. What role does CO_2 play in climate change?
   c. Is CO_2 naturally occurring?
   d. If the burning of fossil fuels completely halted, would there still be greenhouse gases in the atmosphere?
   e. Besides the burning of fossil fuels, how does CO_2 get into the atmosphere?
   f. There are some clear spikes in the historic levels of CO_2, long before man was burning fossil fuels. To what might you attribute such spikes?
   g. What would happen to Earth if greenhouse gases were eliminated from the atmosphere?

Extension Ideas:

1. Ask students to journal, for 24-hours, activities they engage in that create carbon footprints. Visit the Website Alaska Conservation Solutions at http://www.alaskaconservationsolutions.com. Click on the link that says "Alaska Carbon Reducer." Ask students to research ways to reduce their "carbon footprint" by researching resources and methods already in place.
2. Ask students to research per capita carbon dioxide emissions around the world and see how their community compares, then speculate why there are significant differences. (Such as the need for heating fuel in cold climates, etc.)
3. Visit NOAA's (National Oceanic and Atmospheric Administration) Tracking the World's Carbon page at http://www.noaa.gov/features/climate/carbon.html and research CarbonTracker, "a system that calculates carbon dioxide uptake and release at Earth's surface over time."

Answers:

STUDENT WORKSHEET: Carbon, Footprints, and Green Houses

1. A. energy from the sun; B. radiant energy from greenhouse gases in the atmosphere
2. The following words should be circled: carbon dioxide, CFC, methane, nitrous oxide and water vapor.
3. Greenhouse gases absorb and hold heat. Other gases do not have the same characteristic or ability.
4. climate and /or global temperature
5. Any of the following five are correct: cattle, landfills, decaying plants, plant respiration, animal respiration, volcanic eruption, evaporation, burning of fossil fuels, forest fires.
6. Carbon dioxide dissolves in ocean surface water. Warmer ocean surface water evaporates more quickly and releases the carbon dioxide into the atmosphere. Colder water doesn't evaporate as quickly and it sinks to the bottom of the ocean, so more carbon dioxide stays dissolved in the water.
7. carbon dioxide
8. 1.4 to 5.8
9. A. degassing; B. eruptions

STUDENT WORKSHEET: Carbon Footprint—Bringing it Home

1–13. Answers will vary but should show appropriate calculations.

14–15. Answers will vary according to student and community values but should reflect logical thought process.

16–18. Answers will vary according to personal and community usage, but should match the equations provided.

Example:

16. A. 1 gallon per week

    B. (1 gallon) * (52 weeks) = 52 gallons per year

    C. (52 gallons * 2,425 g) * (44/12 g C) * (1/1,000,000) = 0.462 metric tons of CO_2 per year
17. 50 ATVs
18. (50 ATVs) * (0.462 metric tons of CO_2) = 23.118 metric tons of CO_2 per year from this community.

GLOBAL CARBON DIOXIDE TRANSPORT FROM AIRS DATA

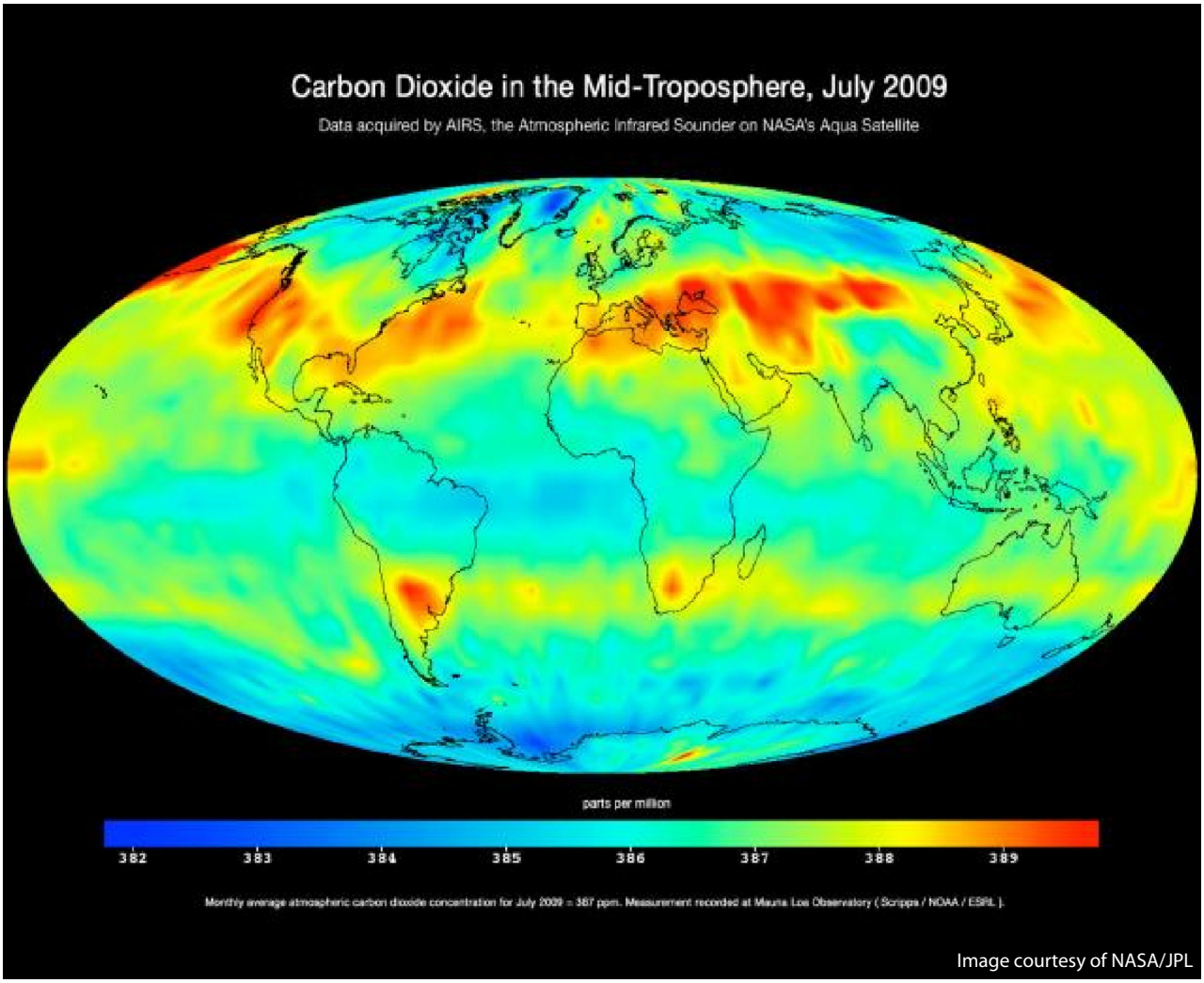


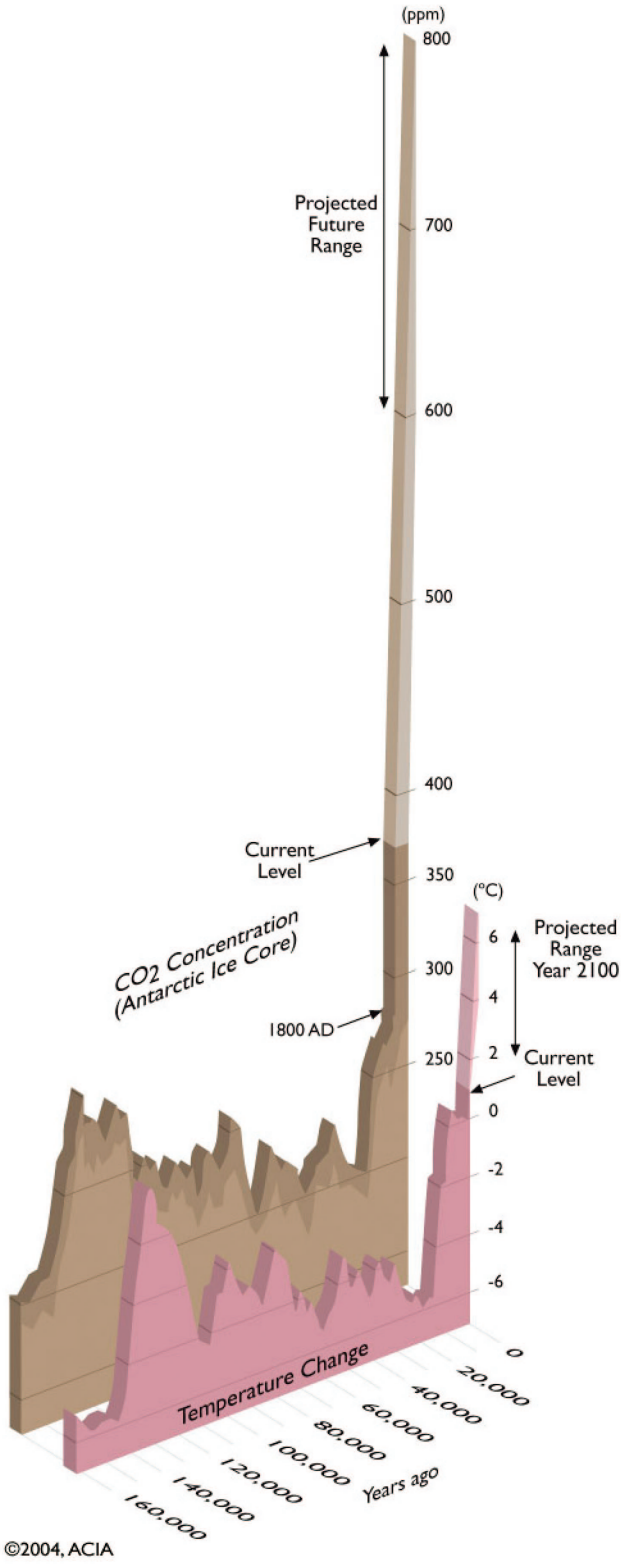
Image courtesy of NASA/JPL

This image was created with data acquired by the Atmospheric Infrared Sounder instrument (AIRS) on NASA's Aqua satellite during July 2009. The image shows large-scale patterns of carbon dioxide concentrations that are transported around Earth by the general circulation of the atmosphere. Dark blue corresponds to a concentration of 382 parts per million and dark red corresponds to a concentration of almost 390 parts per million. The northern hemisphere mid-latitude jet stream effectively sets the northern limit of enhanced carbon dioxide. A belt of enhanced carbon dioxide girdles the globe in the southern hemisphere, following the zonal flow of the southern hemisphere mid-latitude jet stream. This belt of carbon dioxide is fed by biogenesis activity in South America (carbon dioxide is released into the atmosphere through respiration and the decomposition of vegetation), forest fires in both South America and Central Africa, and clusters of gasification plants in South Africa and power generation plants in southeastern Australia.

The AIRS instrument flies on NASA's Aqua satellite and is managed by the Jet Propulsion Laboratory, Pasadena, California, under contract to NASA. JPL is a division of the California Institute of Technology in Pasadena.

More information about AIRS can be found at http://airs.jpl.nasa.gov.

CARBON EMISSIONS, CO_2 CONCENTRATIONS AND TEMPERATURE



CARBON, FOOTPRINTS, AND GREENHOUSES

There are lots of climate terms in today's conversation – via media, textbooks, and online. It is important to know what they all mean in order to be climate literate.

Term you hear: Greenhouse gases

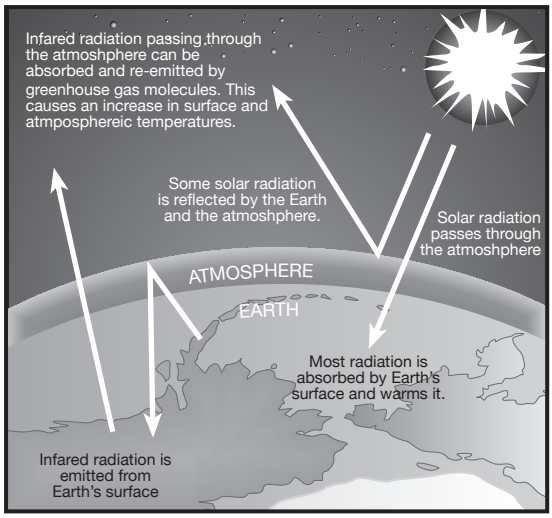
Earth's atmosphere is a natural shield that protects the planet and keeps it hospitable to life. About one percent of the atmosphere is made up of gases referred to as greenhouse gases. These gases absorb radiant heat from Earth keeping the planet warm. Without them, Earth would be frozen and inhospitable.

Greenhouse gases:

- include water vapor, carbon dioxide, ozone, methane and nitrous oxide
- absorb and reflect heat back to Earth
- are naturally occurring and play a vital role in regulating the planet's climate

The balance of greenhouse gases in the atmosphere keeps the climate stable. When the balance changes, the climate changes.

The Greenhouse Effect



Term you hear: Greenhouse effect

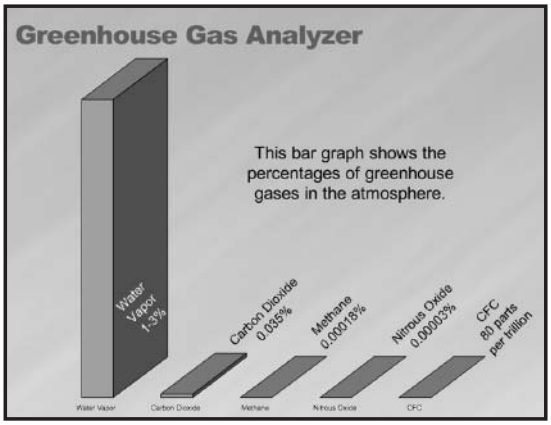
A greenhouse traps the sun's energy. Short wavelengths of visible light energy pass through the windows and are absorbed by the soil. The warm soil then radiates heat, but that heat energy has a longer wavelength and cannot pass back through the window. More and more heat is trapped over time and the greenhouse heats up.

About 80-90 percent of Earth's natural greenhouse effect is due to water vapor. The remainder is due to carbon dioxide, methane, and a few other trace gases.

A similar process takes place on Earth. Sunlight penetrates the atmosphere and warms the planet surface then the planet radiates the heat. Some radiant energy escapes the atmosphere, but greenhouse gases absorb some radiant energy. The trapped heat energy warms the lower atmosphere. (The upper atmosphere is actually colder because the layer of gases keeps the heat from reaching it.)

Term you hear: Carbon dioxide (or CO_2)

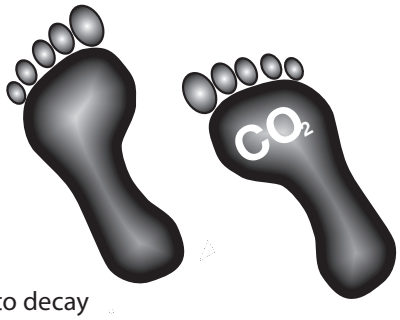
Carbon dioxide, or CO_2, is a significant greenhouse gas; it traps infrared energy and is important in maintaining global average temperature, which is about 59° Fahrenheit (15°Celsius). Without water vapor, CO_2, and methane (CH_4) (the three most important naturally produced greenhouse gases), Earth's surface would be about 0° Fahrenheit (-18° Celsius). At this temperature, the planet would be a much different place.



The level of CO_2 in the atmosphere has increased nearly 30 percent since the 1750s, when the burning of fossil fuels became an important part of the industrialized world. Scientists are monitoring this increase to see how it might be contributing to global climate change.

CARBON, FOOTPRINTS AND GREEN HOUSES

Term you hear: Carbon footprint



At its most basic, a carbon footprint is an estimate of the amount of carbon a person uses, directly or indirectly, through the use of natural resources. The use of carbon releases carbon dioxide (CO_2) into the atmosphere. Humans add CO_2 through:

- burning fossil fuel; combustion accounts for 65 percent of the human contribution
- deforestation; CO_2 released from trees that are cut and burned or left to decay accounts for 33 percent of the human contribution
- cement production; the by-products account for the remaining 2 percent of the human contribution

Term you hear: Go green

The "green" movement is a social movement concerned with environmental issues. "Going green" is a term used to describe living a lifestyle that is conscious of daily decisions that may impact global warming, pollution, loss of animal habitats, and other environmental concerns.

Ways to "go green" include:

- save energy
- save water
- use less gas
- eat locally grown food
- reduce, reuse, recycle

Go Green!

In place of a motorized vehicle, walk or ride your bike once a week.

Find ways to reduce your home energy bill.

Term you hear: Carbon cycle

The carbon cycle is the continuous process by which carbon is exchanged between organisms and the environment. Plants draw carbon from the air and water from the soil. When the plant dies, decomposers break down the plant and respire the carbon back into the air. If the plant is eaten by an animal, the animal's body will recombine the carbon and it will respire some of the carbon back into the air. If that animal is eaten by a carnivore, the carbon compounds will be reused and respired back into the air. When the animal dies and decomposers break down the remaining organic material, the carbon will be respired back into the air.

Each time it is respired back into the air, it becomes available for green plants again. Under certain conditions where decomposers can't complete the job and geologic processes bury the organic material, carbon will accumulate in reservoirs. One kind of reservoir leads to what we now refer to as fossil fuel. When such fuel is burned, the trapped carbon is released into air again.

NAME: _____

CARBON, FOOTPRINTS AND GREEN HOUSES

Directions: After you have watched the DIGITAL LECTURE: "Professor Jon Dehn: Volcanoes Leave a Giant Carbon Footprint," reviewed the MULTIMEDIA: "Climate Change in the Arctic: Greenhouse Gases" and read the STUDENT INFORMATION SHEET: "Carbon, Footprints and Green Houses," complete the following worksheet.

1. Name two ways Earth's surface receives heat energy.

   A. _____

   B. _____

2. Circle the atmospheric gases that are greenhouse gases.

oxygen	helium	carbon dioxide	nitrogen	CFC
methane	nitrous oxide	neon	hydrogen	argon
carbon monoxide	xenon	ammonia	water vapor	

3. What makes a greenhouse gas different from other gases present in the atmosphere?

   _____

4. Greenhouse gases play a vital role in regulating what?

   _____

5. Name five ways carbon dioxide gets into the atmosphere.

   A. _____ D. _____

   B. _____ E. _____

   C. _____

6. Why does cold ocean water hold more carbon dioxide than warm ocean water?

   _____

7. The rise in the concentration of _____ corresponds with a rise in global surface temperature.

8. Some scientists predict that human contributions to greenhouse gases in the atmosphere could cause a global temperature change of _____degrees Celsius in the next 100 years.

9. What two ways do volcanoes make a contribution to CO_2 in the atmosphere?

   A. _____

   B. _____

NAME: _____

CARBON FOOTPRINT— BRINGING IT HOME

Directions: Read the following questions and circle your answer. Use the scoring instructions on the second page to calculate your "carbon footprint."

1. _____ How do you get to school?
   A. walk or ride a bike B. snow machine or four wheeler C. car D. bus or van

2. _____ What kind of vehicle does your family drive? (If more than one, choose the largest.)
   A. none B. snow machine/4-wheeler only C. car D. SUV, van or truck

3. _____ How often does your family fly in a plane?
   A. less than once per month B. once per month C. 2-4 times per month D. once per week or more

4. _____ What kind of food does your family eat?
   A. subsistence B. combination of store bought and subsistence C. store bought

5. _____ How often does your family eat out or order food from a restaurant?
   A. never B. once a month C. once a week D. twice a week or more

6. _____ How much soda do you drink?
   A. none B. 1 can a day C. 2 cans a day D. 3 cans a day or more

7. _____ How often does your family do laundry?
   A. once per month B. twice per month C. once per week D. twice per week or more

8. _____ Do you get a newspaper or magazine at home? A. No B. Yes

9. _____ Do you turn off the lights when you leave a room? A. Yes B. No

10. _____ Do you turn off your computer and other electronics when they are not in use? A. Yes B. No

11. _____ What type of fuel is used to heat your house?
    A. wood B. propane C. fuel oil D. natural gas

12. _____ Circle each of the things your family owns.
    A. cell phone D. computer G. refrigerator
    B. TV E. washing machine H. snow machine, 4-wheeler, motor bike
    C. DVD player F. dishwasher I. boat with motor

Scoring Instructions:

Calculate points for questions 1 through 11: A = 1 point B = 2 points C = 3 points D = 4 points
For question 12, assign yourself 1 point for each item circled.
Add all the points together to determine your "carbon footprint." Enter the total number of points in #13.

13. **Total Carbon Footprint:** _____

NAME: _____

CARBON FOOTPRINT — BRINGING IT HOME

Directions: Think about what you have learned about greenhouse gases, CO_2, and carbon footprints, then answer the following questions.

14. List two ways that a significant rise in the level of greenhouse gases could affect your community.

    A. _____

    B. _____

15. Review the list of Athabascan cultural values. Select one value and explain how that value relates to a decision you might make to reduce your carbon footprint.

    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____

Athabascan Cultural Values

- Self-sufficiency and hard work
- Care and provision for the family
- Family relations and unity
- Love for children
- Village cooperation and responsibility to village
- Humor
- Honesty and fairness
- Sharing and caring
- Respect for Elders and others
- Respect for knowledge and wisdom from life experiences
- Respect for land and nature
- Practice of native traditions
- Honoring ancestors
- Spirituality

16. Use the following information to calculate the amount of CO_2 you are contributing to the atmosphere while riding a snow machine or an ATV:

    To obtain the number of grams of CO_2 emitted per gallon of gasoline combusted, the carbon content of a gallon of fuel is multiplied by the oxidation factor and the ratio of the molecular weight CO_2 to that of carbon.

    Carbon content of gasoline: 2,425 grams of carbon per gallon (prior to combustion)

    Fraction oxidized to CO_2 is 100 percent

    Ratio of molecular weight of CO_2 to carbon is 44/12

Atomic Weight

	O =	16
	O =	16
+	C =	12
	CO_2 =	44

(2,425 grams C/gallon) * (100% oxidation factor * 44 g CO2/12 g C) * (1 metric ton/1,000,000 g) = 8.89 * 10-3 metric tons CO_2/gallon of gasoline

A. How many gallons of fuel, on average, do you use in a week to run a snow machine or ATV? _____

B. How many gallons do you use in one year? _____

C. How many metric tons of CO_2 does that put into the atmosphere each year? _____

17. Approximately how many snow machines and ATVs are there in your community? _____

18. If everyone in your community uses about the same amount of fuel, how many metric tons of CO_2 does that put into the atmosphere each year? _____