Protect Your Climate

Bay Area Air Quality Management District

Welcome to the Protect Your Climate Curriculum Program!

- Curriculum contains 16 science-based lessons for 4th and 5th grade.
- Lessons investigate the science and causes of climate change and how to take action to protect our climate.
- Hands-on activities explore air quality, energy, waste, and transportation issues related to climate change.
- Science and other State Content Standards addressed.

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PROTECT YOUR CLIMATE CURRICULUM
TEACHER'S GUIDE

Welcome and thank you for choosing to use *Protect Your Climate!* The objective of this curriculum is to teach students about the science of climate change and to inspire students to protect their climate by empowering them with knowledge, tools, and skills to reduce greenhouse gas emissions in their daily lives.

The Importance of Teaching Climate Protection

Climate change is one of the biggest challenges facing the world. Climate change is caused by the large amounts of greenhouse gases that human activities are releasing into the atmosphere. The largest source of greenhouse gas emissions is the burning of fossil fuels for energy, electricity, and transportation uses. Greenhouse gases trap heat which is leading to global warming and as a result, changes in global climate conditions. Changes in climate worldwide have already and will continue to cause droughts, flooding, wildfires, and food and water shortages. Climate change is a global challenge, however, all of us can act together to avoid severe climate change impacts in the future. This curriculum teaches students how they can take action and reduce greenhouse gas emissions at home, at school, and in the community.

About the Curriculum

This interdisciplinary curriculum uses hands-on demonstrations, interactive activities, discussions, experiments, and home assignments to engage students in understanding and applying important climate change concepts. Students are encouraged to use logic, foresight, and critical thinking in making informed decisions and taking action for climate protection.

We welcome all comments, suggestions, and critiques you may have regarding the *Protect Your Climate* curriculum. Feedback on content, activities, and relevance to California State Content Standards and the Environmental Principles and Concepts is essential in making this educational tool the best it can be.

The *Protect Your Climate* curriculum is a program from the Bay Area Air Quality Management District (District). With the help of Strategic Energy Innovations, the contracted consultant for the program, the District developed *Protect Your Climate* and launched it in schools across the Bay Area.

BAAQMD has allowed its curriculum to be used and adapted as appropriate by other air districts, local governments, and government organizations. BAAQMD is not responsible for the modifications, additions, and any changes in information and content made to the Protect Your Climate curriculum by other entities.

Bay Area Air Quality Management District is responsible for maintaining air quality in the San Francisco Bay Area.

Strategic Energy Innovations is a non profit organization that provides energy efficiency and renewable energy consulting and related services to schools and universities, local governments, small businesses and affordable housing communities.

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How to Use the Curriculum

Target Grade Levels

Protect Your Climate targets 4th and 5th grades but is easily adaptable to other grades. The lessons, background, and support materials are tailored to meet a wide range of student learning styles, skill levels, and prior knowledge.

Topic Sections

The curriculum contains 16 lessons that are presented in four topic sections with three to six lessons in each section and a final lesson that can be used as an assessment for the whole unit. Each section begins with background for teachers on the section topic. The backgrounds summarize definitions, science, and current issues for each topic area.

Climate Change Basics
Students will become aware of the key scientific principles around air pollution and climate change.

Reducing Impacts from Energy Use
Students will discover how energy, and specifically electricity use, is connected to climate change. Students will also examine renewable energy sources and ways to conserve electricity.

Reducing Impacts from Waste
Students will examine their own waste habits at school and learn and discuss the benefits of reducing waste, recycling, and composting.

Reducing Impacts from Transportation
Students will be introduced to how transportation contributes to climate change and will explore ways to avoid emissions from transportation uses.

Tool Kit & Image Library

Protect Your Climate includes a tool kit with necessary materials for the lessons, such as thermometers, hanging scales, and candles. Basic classroom materials, such as paper, pencils, and scissors, are not included in the tool kit. Any additional classroom materials necessary for the lesson are listed in the lesson page sidebar.

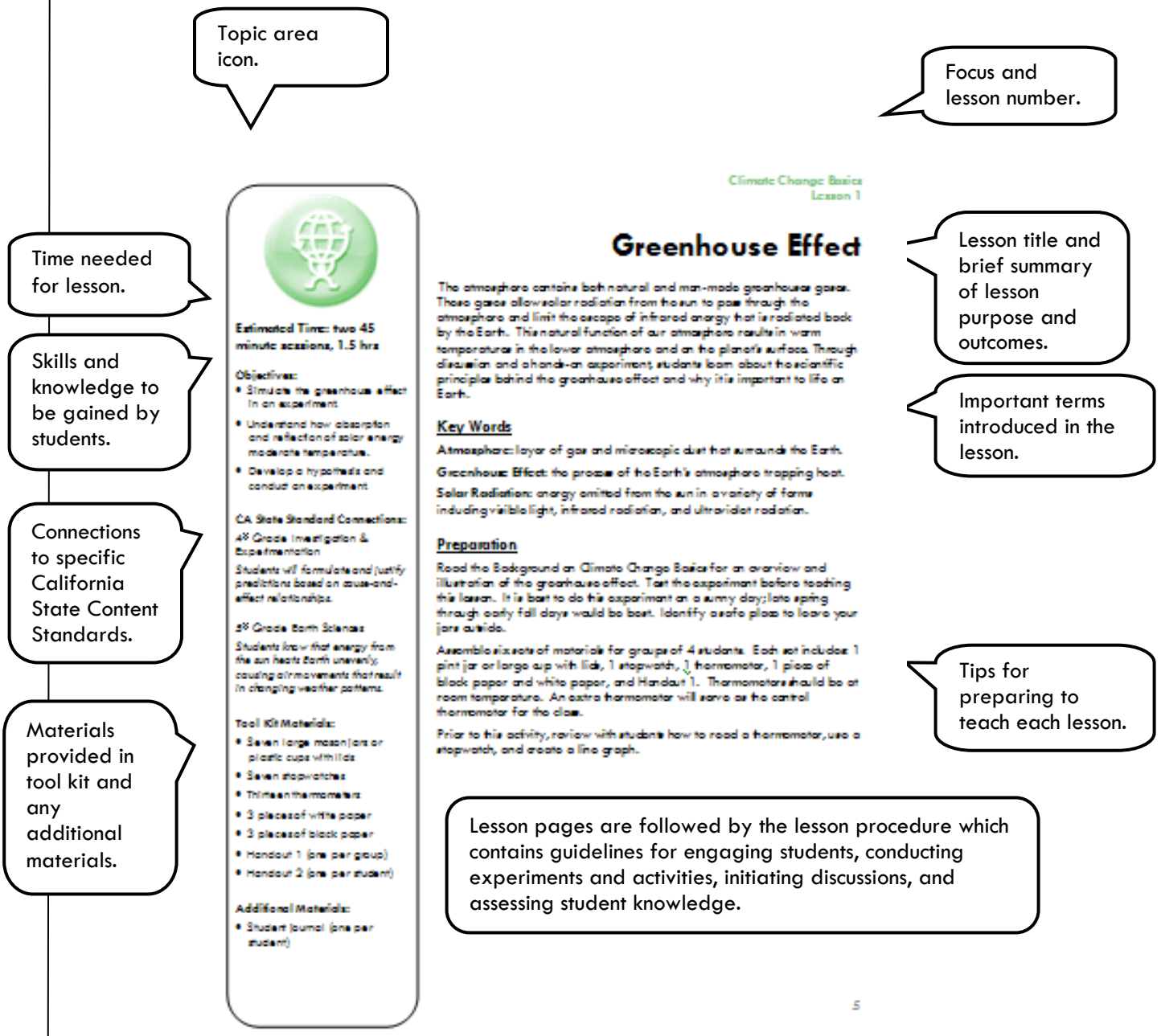
The toolkit also includes a CD with images to engage students. Images can be projected with a computer projection system or printed from the CD onto an overhead transparency.

 Look for this camera icon within lessons for image recommendations.

Using the Lessons

The *Protect Your Climate* lessons build knowledge and skills in a sequential manner for students to gain a fundamental understanding of climate change and its causes. Teachers are encouraged to follow the lesson sequence.

Sample Lesson Page



Assessments

Lessons include suggestions for observing student learning within the course of the lesson activities. These assessment opportunities include journal writing, discussion responses, and completion of activities. Teachers can prepare to use these opportunities by thinking about various levels of performance that can confirm student learning.

 Look for this pencil icon within lessons for student journal prompts.

Inspiring Change Projects

Each section includes a "What Can You Do" page that provides service learning project recommendations to implement at home, at school, or in the community. Service learning integrates classroom learning with meaningful projects outside the classroom. These projects promote civic responsibility by connecting students' lives with issues that affect them, their families, and their communities. Service learning projects also foster opportunities for the community or school to participate in student learning.

Look for inspiring change project recommendations at the end of each lesson, and on the "What Can You Do" page at the end of each section. Inspiring change projects are organized by scope of impact.

 **Small Steps**: projects inspiring personal behavior change.

 **Medium Steps**: projects inspiring change at home and school.

 **Big Steps**: projects inspiring change in the community.

California State Standard Connections

Curriculum lessons provide skill practice for science, reading, writing, research, and mathematical skills. See the Standards Connection table for how lessons connect with State Content Standards.

Environmental Principles & Concepts

Lessons are also aligned with the Environmental Principles & Concepts (EP&C). EP&C are guidelines for integrating environmental studies into grade levels.

Further information about the Education and the Environment Initiative is available at http://www.calepa.ca.gov/Education/EEI/.

Standards, Environmental Principles and Concepts, and Related Subjects Connections per Lesson

	Lesson	California State Content Standards	Environmental Principles & Concepts	Related Subjects
1	The Greenhouse Effect	• 4th Grade Investigation & Experimentation (c) • 4th Grade Measurement & Geometry • 4th Grade Statistics, Data Analysis & Experimentation • 5th Grade Earth Sciences (4) • 5th Grade Mathematical Reasoning	• Principle III: Natural systems proceed through cycles and processes that are required for their functioning. • Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both.	Math & Science
2	The Heat is On	• 4th Grade Life Science • 4th Grade Measurement & Geometry • 4th & 5th Grade Statistics, Data Analysis & Experimentation • 5th Grade Earth Science (4) • 5th Grade Mathematical Reasoning • 4th & 5th Grade Reading Comprehension • 4th & 5th Grade Listening & Speaking • 4th Grade History-Social Science (4.1)	• Principle III: Natural systems proceed through cycles and processes that are required for their functioning.	Science, Math, Language Arts & Visual Arts
3	Studying Air Pollution	• 4th Grade Life Science • 5th Grade Investigation and Experimentation • 4th & 5th Grade Visual Arts • 4th & 5th Grade Listening & Speaking	• Principle I: Students understand the health of individuals and human communities depends on the health of natural systems. • Principle IV: Students know that the exchange of matter between natural systems and human societies affects the long-term functioning of both. • Principle V: Students know that decisions affecting natural systems are based on a wide range of considerations and decision-making processes.	Science, Visual Arts & Language Arts
4	Climate Change Action	• 4th Grade Life Sciences • 5th Grade Earth Sciences • 5th Grade Life Sciences • 4th Grade Language Arts Word Analysis & Vocabulary Development • 5th Grade Visual Arts Connections & Applications	• Principle III: Natural systems proceed through cycles that humans depend upon, benefit from and can alter. • Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both.	Science, Language Arts, & Visual Arts
5	Energy Choices	• 4th Grade Statistics, Probability & Data Analysis • 5th Grade Earth Sciences • 4th & 5th Grade Physical Education (5.0) Social Interaction • 4th & 5th Grade Listening & Speaking	• Principle II Concept b: Students need to know that methods used to extract, harvest, transport and consume natural resources influence the composition and viability of natural systems. • Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts.	Science, Math, Language Arts, & Physical Education
6	Combustion Energy and Air Pollution	• 4th Grade Investigation & Experimentation (c) • 4th Grade Language Arts Vocabulary Development • 4th & 5th Grade Listening & Speaking	• Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both. • Principle V: Students know that decisions affecting natural systems are based on a wide range of considerations and decision-making processes.	Science & Language Arts
7	Using the Sun's Energy	• 4th Grade Physical Sciences • 5th Grade Physical Sciences (b) (c) • 4th & 5th Grade Vocabulary Development • 4th & 5th Grade Physical Education 5.0	• Principle I: Students understand the health of individuals and human communities depends on the health of natural systems.	Science, Language Arts & Physical Education

8	Generating Electricity	• 4th Grade Physical Sciences (c) & (d) • 4th Grade Number Sense (3.0) • 4th & 5th Grade Vocabulary Development	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts	Science & Language Arts
9	Home Energy Audit	• 4th Grade Physical Sciences (g)	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.	Science
10	Thinking About Consumption	• 4th Grade Visual Arts Connections & Applications • 4th & 5th Grade Listening & Speaking • 4th & 5th Grade Investigation & Experimentation	• Principle IV Concept b: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effects.	Visual Arts, Language Arts & Science
11	Class Waste Audit	• 4th Grade Investigation & Experimentation (b) • 5th Grade Investigation & Experimentation (a)	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts.	Science & Math
12	Recycling & The Climate	• 4th Grade Number Sense (1.0) • 4th Grade Statistics Data Analysis (1.0) • 4th Grade Visual Arts (5:3)	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts.	Math, Visual Arts, & Science
13	Composting Benefits	• 4th Grade Life Science (c) • 4th & 5th Grade Listening & Speaking • 4th & 5th Grade Vocabulary Development • 4th & 5th Grade Measurement & Geometry • 4th & 5th Grade Physical Education 5.0	• Principle IV Concept b: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effects.	Science, Language Arts, Math, & Physical Education
14	Car Tally	• 5th Grade Visual Arts (5:2) • 4th & 5th Grade Statistics, Data Analysis, & Probability • 4th & 5th Grade Mathematical Reasoning • 4th & 5th Grade Investigation & Experimentation	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts. • Principle IV Concept b: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effects.	Math, Science, & Visual Arts
15	Calculating School Trip Emissions	• 4th Grade Number Sense (3.0) • 5th Grade Mathematical Reasoning • 4th & 5th Grade Listening & Speaking • 4th & 5th Grade Investigation & Experimentation	• Principle IV Concept a: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of resulting byproducts. • Principle IV Concept b: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effects.	Science, Language Arts & Math
16	Designing A Clean Air City	• 4th Grade California: A Changing State (4:1) • 4th Grade Visual Literacy (5:3)	• Principle V: Students know that decisions affecting natural systems are based on a wide range of considerations and decision-making processes.	Social Science, & Visual Arts

Toolkit Supplies List

The following toolkit of materials will be needed for conducting the lesson activities.

The following quantities are based on student groups of 4 in a class of 28 students.

The estimated cost for purchasing these materials is approximately $200.

Quantity	Item
7	glass mason jars
7	sheets of white construction paper
7	sheets of black construction paper
7	stopwatches
8	thermometers, long enough to fit in the jar and for the temperature gauge to be seen outside the jar
1	packet of index cards
1	jar of petroleum jelly
1	roll of aluminum foil
1	roll of plastic wrap
7	paraffin candles
7	beeswax candles
1	bar magnet
1	roll of copper wire
2	alligator clips
1	ammeter
1	13 watt compact fluorescent light bulb
1	60 watt incandescent light bulb
1	hanging scale
1	spray bottle
1	plastic bin to store all items

Curriculum Tips

The following teaching tips will help teachers get the most out of the curriculum and address the learning styles of a wide variety of students.

- Read the Background for each lesson to familiarize yourself with the 'big picture.' You may want to print the Background summaries for your students to read.
- Test all demonstrations, experiments, and activities before implementing.
- Include as many students as possible when conducting experiments and demonstrations such as working in a lab format or using students as helpers.
- Build scientific skills from the Investigation and Experimentation standard:
  - Encourage students to make predictions about experiment outcomes and apply the scientific method.
  - Encourage students to create their own tables, charts, and diagrams for the data they gather.
  - In student discussions of controversial issues, encourage students to speak from an informed point of view, citing the source of their knowledge.
  - Lead students to conclusions through the use of questions, rather than telling them the answer.
  - Encourage students to share their knowledge and findings with their school, families, and community.
- Use visuals and models to illustrate concepts and terms. This is especially effective for second-language learners.
- Help students see connections between what they are learning, other curricular areas, and the real world.
- For controversial issues, like how to respond to climate change, provide balanced resources and perspectives from websites, news articles, books, or news clips.
- Encourage students to gather information and knowledge from experts and resources outside the classroom. Use guest speakers and experts as resources when possible.
- Help students understand that as citizens of their community, state, nation, and the world, they have a responsibility for what happens and can make a difference through their choices and actions.
- Learn with your students!

GLOSSARY

Aerobic: decomposition in the presence of oxygen.

Air Pollution: the presence of harmful substances in the air.

Ammeter: device used to measure the electric current in a circuit.

Anaerobic: decomposition in the absence of oxygen.

Atmosphere: layer of gas and microscopic dust that surrounds the Earth.

Carbon Dioxide (CO_2): a gas made of carbon and oxygen atoms that plants use for photosynthesis. CO_2 is a greenhouse gas.

Carbon Footprint: a measure of the total greenhouse gases produced by a process, an activity, or a person. A product's carbon footprint includes all greenhouse gas emissions produced by its lifecycle.

Carpool: to share a ride with other people in one vehicle.

Circuit: path that an electrical current flows through.

Climate: average pattern of weather for an area over a long period of time, 30 years or more.

Climate Change: global shift in long-term climate patterns.

Combustion: chemical process of burning.

Commute: regular travel from two destinations, such as home to work or home to school.

Composting: the process of collecting organic waste and letting it decompose naturally through aerobic decomposition.

Compost: natural decomposition of organic matter, like grass clippings, food scraps, and leaves, that can be used to enrich the soil.

Conservation: careful use and protection of natural resources.

Decomposition: breakdown of organic materials by bacteria and other decomposers, fungus and insects.

Efficiency: amount of work that a machine does compared with the quantity of energy input.

Electric Power Plant: factory that generates electricity.

Electrical Current: flow of electrons.

Electricity: form of energy produced when electrons move from one place to another. We use electricity for light, heat, and power in homes and industries.

Electron: negatively charged particle in an atom.

Energy Audit: evaluation of energy consumption in a home or business to determine ways that energy can be conserved.

GLOSSARY

Energy Input Pathways: concept used to track how energy is consumed through the lifecycle of a product, from its production, consumption, and disposal or reuse.

Fossil Fuels: coal, petroleum, and natural gas are formed over millions of years from the decayed remains of ancient plants and animals.

Fuel: something such as wood or oil which is burned to produce energy.

Fuel Efficient Vehicle: vehicle that requires less fuel to travel compared to other vehicles.

Generator: machine that converts mechanical energy into electrical energy.

Greenhouse Effect: the process of the Earth's atmosphere trapping heat.

Greenhouse Gas: a gas that traps heat in the atmosphere. An over-abundance of greenhouse gases is contributing to climate change.

Idling: an engine running while not doing useful work, such as a car sitting still with its engine running.

Landfill: large outdoor area, usually specially constructed, where waste is dumped and buried.

Manufacturing: process of turning raw materials into products that can be used or consumed.

Methane: a greenhouse gas created by anaerobic decomposition.

Miles per Gallon: number of miles a vehicle can travel on one gallon of fuel.

Mixed Use Community: community with schools, offices, homes, stores, green space, and public spaces easily accessible to one another.

Non-Renewable Energy: energy from a source that cannot be replaced or can only be replaced very slowly by natural processes, usually over millions of years.

Ozone (O_3): ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals and humans. Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth's surface.

Paraffin: type of wax made from petroleum, a fossil fuel.

Particulate Matter: tiny particles and liquid droplets in the air, including acids, organic chemicals, metals, and dust particles.

Passenger Miles per Gallon: number of miles a single vehicle can travel on one gallon of fuel multiplied by the number of passengers.

Phantom Load: energy used by electrical devices when they are plugged in but not being used.

Photon: tiny particle of radiant energy.

Precipitation: water falling from clouds in any form, such as snow, ice, rain, or drizzle.

Product Cycle: the total process of a particular product's manufacture, transportation, use, and disposal.

GLOSSARY

Raw Material: natural material used as input to production.

Reduce: using fewer products and materials in our daily lives.

Recycle: collecting and processing products into new or different products.

Recycled Content: amount of recycled material in a new product.

Renewable Energy: energy from a source that is replaced rapidly by natural processes.

Reuse: to use again.

Solar Cell: device that changes energy from the sun into electricity. A solar panel is comprised of many solar cells.

Solar Radiation: energy emitted from the sun in a variety of forms including visible light, infrared radiation, and ultraviolet radiation.

Soot: fine black particulate matter produced by combustion of coal, oil, wood, or other fuels.

Smog: air pollution made primarily of ozone (O_3) that forms when pollutants from vehicles and industry react in the air with sunlight.

Sustainable: actions done in a manner that do not deplete natural resources faster than they can be naturally replenished.

Traffic: movement of cars and other vehicles on the road.

Transportation: ways of moving people or goods from one place to another.

Turbine: machine that extracts energy from fluid flows like wind, moving water, or steam to do work.

Urban Planner: person who helps plan communities.

Waste: items thrown away and not used again.

Water Cycle: change of water from one state to another as it moves between Earth's surface and atmosphere included the processes of evaporation, condensation, and precipitation.

Weather: short-term condition of the atmosphere at a place for a given time.

Background for Lesson 1

The Greenhouse Effect

The Earth's atmosphere, a layer of gases and microscopic dust that surrounds the planet, acts like a greenhouse in keeping the Earth warm enough to support life. Like the glass panes in a greenhouse, gases in the atmosphere let sunlight pass through and warm Earth's surface, and limit the amount of heat that escapes back into space. Without this greenhouse effect, the Earth would be a frozen planet.

Figure 1 illustrates the greenhouse effect. Energy emitted from the sun, known as solar radiation, which includes visible light, infrared radiation and ultraviolet radiation, passes through the atmosphere and is either absorbed or reflected back from clouds or the earth's surface. Darker surfaces like vegetation and asphalt absorb more energy than lighter surfaces like ice and snow. This process warms the planet's land and water surfaces.

The Earth's surface warms the air above it by radiating it's energy as infrared radiation. Some of this infrared radiation escapes out to space, while some remains trapped in the atmosphere by greenhouse gases. Naturally occurring greenhouse gases, like water vapor and carbon dioxide, absorb the heat, keeping the planet warm enough for life to survive.

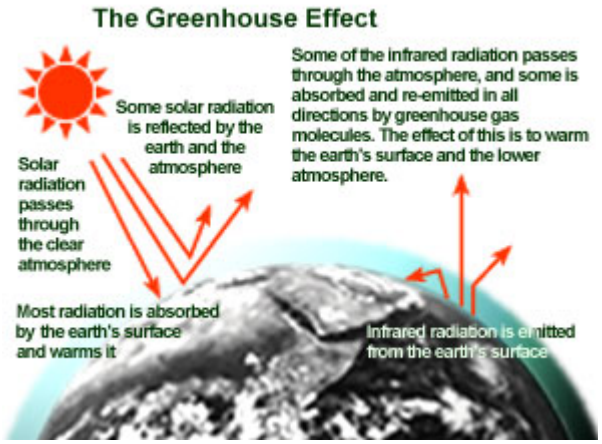
Climate Change Connection: Greenhouse gases occur naturally in our environment and serve a critical role in keeping our planet livable. However, greenhouses gases are also emitted from man-made sources. The burning of fossil fuels, such as coal and oil, emits carbon dioxide, the most common greenhouse gas. Since the Industrial Revolution, as energy needs have grown in our society, the rate of greenhouse gases emitted into the atmosphere has been increasing. The atmosphere's over abundance of greenhouse gases is enhancing the Earth's greenhouse effect, leading to warmer temperatures and changes in climate around the planet.

Background for Lesson 2

Climate and Weather

Weather is driven by heat, the rotation of the Earth, and variations in the Earth's surface. Heat from the sun warms the Earth's land and oceans, which in turn heat the air above their surface. The warm air then rises and is replaced by neighboring cooler air. This

Figure 1. Source: Environmental Protection Agency, 2008, http://epa.gov/climatechange/kids/greenhouse.html



movement creates currents of air that distribute heat across the planet. Ocean currents also distribute heat around the planet. As heated air and water move around the Earth and mix with colder air and water, we get weather in the form of clouds, rain, and wind. Other factors, like how much sunlight hits a region, nearby bodies of water, and how flat or mountainous an area is, affect weather conditions around the globe. For instance, a mountain range could stop rain clouds from passing through. As a result, one side of the mountain will be lush with forests while the other side may be dry.

Climate describes weather patterns in an area over a long period of time, 30 years or more. Earth's climate has changed over the planet's five billion year history through different ice ages and warming periods. However, these climate changes occurred over periods of thousands of years.

Climate Change Connection: The Earth's average temperature has increased by one degree Fahrenheit over the past 100 years. Scientists have recorded an overall global warming trend, with the most rapid warming occurring over the last twenty years. Scientists believe that the increasing concentration of greenhouse gases in Earth's atmosphere is affecting global temperatures by enhancing the planet's greenhouse effect. The warming of the atmosphere is currently affecting, and will continue to affect, weather conditions around the planet. Expected weather impacts include changes to rainfall patterns; more frequent and intense droughts and flashfloods; and less snowfall in mountain ranges.

Background for Lesson 3
Air Pollution

Air pollution is comprised of gases and particles emitted in the air that can be harmful to human health and the environment. Some air pollution may be caused by natural events like forest fires and volcano eruptions; however, most air pollution comes from man-made sources. The biggest source of air pollution is from the burning of fossil fuels, such as coal and oil for energy in transportation, power plants, and factories. Some of the more prevalent forms of man-made pollution include smog, particulate matter, and greenhouse gases.

The main component of smog is **ozone** (O_3), a colorless gas. Exposure to ozone can trigger chest pain, coughing, throat irritation, and can cause respiratory diseases. Harmful concentrations of ozone occur when pollutants we call nitrogen oxides (NO and NO_2) and volatile organic compounds (VOCs) react in sunlight to form ozone. Nitrogen oxides and VOCs are emitted by vehicle exhaust, gasoline vapors, industrial emissions, and even consumer products. Many urban areas experience unhealthy levels of ozone in the summertime. However, less urban areas may also experience high ozone levels because wind can carry nitrogen oxides, VOCs, and even ozone miles away from their original sources. In some cases, mountains can stop the transport of pollutants, resulting in extremely harmful ozone concentrations in areas like the San Joaquin Valley and Los Angeles.

Particulate matter (PM) is composed of tiny particles and liquid droplets. It is made up of various components, such as acids, organic chemicals, metals, and dust particles. These small particles can lodge into the lungs and even invade the bloodstream. The most dangerous particles are the smallest: those less than 10 micrometers in diameters, such as those found near roadways and dusty industries; and fine particles less than 2.5 micrometers in diameter, such as those found in smoke and haze. Breathing in PM can result in serious health effects, like respiratory diseases, irregular heartbeat, and premature death in people with heart or lung disease. PM in the Bay Area is emitted from diesel exhaust, industrial processes, and construction activities. In the wintertime, wood burning in fireplaces is the biggest source of PM in the Bay Area.

Among the most emitted man-made greenhouse gases is **carbon dioxide** (CO_2). CO_2 occurs naturally but is also emitted from the burning of fossil fuels. The amount of CO_2 in the atmosphere has been increasing significantly as fossil fuel use has grown around the world. While CO_2 emissions do not usually cause immediate health impacts, they accumulate in the atmosphere for hundreds of years and contribute to climate change.

In 1970, the United States passed the Clean Air Act to control air pollution and protect human health and the environment. As part of the Act, the Environmental Protection Agency set limits for major pollutants, including ozone, NO_2 and PM. States are required to meet these limits by regulating and reducing air pollution emissions in their state.

In California, the state established even more stringent air quality standards to follow. Regional air districts are responsible for regulating air pollution. The Bay Area Air Quality Management District (BAAQMD) regulates air pollution in the Bay Area. BAAQMD controls the amount of air pollution that industrial sources, such as power plants, may emit. BAAQMD also directs different education and public outreach programs to reduce air pollution from transportation.

Climate Change Connection: Since smog formation is directly related to warm days, air quality is expected to worsen as temperatures increase from global warming. Higher temperatures and more smog threaten public health with more respiratory and heat related illnesses. In addition, climate change is expected to increase fire hazards contributing to higher levels of air pollution.

Background for Lesson 4
Carbon Cycle

Carbon is a key element in all living matter, found in people, animals, soil, and oceans. Trees, plants, and fossil fuels store carbon. Carbon circulates through Earth's environment, moving between the atmosphere, trees, plants, animals, people, land, and water. Carbon exists in the atmosphere as carbon dioxide, a greenhouse gas.

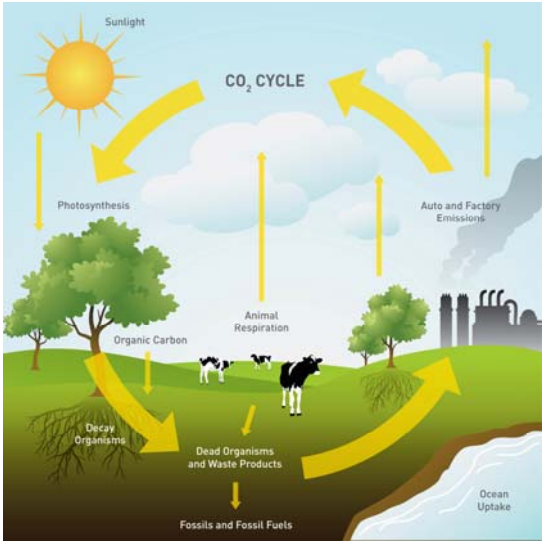
Figure 2 illustrates how carbon flows through the environment. Trees and plants use sunlight, water, and carbon dioxide to make food through photosynthesis. Carbon is then stored in trees and plants until they are eaten, burned, or decomposed. Animals consume the carbon in plants and release

carbon dioxide through respiration. When burned, plants and trees release their stored carbon into the atmosphere as carbon dioxide. As plants and trees decompose, their stored carbon breaks down into the soil and can even turn into a fossil fuel after thousand of years of compression. Once the fossil fuel is burned the stored carbon is emitted as carbon dioxide. Carbon dioxide in the atmosphere is absorbed by plants and trees for food. Oceans also absorb carbon dioxide.

Climate Change Connection: People are emitting carbon dioxide into the air faster than the planet is absorbing it, leading to an accumulation of carbon dioxide in the atmosphere. The surplus of carbon dioxide in the atmosphere is escalating the planet's greenhouse effect, leading to global warming and climate change.

Climate Change Impacts and Causes

Climate change refers to the changes in climate that are occurring, and are expected to occur, from the warming of the planet. Small shifts in climate are already being seen around the world with the melting of glaciers and changing weather conditions. In California, our climate is expected to become considerably warmer. We cannot predict the exact degree to which temperature will change but the extent of change will depend on the decisions we make as a society in the next several years. Scientists predict that a medium warning scenario of 5 to 8 degrees Fahrenheit by 2090 would significantly reduce the snow pack in the Sierra Nevada, raise sea levels, and lead to more heat waves, wildfires, and air pollution. These climate changes threaten our health, agriculture, natural resources, and built environment. For example, reduced snow pack means that there will be less water available for agriculture irrigation, drinking, and hydropower generation.



While carbon dioxide is the most common greenhouse gas emitted, human activities emit other pollutants that also act as greenhouse gases including: methane, nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). These pollutants are emitted in smaller quantities than carbon dioxide, but are able to store more heat per molecule than carbon dioxide. For example, methane absorbs 21 times more heat than carbon dioxide, meaning the **carbon dioxide equivalent** of methane is 21. Methane is mostly emitted from waste landfills and large livestock facilities; N_2O is emitted from agricultural processes; HFCs are emitted from industrial processes and refrigeration equipment.

The burning of fossil fuels accounts for close to 75% of total greenhouse gas emissions. Another source of greenhouse gas emissions is deforestation. Trees absorb carbon dioxide, which means they act as carbon sinks. If cut down, they no longer remove carbon dioxide from the atmosphere; and when burned, they release carbon dioxide into the atmosphere.

Climate Change Connection: Governments and organizations around the world are working hard to reduce our greenhouse gas emissions and protect our climate, however they need help. Many of the choices we make as individuals every day at home, in our schools or where we work affect the amount of pollution that is emitted into the environment. Conserving energy, choosing environmentally friendly products, and driving less are all actions that reduce greenhouse gas emissions, helping to protect our environment, air quality, and climate.

Need More Information?

- Air Quality
  - Bay Area Air Quality Management District: www.baaqmd.gov
  - Air Quality Primer (BAAQMD): www.sparetheair.org/teachers/primer
- Greenhouse Gas Effect Animation: http://earthguide.ucsd.edu/earthguide/diagrams/greenhouse/
- Climate Change
  - EPA: epa.gov/climatechange/kids/index.html

Greenhouse Effect

Estimated Time: two 45 minute sessions, 1.5 hrs

Objectives:

- Simulate the greenhouse effect in an experiment.
- Understand how absorption and reflection of solar energy moderate temperature.
- Develop a hypothesis and conduct an experiment.

CA State Standard Connections:

4th Grade Investigation & Experimentation

Students will formulate and justify predictions based on cause-and-effect relationships.

5th Grade Earth Sciences

Students know that energy from the sun heats Earth unevenly, causing air movements that result in changing weather patterns.

Tool Kit Materials:

- Seven large mason jars or plastic cups with lids
- Seven stopwatches
- Thirteen thermometers
- 3 pieces of white paper
- 3 pieces of black paper
- Handout 1 (one per group)
- Handout 2 (one per student)

Additional Materials:

- Student journal (one per student)

The atmosphere contains both natural and man-made greenhouses gases. These gases allow solar radiation from the sun to pass through the atmosphere and limit the escape of infrared energy that is radiated back by the Earth. This natural function of our atmosphere results in warm temperatures in the lower atmosphere and on the planet's surface. Through discussion and a hands-on experiment, students learn about the scientific principles behind the greenhouse effect and why it is important to life on Earth.

Key Words

Atmosphere: layer of gas and microscopic dust that surrounds the Earth.

Greenhouse Effect: the process of the Earth's atmosphere trapping heat.

Solar Radiation: energy emitted from the sun in a variety of forms including visible light, infrared radiation, and ultraviolet radiation.

Preparation

Read the Background on Climate Change Basics for an overview and illustration of the greenhouse effect. Test the experiment before teaching this lesson. It is best to do this experiment on a sunny day; late spring through early fall days would be best. Identify a safe place to leave your jars outside.

Assemble six sets of materials for groups of 4 students. Each set includes: 1 pint jar or large cup with lids, 1 stopwatch, 1 thermometer, 1 piece of black paper and white paper, and Handout 1. Thermometers should be at room temperature. An extra thermometer will serve as the control thermometer for the class.

Prior to this activity, review with students how to read a thermometer, use a stopwatch, and create a line graph.

SETTING THE STAGE

 View greenhouse picture from CD.

- A greenhouse is sort of like a car with the windows rolled up. "Has anyone ever been in a car with the windows rolled up on a hot sunny day?" "What was it like inside?" "How did it feel?"
- The glass of a greenhouse or car acts like greenhouse gases in our atmosphere that allow sunlight to pass through and warm the inside surfaces, and then traps heat that radiates back from the surfaces.
- We're going to do two experiments to explore the greenhouse effect. The first experiment models what happens in our atmosphere on a small scale. The second activity explores the effect of different surface colors on the greenhouse effect.

ACTIVITY 1 – Modeling the Greenhouse Effect

In this experiment we want to make a model that will act like the atmosphere on a small scale. The jar's surface walls acts like the atmosphere and greenhouse gases by allowing sunlight to enter the jar but not allowing the sun's heat to escape easily. We want to see if the air in the jar will heat up just from sunlight passing through and warming the surface inside. The open air beside our jar allows heat to escape more easily, so this will be our control experiment.

1. Review and demonstrate the following procedure:
   - One thermometer will be used as the control thermometer for the class.
   - Check that your thermometers are starting from the same temperature. Record the starting temperature at Minute 0 on your chart before we go outside.
   - Outside, arrange your jar on its side, and prop it up with a rock or some sticky tape so it won't roll away.
   - Place the thermometer firmly through the lid hole so that you can see the temperature gauge outside of the lid and screw the lid onto the jar.
   - Then set up your control thermometer as your control experiment right beside your jar.
   - Use the stopwatch to measure when to read the temperature. You'll take 5 readings, during a10 minute period.
2. Draw the data chart on the board. Explain that each group of four will need to have a timekeeper, 2 observers, and a recorder. The timekeeper will use the stopwatch and say 2, 4, 6, 8, and 10 minutes at the appropriate times. Each observer will read and report the temperature from the thermometer. The recorder will enter temperature readings on the data chart and share results at the end. Pass out materials to students. A group of students should be assigned to monitor the control thermometer.
3. Pass out Handout 1 to students. Ask students to write their names, what they think will happen on the hypothesis line, and to look at the thermometers and record their starting temperatures. The group for the control thermometer should share the recorded temperatures with the class.
4. Go outside and set up the jars and the control thermometer as described above. All of the jars should be on the same surface, such as a bench or the grass. The temperature of the surface will affect the temperature in the jars.
5. Every 2 minutes, each group should record the temperatures on both thermometers.

6. After all groups have reached 10 minutes, ask groups to complete their data tables and discuss the results among themselves and then come back to the classroom to share data and discuss results:
   - "What happened during the experiment?" (The thermometer in the jar registered a higher temperature than the thermometer outside the jar.)
   - "Were everyone's results the same?" "Was it what you expected in your hypothesis?"
   - "Why do you think the air inside the jar was warmer?" Accept student responses then explain the Greenhouse Effect using the CD image and drawing the diagram on the board.

 View greenhouse effect diagram on CD.

On the board, draw an arc at the bottom right corner to represent the Earth's surface, and a sun far above the arc. Introduce students to the basic atmospheric principles of the **greenhouse effect** by drawing another arc between the Earth and the sun to represent the atmosphere; and arrows from the sun to the Earth representing **solar radiation**. Explain that the greenhouse effect is a natural mechanism that keeps our planet warm compared to the deep cold of space that surrounds our planet. Planets without greenhouse gases in their atmosphere, like Mars, are very cold (-81° F). Planets with more greenhouse gases in their atmosphere, like Venus, are very hot (860° F).

7. Ask the class,
   - "How do you think the greenhouse effect benefits the Earth?" (Outer space is very cold. The greenhouse effect of the atmosphere is critical to keeping the Earth warm enough to sustain life.)
   - "How do you think an increased greenhouse effect could harm the Earth?"

 Have students draw and label a greenhouse illustration for their science journals. Ask students to put their Data Sheet in their journal to use in the next experiment.

ACTIVITY 2 – Effect of Surface Color on the Greenhouse Effect

1. One of the effects of warming our atmosphere that scientists are already measuring is the melting of the ice and snow around the North Pole. Ask students:
   - "If there is less white snow and ice and more dark ground do you think it could make a difference in warming?"
   - "What difference would you expect?" "Any ideas why?"
   - "How could we change our experiment to test this so that the only difference or variable is the color of the surface under the air we're measuring?"

In the first activity we saw that sunlight could cause an increase in air temperature if heat is trapped, similar to the greenhouse effect. The glass jar represented the greenhouse gases that absorb and trap heat in our lower atmosphere. In this next greenhouse experiment, we will explore how changing the color of the surface that the light hits affects the air temperature over that surface.

1. Divide the class into the same groups of four. One group will run the experiment with the jar and no paper. Half of the remaining groups will use the white paper in their experiment, and the other half will use the black paper.

2. Ask the students to each develop an hypothesis based on the following question:
   - "Do you think the surface color will cause a difference in the air temperature?" Write what you think might happen, and your reasoning, on the hypothesis line of Handout 1.
3. The groups with the paper should roll the piece paper into the jar as seen in the photograph. Lay the jar on its side with the paper like landscape on the bottom. Place the thermometers into the hole in the lid and close the jar.
4. Review the group assignments and data collection procedure from the previous experiment. Pass out materials.
5. Have all groups assemble the jars and record their starting temperatures on the chart for Experiment 2. Go outside and place the jar on its sides in direct sun with the "landscape" side on the bottom. All jars should be on the same surface, such as a bench or the grass. The temperature of the surface will affect the temperature in the jars. Position the jars so that students will not have to pick them up or shade them to read the thermometer. Make sure each group has Handout 1 to record the experiment results.
6. Tell students to start their experiments, taking data every 2 minutes. After all groups have finished their 10 minutes, pick up the jars and return to the classroom to share data and discuss results.
7. Tell groups to complete their data tables and reflect on their written hypothesis. Then bring group together to discuss results:
   - "In which jar did the temperature rise the most?" (The jar with black paper should heat up the most.) "Is that result what you expected?"
   - "Did everyone get the same results?" "If not, what might have changed results for different tests?" (Possible answers: Jars not sealed, differences in thermometers, clouds slowed the heating of the jars, students blocked the sun during experiment.)
   - "Why do you think you saw these results? What was happening?"
8. Listen and record all possible answers and then provide science vocabulary from Key Words to clarify results. Matter, like air or paper or water, gets warmer when their molecules start moving faster. The white paper stayed cooler because solar radiation bounces off or reflects from this color. The dark paper gets warmer because more of the solar radiation is absorbed by darker colors and causes the molecules to speed up, changing the heat energy and temperature.
   - "Now that we've done the experiment, what do you think it might mean if there is less ice and snow and more exposed ground?" (Warming could increase over those areas.)

Ask students to draw a diagram of the model used in this experiment in their journal with labels that show the major parts of the model and what they stand for: sunlight, the jar glass, the paper, the air in the jar. Help students complete the line graph in Handout 2 showing the beginning and ending temperatures for each of the jars in Experiments 2 and 3.

ASSESSMENT

Have students write a caption under their journal drawing of the greenhouse effect, describing with words what is happening. Use the diagrams and writing to assess how well students understand the greenhouse effect concept.

EXTENSIONS

1. Further experimentation – Add different materials, like water and soil, to the jars and conduct the experiment, comparing results with the initial experiment. Soil and water have different absorptive and reflective capacities. What effect will this have on the experiment?
2. EPA Website – Students can visit the EPA Kids website to learn more about the greenhouse effect: http://epa.gov/climatechange/kids/greenhouse.html

NAME:_____ DATE:_____

Greenhouse Effect Experiments

Lesson 1, Handout 1

In these experiments you will model the greenhouse effect and then study the impact of the color of the surface warmed by solar radiation.

Activity 1:

In our first experiment, we want to see what effect the clear glass jar has on the temperature of the air directly over some surface. You will be measuring the air temperature inside the jar and the temperature of the air just outside the jar, at the jar's same elevation and surface.

Hypothesis: Do you think the temperature will be different inside and outside the jar? Any guesses about why?

_____

Procedure:

1. Record the starting temperature of the two thermometers on the chart below.
2. Outside, arrange your jar on its side in the sunshine, and prop it up so it won't roll away.
3. Stick your thermometer through the hole in the lid so that you can read the gauge outside the lid.
4. Record the temperature every 2 minutes.

Experiment #1 Closed Jar Measurement		**Experiment #1 Open Air Measurement**
Minute	Temperature (°F)	Temperature (°F)
0		
2		
4		
6		
8		
10		

Which thermometer measured higher temperatures? _____

Why do you think this happened? _____

_____

Activity 2:

Lesson 1, Handout 1, Page 2

The second experiment looks at the effect of surface color on the temperature of air above it.

Hypothesis. Which jar's air do you expect to heat up most, a jar with black paper inside or a jar with white paper inside, and why?

The jar with _____inside will heat up the most because_____

_____

Procedure:

1. Record the starting temperature of the thermometer on the chart below.
2. Outside, arrange your jar on its side in the sunshine, and prop it up with a rock or some sticky tape so it won't roll away.
3. Stick your thermometer through the hole in the lid so that you can read the gauge outside the lid.
4. Record the temperature every 2 minutes.
5. Complete the table by recording the data from groups that used the black, white, or no paper.

	Experiment #2 Closed Jar with Black Paper	**Experiment #2 Closed Jar with White Paper**	**Experiment #2 Closed Jar Measurement**	**Experiment #2 Open Air Measurement**
Minute	Temperature (°F)	Temperature (°F)	Temperature (°F)	Temperature (°F)
0				
2				
4				
6				
8				
10				

1. Which jar heated up the most? Why do you think this happened?

_____

_____

2. Which jar heated up the least? Why do you think this happened?

_____

_____

3. Is this what you expected might happen in your hypothesis?

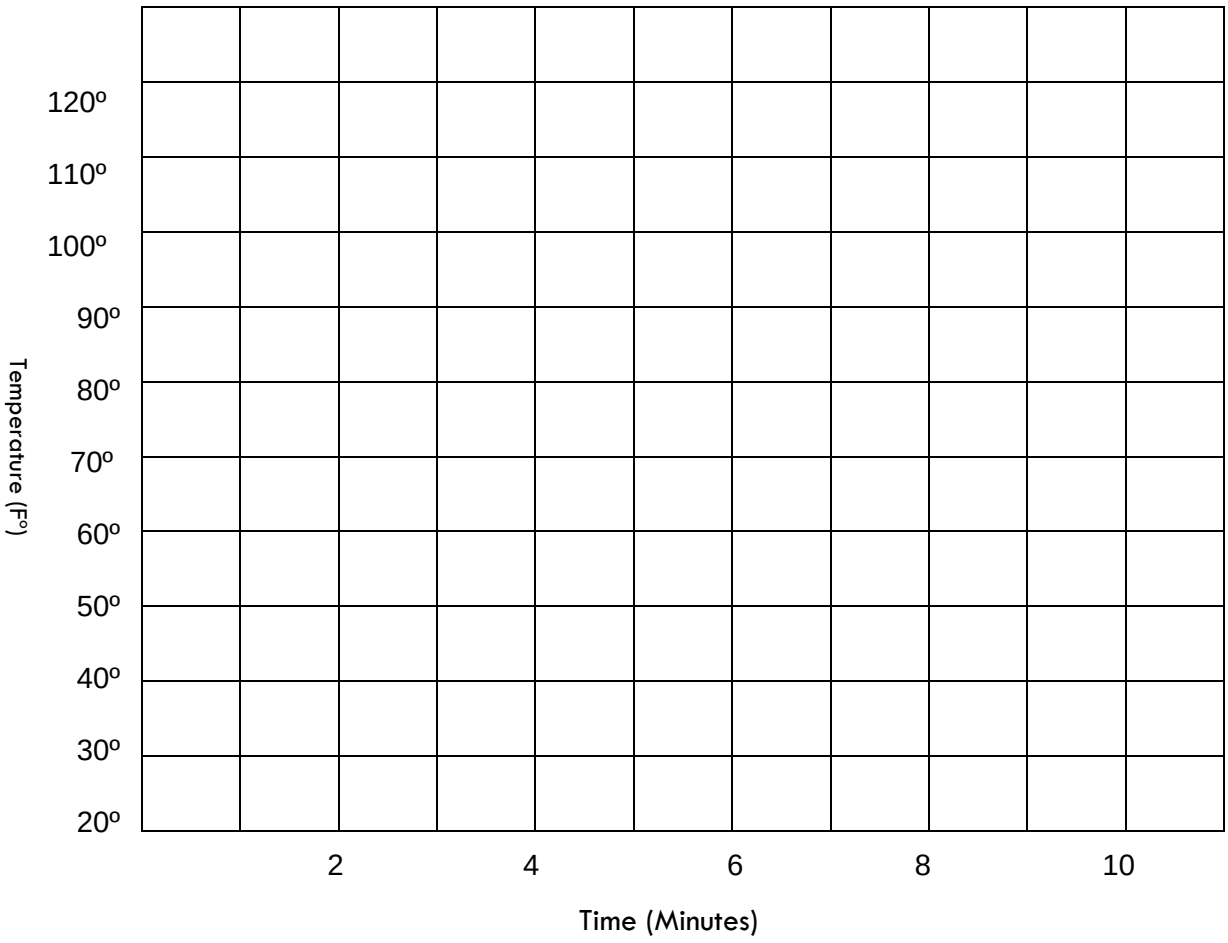
_____

NAME:_____ DATE:_____

The Greenhouse Effect

Lesson 1, Handout 2

Make a line graph of the beginning and ending temperatures of each jar on the chart below. Use a different line style for marking the temperatures of the jar with the black paper, the temperatures of the jar with the white paper, the temperatures for the empty jar, and the outside open air temperature.



Key

Open Air Temperature ——————

Empty Jar — — — — —

Black Paper • • • • • • • • • • • • • • •

White Paper —— —— ——

Estimated Time: 1 hr

Objectives:

- Define weather and climate.
- Understand that the sun's radiant heat energy is the primary driver of weather and that trapping more heat to the Earth affects global weather patterns.
- Read yearly temperature data and translate data into graphs.

CA State Standard Connections:

4th Grade Statistics, Probability & Data Analysis
Students organize, represent, and interpret numerical and categorical data.

5th Grade Earth Sciences
1) Energy from the Sun heats Earth unevenly, causing air movements that result in changing weather patterns.
2) The oceans influence the weather, and the water cycle plays a role in weather patterns.
3) Earth's atmosphere exerts a pressure.

Tool Kit Materials:

- Handout 2 (one per student)
- Handout 3 (one per student)

Additional Materials:

- Copy of weather page from newspaper / weather.com
- One piece of 8.5"x11" paper and foot long piece of thread
- Several marbles placed on a plate
- Student Journal
- Computer and Internet access for teacher and/or students (See options in lesson)

The Heat Is On

The increase of greenhouse gases in the atmosphere is causing heat to build up in the atmosphere and oceans which is leading to global climate change. In this lesson, students learn what causes weather and graph changes in a local weather pattern over time to investigate how weather conditions define climate.

Key Words

Weather: short-term condition of the atmosphere at a place for a given time.

Climate: average pattern of weather for an area over a long period of time, 30 years or more.

Water Cycle: the change of water from one state to another as it moves between Earth's surface and atmosphere; includes the processes of evaporation, condensation, and precipitation.

Precipitation: water falling from clouds in any form, such as snow, ice, rain, or drizzle.

Preparation

Review Lesson 2 Background in Climate Change Basics for an overview on weather and climate change. Prepare copies of both Handouts for each student. Make copies of the weather report from a local paper or print a report with local and national data from a website like weather.com.

Activity 1: Cut along spiral line on handout 1and cut one foot long piece of thread or string. Prepare a heat source such as table lamp or candle from kit. Conduct activity as a class demonstration.

Activity 2: There are several different websites with temperature and other meteorological data. The Bay Area Air Quality Management District website displays weather data for the past ten years. http://gate1.baaqmd.gov/aqmet/MetYearly.aspx.
The Western Regional Climate Center has a variety of climate data from stations around the western US:
http://www.wrcc.dri.edu/summary/Climsmnca.html
http://www.wrcc.dri.edu/summary/ccaF.html (WRCC page for Bay Area data, go to Monthly Temperature Listings, "Average")

Go to one of these websites to review the temperature data over the last ten years from the station closest to your school.

Procedure

SETTING THE STAGE

- Weather, global warming, and climate change are all related. We're going to look at why they're related.
- Ask the class, "What is the weather for today?" (Student answers could include "It is cloudy, foggy, rainy, cold, humid, windy) On the chalkboard, write down the words students are using to describe the weather.
- Provide copies of a weather report with local and national weather data from a local paper or weather.com. Have students look for weather in other cities in the state or around the country. Ask students "What data is being measured and reported?" "How is it different from our weather right now?" Add new words to the list on the board (temperature, precipitation, wind speed, humidity, air pressure.)
- Provide each student with a copy of Handout 2. Ask one or more students to read the paragraph under Section 1, Describing Weather. Clarify any vocabulary or concepts as necessary before providing the groups some time to answer and discuss the questions.
- Ask the class "How would you define weather?" (Weather is how hot or cold, wet or dry, stormy or calm it is in an area over a short period of time. **Weather** is defined as the short-term condition of the atmosphere at a place for a given time. When you get dressed in the morning, you think about the weather. It's cold, I'll wear a sweatshirt. It's hot, I'll wear shorts.)
- "What's the warmest thing you have in your closet?" Our lowest average temperature in the Bay Area is pretty mild. If it got down to -50°F every winter, like in some parts of Russia, you'd probably have different clothes in your closet. We have a different **climate**, defined as the average pattern of weather measured over long periods. Weather influences what you wear each day. Climate influences what clothes you have in your closet.


Have students record the definition of weather and climate in their journals.

- Today we'll be looking at factors that influence weather and how these factors are related to atmospheric warming and climate change.

ACTIVITY 1 – Weather and Heat from the Sun

1. As a class demonstration, cut out the spiral in handout 1and make a pin hole through the center of the spiral. Next, tie the thread to the pin hole so that the spiral can hang down with the widest part at the bottom.
2. Let students hold the spiral by the thread over a lighted candle or bulb (model for the heated Earth) to see the hot air rising and causing the spiral to spin.
3. "What did you observe?" "What do you think causes that to happen?" (The hot air rises, causing the spiral to spin. Similar to why a pinwheel spins when we blow it.)
4. Weather and climate are influenced by many factors. Write: Causes of Weather on the board. One of the most important factors is heat from the sun. In our last experiments we saw how solar radiation can warm surfaces and the air over the surfaces. Today we'll look at what happens when air is heated and how that affects weather.

5. **Heat from the sun drives air pressure.** Remember that temperature is a measure of the heat energy of matter. Increased heat energy means increased vibration of molecules in the matter. Show students some marbles on a plate. When heat energy is added, the molecules start to vibrate more and they push each other apart. (Shake the plate.) This happens on a large scale when atmospheric gases are heated over a warm surface like a large desert. The molecules move further apart from one another, making the air mass lighter and making it rise. Colder air, with molecules closer together, is heavier and will flow in under the rising warm air. The way molecules act when heated creates the currents in the air (winds) and the currents in the oceans.
6. **Heat from the sun also drives the water cycle.** Ask questions to guide students through a review of this process. "What does liquid water do when you heat it?" (It evaporates.) "Does anyone know what happens as the air rises and the water vapor in the air starts to cool down rapidly?" (Clouds and rain, condensation and precipitation.) So, heat from the sun is powering the currents in the air that move heat around and the entire water cycle that moves water around the globe. Write "heat from the sun" on the top of the list under Causes of Weather.
7. In addition to heat from the sun there are other factors that make winds and currents move as they do. While columns of air are moving up and down they are also being twirled. The rotation of the earth twirls these shifting currents in air and water around the globe. Write "rotation of the Earth" on the list.
8. "What else influences weather?" "Where does it rain?" (Where clouds cool off over mountains, or cooler vegetated areas, or near big, cool water masses like lakes or oceans that take a long time to heat up.) Write "land features and water bodies" on the list.
9. Ask other student(s) to read the paragraph under Causes of Weather on Handout 1. Again, clarify any vocabulary or concepts before providing the groups time to answer the corresponding question, "What is the main factor that makes weather happen?" Students should understand at this point that the buildup and distribution of heat, primarily from the sun, is the force driving weather.

   Once groups have written their responses, ask groups to share with the rest of the class. Note any commonalities in groups' responses.

ACTIVITY 2 – Studying Our Climate

Climates can be generally described using different words. A tropical climate could be described as rainy and hot; a desert climate is dry with extreme day and nighttime temperatures; and a polar climate is extremely cold with dark winter days and light summer days. We're going explore our own climate by looking at the average annual temperature over a ten year period in comparison with data from Mt. Shasta (a station on a tall, snowy mountain in California) and Death Valley (a station in a desert in California).

1. Distribute Handout 32 to each student. Ask one or more students to read the text in the first section, Describing Climate. Ask class to write a description of the climate in your area on their handouts.
2. Explain that students will work in pairs to look at the average annual temperature over ten years for different places in California and record their data on a graph. The graph already has data for Mt. Shasta and Death Valley. Students will be able to compare their results to see differences in the climate for the weather stations they choose.

3. Tell your students where they can get the data for the average annual temperature. Given your access to and your students' familiarity with the internet, choose an option for accessing this web-based data:
   - Option 1: Each group sits before their own internet-equipped computer and accesses one of the websites.
   - Option 2: Use an internet-equipped computer in classroom to access a website and project it onto a wall with an LCD projector.
   - Option 3: Access website prior to class and make photocopies or makes overheads of the required information to share with the class.
4. There are several different websites with temperature and other climate data. The Bay Area Air Quality Management District records and tracks weather data around the Bay Area, and displays weather data recorded for the past ten years. Website may freeze if too many groups attempt to access data at the same time. You may want to have the groups space out their work. Use the bar on the left side of the web page to select different years for temperature data. At the top center of the page are three tabs: Daily, Monthly, and Annual. Collect yearly average temperature values from the Annual tab. On the right hand side of the chart are two columns for Yearly Max (maximum temperature recorded for that year) and AVG (average temperature recorded for that year).

   You may print out the Temperature page for the past ten years.
   http://gate1.baaqmd.gov/aqmet/MetYearly.aspx.
   The Western Regional Climate Center has data for the west in general at:
   http://www.wrcc.dri.edu/summary/Climsmnca.html and for the Bay Area in particular, at http://www.wrcc.dri.edu/summary/ccaF.html (go to Monthly Temperature Listings and Average).
5. Give students appropriate instructions for finding the average annual temperature depending on the option and websites you choose. Tell the class to write down the name of the specific weather station they are using for their data on average annual temperature. Students will work in pairs to plot the data on the graph shown in Handout 2 and answer the question below the graph.
6. Once groups have completed Handout 3, discuss the following questions:
   - "What average annual temperatures did you find in Bay Area sites?" (Answers may vary, depending on station used.)
   - "How does climate vary in different parts of the Bay Area? Are some places always cooler or warmer than others?" (Climate around the Bay Area can be influenced by proximity to the ocean or to the hills.)
   - "What similarities did you notice between the data for Mt. Shasta, Death Valley, and your site?" (They both have relatively constant temperatures.)
   - "What differences did you notice between the data for Mt. Shasta, Death Valley, and your site?" (The average annual temperatures for the Bay Area sites should be between the more extreme climates.)
7. We don't see any real change in average annual temperature in these graphs because the time span is too short. Scientists see measurable changes a few degrees by looking at the record over the last 100 years. Ask students:

- "How do you think the increased temperatures might affect weather patterns?" (Student answers may include: Weather would change in various ways; less snow on mountains; glaciers would melt, causing sea level rise; cities will be hotter because heat is trapped and cannot escape; because winds and precipitation are strongly affected by heat there may be changes in average temperatures, extreme temperatures, rainfall, snowfall, and storm severity.)

ASSESSMENT

Have students make a journal entry summarizing this lesson by explaining the difference between weather and climate and how a change in climate could affect them in the future. Reading through their journal entries should show who understands the concepts taught and who needs additional help.

EXTENSIONS

1. Guide students in measuring annual precipitation in the past ten years using the website used in activity. Select precipitation in the measurement field in the bar on the left side of the web page. Students can track the data and describe the precipitation patterns at the selected weather station.
2. Use an online image search engine to find graphs of surface temperature trends across the globe over much longer periods of time. Students can view graphs for California, the nation, polar and sub-polar regions, or the entire globe. Search keywords can include: Pew Center on Global Climate Change, IPCC Report, Earth surface temperature trend, polar temperature rise. Are temperatures rising, falling or staying the same over a long period? From the global temperature graphs, in what part of human history did temperatures begin to rise sharply? With what might this sharp rise coincide?

Research Climate Change in the News

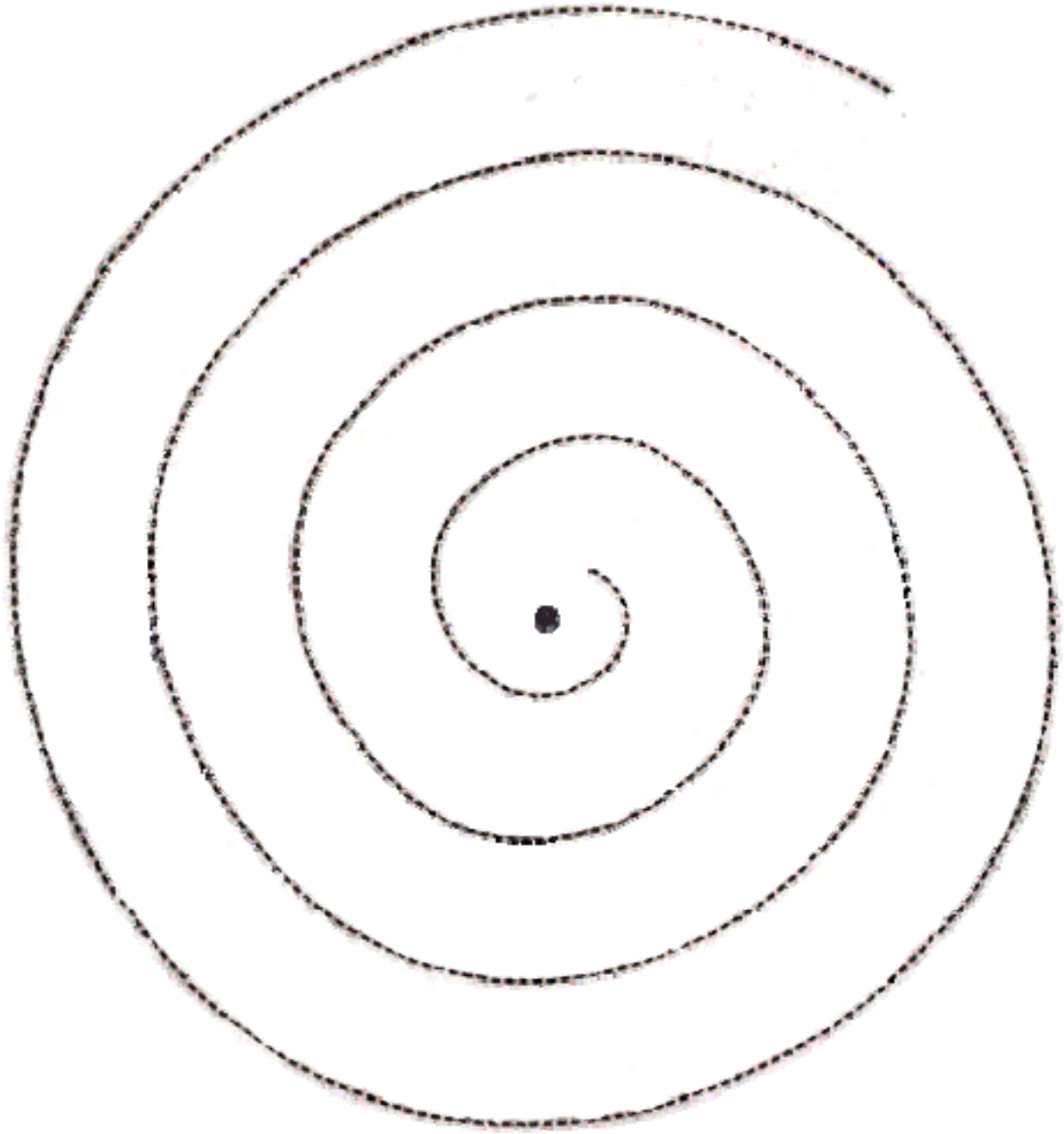
This project connects students with current events reported in the news about climate change. Students develop research skills as they access web and print news sources. Direct students to collect news articles related to climate change and associated weather, environment, and health issues from print or web sources. Different themes could be:

- Examples from around the world (what is happening in China, Africa, etc.)
- Environmental issues in California (snowpack, wildfires)
- Scope of impact on a global scale (ice caps melting), regional scale (sea level rise along the US coastlines), and local scale (drought in the Bay Area)

Develop the students' climate research into a regular activity with class discussions where students speak about what they have learned in the news.

The Heat is On

Lesson 2, Handout 1



NAME:_____ DATE:_____

The Heat is On

Lesson 2, Handout 2

Read the paragraphs below about the weather and answer the questions.

1. Describing Weather

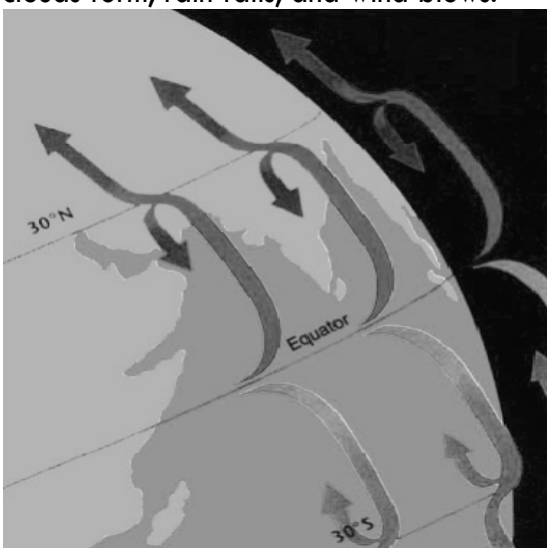
Weather describes the daily precipitation, temperature, air pressure, humidity, and wind conditions at a given location at a given time. Weather happens from minute to minute and can change a lot within a very short time. For example, the day may start out clear, then become cloudy, and be followed by rain in the afternoon. We make plans about what to wear, where to go, and how to travel there depending on what we know about the weather. Check a local paper or weather website (weather.com) to record your current weather conditions:

What is the weather like today?

_____

2. Causes of Weather

The sun is a fiery ball of burning gases. Rays of sunlight (solar radiation) shine down on Earth every day. Some of these rays bounce off our atmosphere and return to space and about half pass through our atmosphere. When sunlight hits the Earth's surface most of it turns into heat (thermal energy). This drives weather patterns all over the planet. As the land and oceans warm, they heat the air above them, causing that air to rise. As the heated air rises, cooler surrounding air flows in, setting in motion an endless movement of air in great swirling, churning currents that distribute heat energy from the sun across the planet. The oceans also distribute heat around the globe. As heated air and water move around the Earth and mix with colder air and water, we get weather: clouds form, rain falls, and wind blows.



Because the Earth is spherical and not flat, the Sun shines more directly around the Equator, heating it more intensely so that it is warm all year long. However, the Polar regions are at such an angle to the Sun that they get little or no sunlight during the winter, causing them to be cold and ice-bound.

What is the main factor that makes weather happen on the Earth?

_____

_____

NAME:_____ DATE:_____

The Heat is On

Lesson 2, Handout 3

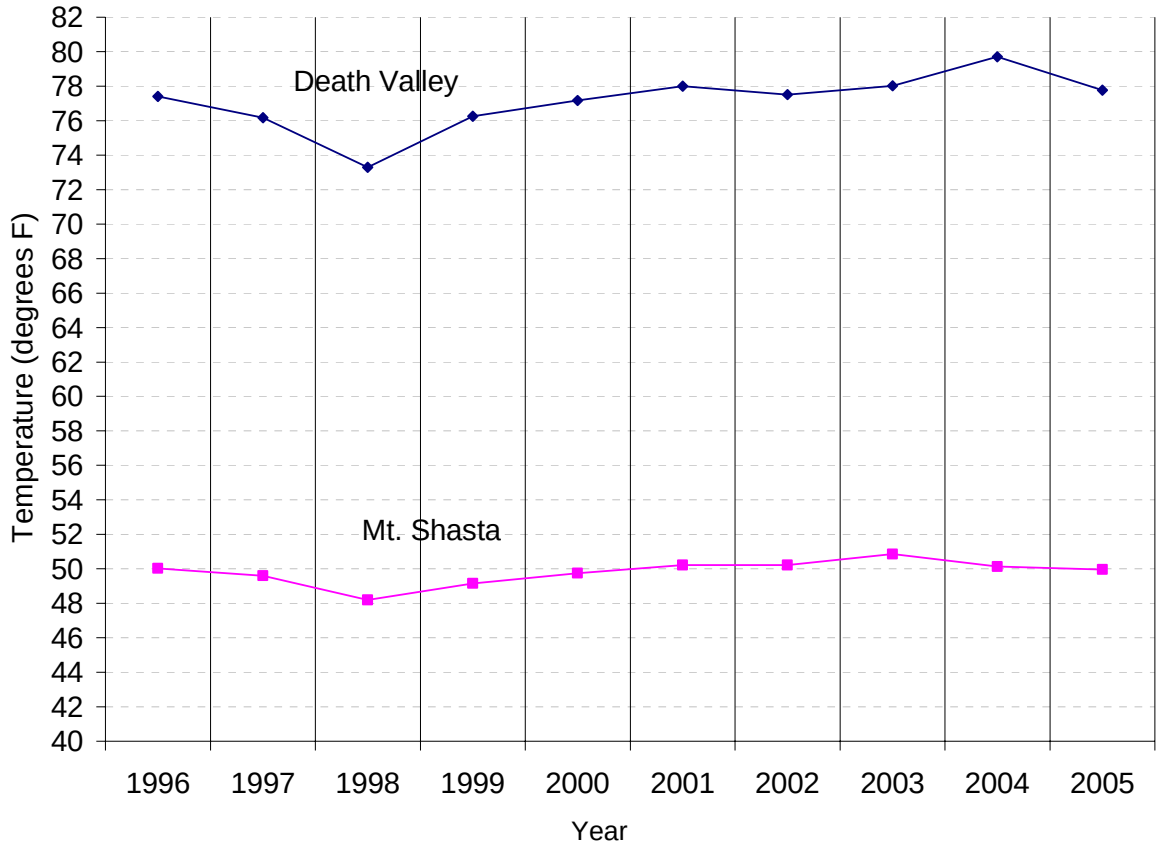
1. Describing Climate

Weather may change on a daily basis, but climate only changes over a long period of time. Climate describes the pattern formed by weather occurring over a period of at least 30 years in a given place. This includes average weather conditions, seasonal weather variations, and special weather events such as tornadoes and floods. Climate tells us what it's usually like in the places where we live. San Diego is known as having a mild climate, New Orleans a humid climate, Buffalo a snowy climate, and Seattle a rainy climate.

How would you describe the climate where you live?_____

2. Average Temperature in California

Average temperature is one measure of climate. Label the years and graph the yearly average temperatures for the Bay Area over the past ten years on the blank chart (next page). Label your line with the name of the station used. Can you describe how your average climate compares with Death Valley and Mt. Shasta?



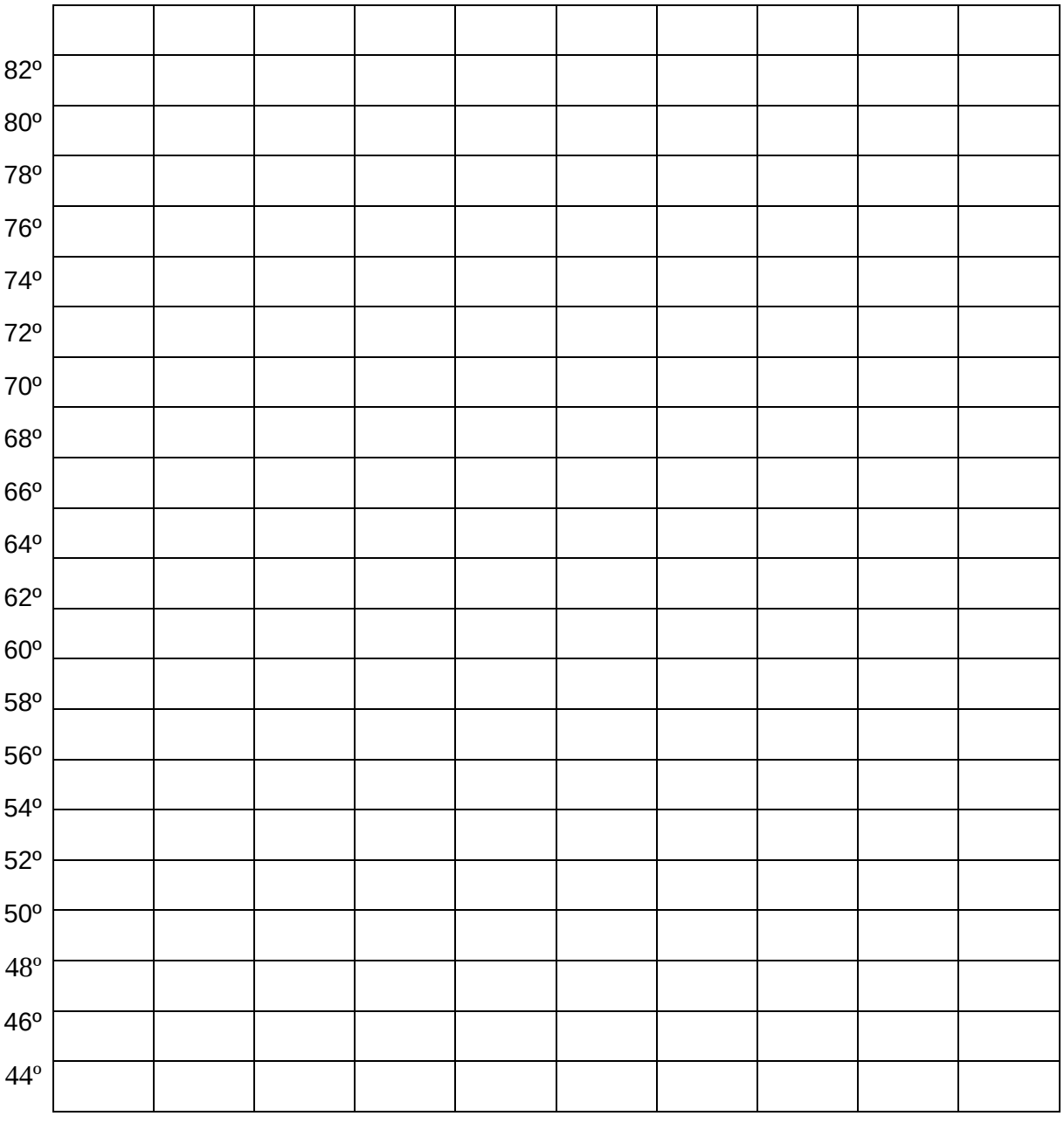
How does average temperature in your climate compare with the climate of Death Valley and Mt. Shasta:

_____

NAME:_____ DATE:_____

The Heat is On

Lesson 2, Handout 3



Studying Air Pollution

Estimated Time: 1-1.5 hrs each day for 2 days

Objectives:

- Observe, identify and list visible and invisible air pollutants around the school and in the community.
- Identify at least three solutions to prevent air pollution.

CA State Standard Connections:

4th Grade Life Sciences
Students know that living organisms (including humans) depend on a healthy environment for survival.

5th Grade Investigation and Experimentation
Scientific progress is made by asking meaningful questions and conducting careful investigations.

5th Physical Science:
Each element is one kind of atom, organized in Periodic Table.

Tool Kit Materials:

- Blank, white index cards (one per pair)
- Petroleum jelly
- Handout 1 (one per pair)
- Handout 2 (one per pair)
- Handout 3 extension (one per pair)

Additional Materials:

- Pins (tacks) and/or tape
- Student Journal
- Glue sticks or paste/staples
- White construction paper
- Scissors

Air pollution is comprised of gases and particles that can be harmful at high concentrations. In this lesson, students will observe, identify and chart both visible and invisible air pollutants, and through an art project describe solutions for preventing air pollution in their communities.

Key Words

Air Pollution: the presence of harmful substances in the air.

Smog: air pollution made primarily of ozone (O_3) that forms when pollutants from vehicles and industry react in the air with sunlight.

Ozone (O_3): ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals and humans. Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth's surface.

Particulate Matter: tiny particles and liquid droplets in the air, including acids, organic chemicals, metals, and dust particles.

Preparation

Review Lesson 3 Background on air pollution. Test the experiment first. You can coat petroleum jelly on all the student cards first or have students do this themselves when they set up their experiments. Students should place the index cards in secure test area, and ask the custodians not to remove them. The air pollution collectors will need to remain in their test areas for at least two full days.

Procedure

SETTING THE STAGE

- Today we'll be studying different kinds of air pollution that affect the climate and our health.
- "Have you ever been stuck behind a big rig truck? What did you notice?" (Elicit observations of how the exhaust looks and smells.) "How does standing behind a bike differ from standing behind a truck?"
- We can both smell and see pollution because air pollution consists of both very small particles and droplets, called **particulates**, and different gases, some of which are invisible.
- Sometimes all the air pollution collects in an area and creates a "bad air day." It can look like this:

 Air Pollution Image on CD. This is a picture of **smog**.

When this happens there are announcements from the Air Quality Management Districts to tell people to avoid heavy exercise or stay indoors if they have breathing problems like asthma.

- Smog is air pollution made primarily of ozone (O_3) that forms when pollutants from vehicles and industry react in the air with sunlight. Ozone (O_3) is made of the element oxygen, but it is a different molecule than the oxygen gas we breathe because it has 3 atoms rather than 2 in each molecule. This difference gives ozone different properties. Ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals and humans. Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth's surface.
- Since smog formation is directly related to warm days, air quality is expected to worsen as temperatures increase from global warming.
- In addition to pollution that directly affects our health like particulates and smog, there are also air pollutants that increase the rate of climate change.

ACTIVITY 1– Discussion of Air Pollution and Sources

1. Let's work on developing a definition for air pollution. Ask students:
   - "What does the word "pollute" mean?" Lead discussion to the idea of adding harmful or unpleasant substances to the environment.
   - "What are some substances that pollute the air?" (Natural air pollutants include pollen, dust and volcanic ash. Human-caused air pollutants include vehicle exhaust, invisible gases, and smoke.)
   - "How should we define air pollution?" Write responses on the chalkboard. Through discussion, help students arrive at one definition. (Unwanted gases or particles in the atmosphere that can harm human health and the environment.)
2. "Where do you think man-made pollution comes from?" Write answers on the board. (Cars, trucks, powerplants, industry, trains, planes, fireplaces.) Explain that incomplete combustion of different fuels like wood, oil, and gasoline, create a variety of air pollutants including ozone, particulates, and sulfur dioxide, which contributes to acid rain.
3. Over the next two days we'll be looking at air pollution, where it comes from and some different things we can do to reduce air pollution.

ACTIVITY 1 – Air Pollution Collector

Day 1:

1. Over the next two days, we are going to study particulate air pollution around our school. We will be 'collecting' air pollution samples in and around the school on petroleum jelly-coated index cards. The index cards will be left for a couple days at various sites around our school.
   - "Why do you think we will coat the index cards will petroleum jelly?" (Some pollutants will stick to the petroleum jelly for us to see.)
   - "Where do you think we could place a card that might show air pollution (Near the bus turnaround, by an open window, near a heating vent.) "Where would be some places that might not show air pollution?" (Undisturbed spot in the classroom, Principal's office.)
   - Keep a list of good test areas around the school; adding some spots as needed; these can be inside or outside, as long as other classes are not disturbed.
2. Divide the class into pairs. Provide each pair with one index card, petroleum jelly and a swab, and a piece of construction paper. Provide the following instructions:

   - Staple or glue the index card to the center of the construction paper.
   - Write the names of the students in the group and the sampling location they've selected above the card.
   - Write "Investigation in progress. Please do not disturb." below the index card.
   - Swab a thin layer of petroleum jelly on the index card.
3. Next, distribute a copy of **Handout 1** to each pair and ask them to read the questions so that they know what they have to record about their sites. Have students place the cards in test areas, one card per test area. Use pins or tape as needed to secure the cards. The petroleum side should be facing out.
4. Once all groups have placed their cards, return to class and have pairs complete the questions in Handout 1 together. Lead a discussion of Handout 1, prompting students to identify possible sources of air pollution nearby or at the school.

Day 2 or 3:

1. Air pollution collector cards should remain in the test areas for at least two whole days, but preferably over several days, or a weekend. You may want to have groups check their cards daily and report back to the class on their observations.
2. Bring cards back to class for comparison. Consider having students look at their collector cards under magnification if microscopes or magnifying glasses are available.
3. Observe and rank the cards from the one with the most visible pollutants to the one with the least. You can do this by placing cards side by side on a table.
4. Lead students in a discussion about air pollution at the school:
   - Where around the school was the most visible air pollution collected?
   - Where was the least?

- What assumptions can students make about air quality around the school and the proximity to sources of air pollution?

5. Have students get back into their groups with their cards and complete Handout 2. Discuss student responses from Handout 2. (Refer to Lesson 3 Background for ideas on how to engage students in thinking about health and environmental impacts of air pollution, as well as pollution prevention measures.)


On the chalkboard draw a two-row table, with the first row titled 'air pollution sources' and the second row titled 'air pollution solutions.' Have students make a like table in their journals and give them time to write their ideas. Next, discuss student responses and write ideas on the board. Any new sources or solutions can be added by students to their journals.

- What are the sources of air pollution in our community? (Automobiles, factories, hospital incinerators, burning wood, etc.)
- Are there ways we could reduce emissions from some of these sources? (Walk and bike instead of drive, educate people about the pollution, etc.)

ASSESSMENT

Look over student work on Handout 1 and Handout 2 to assess whether students were able to complete the experiment and what conclusions they came to. Look at student journals to see their lists of pollution sources and possible solutions to reduce pollution.

EXTENSIONS

1. Pollution Solution Poster – students in small groups make posters of air pollution sources and solutions. Provide each group with scissors, glue sticks, coloring pencils and a piece of construction paper. At the top of the construction paper, have groups write 'Air Pollution Sources.' At the bottom of the paper, have groups write, 'Air Pollution Solutions.' Then have groups draw a line across the paper in the middle.

   For the top half of the poster, groups will cut out or draw pictures of air pollution sources like automobiles, smoke stacks, fires. On the bottom half of the poster, groups will cut out or draw pictures of air pollution solutions like people walking and bicycling and taking public transit.

   Ask students to present their completed posters and share their knowledge and understanding of air pollution sources and solutions illustrated in the poster. Display posters in the classroom or around the school for others to see. This could also be used as an assessment.

NAME:_____ DATE:_____

Studying Air Pollution

Lesson 3, Handout 1

Air Pollution Collector

Find a place to put your index card with the jelly-side facing up. Then, answer the following questions:

1. Where did you put your Air Pollution Collector card?

_____

_____

2. Are there any nearby sources of air pollution that you can see or that you know about? If so, what are they?

_____

_____

3. What kinds of air pollution do you think you will collect?

_____

_____

4. What do you think the card will look like after a few days?

_____

_____

NAME:_____ DATE:_____

Studying Air Pollution

Lesson 3, Handout 2

Air Pollution Collector

Your Air Pollution Collector card has been somewhere in or around your school for some time now. Look closely at the card but do not touch it. Has it changed since you first put it out? Describe those changes by answering the following questions:

1. Did your Air Pollution Collector card change color? If so, what color is it now?

_____

2. What do you see in the petroleum jelly? List what you see:

_____

3. What do you think are the sources of this air pollution? List the sources:

_____

_____

4. How does air pollution affect your health?

_____

_____

5. How does air pollution affect the environment?

_____

_____

6. What are some ways to prevent air pollution?

_____

7. Do you think your card would look different at a different time of year? Why or why not?

_____

8. If you could do this experiment again, where in your community would you like to put the Air Pollution Collector card? What do you think you would find?

_____

Climate Change Action

Estimated Time: Two 45 min sessions, 1 week apart

Objectives:
- Understand that carbon dioxide cycles through natural systems.
- Understand that an overabundance of man-made greenhouse gases like carbon dioxide are contributing to climate change.
- Identify some actions to reduce climate change.

CA State Standard Connections:

4th Grade Life Sciences
Students know that living organisms (including humans) depend on a healthy environment for survival.

5th Grade Life Sciences
Plants use CO_2 and energy from sunlight to build molecules of sugar and release oxygen. Plant and animal cells break down sugar to obtain energy, a process resulting in CO_2 and water (respiration).

5th Physical Science:
Each element is one kind of atom, organized in Periodic Table.

Tool Kit Materials:
- Overhead of Carbon Cycle
- Handout 1 (one per student)
- Handout 2 (one per student, cut prior to lesson)

For Extension:
- Timepiece
- Handout 3 (one per student)

Additional Materials:
- Piece of charcoal
- Bowl, hat, or bucket
- Student journals

This lesson introduces the linkages between carbon dioxide, air pollution, the greenhouse effect, and global climate change. Students will learn about the carbon dioxide cycle and the 'cause-and-effect' associations resulting in climate change. Students will apply their knowledge with an action-oriented assignment to curb greenhouse gas emissions at home.

Key Words

Greenhouse Gas: a gas that traps heat in the atmosphere. An over-abundance of greenhouse gases is contributing to climate change.

Climate Change: global shift in long-term climate patterns.

Carbon Dioxide (CO_2): a gas made of carbon and oxygen atoms that plants use for photosynthesis. CO_2 is a greenhouse gas.

Preparation

Review Lesson 4 Background for an overview on the carbon cycle and climate change. Make a transparency, or use an LCD projector, to project the Carbon Cycle image from the CD to the class. Prepare all handouts.

Cut out all words on Handout 3 prior to the first extension lesson.

Add the following book to your bookshelf for students to read: *How We Know What We Know About Our Changing Climate: Scientists and Kids Explore Global Warming* by Lynne Cherry and Gary Braasch, Dawn Publications.

Procedure

SETTING THE STAGE

 Picture of polar bear on floating iceberg from CD.

- Begin by showing students a picture of a bear on a floating iceberg and ask students "What have you heard about climate change on the TV or other places?" "What do you think or wonder about climate change?" Record observations or questions.
- Today we're looking more closely at one of the greenhouse gases that causes climate change, carbon dioxide.
- Ask "Have you ever picked up a piece of charcoal?" "Do you know what that black stuff is that gets on your hands?" If possible, have a piece to show the class, or a piece of burned wood that has turned to charcoal. Charcoal is mostly made of carbon from petroleum or from wood depending on the type of charcoal.
- Carbon is an element. Point to the symbol on the Periodic Table, if you have one, or draw it on the board: C is the symbol for Carbon.
- Carbon is a naturally-ocurring element that can be found in all living and once-living things, in the soil, and in the atmosphere. One of the most familiar molecules using carbon is a gas that we breathe out. "Does anyone remember what that gas is?" (Carbon dioxide)
- The symbol for Carbon Dioxide, made of 1 carbon atom and 2 oxygen atoms, is CO_2. Plants use CO_2, with water and sunlight to make food through photosynthesis. Carbon is then stored in trees and plants until they are eaten, decomposed, or burned. Animals consume the carbon in plants and release carbon dioxide through respiration.
- Carbon and CO_2 are natural parts of our environment and CO_2 is one of the greenhouse gases we've always relied on to keep our planet warm enough for life. But in the last 100 years we've seen a sharp rise in CO_2 levels that is warming our planet too much. We're going to look at why there's been an increase and what we can do to reduce carbon emissions.

ACTIVITY 1 – Mapping the Carbon Cycle

1. Have students complete Handout 1, the Climate Change Word Search, to learn the basics of climate change. Provide each student with Handout 4, the Climate Change Word Search. Request students to read aloud one sentence each from the handout, clarifying terms or prompting discussion as needed to ensure student comprehension. Either individually or in small groups, have students complete the word search using the underlined words in the handout. This is not a competition, but if you prefer you can set a time limit. Help students as needed to ensure that everyone completes the word search.

 Carbon Cycle image on an overhead projector.

2. Introduce students to the carbon cycle using the image on the CD or drawing an image. The flow of carbon through plants, animals, soils, and air can be drawn as a picture of the carbon cycle. Let's start thinking about where carbon goes with trees and plants. Trees and plants are

making food through the process of photosynthesis, using sunlight, water, and carbon dioxide. "Do you see the word photosynthesis on this drawing?" "So what way should we draw our carbon arrow going into the trees or out?" Draw an arrow on the overhead going from the air into the word "Photosynthesis."

3. There are cows in this picture to represent animals, including us. Animals consume the carbon in plants and other animals and release carbon dioxide through respiration. "How shall we draw the carbon arrow from the cow, moving in or out?" We breathe carbon dioxide out into the air. Draw an arrow on the overhead.

4. Once the carbon is in the air again as carbon dioxide, it can be absorbed by plants again or some can be absorbed by the ocean. Draw an arrow from the air into the words "Ocean Uptake."

5. As plants and animals decompose, their stored carbon breaks down into the soil. If this organic material is compressed for thousands of years it can become oil, coal, or gas. That's why these materials are called **fossil fuels**. They contain the energy and carbon from plants and animals that lived thousands of years ago. On our picture of the carbon cycle, the carbon is moving from decaying organisms and dead organisms and waste products into fossils and fossil fuels. Draw an arrow on the overhead.

6. All of the arrows we're showing now have been a natural part of the carbon cycle on this planet for millions of years. But there's something new on our picture that has only been around for the last 100 years. "What is it?" (Factories and automobiles.)

7. When wood or fossil fuels like oil, gas, or coal are burned, the stored carbon is emitted as carbon dioxide. Scientists now know that these additional, man-made emissions are causing global warming.

8. Distribute Handout 1 to students. Ask students to draw lines with arrows indicating the direction that CO_2 flows into and out of the pictures in the diagram.

9. Once scientists began to measure an increase in the average annual temperature over the last 100 years, they began to study changes in the atmosphere that might explain such a warming. They found growing concentrations of the greenhouse gases, like carbon dioxide, that are emitted by combustion of carbon-based fuels.

 Graph of CO_2 concentrations by the National Oceanic and Atmospheric Administration.

Let's put that fact together with knowledge from our previous lessons. Write questions on board.

- "What effect does carbon dioxide have on our atmosphere?" (It is a greenhouse gas that traps heat in the atmosphere.)
- "What is **climate change**?" (A global shift in long-term weather patterns.)
- "How will higher temperatures affect the Earth and weather patterns?" (Various answers: ice melting, less snow, changes in winds and storms leading to changes in rainfall patterns, more extreme weather events.)

- "Where does the extra carbon dioxide in the atmosphere come from?" (Emissions from combustion of fuels for electricity, manufacturing, transportation.)


Collect answers on the blackboard, discussing student responses and highlighting commonalities. Ask students to record the results of the discussion in their journals, with answers to each of the questions above.

ASSESSMENT

Read journal entries summarizing the role of carbon dioxide in increasing the greenhouse affect, and climate change action. Look for students understanding of the role of carbon dioxide and other greenhouse gases, the effect on climate (long-term weather patterns), where greenhouse gas emissions come from, and what we can do to reduce our emissions.

EXTENSIONS

1. Guess the Climate Change Word - Tell students that they will play a game utilizing terms from Handout 3. The goal of the game is to have students describe climate change terms, without actually saying the term, while the rest of the class tries to figure out the term. One student at a time gets up before the class and picks a term out of a hat or bucket. After the teacher says 'Go!' the student describes the term without actually saying it. For example, if the term is 'Earth', the student might say, "This is the planet I live on." Once a class member shouts out the right answer, he or she must use the term in a sentence about climate protection (I help the Earth by planting a tree), getting help as needed from the rest of the class.

   Students should not put any correctly identified term back into the bucket. A time limit per student should be set depending on the size of the class. If classmates do not guess the term when time is up, that term goes back into the bucket. Once all of the terms have been removed from the bucket, the game is over.

   After you have explained the instructions, place the terms cut out from Handout 3 in the bucket. Play the game, making sure all students get a chance to play the game. As time permits, ask students for ideas to prevent climate change. List their responses on the board and discuss some simple actions students can take in their lives.


Investigate the Sources of Greenhouse Gas Emissions in your County

Guide students in accessing online the *Source Inventory of Bay Area Greenhouse Gas Emissions* report from the Bay Area Air Quality Management District's website, www.baaqmd.gov/pln/ghg_emission_inventory.pdf. Using the report, discuss with students the major sources of air pollution in the region and in their county, grounding the discussion in how they and their families contribute to these emissions. Work with students to make posters demonstrating what they learned about sources of greenhouse gases in their county, perhaps including a chart of major sources of greenhouse gases and the amount of greenhouse gas emissions those sources produce. Discuss the posters in class, present posters to other classes, or post the students' work in and around the school.

NAME:_____ DATE:_____

Climate Change Action

Lesson 4, Handout 1

Climate Change Word Search
Read the Climate Change Rundown, and then complete the Word Search using the underlined words.

Climate Change Rundown

It may seem hard to believe that people can actually change the Earth's climate. But scientists agree that the things people do that emit **greenhouse** gases into the atmosphere are making our planet warmer. Human activities such as fossil fuel burning, driving, and manufacturing emit greenhouse gases into the atmosphere. Greenhouse gases, like **carbon** dioxide and methane trap heat from the **sun** in the **atmosphere**. A warmer **Earth** is leading to changes in rainfall patterns, melting **glaciers**, rises in **sea level**, and a wide range of impacts on plants, wildlife, and humans.

When scientists talk about **climate** change, their concern is about the greenhouse gases caused by human activities, like deforestation, the cutting down of **trees**; the burning of fuel in engines for transportation; and the burning of fossil fuels in power plants to create electricity.

How can you help prevent climate change? **Plant** a tree! Trees absorb carbon dioxide, helping to remove a greenhouse gas from the atmosphere. **Recycle**! Recycling reduces the natural resources required to make new items and keeps waste out of landfills where it produces methane as it decomposes. Ride a **bicycle** or carpool, and turn off the lights to save **energy**!

Word Search

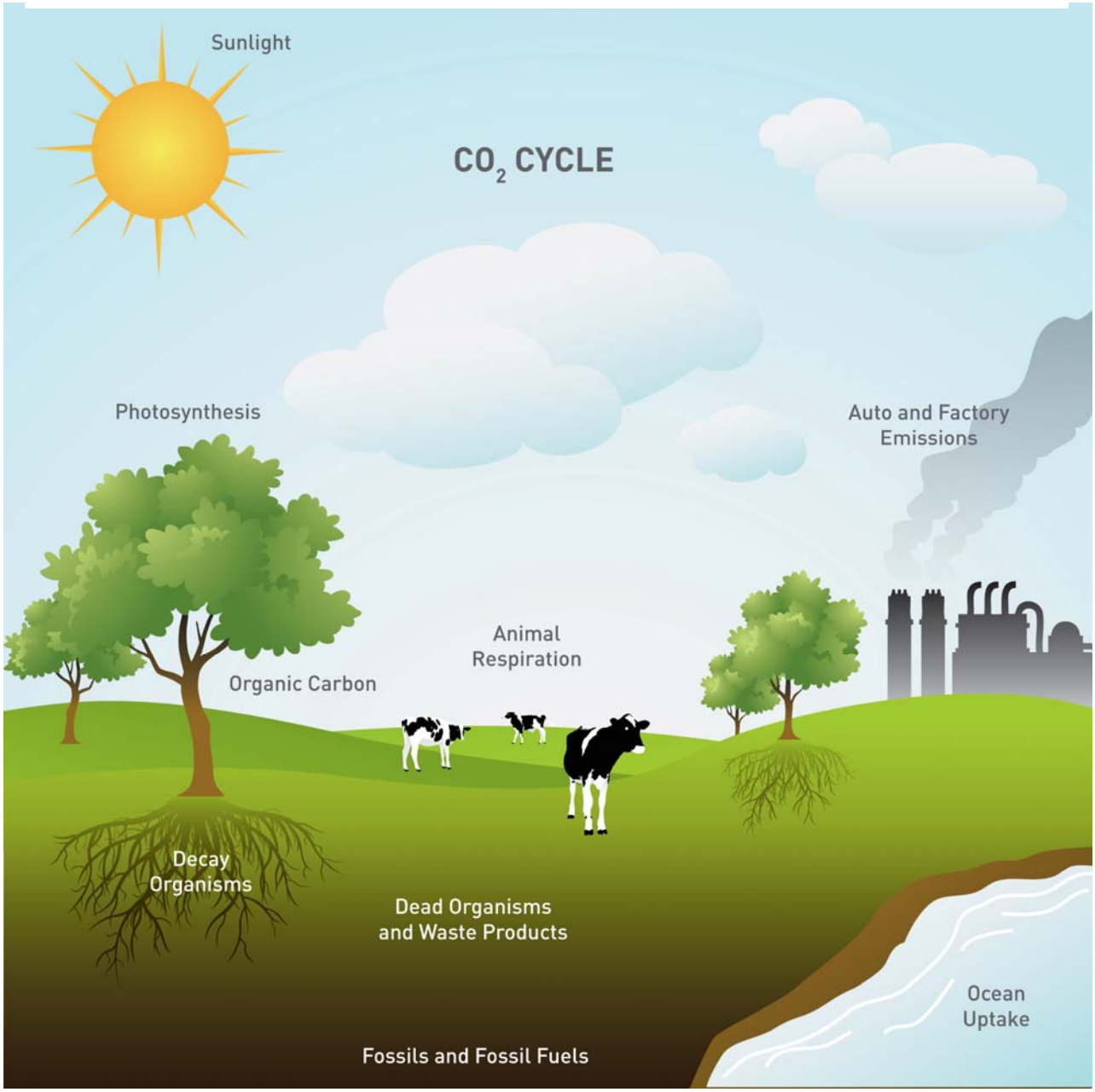
T	R	E	E	S	U	W	I	N	A
Z	C	K	E	N	E	R	G	Y	T
S	A	B	I	C	Y	C	L	E	M
R	R	P	L	A	N	T	E	Q	O
E	B	L	E	V	E	L	A	E	S
I	O	X	R	M	C	U	Y	F	P
C	N	J	F	Y	W	S	U	N	H
A	A	Z	C	L	I	M	A	T	E
L	J	E	A	R	T	H	Q	F	R
G	R	E	E	N	H	O	U	S	E

NAME:_____ DATE:_____

Climate Change Action

Lesson 4, Handout 2

Complete the diagram below by drawing in arrows to indicate the flow and direction that carbon travels through the carbon cycle.



Climate Change Action

Teacher Copy

Extension 1, Lesson 4, Handout 2

Climate Change Game Terms

Cut out each term along the dotted lines. Some of the boxes are left blank for you to add terms you feel appropriate for your class.

CARBON DIOXIDE	GREENHOUSE EFFECT	CARPOOL
GREENHOUSE GASES	TEMPERATURE	TREES
TRUCK	EXHAUST	GASOLINE
GLACIER	RECYCLE	PARTICULATE MATTER
LAND	SUN	CLIMATE
BICYCLE	EARTH	POLLUTION
ATMOSPHERE	WEATHER	POWER PLANT
HEAT	OCEAN	ANIMALS
PEOPLE	ENVIRONMENT	ENERGY

INSPIRING CHANGE PROJECTS

Research Climate Change in the News

This project connects students with current events reported in the news about climate change and develops their research skills. Direct students to collect news articles related to climate change and associated weather, environment, and health issues from print or web sources. Different themes could be: examples from around the world (what is happening in China, Africa, etc.); environmental issues in California (snowpack, wildfires); scope of impact on a global scale (ice caps melting); regional scale (sea level rise along the US coastlines); and local scale (drought in the Bay Area). Develop the students' climate research into a regular activity with class discussions.

Investigate the Sources of Greenhouse Gas Emissions in your County

Guide students in accessing online the *Source Inventory of Bay Area Greenhouse Gas Emissions* report from the Bay Area Air Quality Management District's website, www.baaqmd.gov/pln/ghg_emission_inventory.pdf. Using the report, discuss with students the major sources of air pollution in the region and in their county, grounding the discussion in how they and their families contribute to these emissions. Work with students to make posters demonstrating what they learned about sources of greenhouse gases in their county, perhaps including a chart of major sources of greenhouse gases and the amount of greenhouse gas emissions those sources produce. Discuss the posters in class, present posters to other classes, or post around the school.

Calculate Household CO_2 Emissions

EPA's Global Warming Wheel Card is a hand-held tool students can use to estimate a household's emissions of CO_2 and to learn how to reduce those emissions. For this project, download the wheel with assembly instructions from the EPA website below, make copies, and guide the students in assembling their Global Warming Wheels. Identify willing participants, such as teachers, staff, or family members for students to interview about their greenhouse gas generating activities. Students should discuss reduction strategies with participants and have participants complete a pledge card, also from the EPA website, to reduce emissions. Students can report how many estimated pounds of CO_2 were saved. EPA Global Warming Wheel Card http://www.epa.gov/climatechange/emissions/wheel_card.html

Reduce Your School's Carbon Footprint

In this exercise, students can practice research and data gathering skills and creatively explore strategies for reducing the carbon footprint for the school. Download the school calculator and instructions from the site below. Work with students to collect the required data to calculate the school's footprint. Discuss and identify with students ways to reduce their school's footprint. Present the results to the School Board. School calculator spreadsheet and instructions: http://www.earthteam.net/GWCampaign/calculate.html

Take Part in Your Local Government

In this project, students learn about participation in local governance structures and the importance of local actions in protecting the climate. Identify 1-2 key initiatives that local governments are adopting or implementing (green building ordinances, green vehicle fleets, etc.), but that your local government has not yet implemented. Students collaborate to prepare a brief on the issue and present it to their local government (city council, mayor, etc.). Arrange to be put on the agenda for a local government meeting or to speak during the public comment portion of a public meeting. Present the brief to a local government agency and ask them to commit to specific steps. Learn about efforts to protect the climate:

US Mayors Climate Protection Center: http://usmayors.org/climateprotection/

Berkeley's green building programs: http://www.ci.berkeley.ca.us/sustainable/buildings/

San Francisco Department of the Environment: http://www.sfenvironment.org/index.html

Background for Lessons 5 & 6

Energy Choices

Energy for power, electricity, and heat is necessary for our daily lives. We use energy to cook food, drive cars, manufacture products, and construct buildings. Energy comes from two different types of sources, non-renewable and renewable. A **renewable energy source** is one that can be replaced rapidly; a **non-renewable energy source** cannot be replaced or can only be replaced over a very long period of time.

Non-Renewable Energy Sources

The most common types of non-renewable energy sources used worldwide are fossil fuels like oil, coal, natural gas, and nuclear energy. **Fossil fuels** were created over millions of years, as heat and pressure transformed the remains of decayed plants and animals buried underground by layers of sediment. Fossil fuels store carbon, so when burned, fossil fuels emit carbon dioxide. Other pollutants like particulate matter, nitrogen dioxide, and sulfur dioxide are also emitted.

Coal is generally used for electricity and manufacturing in the United States. Coal supplies over half of the country's electricity. **Oil**, used for transportation and manufacturing, is the raw material for diesel, gasoline, and plastic products. The United States imports most of its oil from other countries. Oil, and coal even more so, are considered to be the dirtiest burning fossil fuels because upon combustion they emit air pollution that is unhealthy to breathe. **Natural gas** is used for heating, electricity, transportation, and manufacturing. Natural gas burns much cleaner than oil and coal.

Nuclear energy is also a non-renewable energy that is used to produce electricity. Using uranium as a fuel, nuclear power plants break apart atoms to release the energy in their bonds. The uranium used is a non-renewable resource. Nuclear energy does not emit greenhouse gases since it does not require fossil fuel combustion.

Renewable Energy Sources

Renewable energy harnesses power from natural resources, like sunlight and wind, that are plentifully supplied by nature. The most common forms of renewable energy are solar, wind, hydropower, geothermal, and biomass.

Renewable energy sources do not generally emit greenhouse gas emissions directly.

Solar energy harnesses energy from the sun to create heat and electricity. For example, solar water heaters use energy from the sun to heat water; and solar cells convert the sun's energy into electricity. Solar cells are charged cells of silicone that can create an electric current. **Wind** energy uses the force of wind to rotate turbines to produce electricity. Wind farms are large collections of wind turbines that generate electricity. **Geothermal** energy comes from hot water or steam naturally created underground. Pipes are drilled into these sources to collect steam and turn turbines. Geothermal power plants emit some carbon dioxide and air pollutants, but significantly less than burning fossil fuels. **Hydropower** is created when the force of flowing water from rivers is used to turn turbines built inside a dam. Large hydropower dams, like the Hoover Dam in Nevada, do not emit greenhouse gas emissions. However, they can harm the surrounding ecology by blocking the movement of fish and sediments in the river. **Biomass** energy is the burning of organic matter such as cow manure, agriculture waste, or methane from landfills to create energy. Biomass energy can be used for electricity or converted into fuel for transportation. When used to burn off waste gases, biomass can reduce greenhouse gases entering the atmosphere. When crops are grown to make biomass fuel, biomass takes up as much carbon dioxide during growth as it emits during combustion.

Energy Use in the United States, California, and Bay Area

The United States is largely dependent on oil, coal, and natural gas for its energy. We use fossil fuels mostly for transportation fuel and electricity. As shown in Table 1, the United States relies mostly on coal for electricity generation since it is widely available. California uses mostly natural gas for electricity. California extracts some natural gas from within the state and imports most of it from states nearby like Colorado and Arizona.

Historically, fossil fuels have cost much less to use

than renewable energy, and are therefore, used much more widely than renewable energy. However, concern over our reliance on fossil fuels is growing worldwide. Fossil fuels emit greenhouse gas emissions, are becoming more expensive and complicated to extract, and involve numerous environmental, political, and social risks. New interest in renewable energy is blooming as the technology and economic incentives for renewable energy improve.

Table 1. Electricity Resource Mix for 2006

Resource Type	US	CA	SF Bay Area		GHG Emissions Level
Coal	49%	15.7%	3%		High
Large Hydro	7%	19%	19%		Low
Natural Gas	20%	41.5%	42%		Medium
Nuclear	19.4%	12.9%	23%		Low
Oil	1.6%	0	0		High
Other	.7%	0	0		
Renewables	2.4%	10.9%	13%		Low

Source: California Energy Commission, http://www.energy.ca.gov/electricity/electricity_resource_mix_pie_charts/index.html
U.S. Energy Information Administration: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html

California has made it a priority to use clean energy sources and invest in renewable energy. As a result, renewable energy is used much more in California, and even more so in the Bay Area, as compared to the rest of the United States. In California and the Bay Area, we are also much less dependent than the United States on coal. Around the Bay Area, we can see many examples of renewable energy: wind energy at the Altamont Pass Wind Farm by Livermore; solar energy by photovoltaic solar panels on rooftops the Bay Area; a geothermal energy plant in Sonoma County; and a biomass plant at Strauss Dairy in Marin County. The last column in the table above provides an overview of the level of greenhouse gas emissions associated with each energy source.

Climate Change Connection: In the United States, 87% of greenhouse gas emissions are emitted from burning fossil fuels[1] mostly for electricity and transportation. Relative to the rest of the world, the United States emits 21% of the world's carbon dioxide.[2] Other countries with significant greenhouse gas emissions include China, Russia, and Japan. In California, most of our greenhouse gas emissions are also from fossil fuel burning, with 23% in electricity and 38% in transportation.

Background for Lesson 7
Creating Electricity with Solar Energy

Solar energy can be converted into other forms of energy, such as heat and electricity. For example, solar water heaters use the sun's heat energy to warm water for home use or even swimming pools. Solar energy can be converted into electricity through **photovoltaic** cells. Photovoltaic cells, also called **solar cells**, are used in calculators, on rooftops to supply a building's electricity, and even on satellites in space. Solar cells are made from layers of **silicon**, a type of melted sand that is commonly found worldwide. The solar cell's different silicon layers are charged with a positive or negative charge. When sunlight strikes the cell, **electrons** from the negatively charged layer are knocked loose and flow into free spaces in the positive layer. This flow of electrons creates an electrical current that then flows through a wire circuit. Energy from solar cells can be stored in batteries for later use. For example, emergency roadside telephones are powered by stored solar energy.

Solar cells could be expensive to construct and install on buildings for energy. However, the solar energy industry is growing rapidly and is becoming more affordable as technology improves. For California, solar energy is an especially attractive energy option because California has sunny weather year-round and solar energy does not directly emit greenhouse gas emissions. California adopted a one million solar roofs plan that aims to provide 3,000 megawatts of solar energy by 2018. This effort would avoid 3 million tons of greenhouse gas emissions, equaling one million cars off the road.

[1] U.S. Energy Information Administration, for 2006: http://tonto.eia.doe.gov/energy_in_brief/greenhouse_gas.cfm
[2] U.S. Energy Information Administration, for 2005: http://tonto.eia.doe.gov/energy_in_brief/greenhouse_gas.cfm

for Lesson 8
Creating Electricity with Turbines

Almost all **electricity** in the United States is generated by large, centralized power plants using turbine generators. **Power plants** use an energy source to turn a **turbine generator** which spins an electromagnetic shaft, a magnet created by electricity. The shaft is surrounded by insulated coils of wire. The rotation of the shaft moves electrons, creating an electric current in the wire coil. The electrical generator must build up enough electrical pressure with the spinning shaft to push the electric current through the wires and to power lines. The amount of push, or **voltage**, provided by the generator is measured in **volts**. The rate of electrons moving through a wire is known as current and is measured in **amps**.

Steam-driven electric turbines can be powered by both renewable and non-renewable energy sources. Fuels are used to heat water and produce steam to turn the turbines. The most commonly used fuels for electric generation are coal, gas, and oil. Nuclear energy, geothermal energy, and biomass are also used to heat steam.

Electric turbines can also be turned directly with the force of wind in wind turbines or water in hydroelectric turbines.

The generation and transmission of power plants is surprisingly inefficient. Most power plants are only about 35% percent efficient; meaning that for every 100 units of energy put in, only 35 units of usable electrical energy is made.[3] In addition, about 7% of electricity from the power plant is generally lost in transmission.

Background for Lesson 9
Energy Conservation and Efficiency

Energy conservation and efficiency means using less energy and using it wisely. **Energy conservation** is behavior that results in the use of less energy, such as turning the lights off. **Energy efficiency** is the use of technology that requires less energy to perform the same function. For example, compact fluorescent light bulbs use significantly less energy to produce the same amount of light as an incandescent light bulb.

Americans use six times the amount of energy as the world average. However, California has proven that energy conservation and efficiency practices could greatly reduce energy use without lowering quality of life. Due to efficiency and conservation practices Californians use much less electricity per person than the average person in the United States.

Energy conservation and efficiency is also connected to water use. Water requires significant amounts of energy to pump, transport, and heat. One-fifth of California's electricity is used for water use. Conserving water and using water more efficiently saves energy and reduces greenhouse gas emissions.

Climate Change Connection: We can take many steps in our own lives to reduce our use of electricity and protect the climate.

- Purchase Energy Star® appliances. Energy Star is a government program that identifies energy efficient products.
- Use compact fluorescent lamps (CFL) instead of incandescent bulbs. CFL's use 75% less energy and last longer than regular bulbs.
- Set the thermostat at 78°F in the summer and at 68 °F in the winter to avoid overuse.
- Turn off equipment when not in use.
- Take shorter showers to save energy in heating and pumping water.

Need More Information?

- U.S. Energy Information Administration, www.eia.doe.gov/kids/energyfacts/
- CA Energy Commission, www.energy.ca.gov/renewables/

[3] U.S. Energy Information Administration: http://www.eia.doe.gov/kids/energyfacts/sources/electricity.html#Generation

Estimated Time: Two 45 min periods

Objectives:

- Be able to identify at the major carbon-based fuels currently used and at least 3 alternative energy sources
- Know the difference between renewable and non-renewable energy sources
- Understand how different sources of energy can impact air quality.

CA State Standard Connections:

4th Grade Physical Science
Electrical energy can be converted to heat, light, motion (electrical cars and trains, power to homes)

Tool Kit Materials:

- One roll heavy duty aluminum foil
- One roll saran wrap
- Thermometers (six per class)
- Handout 1 (one per student)
- Handout 2 (one per student)

Additional Materials:

- Pizza boxes (one per student, donated from pizza restaurant)
- Index cards
- Black construction paper
- White glue
- Masking tape
- Scissors
- Food to cook in solar oven (e.g., tortilla and cheese quesadillas, s'mores)
- Student journal (one per student)

Lesson adapted from The Pizza Box Lesson by Solar Now, Inc, www.solarnow.org/pizzabx.htm.

Energy Choices

We use different kinds of energy sources to create electricity, run our transportation systems, and power equipment. These sources have different kinds of pollution impacts. The world's dependence on carbon-based fossil fuels is the major cause of climate change. These fuels are also non-renewable, becoming scarcer and more expensive as their supplies are depleted. This lesson looks at the variety of energy sources currently available and their impacts on air quality.

Key Words

Renewable Energy: energy from a source that is replaced rapidly by natural processes.

Non-Renewable Energy: energy from a source that cannot be replaced or can only be replaced very slowly by natural processes, usually over millions of years.

Fossil Fuels: coal, petroleum, and natural gas are formed over millions of years from the decayed remains of ancient plants and animals.

Electricity: form of energy produced when electrons move from one place to another. We use electricity for light, heat, and power in homes and industries.

Preparation

Review the Background topics for Lesson 5 for an overview on renewable and non-renewable energy sources. Review Handouts 1 and 2 and practice building and using the solar oven.

This lesson is best taught on a sunny afternoon late spring to early fall.

Procedure

SETTING THE STAGE

- There are lots of different kinds of energy that we use everyday: electricity from wires and batteries and gas are the most common types we see as consumers.
- "What are some things you use energy for?" (Lights, heat, driving a car, cooking, computers, TV.) In the next few lessons we'll be looking at where these common types of energy come from and how different energy sources affect climate change.
- Ask students to imagine that while they and their family are eating a pizza dinner at home, a major earthquake strikes and the gas and electrical service is disrupted. They have first aid supplies, a radio, flashlights, and food and water for two weeks, but only enough gas left in their gas barbeque or camp stove for one day of cooking. The power company cannot get power restored for about a week or more. Ask the following questions:
  - "What can your family do to cook their food for the rest of the week?" (Brainstorm solutions- use the barbeque until the gas runs out, make a solar oven, build a fire with furniture and books, etc.)
  - "What is the problem with the gas barbeque or camp stove?" (The propane gas is a non-renewable source of energy and once it is burned it is gone. The supply is limited.)
- This is your lucky day because we're going to learn how to make a solar oven from a cardboard box. As a matter of fact, many people in developing countries use cardboard solar ovens everyday to cook their food.

ACTIVITY 1 – Build a Solar Oven

1. Distribute one copy of Handout 1 to each student. You may want to have students work in groups of two to three. Discuss the directions in the handout with the class.
2. Distribute the solar oven materials to the students. They may need approximately 15 to 20 minutes to complete construction of their ovens. Tell students that they should make sure that they glue the foil onto the cardboard with the shiny side facing out.
3. Ask: "Why is it important for the shiny side of the foil to face out?" (For greatest reflectivity.) "Why do we place foil under the black paper?" (To insulate the box to make it hotter.)
4. Once ovens are constructed, take the class outside. Position ovens facing the sun. Use pencils or sticks to prop open box flaps. Help students align ovens so that the maximum sunlight is focused into the ovens.
5. Provide students with food to "cook" in their ovens. The ovens may only get hot enough to melt or warm up food. Have students place the food on a small piece of wax paper inside the ovens to prevent a mess. Students should also place a thermometer inside their ovens to track the temperature increase Have students make predictions in their journals about how hot their oven will get and how long it will take to "cook" their food. If thermometers are put in the ovens, be sure to have the students record beginning and ending temperatures.
6. Ovens will need at least 15 to 30 minutes to heat up food. Have students measure and chart the heat build-up in their ovens by reading the thermometer, inside the oven, every 2-3 minutes. Have them graph their results.

ACTIVITY 2–Renewable and Non-Renewable Energy

 Renewable energy sources image on CD.

1. The sun is just one type of energy source that we call **renewable**. "Can anyone guess what that might mean?" (Guide discussion to the definition: Renewable Energy: energy sources that can be replaced rapidly by natural processes.)
2. Renewable energy sources harness the power of natural forces like energy from the sun (solar energy), heat underground creating hot geothermal liquid (geothermal energy), the natural flow of water (hydroelectric energy), the wind (wind energy), and the ability of plants to capture the sun's energy as biomass (biomass energy).
3. Provide each student with a copy of Handout 2. On the chalkboard, make two tables, the first table for renewable energy sources and the second table for non-renewable sources to record student ideas.

Table 1 – Renewable Energy Sources

Renewable Energy Source	How do we get it?	What do we use it for?
(Solar)	(Solar panels)	(Electricity and hot water)

Table 2 – Non-Renewable Energy Sources

Non-Renewable Energy Source	How do we get it?	What do we use it for?
(Coal)	(Mining)	(Electricity)

4. Fill out the tables together by asking a series of questions:
   - Can anyone name an energy source that is renewable? (Wind, solar, hydro and geothermal.)

     As students call out a renewable energy source, list it in the first column. Students should fill in columns 1 to 3 of the corresponding table in Handout 2 as you complete the table on the chalkboard. Refer to the Lesson 5 Background to complete the list of renewable energy sources, explaining each source as needed.
   - "What are some ways that we can use renewable energy?" (To make electricity, fuel for transportation, heat water, and cook food.)
   - "Can anyone name an energy source that is non-renewable? That means a source that cannot be renewed quickly because it is formed over a long period of time." (Fossil fuels like coal, petroleum, and natural gas; and uranium for nuclear power.)

     As students call out non-renewable energy sources, list them in the first column of the non-renewable energy sources table, explaining each source as needed by referring to lesson 6 Background. Students should fill in columns 1 to 3 of the corresponding table in Handout 1 as you complete the table on the chalkboard.
   - "What are some ways that we use non-renewable sources of energy?" (To generate electricity, fuel for transportation, etc.)
   - "Most of our current energy supply, both electricity and fuel for transportation, comes from fossil fuels. Can you think of some reasons why we might want to use more renewable sources?"

(Renewables can last longer, non-renewables get more expensive to produce as they get scarcer.)

- "Does anyone remember which of these energy sources emit carbon dioxide?" (Fossil fuels because they store carbon. Wood and biomass are carbon based but they only release the same carbon dioxide they took from the air to grow through the carbon cycle.)

5. In our next lesson we'll be looking at the carbon emissions from fossil fuels. Keep Handout 2 in your Journals to use next time. (Students will complete column 4 of Handout 2 in Lesson 6.)

ASSESSMENT

In their journals, have students list the reasons to use more renewable energy. Ask student to write about the advantages and disadvantages of using a solar oven and the problems they would face if the solar oven was their only means of cooking food. Make a brochure or poster advertising your solar oven.

EXTENSIONS

1. Energy Sources Game – Using index cards, create the following energy source cards: clearly write coal on 2 cards; natural gas on 21 cards; hydro on cards; nuclear on 11 cards; wind on 1 card; biomass on 3 cards; geothermal on 1 card; and small hydro on 2 cards. The quantity of each energy type represents the energy source mix used by Pacific Gas and Electric for the Bay Area. At one end of a field place two containers at least four feet apart. Label the first container "Non-renewable" and the second container "Renewable." Have students stand in a single file line on the opposite end of the field. Hold up a card with the name of an energy source on it. The first person in line is to take the card from your hand, run with it to the other end of the field, and place it in the appropriate container. Students with a non-renewable source make a new line next to the "Non-renewable" container. If the source is renewable they run back to the original line. Continue the game until all students are in line by the "Non-renewable" container. This will happen before you use all the cards. Discuss the results. "Why did the original line get shorter?" (The non-renewable energy was used up and couldn't be replaced.) "What did they learn about renewable and non-renewable sources of energy?" (The renewable sources returned to the line while the non-renewable sources were used up.)

2. Solar oven experiments – Bring to class extra cardboard, materials for insulation (e.g., newspaper), Mylar or other reflective material for students to be creative in improving their solar ovens. Students can measure and chart the heat build-up in their ovens by reading a thermometer inside the oven once every 2 to 3 minutes.

Develop Earthquake Emergency Kits

Have students use the internet and/or camping supply catalogs (www.rei.com) to find and make a list of equipment to supply an earthquake emergency kit for their family. They should think about renewable and non-renewable sources of energy as they make their list. Have them make recommendations about what equipment would be good to have and why and whether it uses renewable or non-renewable sources of energy. As a class, compile a list to give to families and the school Parent Club/PTA. Potential items on their lists: crank operated radios and flashlights, solar battery chargers, and solar water purifiers.

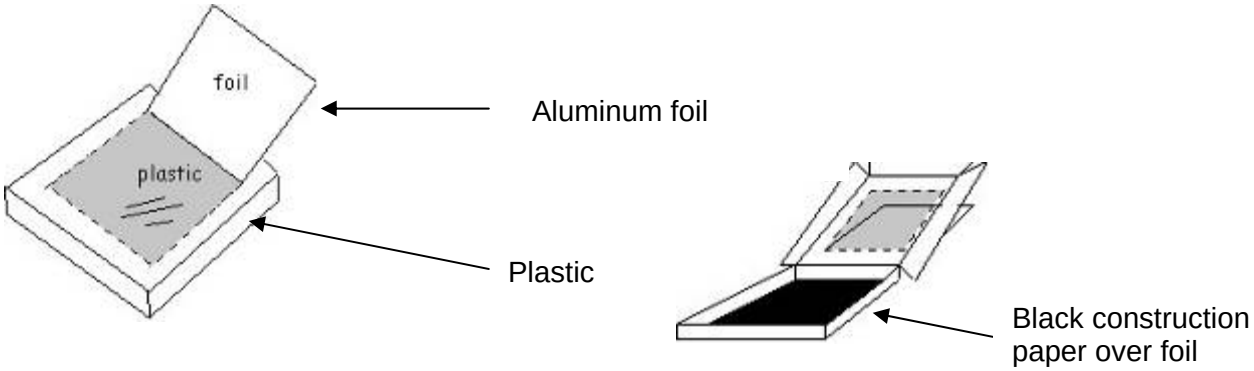
Renewables in Action

Lesson 6, Handout 1

Build a Solar Oven!

1. Using a ruler and pencil, draw a one inch border on all four sides of the top of the pizza box. With scissors, carefully cut along three sides, leaving the line along the fourth side uncut.

2. Form a flap by gently folding back along the uncut line to form a crease. Cut a piece of aluminum foil to fit on the inside of the flap. Smooth out any wrinkles and glue into place. Measure a piece of plastic to fit over the opening created by forming the flap in your pizza box. The plastic should be cut larger than the opening so that it can be taped to the underside of the box top. Be sure the plastic becomes a tightly sealed window so that heat cannot escape from inside the oven.



3. Cut another piece of aluminum foil to line the bottom of the pizza box and carefully glue into place. Next, cover the aluminum foil in the bottom of the pizza box with a piece of black construction paper and tape into place.

4. Close the pizza box top and prop open the flap with a stick or pencil. Your oven is ready!

5. Take the oven outside and face it towards the sun. Adjust until the aluminum reflects the maximum sunlight through the window and into the oven.

NAME:_____ DATE:_____

Renewables in Action
Energy and Air Pollution

Lesson 5 & 6, Handout 2

Note: This handout will be used for both Lesson 5 and Lesson 6.

Lesson 5: Complete only columns 1, 2, and 3 in the following tables by listing renewable and non-renewable energy sources.

Lesson 6: Complete column 4 and 5 by identifying which energy sources require combustion and cause air pollution.

Table 1 – Renewable Energy Sources

1	2	3	4	5
Renewable Energy Source	**How do we get it?**	**What do we use it for?**	**Does it require combustion to make energy?**	**Does it create air pollution?**

Table 2 – Non-Renewable Energy Sources

1	2	3	4	5
Non-Renewable Energy Source	**How do we get it?**	**What do we use it for?**	**Does it require combustion to make energy?**	**Does it create air pollution?**

1. What energy sources are used most in your community?_____

_____

Combustion Energy & Air Pollution

Estimated Time: 45 min

Objectives: Students will

- Understand that combustion of fuels causes air pollution.
- Identify at least three energy sources that do not require combustion.

CA State Standard Connections:

4th Grade Investigation & Experimentation
Students will formulate and justify predictions based on cause-and-effect relationships.

5th Grade Physical Sciences
Students know that during chemical reactions the atoms in the reactants rearrange to form products with different properties.

Tool Kit Materials:

- Six large mason jars (one per group)
- Paraffin candle (one per group)
- Beeswax or soy-based candle (one per group)
- Handout 1 (one per student)
- Handout 1 from Lesson 5 (return to students)

Additional Materials:

- Matches or lighter
- Paper towels (two per group)

Lesson adopted from Geothermal Energy, GR 4-8 Curriculum, Geothermal Education Office, www.geothermal.marin.org

The combustion of fossil fuels provides most of our energy, but it also creates air pollution, carbon dioxide, particulate matter, nitrogen dioxide, and sulfur dioxide, which contribute to global climate change. In this lesson, students observe the particulate matter generated from combustion and develop strategies to reduce pollution associated with energy use at home and in the school.

Key Words

Fuel: something such as wood or oil which is burned to produce energy.

Combustion: chemical process of burning.

Paraffin: type of wax made from petroleum, a fossil fuel.

Soot: fine black particulate matter produced by combustion of coal, oil, wood, or other fuels.

Preparation

Review Background for lessons 6 and 7. This lesson involves observing lit candles. You may want to provide small groups with their own candles, or conduct the experiment in front of the class with just one type of candle at a time. Set up a standard paraffin candle - do not use birthday candles Test the activity before teaching this lesson.

Assemble Materials: Make six sets of materials for group of 4-5 students. Each set should include a mason jar, a paraffin candle, a beeswax candle, and a paper towel. Prepare Handouts for all students.

Procedure

SETTING THE STAGE

- Begin by asking students if they have ever been around a campfire or a fireplace. What was the **fuel** for the fire? (Wood.)
- What did you feel and see from the fire when you were near it? (The fire generated heat, light, smoke, and sparks)
- What are the positive and negative aspects of burning fuel? (Positive – gives off light, gives off heat, cooks our food, etc. Negative – causes air pollution, uses up resources.)
- Scientists use the word **combustion** to describe what happens when wood or other material burns.
- Today you will be burning two different fuels, a paraffin candle and a beeswax candle, and noting what happens as they burn, how they behave in like ways and in ways that are different and what is left after they burn.

ACTIVITY 1– Combustion Demonstration

1. Divide class into small groups for a total of six or fewer groups. Distribute one copy of Handout 1 to each student. Distribute the prepared materials to each group. Tell students that they will conduct an experiment with lit candles. Safety around lit candles should be discussed before starting the experiment.
2. Have students complete question #1 on Handout 1. Ask students what they think might happen to the bottom the mason jar, when it is held over the flame of the candle and why they think as they do. Take all ideas. This is an opportunity to assess prior knowledge and uncover misconceptions before teaching.
3. Go to the first group and light their paraffin candle. As you hold the lit candle, have one student hold the jar just above the burning candle for about 10 seconds, slowly moving the jar back and forth so that the flame touches the entire bottom of the jar. As the candle burns, have students watch and record what they notice, as well as what they wonder about the candle and what is happening. Remind students to watch as they blow out the candle and until it is completely finished burning and/or smoking.
4. Repeat for each group. Have students look at the bottom of the jar with a hand lens and describe what they see, smell, feel. Have them rub a small sample between their fingers and rub it on their recording sheet at the bottom of the page. Next have them use the paper towel to wipe off the soot and look at it carefully, using a hand lens.
5. Repeat the experiment, using a beeswax candle. Similar results should occur with the beeswax candle. Students will see that all combustion creates air pollution. However, beeswax may be slightly cleaner burning than paraffin.
6. After everyone has observed the results of the experiment, students should complete questions #2 to 6 on Handout 1 for each type of candle. On the back of Handout 1 have students make a drawing of what happened in each experiment and label their drawings.

DISCUSSION– Energy and Air Pollution

1. Go over Handout 1 with the class and discuss their findings from the experiment.
2. Ask students:
   - "How was the candle burning similar to the wood-burning campfire?" (Heat, light, and soot are generated. It could be felt, seen, smelled.)
   - "Did the candle change during the experiment; if so, how did it change?" (The candle changed from solid paraffin or beeswax into soot, heat, light, and gases such as carbon dioxide, sulfur dioxide, etc.)
   - "Was this a physical or chemical change?" (Chemical change) "What makes you think so?" (New substances were formed.)
   - "Did both candles seem to produce the same things?" (Yes, soot) "Why?" (Combustion took place in both instances.) "Was there a difference between the paraffin and beeswax candle?" (Yes, the beeswax candle burns slower and is cleaner burning than the paraffin candle. Beeswax is a cleaner fuel than paraffin, which is made from oil.)
3. Have students complete question #7 on Handout 1. Students can discuss this question within their groups. Solicit student responses to question #7, and write them on the chalkboard. Answers might be that cars and trucks burn fuels like gasoline and biodiesel for power, or power plants burn fuels like coal and biomass to make electricity for lights, television, washers , fireplaces burn wood to heat homes barbeques burn wood or charcoal to heat/cook food, and so on.
4. Now ask students,
   - "Do all sources of energy produce air pollution? Why or why not?" (Some energy sources, like solar, do not require combustion, and therefore do not produce air pollution.)
   - "What conclusions can you draw from this demonstration?" (With any fuel combustion you get light and heat, but also air pollution.)
   - "What are some ways to get light and heat without air pollution?" (Electricity from wind power can be used to power a light and solar power can make electricity and heat, nuclear energy generates electricity.)
5. Have students complete #8 in Handout 2 and then solicit their responses. Collect the completed worksheets.
6. Now provide students with the partially completed Handout 1 from Lesson 5 and have them complete Columns 4 and 5 in Table 1 and Table 2 for renewable and non-renewable sources.
7. Lead the class in a discussion about the use of energy sources that do not require combustion, such as wind and solar, to replace the non-renewable energy sources they are now using. Remind students that the best way to prevent pollution is to reduce the amount of energy we use, since most of the energy we use involves combustion.

ASSESSMENT

In their groups, have students develop a list of three actions to reduce the amount of energy they use, such as taking shorter showers, meaning less water needs to be heated, turning off lights, or riding a bike. Have groups share their lists with the rest of the class. On the chart paper write down the class responses. Read the list out loud, asking students to raise their hand for each

action they can take in their own lives. Post the chart for the next week, and check in with students from time to time to see if they have been able to incorporate the listed actions into their lives.


Have students write in their journals one or two things they personally will try to do over the next week or more. Explain how your effort will help reduce air pollution. Explain why you think children can or cannot make a significant difference in the effort to stop or reduce global warming.


Did you know that only 5% of the people in the world live in the United States, yet in the year 2000 it used 23.3% of the world's energy? In the same year, India represented 15% of the world's population and used only 3.2 % of the world's energy. Ask your class how they think this could this happen?

EXTENSION

1. Create a Renewable/Non-renewable Essay & Poster Project- Students research one non-renewable energy source and one renewable energy source, identifying how those sources are used and the pros and cons of each. Students write an essay on their findings and recommendations for the preferable energy source. Students present their essays to the class.


Hold a Renewable Energy Science Fair!
Holding a science fair can educate students, parents, teachers, and staff about the possibilities of renewable power while exploring the barriers to mainstream adoption of these technologies. Organize a school science fair with the requirement that all projects be related to renewable power. Students' projects can be informational posters or working projects. Invite local renewable energy professionals to make presentations and demonstrations at the fair. Publicize the fair and open it to the public.
Solar related science fair ideas: http://www.makeitsolar.com/science-fair-ideas/index.htm
Energy efficiency science fair ideas:
http://www1.eere.energy.gov/education/science_projects.html
Energy efficiency science fair ideas: http://www.need.org/energyfair.php

NAME:_____ DATE:_____

Energy and Pollution

Lesson 6, Handout 1

Candle Experiment Student Worksheet

1. In this experiment the bottom of a glass jar will be held over the flame of a paraffin candle and the flame of a beeswax candle.

What do you predict you will see on the bottom of the glass jar as it passes through the each candle's flame?

A. Paraffin candle flame:_____

B. Beeswax candle flame:_____

2. Are the candles an example of a renewable or non-renewable source of energy? Why?

Paraffin candle: _____

Beeswax candle: _____

3. What did the candles give off as they were burning?

Paraffin: _____ Beeswax: _____

4. What happened when the jar was held over each burning candle?

Paraffin: _____ Beeswax: _____

5. Why did this happen?

_____

6. What is the stuff on the bottom of the jar called? _____

7. List three other things that are burned to produce energy, for heat, light, or do work.

_____

_____

_____

8. We can make energy without burning petroleum products. For example, we can use renewable sources like solar energy to heat water, or wind energy to make electricity to give off light. Would you see smoke or soot given off by a windmill or a solar panel? Why or why not?

_____

Estimated Time: 1 hr

Objectives:

- Understand the fundamentals of electrical generation.
- Be able to demonstrate how a solar cell works.
- Be able to identify solar as a non-polluting renewable energy source for electricity.

CA State Standard Connections:

4th Grade Physical Sciences
Students know electrical energy can be converted to heat, light, and motion.

Additional Materials:

- Chalk
- Solar powered calculator

Using the Sun's Energy

Solar cells are miniature power plants that generate electricity without creating greenhouse gas emissions. Through discussion and an outdoor activity, students learn how solar cells work and understand the role solar energy can play in curbing air pollution and climate change.

Key Words

Photon: tiny particle of radiant energy.

Electron: negatively charged particle in an atom.

Electrical Current: flow of electrons.

Solar Cell: device that changes energy from the sun into electricity. A solar panel is comprised of many solar cells.

Preparation

Review Lesson 7 Background for an overview on electricity and solar as a renewable energy source. Carefully read through the instructions for the outdoor activity prior to teaching this lesson.

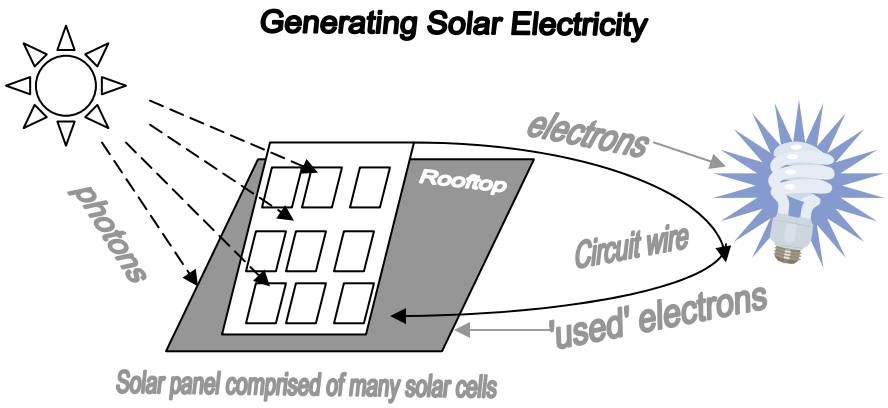
Procedure

SETTING THE STAGE

- Begin by asking the class what solar collectors they or their family and friends use in their day to day lives. (Calculators, watches, water heaters, attic fans, etc.)
- Hold up a solar powered calculator for the class to see, and ask:
- Where does this calculator get its electricity? (It uses a solar cell to convert radiant energy from the sun or lights directly into electricity.)
- How can you prove that the sunlight is powering the calculator? (Check to see what happens when you block the sunlight striking the solar cell of the calculator.)
- If blocking light rays stops the solar cell from generating electricity, does anyone know what scientists, engineers, and inventors have done to keep the energy flowing? (The energy from solar cells can be stored in batteries for later use.)

ACTIVITY 1 – Renewable and Non-Renewable Energy

Solar Cell Diagram image on CD.



1. Explain to the class that they will be learning how a solar cell generates electricity. Draw a solar panel on the chalkboard following the steps below. Use the above diagram to guide you. Engage students as you draw each component to ensure comprehension:
   - Draw a picture of the sun.

- Draw sunrays hitting the roof of a house. Explain that the sun's rays are composed of **photons**, which are packets of radiant energy.
- On the roof of the house draw a solar panel. Fill the inside of the panels with rectangles, which represent solar cells. Explain that a solar panel is comprised of many solar cells wired together.
- Draw 'e-'s inside of the smaller rectangles to illustrate **electrons** moving.
- Next draw a line from the solar panel to a light bulb in the house and back to the solar panel to illustrate the **circuit** by which all electricity must flow.

2. Explain to the class how a solar cell makes electricity out of sunlight. Solar cells are composed of layers of neutrally charged silicon that are mixed with other elements so that the top layer has an overall negative (-) charge and the bottom layer has an overall positive (+) charge.
3. Explain to the class that the negatively charged layer has 'extra' electrons, while the positive layer has an absence of electrons. When sunlight strikes the cell, the energy knocks the 'extra' electrons loose, which then want to fill in the free spots in the positively charged layer. An electric field is created at the junction of the negative and positive charged layers, which forces those freed electrons to flow in a single direction. This flow of electrons is a **current**, and by placing metal contacts on the top and bottom of the solar cell, we can enable that current to travel along wires to power things like a light bulb.
4. Draw more 'e-'s to represent electrons traveling from the panel to the light bulb. Draw more 'e-'s coming back to the panel from the light bulb. Explain that this drawing describes the photovoltaic effect, the process by which sunlight generates the electricity in a solar cell.
   - "Why does electrical current have to flow in a circuit?" (Electrons need to return to the solar cell, otherwise the negatively charged layer would run out of electrons and the solar cell would stop working.)

ACTIVITY 2 – Solar Cell Demonstration

1. Once the students are comfortable with the solar cell generator concept, bring them outside to a flat open area such as a basketball court.

2. Using chalk, outline a circle and a rectangle about ten paces apart. Both the circle and the rectangle should each be large enough to accommodate half the students in the class. Tell students that the circle represents the sun and the rectangle represents a solar cell.

3. Draw a line across the middle of the solar cell rectangle. See the diagram to guide you. Tell students that the line separates the positive charged layer from the negative charged layer in the solar cell. The negative layer is the closest part of the solar cell to the sun.

4. Draw a line from the positive layer, looping it away and then back into the negative layer. Halfway along this line draw a large light bulb. Tell students that this line is the electrical wire connecting the positive layer of the cell in a solar panel through the light bulb to the other layer of the cell to make a circuit.

5. Ask one student to stand inside the light bulb. Ask about half of the rest of the class to stand inside the sun. Tell the students in the sun that they represent photons. Next, have half of the

remaining students stand in the positive layer and the other half stand in the negative layer of the solar cell. Tell these students that they represent electrons.

6. Ask the electrons in the negative layer to line up so that everyone is shoulder to shoulder, facing the sun, with their hands held out in front of them. Next, have the electrons in the positive layer line up behind the electrons in the negative layer, shoulder to shoulder, facing the sun with their hands out in front of them. The hands of the students representing the positive layer electrons should almost touch the backs of the electrons in the negative layer.

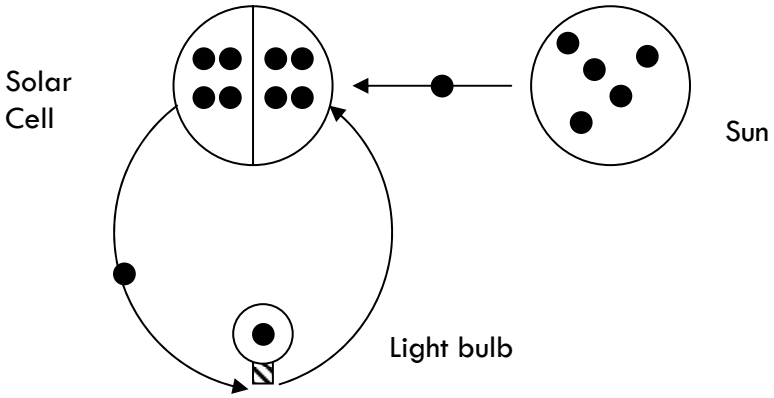
7. Tell one of the *photons* to walk from the sun circle to the solar cell. When the photon gets to an electron in the negative layer, the photon 'excites' an electron by touching the electron's hand.

8. The excited electron from the negative layer takes a step back, running into the hands of an electron in the positive layer. The electron from the negative layer now takes the place of the electron from the positive layer. Meanwhile, the now-excited electron from the positive layer walks down the wire to the light bulb and gently tags the student there.

9. The light bulb student does jumping jacks, hums, or does some other activity of their choosing to indicate that power is on. The electron then continues along the wire and gets back in line with the other electrons in the negative layer.

10. Have students repeat this cycle to show how photons excite electrons to flow through wires to power equipment.

Diagram of chalk outline an d movement of students:



ASSESSMENT

Assess the students' comprehension of the demonstration by leading a discussion on how the system can be used to combat climate change.

- "Can we use solar electricity for all of our energy needs?" (It can be used for much of our needs, but not for everything. It has its limits. For example, solar works only when the sun is out, but scientists are working on better ways of storing the energy in batteries while the sun is shining on the solar cell.)
- "Why is solar power important to improving air quality or tackling climate change?" (Solar energy does not emit air pollution or greenhouse gases here on Earth when it generates electricity because no combustion takes place.)


Have students complete the following journal entry, "What would you tell a third grade student to explain how a solar panel works?"

EXTENSIONS

1. Over the next week have students spot solar panels in their community. Students should list where they see the panels and for what they might be used.
2. Have the class visit a third grade classroom to teach them how a solar panel works by leading the Solar Cell Demonstration activity. Have them partner with a third grade student to answer any questions they might have about how a solar panel works. Explain why using solar energy can help slow global warming.
3. Direct students to do a web search to find out how solar is being used in their community. For example, check out the solar electric system on the San Francisco Giant's stadium, http://www.bizjournals.com/memphis/stories/2007/07/09/daily9.html,

   or the K-12 solar program in Pleasanton
   http://www.solardaily.com/reports/Honeywell_Awarded_Unique_Solar_Project_999.html


Bring Solar Power to Your School

Solar power systems can be incredible teaching aids in schools. Invite a local solar power expert to give a presentation to your students on solar power and to explain how energy from the sun is converted into electricity with photovoltaics. Lead your students in gathering information about your school's energy use (ask your district energy manager or facilities manager), photovoltaic system options, and potential costs and payback time. Have students develop a report containing a cost estimate and recommendation. Have students present this report to the School Board to generate awareness, and gain support. Organize a group of teachers and parents to apply for grants and oversee installation.
FindSolar.com PV system estimator: http://www.findsolar.com/index.php?page=rightforme
PG&E Bright Ideas solar school grants: http://www.need.org/pgesolarschools/big.htm
CA renewable energy:
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=CA

Estimated Time: 1.5 hrs

Objectives: Students will

- Identify three components of an electric generator.
- Identify three stages in the path of electricity transmission.
- Understand that using electricity in the home is connected to power plant emissions.

CA State Standards:

4th Grade Physical Sciences
Students know the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.

5th Grade Physical Sciences
Conductivity is a common property of metals.

Tool Kit Materials:

- Strong bar magnet with north and south poles
- 13 feet of insulated copper wire rolled into a coil
- Ammeter with alligator clips
- 60 watt incandescent light bulb
- Handout 1 (one per student)
- Handout 2 (one per student)

Additional Materials:

- Scissors
- optional: a bicycle or a can opener to demonstrate changing human energy into mechanical energy

Adapted from the Plant to the Home less in Energy for Keeps: Electricity from Renewable Energy, Energy Education Group.

Generating Electricity

Electric power plants use different types of energy sources to spin turbines, turning generators that create electric current. In this lesson, students learn how electricity is generated, transmitted, and used. Students will experiment with an electrical generator, identify where greenhouse gas emissions are produced, and trace the transmission of electricity from the power plant to their home.

Key Words

Turbine: machine that extracts energy from fluid flows like wind, moving water, or steam to do work.

Generator: machine that converts mechanical energy into electrical energy.

Circuit: path that an electrical current flows through.

Electric Power Plant: factory that generates electricity.

Ammeter: device used to measure the electric current in a circuit.

Preparation

Review Lesson 8 Background on generating electricity before you teach this lesson. Review the generator diagram. The diagram is on the CD as well. Prepare to project or draw the diagram for the class. Test the generator experiment prior to teaching the lesson. Review open and closed circuits with students before doing Activity 1. During the lesson, you may want to have students help with the assembly of the generator and with attaching the ammeter.

Procedure

SETTING THE STAGE

- One of the primary rules of our universe is that the total amount of energy remains constant. However, that energy is constantly changing from one form to another. Let's think about some common conversions that are happening all around us:
  - What form does energy from the sun take? (Light energy, infrared radiation (heat), ultraviolet radiation.)
  - When you ride a bike, you use the **chemical energy** in your body to move your muscles, creating **mechanical energy and heat energy** – that's why we sweat when we exercise.
  - What are some other simple machines we power with the chemical energy in our bodies? (Push lawn mower, crank flashlight or radio, pulley, broom, grocery cart, wagon, etc.)
  - People have been using machines to harness natural energy sources for centuries. Windmills and waterwheels were built by early civilizations to use of the flow of water or wind to turn wheels connected to mill wheels that ground grain. A machine with a large wheel that turns fluid flow into mechanical energy is called a **turbine**.

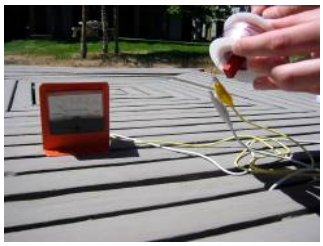
  Windmill or waterwheel Image on CD.
- A **turbine generator** is a modern machine that uses a turbine to turn a generator, converting mechanical energy to electrical energy. The turbine uses the energy from wind, moving water, or moving steam to turn an enormous generator wheel. As the wheel turns, the generator uses magnets to convert motion into electricity.
- Electricity is the flow of electrons in a metal wire. When electrons move they create an invisible field of magnetic force. Magnets also have a magnetic force. This means that you can make electrons move in a wire by pushing them with the magnetic force from a magnet. A turbine generator uses magnets to move electrons through wires to create electricity.
- Tell the students that they are going to learn how the properties of magnets can be used to generate electricity in a copper wire. They will use a special meter to measure the amount of electricity they generate.

ACTIVITY 1– Making an Electric Generator

1. Distribute a copy of Handout 1 to each student. Show the students the different materials to be used in the demonstration (the magnet, the coiled wire, and the **ammeter**).
2. Assemble the circuit through the ammeter:
   - Unravel a piece of the wire from the outside of the coil and a piece of wire from the inside of the coil, so that there are two ends leading out of the main coil.
   - Use the scissors to scrape off about an inch of the coating at each of the ends leading from the wire coil. Ask the students, "Why they think this is important?" (Because the metal wire will conduct electricity and the plastic won't. the metal is a conductor – a material that allows heat energy to flow.)

Connect the ammeter's clips to the copper wires

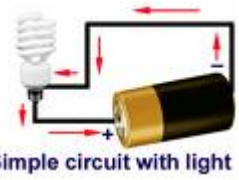
- Connect one of the loose wire ends leading from the coil to each of the clips from the ammeter.
- Connect the free ends of the clips to the back of the ammeter to create a circuit. (See image to guide you.) Review closed and open circuits with students.



Ask students to make the following journal entries:

- Draw and label a diagram of the set-up for this demonstration.
- Predict what they think will happen and why. Ask them to share their thoughts with the class.
- Record the readings on the ammeter before the magnet is moved through the center of the coiled wire. The reading will be zero.

3. Explain that students come up in groups of 4 and take turns to slowly move the entire magnet back and forth through the coil of wire. Ask two students to read the first two questions out loud. Make sure student know what they'll do and what they'll look for. Have students take turns doing the experiment. Ask the students to return to their desks and complete question #1 and #2 on the handout without telling their answers.



Simple circuit with light

For this activity, the ammeter acts as the light, and the wire coil is acting as the battery.

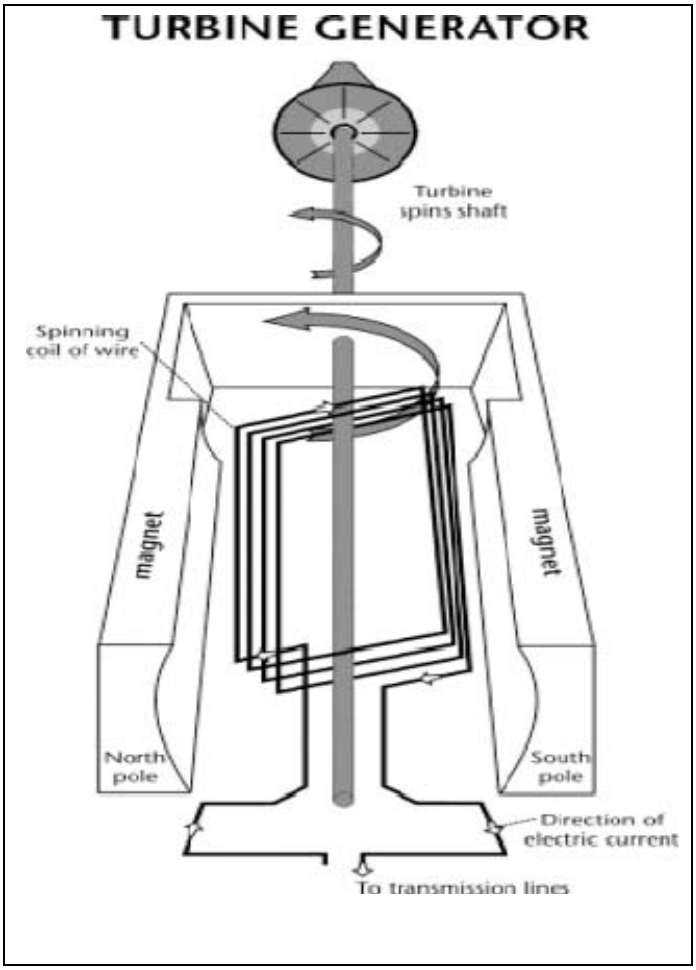
Source:www.energyquest.ca.gov

4. Discuss the answers to questions 1 and 2:
   - "How does the magnet make the ammeter react?" (The dial moves because there is electricity flowing through the wire. The magnet has a magnetic field. When you move the magnet through the wires, the magnet's magnetic field pushes the electrons in the wire to move, creating electricity.)
   - "How does the ammeter's movement change when you are pushing the magnet in versus pulling it out?" (The ammeter's needle twitches in opposite directions. Moving the magnet changes the direction of the flow of the electrical current.)
   - Also, try moving the different pole ends of the magnet through the wire coil. The ammeter's needle will move in the opposite direction depending on how the magnet's magnetic field moves the electrons in the wire.
5. The generator in an electrical power plant uses this same effect to generate large amounts of electricity.

   Use Turbine Generator Image on CD as an overhead, drawing or computer projection.

6. A **generator** has the same basic parts we just worked with: coils of wire and magnets. The principal differences are that instead of moving the magnet inside the wires, big generators turn the wires between two enormous and powerful magnets. The same thing happens that we observed: moving the wire and magnet relative to each other creates an electric current in the wire.

7. In the **turbine generator**, a turbine is used to harness the power of a moving fluid, like air or water, to turn the wire, rather than using our muscle power for movement. In this way, motion (mechanical energy) is changed into electrical energy.
8. Identify and describe the key parts of the turbine generator: the shaft attached to the turbine, the coil of copper wire, and the magnet.
9. As we discussed earlier all sorts of different flows can be used to turn the turbine. "Do you remember what they were?" (wind, moving water, or steam.) Wind power is just a turbine generator with the turbine blades up in the sky to catch the wind. Hydroelectric turbines use water dropping from the top of a dam to turn the turbine.
10. The other, and most common, force for a turbine is the movement of steam. Most electricity in the world in generated by heating water by burning oil, gas, coal, or nuclear energy. The water turns to steam which drives the turbine to turn the generator shaft.



11. Next, write the words 'steam', 'wind', and 'water' in a column on the chalkboard. Write the following percentages beside each of their sources on the board. These figures indicate the energy sources used to generate electric power in the United States, California, and the Bay Area.

Resource Type	US	CA	SF Bay Area
Coal	49%	15.7%	3%
Large Hydro	7%	19%	19%
Natural Gas	20%	41.5%	42%
Nuclear	19.4%	12.9%	23%
Oil	1.6%	0	0
Other	.7%	0	0
Renewables	2.4%	10.9%	13%

12. Discuss this table:
    - "What source is used most for electricity in the United States?" (Coal is used the most.)
    - "What source is used most for electricity in California?" "…in the San Francisco Bay Area? (Natural gas is used most.)
    - "What sources of energy would be included in the Renewables category?" (Solar, wind, geothermal, biomass, and hydroelectric power.)

- "What are some problems caused by the sources we use to make electricity?" (Burning coal and other fossil fuels causes air pollution and contributes to climate change. Some of the renewables also create pollution (i.e. biomass because it is burned to produce power, nuclear power is potentially dangerous due to radiation.)
- "What are some less polluting ways to spin the turbines in electric generators?" (Wind and geothermal steam, and moving water can spin turbines and do not cause air pollution.)
- Have students complete question 4 on Handout 1.

ACTIVITY 2 – Electricity, Watts, and Energy

1. Distribute a copy of Handout 2 to each student and read the directions aloud.
2. Pass around the 60 watt light bulb and tell students to look at the '60W' label on the top of the bulb. On the chalkboard, write 'watts,' 'kilowatts,' 'watt-hours' and 'kilowatt-hours.' Explain to students that we measure electricity in watts. Watts are used to describe how much electricity a light bulb and other devices use. 1000 watts = 1 kilowatt.
   - "We use "W" to stand for watts. Look at the top of this bulb to find out how many watts of electricity it uses to produce light. Record your answer." The light bulb uses 60 watts of electricity to make a certain amount of light.
   - "What if we turned on twenty 60W light bulbs at the same time? How many watts are we using?" Write 20 X 60W = 1200W on the chalkboard.
   - How many kilowatts are we using? Write 1200W ÷ 1000 = 1.2 kW
3. Next, explain that we measure energy in watt-hours, the number of watts consumed over a period of time. To find the amount of energy used by the light bulb, we multiply the number of watts by the amount of time the light bulb was on.
   - "If the 60W light bulb was on for one hour, how much energy did it consume?" Write 60W X 1 hour = 60 watt-hours on the chalkboard.
   - "If the 60W light bulb was on for 20 hours, how much energy did it consume?" Write 60W X 20 hours = 1200 watt-hours = 1.2 kilowatt-hours on the chalkboard.
4. Have students complete Handout 2.

ASSESSMENT

Have students share their answers to the questions on Handout 2.

Have students answer the following question in their journal: What could you tell your family to convince them to replace incandescent light bulbs with CFLs? Do you think they will change the incandescent bulbs in your home with CFLs or not? Why or why not?

EXTENSIONS

1. Students research the sources for the electricity used in their community. Students will need to identify their electricity provider (e.g., in the Bay Area it is usually Pacific Gas & Electric); next, students can look online at the provider's 'power content label,' which is sent out from time to time as an insert with the monthly utility bill. To see Pacific Gas & Electric's most recent, enter 'PG&E power content label' into a computer search engine.

2. Take a field trip to your nearest power plant to see first-hand how electricity is made, and how the pollutants and greenhouse gases from electricity production are dealt with.

 **Exchange Incandescent Bulbs for Compact Fluorescents (CFLs)**

Host an event with free exchanges of CFLs for students, teachers, and staff. Talk with local lighting suppliers or your local PG&E representative about donating CFLs to the school or ask the PTA (or other groups) to sponsor the purchase of CFLs to give away. Plan to have the exchange occur during a regularly scheduled school-wide event. Advertise the event. Set up a table at the event with the bulbs and information about energy consumption and CFL efficiency. After the event, calculate the savings – the difference in kilowatts from the bulbs collected and CFLs exchanged multiplied by the average hours per year use of a bulb multiplied by the cost per hour of electricity. Make posters celebrating the savings.

NAME:_____ DATE:_____

Generating Electricity

Lesson 8, Handout 1

1. Why does moving the magnet through the coil of wire make the ammeter move?

_____

_____

_____

_____

2. How does the ammeter's movement change when you push the magnet through the wire coil and when you pull it out?

_____

_____

_____

_____

3. On the back of this paper, draw a power plant that could generate electricity for your home. The drawing should give the following information:

- What is the power plant's energy source?
- Is the energy source renewable or non-renewable?
- Does the power plant use a turbine to generate electricity?
- Are greenhouse gas emissions produced? If so, where?

NAME:_____ DATE:_____

Generating Electricity

Lesson 8, Handout 2

Electricity is measured in watts. **Watts** describe how much electricity a device uses in an hour and is often indicated by the letter "W." Different bulbs and devices use different amounts of energy, just as different cars or vehicles require differing amounts of energy to make them move.

1000 watts = 1 kilowatt.

Watt-hours describes how much electricity is consumed over a period of time. To calculate the light bulb's watt-hours multiply its watts by the amount of time it is turned on.

Using this information, now answer the questions below. Be sure to write units for all answers.

1. How many watts (W) of electricity are needed by the light bulb ?_____
2. If a 60W light bulb was on for one hour, how much energy does it consume?

   _____=_____watt hours
3. What if we turned on twenty 60W light bulbs at the same time, how many watts are we using?_____=_____ watt-hours
4. If one 60W light bulb was on for 20 hours how much energy does it consume?

   _____=_____watt hours
5. If twenty 60W light bulbs are on for 20 hours, how much energy is consumed?
   _____=_____
6. How many kilowatts are used?

One 60 W bulb for 20 hrs. _____=_____

Twenty 60W bulbs for 1 hr. _____=_____

7. An average home in the California uses 16 kilowatts of energy per day. How many kilowatt-hours will the home use in a year?

_____

8. In California, 0.8 pounds carbon dioxide, CO_2, are emitted from a power plant for each kilowatt-hour of electricity used in the home. How many pounds of CO_2 are emitted per day for the average home? How many pounds of CO_2 are emitted each year?

_____

Estimated Time: 45 min

Objectives: Students will

- Understand the services that are provided to them in their homes through electricity.
- Understand how energy conservation can help reduce greenhouse gas emissions.

CA State Standard Connections:

5th Grade
Electrical energy can be converted to heat, light, motion (electrical cars and trains, power to homes).

Tool Kit Materials:

- Handout 1 (one per student)
- Handout 2 (one per student)
- 60W light bulb
- 13W CFL bulb

Lesson adopted from Geothermal Energy, GR 4-8 Curriculum, Geothermal Education Office, www.geothermal.marin.org

Home Energy Audit

Energy efficiency and conservation are important steps we can take to protect the climate. Through an energy game and an energy audit exercise, this two-day lesson teaches students how to save energy in their homes.

Key Words

Efficiency: amount of work that a machine does compared with the quantity of energy input.

Conservation: careful use and protection of natural resources.

Energy Audit: evaluation of energy consumption in a home or business to determine ways that energy can be conserved.

Phantom Load: energy used by electrical devices when they are plugged in but not being used.

Preparation

Review Lesson 9 Background. Prepare the Save or Waste Game before hand by making a copy of the "Save or Waste" actions, cutting the pieces apart, and putting them into separate stacks in bags or other containers. Have a copy of the glossary ready. Explanations for each action on the game pieces are provided on the teacher's copy of Handout 4.

Procedure

SETTING THE STAGE

- Show the class a 60W incandescent light bulb and a 13W compact fluorescent (CFL) bulb.
- Place the incandescent bulb in a lamp and turn it on. Let students feel the heat from of the bulb, by placing their hand near, not on, the 60W bulb.
- Remove the incandescent and install the CFL. Let students feel the heat from the bulb by placing their hand near, not on, the bulb.
- Which light bulb is hotter? (The incandescent bulb is hottest.)
- The CFL only uses 13 watts to produce the same amount of electricity that an incandescent uses 60 watts to produce.
- Why is the incandescent hotter than the CFL? (It converts more of the incoming electricity into heat than it does into light. The CFL converts more of the electricity into light than heat.)
- How much energy is the 13W CFL bulb conserving compared to the 60W incandescent bulb? (47 watts)

ACTIVITY 1 – Defining Efficiency and Conservation

1. On the chalkboard, draw two columns with the headings "energy efficiency" and "energy conservation."
2. Ask the class the following questions:
   - "What does it mean to conserve?" (To use less of something.)
   - "What are some things you or your family use less of, or conserve? (Fuel for the car, water, electricity, etc.)
   - 'How do we use energy in our homes?" (We use energy for cooking, heating/cooling air, heating water, powering appliances, lights, and electronics.)
   - "What does energy conservation mean?" (Energy conservation is the reduction or elimination of unnecessary energy use.)
   - "What does energy efficient mean?" (Less energy is used to do the same amount or more work.)
3. Ask the class to give examples of energy efficiency and energy conservation. You can start them out by saying, using a CFL is energy efficient, while turning off the lights is conserving energy. Write student responses under the headings in their respective columns. Have students think about conservation and efficiency within the context of their own lives and within their homes.

ACTIVITY 2 – Save or Waste Game

1. Explain to the students that now they are more familiar with energy conservation and energy efficiency, they are going to play a game called Save or Waste. You will be going over the Save and Waste cards prior to playing the game. Shuffle the game cards before distributing one card to each student.

2. Ask students to read aloud the action on their game card. As the student reads aloud the action, ask them to identify and explain whether the action is a saver or a waster and why. See the answer key for assistance; or possibly as reading material to review with students.
    - Example: The attic is insulated. This is a saver because Insulation saves energy by keeping a house warmer in the winter so you don't need to overuse the heater.
3. Continue going through each of the actions until they have all been discussed.
4. Once all the pieces have been covered in the discussion have a student gather all the cards back into a deck and shuffle them for use in the game.
5. Students may also look over their glossary pages before, but not during the game, to give them the opportunity to review terms.
6. Before starting the game, divide students into four or more teams.
7. Each team starts the game with a "Carbon Footprint Score" of 200. The winning team is the team that reaches zero or the team with the lowest "Carbon Footprint Score" when the teacher decides to end the game.
8. To play the game, students on each team line up. Teams take turns answering questions, so that the class hears the answers and information about protecting your climate is reinforced. When it is their team's turn, ask the first person in line to define a word of your choice from the glossary (you can also prepare glossary word cards for students to pick). For each correct definition their team subtracts 5 points from their "Carbon Footprint Score." Incorrect definitions add 5 points to their team score.
9. After giving the definition, correct or not, the same student is given the option of picking the top card from the "Save or Waste" stack and reading it aloud. If the action on the card saves energy, the student's team removes 10 points from their team "Carbon Footprint score." If the action on the card wastes energy, the student's team adds 10 points to their score.

ACTIVITY 3 – Energy Interview

1. Review Home Energy Audit Handout 1 with students to ensure they understand all concepts and actions. Explain to the students that the audit sheet is only information for their family and neighbors to help them in the fight against global warming. It does not need to be returned. Some families may want to go through the audit to see how they score.
2. **Homework assignment:** they will be taking the Home Energy Audit Handout home to help them tell their parents about what they have been learning at school about energy conservation and energy efficiency.
3. **Next Day Follow-up:** Lead a discussion on the home audit explanation and interview experience. The following questions may help prompt the discussion:
    - Did you find that your house had places that were energy efficient? How about places that were inefficient?
    - What are some changes you saw that could be made to improve your household energy efficiency? How can you and your family conserve more at home?
    - What are some other benefits to saving energy? Saving energy also saves money and protects the climate.

ASSESSMENT


Make a list of things you will tell an adult about how and why to save energy. Use this list for the homework assignment.

EXTENSIONS

1. Energy Pledge: Distribute one copy of Handout 2 to each student. Over the next week, ask students to complete the energy pledge. Students should bring home the pledge to share with their families. Families pledge to make energy savings changes in their homes. Students should report back on the changes to be made at their homes.

2. Students can do a web search to find more energy saving activities. For example, check out the Alliance to Save Energy's Energy Hog website, where students can play energy efficiency and conservation games: www.energyhog.org


Tackle Phantom Loads

By investigating phantom loads in the classroom, this project inspires students to reduce phantom loads in their homes through simple steps like unplugging devices when not in use. Discuss with students the concept of phantom loads and identify where in the classroom phantom loads exist. As homework, students can count the phantom loads at home. As a classroom activity, use a watt meter (available at no cost, see PG&E link below) to measure the wattage of the phantom loads in the classroom. Calculate cumulative annual energy use and CO_2 emissions. Measure and report on savings for 1 month.

A phantom loads handout:
www.ocf.berkeley.edu/~recycle/ssec/download/Phantom%20Load.pdf
PG&E's library:
http://www.pge.com/003_save_energy/003c_edu_train/pec/toolbox/tll/tll_home.shtml

NAME:_____ DATE:_____

Home Energy Audit

Lesson 9, Handout 1

How energy efficient is your home? Do this energy audit with your family and find out if what you already know about and find out new ways to save energy. Check the answer box that best matches you and your home. There are no wrong answers, so be honest. As each home is different, **only answer the questions that apply to your household.**

1. *Insulation*: If you have an attic, is it insulated?
___Yes
___No

2. *Filters:* Air Conditioning and Heating Furnaces have filters. Check your filters: Are they dirty or clean? Ask your parents when they were last changed. Changed in the last…
_____ 3 months
_____ 6 months
_____ Last Year
_____ Never Changed Before

3. *Thermostat:* Check your thermostat and record what temperature it is at here: _____
What temperature is your thermostat set at when you are home?
In the winter (cool months):
_____ 73 or more
_____ 70-72 degrees
_____ 69 or less
_____ We have no furnace or heater

In the summer (warm months):
_____ 74 degrees or less _____ 75-77 degrees _____ 78 degrees or more (5pts)
_____ We have no air conditioner

4. *Electricity:* Search your house for appliances and electronics with the Energy Star® symbol. How many did you find?
___ No Energy Star® labels found
___1-2 Energy Star® labels found
___3 or more Energy Star® labels found

5. *Thermostat*: When you get too cold or too hot at home you…
___ Turn the heat up when you are cold or the air conditioning up when you are hot
___ Put on a sweater when you are cold or wear less clothing when you are hot


6. *Laundry*: At what temperature setting do you wash your clothes?
___Mostly HOT water
___Mostly WARM water
___Mostly COLD water

7. *Laundry:* How often do you use your dryer?
___Always dry clothing in the dryer
___Sometimes dry clothes in dryer but most days hang clothes to dry
___Never, always hang clothes on clothing line to dry


8. *Hot water use:* Time your next shower- how much time did you spend in the shower?
___20 minutes
___10 minutes
___5 minutes


9. *Lighting:* Count the number of compact fluorescent light (CFL) bulbs in your house.
___None ___1-3 CFL bulbs ___ 4 or more CFL bulbs

10. *Weather-stripping*: Open your front door and check the condition of the weather-stripping between the door and the doorframe.
___None ___Worn out ___ Good condition


11. *Phantom Loads:* Check your house for appliances plugged in that are not in use (cell phone chargers plugged in and not charging a phone, VCR that is plugged in and not being used, toaster oven plugged in while not in use etc.)
___Appliances plugged in when not in use
___1-4 appliances unplugged in when not in use
___No appliances plugged in when not in use and/or power bar being used

12. *Dishwasher:* Check your dishwasher after it has been run. Is it….
___ Partially empty
___ Mostly Full
___ Full
___ No dishwasher

13. *Cooking*: How often does your family keep lids on pot and pans when cooking?
___Almost never ___Sometimes ___Always


14. *Water Heater*: Find the Energy Guide label on your water heater and look at the efficiency rating. How much energy does it use compared to similar models?

___Uses the most energy ___Uses average energy ___Uses the least energy

Home Energy Audit

Lesson 9, Handout 2

Save or Waste Game Cards:

Insulate attic.	**Do not insulate attic.**
Clean your home's air filter frequently.	**Do not clean your home's air filter.**
Set thermostats at 68 degrees in the winter.	**Set thermostats at 78 degrees in the winter.**
Set thermostats at 78 degrees in the summer.	**Set thermostats at 68 degrees in the summer.**
Buy Energy Star® labeled appliances.	**Do not check for the Energy Star® label on new appliances.**
Wash clothes in cold water when possible.	**Wash clothes in warm water when possible.**
Use a clothesline for drying clothes when possible.	**Always use a dryer to dry clothes.**
Take 10-minute showers.	**Take 20-minute showers.**
Switch incandescent light bulbs to CFLs.	**Switch CFLs to incandescent light bulbs.**
Weather-strip your home.	**Do not bother weather-stripping your home.**
Unplug phantom loads.	**Leave phantom loads plugged in.**
Run full loads of dishes in the dishwasher.	**Run the dishwasher with only a few dishes in it.**
Keep lids on pots and pans while cooking.	**Do not put lids on pots and pans while cooking.**
Turn the lights off when leaving a room.	**Leave the lights on when leaving a room.**
Use my bike, carpool, walk, or use public transit whenever possible.	**Always use the car even when I could walk, bike, use public transit or carpool.**
Turn off the TV when I am not using it.	**Leave the T.V. on when I am not watching it.**

Home Energy Audit

Answer Key, Lesson 9, Handout 2

Answer Key for Save or Waste Game:

- **Attic is insulated.** Insulation is a material put in walls, under floors, or in attics to prevent heat transfer. It can be made out a variety of materials such as fiberglass, recycled blue jeans, or recycled shredded newspaper. Insulation retains heat, or keeps heat out, so that a heater, or air conditioner, is not overused.
- **Wash clothes in cold water when possible.** It takes a lot of energy to heat hot water. Hot water is not necessary for most laundry.
- **Clean your air filter frequently.** The purpose of the air filter is to trap dust and dirt so they do not collect in the filter and reduce the flow of heated air into your home. If the filter is clogged, the system cannot run efficiently.
- **Set thermostats at 68 degrees in the winter.** Set thermostats to 68°F in the winter to avoid overusing the heater.
- **Set thermostats at 78 degrees in the summer.** Set thermostats to 78°F in the summer to avoid overusing the air conditioner.
- **Buy Energy Star labeled appliances.** Energy Star® appliances meet strict energy efficiency guidelines set by the EPA.
- **Use a clothesline for drying clothing when possible.** Drying clothing on a clothes line conserves energy as heat from the sun is used to dry rather than energy from a dryer.
- **Take short showers.** It takes a lot of energy to make hot water for your showers. Short showers, like ten minutes or less, save water and energy.
- **Switch incandescent light bulbs to CFLs.** CFLs use one quarter of the electricity that an incandescent light bulb uses and last 10 times longer.
- **Weather-strips are in good condition in the home.** Weather stripping seal up spaces around doors and windows to keep out drafts.
- **Unplug phantom loads.** Excess energy is consumed by an appliance or electronic device that is plugged in but not being used.
- **Run dishwasher with full load.** Dishwashers use a lot of energy to heat water and operate.
- **Keep lids on pots and pans while cooking.** Lids heat pots more efficiently because they keep the heat inside the pot.
- **Use an efficient water heater.** Conserve energy and choose the most efficient water heater by looking at water heaters' Energy Guide label.
- **Turn the lights off when leaving a room.** Turning off the lights saves energy.
- **Use my bike, carpool, walk or use public transit whenever possible.** Conserve gas by using alternative modes of transportation
- **Turn off the TV when it is not in use.** Turing off the TV saves energy.

INSPIRING CHANGE PROJECTS

Develop Earthquake Emergency Kits

Have students use the internet and/or camping supply catalogs (www.rei.com) to find and make a list of equipment to supply an earthquake emergency kit for their family. They should think about renewable and non-renewable sources of energy as they make their list. Have them make recommendations about what equipment would be good to have and why and whether it uses renewable or non-renewable sources of energy. As a class, compile a list to give to families and the school Parent Club/PTA. Potential items on their lists: crank operated radios and flashlights, solar battery chargers, and solar water purifiers.

Tackle Phantom Loads

By investigating phantom loads in the classroom, this project inspires students to reduce phantom loads in their homes through simple steps like unplugging devices when not in use. Discuss with students the concept of phantom loads and identify where in the classroom phantom loads exist. As homework, students can count the phantom loads at home. As a classroom activity, use a watt meter (available at no cost, see PG&E link below) to measure the wattage of the phantom loads in the classroom. Calculate cumulative annual energy use and CO_2 emissions. Measure and report on savings for 1 month.
A phantom loads handout: www.ocf.berkeley.edu/~recycle/ssec/download/Phantom%20Load.pdf
PG&E's library: http://www.pge.com/003_save_energy/003c_edu_train/pec/toolbox/tll/tll_home.shtml

Exchange Incandescent Bulbs for Compact Fluorescents (CFLs)

Host an event with free exchanges of CFLs for students, teachers and staff. Talk with local lighting suppliers or your local PG&E representative about donating CFLs to the school or ask the PTA (or other groups) to sponsor the purchase of CFLs to give away. Plan to have the exchange occur during a regularly scheduled school-wide event. Advertise the event. Set up a table at the event with the bulbs and information about energy consumption and CFL efficiency. After the event, calculate the savings – the difference in kilowatts from the bulbs collected and CFLs exchanged multiplied by the average hours per year use of a bulb multiplied by the cost per hour of electricity. Make posters celebrating the savings.

Bring Solar Power to Your School

Solar power systems can be incredible teaching aids in schools. Invite a local solar power expert to give a presentation to your students on solar power and to explain how energy from the sun is converted into electricity with photovoltaics. Lead your students in gathering information about your school's energy use (ask your district energy manager or facilities manager), photovoltaic system options, and potential costs and payback time. Have students develop a report containing a cost estimate and recommendation. Have students present this report to the School Board to generate awareness, and gain support. Organize a group of teachers and parents to apply for grants and oversee installation.
FindSolar.com PV system estimator: http://www.findsolar.com/index.php?page=rightforme
PG&E Bright Ideas solar school grants: http://www.need.org/pgesolarschools/big.htm
CA renewable energy: http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=CA

Hold a Renewable Energy Science Fair

Holding a science fair can educate students, parents, teachers, and staff about the possibilities of renewable power while exploring the barriers to mainstream adoption of these technologies. Organize a school science fair with the requirement that all projects be related to renewable power. Students' projects can be informational posters or working projects. Invite local renewable energy professionals to make presentations and demonstrations at the fair. Publicize the fair and open it to the public.
Solar related science fair ideas: http://www.makeitsolar.com/science-fair-ideas/index.htm
Energy efficiency science fair ideas: http://www1.eere.energy.gov/education/science_projects.html
Energy efficiency science fair ideas: http://www.need.org/energyfair.php

Background for Lesson 10
Thinking About Consumption

We use different materials, food, and machines everyday to live, work, and play. Greenhouse gases are created during the manufacture, distribution, use, and disposal of these materials. Understanding the impacts of our choices can help reduce greenhouse gas emissions.

The **environmental footprint** of a product or process is a measure of its environmental impact based on the amount of natural resources it consumes and the amount of waste or other impacts it generates during its lifetime. In measuring the environmental footprint of a pencil we would consider consumption and impacts over its entire **product cycle**: cutting down trees, transporting the logs to the mill, manufacturing the pencil, manufacturing and transporting the lead and eraser parts, transporting the pencil to the consumer, and disposing the pencil in a landfill. A footprint analysis considers the total environmental impact of the pencil from the cradle, production, to the grave, disposal.

The amount and type of energy used during a product's cycle is an important aspect of measuring any product's contribution to greenhouse gases. We can use the idea of **energy input pathways** to identify points in the product cycle where energy is used and trace the source of that energy. For instance, electricity use for manufacturing the pencil might be traced to a power plant and then to the particular fuels used to run that power plant. Different electricity sources would cause the same product to have different environmental impacts.

Climate Change Connection: Energy is used to make, distribute, use, and dispose of the materials, food, and machines we use everyday. As shown in earlier lessons, when organic or fossil fuels are used to provide this energy, greenhouse gases and other pollutants are emitted.

The **carbon footprint** is a measure of the environmental impact of a product or process in terms of the greenhouse gases produced in its cycle. A carbon footprint considers the greenhouse gas emissions produced over the product cycle from production to disposal. Looking at all the energy input pathways makes it easier to recognize and measure the emissions related to use of particular sources of electricity, means of transportation, or product use. Carbon footprints are typically measured in tons of CO_2 equivalent.

Understanding a product's cycle can help us make informed purchasing and use choices that will reduce greenhouse gas emissions and our impact on the climate.

Background for Lessons 10, 11, 12, 13
Waste and Climate Change

Waste is the everyday items thrown away by people. In the United States, 250 millions tons of waste is thrown away every year.[1] In California, on average, each person discards six pounds of waste a day![2] In most areas, 35% of waste sent to landfills is food scraps and food soiled paper products.

Waste can be organized into several categories. **Organic waste** is all waste that came from plants and animals, food scraps, yard trimmings, and even paper. Inorganic waste is man-made items such as plastics, glass, metals, packaging, and construction materials. **Inorganic waste** may take hundreds of year to decompose, or may not decompose at all. However, inorganic waste can often be recycled. **Hazardous waste** is waste with toxic components such as paint, batteries, electronics, pesticides, and cleaning products. Hazardous waste needs to be disposed at locations specifically prepared for hazardous waste. Some hazardous waste, like batteries and electronics, can be recycled into new products.

Most of our waste is taken to **landfills**, large outdoor areas where trash is buried. In landfills, garbage is buried on top of garbage and undergoes anaerobic decomposition, decomposition in the absence of oxygen.

Anaerobic bacteria decompose organic waste; however, it cannot generally decompose inorganic waste. In a landfill, anaerobic decomposition generates methane, known as landfill gas. **Methane** is a greenhouse gas that traps 21 times more heat than carbon dioxide. In other words, methane's **carbon dioxide equivalent** equals 21 and it contributes significantly to climate change. Landfills have gas control systems that manage the build-up of

[1] EPA, 2006: http://www.epa.gov/msw/facts.htm
[2] CIWMB, 2008: http://www.ciwmb.ca.gov/KidStuff/

methane and capture most of the methane emissions. However, methane does escape into the atmosphere. In California, landfills are the biggest source of man-made methane. Some landfills in California are working on ways to reduce methane emissions by converting methane in landfills into energy for electricity or transportation.

Organic waste undergoes **aerobic decomposition**, which is the breakdown of organic materials by bacteria and other natural decomposers in the presence of oxygen.

Climate Change Connection: Most waste goes to landfills. Disposing waste at landfills generates significant greenhouse gas emissions. First, transporting the waste to the landfills, with garbage trucks or garbage barges, emits greenhouse gas emissions from the burning of fossil fuels for transportation fuel. Second, the anaerobic decomposition in the landfill produces methane, a potent greenhouse gas. Last, throwing away waste usually means that we are replacing our unwanted things with new products. Manufacturing, transporting, and using new products creates greenhouse gas emissions. Reducing the amount of waste that we produce and send to landfills reduces greenhouse gas emissions and helps protect the climate.

The Four R's

The Four 'R's: Reduce, Reuse, Recycle and Rot (or Composting) outline strategies for reducing landfill waste that can be implemented by all sectors of society, from individuals and households, to schools and corporations. These strategies can also reduce greenhouse gases associated with using and disposing of products.

The **reduce** strategy means using less products and materials. For example, we can choose not to purchase disposable water bottles and instead refill a reusable water bottle; however, if we need to purchase water we can choose to purchase a two gallon bottle rather than one pint individual bottles for less waste. Reducing waste has the highest impact for reducing greenhouse gas emissions. Using less products and materials means fewer items need to be manufactured, transported, and disposed, therefore, reducing greenhouse gas emissions at all those points.

The **reuse** strategy emphasizes reducing waste by reusing items. Bags, containers, furniture, and many other things can live many lives as people sell, share, and trade things they no longer need rather than disposing those items.

The **recycle** strategy is about collecting and processing products, like cans and bottles, so that they can be made into new products. Recycling saves enormous amounts of energy and greenhouse gas emissions because it avoids extracting and manufacturing raw materials. Recycling aluminum to make new aluminum cans uses 95 percent less energy than making new cans from bauxite ore, the raw material for aluminum.[3] In supporting the recycling of materials for new products, we should purchase products with post consumer recycled content when possible.

In California, a law was passed in 1989 requiring municipal waste management agencies to divert 50 percent of waste from landfills. California reached this goal in 2005, and today, 54 percent of total waste is recycled in California. The energy savings from California's recycling could power 1.4 million homes every year. Many communities and sanitary districts in the San Francisco Bay Area have set goals which exceed the statewide goal of 50% (i.e. Alameda County has a diversion goal of 75%).

Recycling materials such as aluminum and paper does create air pollution due to transportation and manufacturing. These problems are outweighed by recycling's benefits. Still, reducing and reusing are the best strategies for reducing waste to the landfill.

The **rot** strategy encourages composting organic waste. **Composting** is the process of collecting organic waste and letting it decompose naturally through aerobic decomposition. Aerobic decomposition is decomposition by bacteria, insects, and other decomposers in the presence of oxygen. Decomposers break down organic waste and create a soil rich in carbon from the organic waste. Some of this carbon is released into the atmosphere, but most of it is sequestered, or stored in the compost soil. Greenhouse gas emissions from aerobic decomposition are considered to be part of nature's carbon cycle

[3] U.S. Energy Information Administration, 2008: http://www.eia.doe.gov/kids/energyfacts/saving/recycling/solidwaste/recycling.html

and are not generally accounted as man-made greenhouse gas emissions.

Composting can take place on two levels: 1) The home/individual compost pile for a family or a school and 2) on a large scale, such as for a whole community, county, or region. The home compost pile cannot breakdown meat or dairy products because the compost does not reach a high enough temperature as it decomposes. The large scale compost facility is able to compost plant material, food soiled paper and cardboard, as well as meat and dairy products, because the materials are composted at a higher temperature, which kills disease causing bacteria.

Need More Information?

- Carbon Footprint
  Ecological footprint quiz for kids and lesson plans: http://www.kidsfootprint.org/

- The Four R's
  - Stop Waste: www.stopwaste.org
  - Guide to composting with worms: http://lancaster.unl.edu/pest/resources/vermicompost107.shtml
  - California Integrated Waste Management Board (CIWMB): www.ciwmb.ca.gov

Thinking About Consumption

Estimated Time: 1 hr

Objectives:

- Learn about energy used to produce the products we use everyday.
- Identify when pollution is generated during production, distribution, and disposal.
- Make the connection between manufacturing, pollution, and global climate change.
- Understand that personal choices have environmental consequences.

CA State Standard Connections:

4th Grade Visual Literacy
Students construct diagrams, maps, graphs, timelines, and illustrations to communicate ideas or tell a story about an historical event.

Tool Kit Materials:

- Handout 1

Additional Materials:

- Butcher paper
- Student journal (one per student)
- Markers and/or crayons

We use many things in our everyday life, but we rarely think about the energy used to make, transport, and power those items. At every step where energy is used, pollution is also generated. In this lesson students learn the impact of product manufacturing and distribution on air quality and climate change. Students will study common objects we use to learn about the impact of consumption habits.

Key Words

Carbon Footprint: a measure of the total greenhouse gases produced by a process, an activity, or a person. A product's carbon footprint includes all greenhouse gas emissions produced by its cycle.

Product Cycle: the total process of a particular product's manufacture, transportation, use, and disposal.

Energy Input Pathways: concept used to track how energy is consumed through the cycle of a product, from its production, consumption, and disposal or reuse.

Raw Material: natural material used as input to production.

Manufacturing: process of turning raw materials into products that can be used or consumed.

Preparation

Review Lesson 10 Background for an overview on the impacts of product use and climate change. Become familiar with the handouts and review the product cycle examples in Activity 1 prior to teaching the lesson.

Procedure

SETTING THE STAGE

- The total greenhouse gases that come from our lives can be tallied up as our **carbon footprint**. This includes the electricity we use, the things we use, how we get around, and how we dispose of waste. When we counted the number of pounds of CO2 we could save with our actions, we were talking about reducing our carbon footprint.
- We can reduce the greenhouse gas emissions from the things we use by thinking about how they might cause emissions. For example, say you have a choice between buying bottled water that comes from far away, bottled water that is made close by, and your tap water. "Which one of these drinks would you guess takes the most energy to make it, package it, and bring it to you?" (The bottled water from far away.)
- Anything we eat or use has its own **product cycle** starting from gathering the raw material, making the product ready for consumption, how it gets to us, how we use it, and how we dispose of any waste. (Write definition on board.) Normally when we use the word cycle we're talking about the stages of development in the life of different living things (egg, tadpole, frog). Although the products we use aren't alive, they also have stages of gathering, manufacture, distribution, use, and disposal.
- Some of the product cycle stages use energy. We know from earlier lessons that most of our current energy use creates greenhouse gases and other air pollutants. Thinking about how the things we use and consume are made can help us choose wisely and reduce our emissions.

ACTIVITY 1- Energy Inputs to the Pathway of a Products We Use

Product Cycle of Paper

Let's do a product cycle for paper. You will be developing a picture like Handout 1 on the board or an overhead with the help of the students. To do so you will draw pictures of objects in the pathway and link them with arrows. Start by drawing a sheet of paper at one end of the chalkboard.

1. As you draw, have students help fill in the pathway between the paper and the sun. Prompt students by asking them specific questions, such as:
   - "What is paper made from?" (Wood that comes from trees.) Draw a tree on the far left side of the chalkboard.
   - "What gives the tree energy to grow?" (The sun.) Draw the sun above the tree.
   - "How is paper made?" (A factory called a mill saws up the tree and a paper factory makes paper. Both factories use machines that need electricity to operate.) Draw a factory with a smoke stack in the middle of the board.
   - "How did the tree get to the factory?" (A lumberjack cuts down the tree, a truck uses fuel to transport the tree to the mill to saw up and then to paper factory.) Draw chainsaws and trucks between the tree and factory.
   - "How does the paper come to us?" (Stores, trucks to stores, we go in our car, or walk, to buy it.) Draw trucks, stores, cars, and people walking to store.

- "Do we have to refrigerate it or plug it in to use it?" (Just use it, no special storage or turning it on.)
- "How do we dispose of it? Can it be reused? What if we lose it?"

2. These questions represent the different stages in a product cycle: gathering raw materials, manufacturing, distribution, use, and disposal. Many of these steps use energy. "Which ones do you see?" (Gas and electricity to run farm equipment, diesel to run the trucks, electricity for the factory, diesel for the store truck, electricity for the store, gas for our car.) These are the **energy input pathways**. Draw fat arrows with different color leading into trucks, stores, factories, equipment.
3. Pass out Handout 1. This is a simple diagram of the cycle we've been discussing. To generate further discussion, ask:
   - "What happens if the paper is thrown in the trash?" (It goes to a landfill where it cannot be re-used.)
   - "Does throwing the paper away extend the energy pathway and create more pollution?" (Yes, because a truck has to take the paper to a landfill and landfills cause pollution.)
   - "What can be done with the paper to avoid more pollution?" (Use both sides of paper and recycle it.)

Product Life Cycle of Milk

1. Let's think about the product cycle of milk: Draw milk carton a little in from right side of board. We ask the same kinds of questions:
   - "Where does milk come from?" Draw cow on left side of board.
   - "How do we make milk ready to sell and consume?" (Take it to a factory, clean it, and package it.) Draw arrow to a truck and another arrow to a milk factory.
   - "How does it come to us?" (Transported to stores, mostly by truck.) Draw arrow from milk factory to another truck and another arrow to a store and another arrow to a car and another arrow to a house.
   - "How do we use it?" (Keep it cool, drink it.) Draw an arrow from house to refrigerator to glass of milk.
   - "What do we do with the waste?" (Compost or throw away cartons.) Draw a picture of a trash can.
2. "Where are the energy input pathways?" (Gas and electricity to run farm equipment, diesel to run the truck, electricity for the milk factory, diesel for the store truck, electricity for the store refrigerators, gas for our car, electricity for our house and refrigerator.) Draw fat arrows with different color leading into trucks, stores, factories, equipment.
3. What can you do with milk cartons when you're finished with them?

ACTIVITY 2 – Thinking About Consumption

Now that we know how to think about the energy used in products' cycles, we can start to think about what we can do to reduce the carbon footprint of the things we need and use.

1. In our earlier lesson about energy sources, we learned about the connection between greenhouse gases and different fuels. "Do you remember which sources created greenhouse gases?" (Diesel, gas, oil, coal, wood, biomass.)
2. "How can we change the energy pathway of production and distribution of products to reduce air pollution?" (Shorten the pathway between production and distribution i.e. take out some of the steps such as using recyclable paper rather than cutting more trees; use renewable, non-polluting energy sources such as wind, solar, geothermal, and hydroelectric power; use recyclable materials etc.; use natural light or compact fluorescent lights in the factory; workers could carpool or telecommute to work, reduce packaging.)
3. As a society we can think about the energy sources available to us and how to reduce our reliance on these carbon-based fuels. But we can also do things everyday to reduce the carbon footprint of the things we need. The United States consumes more per person and throws away more than any other country on the planet. We can ask ourselves four questions (write on board):
   - **Do I need the new thing** or could I use something I have?
   - **Can I shrink transportation in the cycle?** (Get food from a source closer to home like farmers' markets rather than supermarkets, walk or bike to pick up.)
   - **Can I avoid waste?** (Don't leave the milk out to spoil, or throw away partially used paper.)
   - **Can I recycle to avoid the first part of the cycle?** (Paper or plastic recycling.)
4. All of these actions will reduce the carbon emissions from the things you use. Reducing consumption and recycling will also remove waste from landfills and avoid air pollution emissions.
5. We're going to work in small groups to do cycles for some other products we use and ways to reduce their carbon footprint. Working in pairs or groups of 4, please think of something you use everyday and draw its product cycle and energy input pathways like the diagrams we've been doing together. Remember to include all the product cycle stages: gathering raw materials, manufacturing, distribution, use, and disposal. At the bottom of the page answer the four questions we just discussed for your product.
6. Once you feel your students are comfortable with the energy pathway concept, pass out poster or butcher paper and markers to each group. As the students work on their energy pathways, visit each group to be sure they understand the concept.
7. Once completed, ask one group to share their energy pathway product cycles and ideas for reducing the carbon footprint with the rest of the class. After the first group has presented, ask if any other group has any steps to add to the process. All the groups should have a chance to add missing steps. Prompt students to explain the linkages in their energy pathways and ideas.

ASSESSMENT

Look for understanding of all the stages in the product cycle, energy input pathways, and answers to the four questions in students' posters. Evaluate the groups' ideas for reducing the carbon footprint of the pathway and their use of vocabulary from the lessons.

EXTENSIONS

1. How Far does Your Food Travel? (Could be a homework assignment) – Students bring in one piece of fruit/vegetable and explain its travel history. Tell students to look for produce that is labeled in terms of where it comes from or ask a store clerk. Ask students to locate the place of origin on a map. Calculate the number of miles that item has traveled from field to grocery store. Create a "Passport" for your produce item. Include an energy pathway for a processed food item including all the inputs and other processes used for that food item. For example, are fuel-burning tractors or other equipment used? Is the item roasted or processed somehow? Is the item packaged? After students complete this assignment (either individually or in groups), they should share their pathways with the rest of the class and develop strategies that they could use to help reduce the air pollution associated with these food items (grow fruits and vegetables at home or school, go to a farmer's market for locally grown produce).
2. Make a poster - What can YOU do to reduce your Food Carbon Footprint?" Some ideas: grow some of your own food such as strawberries, carrots, lettuce etc. in a home or school garden; buy from a farmer's market where food is local and in season, thus not trucked or shipped long distances; buy food or products with little or no extra packaging; bring your own bag to the grocery store to fill up; pack your lunch in a reuseable bag; and combine trips i.e. going to the store and library all in one trip.
3. Visit a farmer's market and make a list of foods that are available there. Include the month and season you visited. Talk to one of the growers to find out how far the food traveled to get to this market and how many day before the market it was picked. Go to your local grocery store and talk to the produce clerk, find out how far the bananas, or other food item, traveled and when it was picked. Report back your findings to the class.

 **Calculate Your Carbon Footprint**

Students inspire their households to adopt changes to reduce emissions associated with their lifestyles. View the online footprint calculators listed below to create a handout that includes the questions from the calculators. Ask students to work with their parents to complete the handout and to use the information they've gathered to enter in the online calculator and record the results. Look over the "take action" calculator and ask students to think about which actions they could try. Have them write an ecological footprint pledge to take home and discuss with their parents about making changes.

Ecological footprint calculator: http://www.earthday.net/Footprint/index.asp
Take action calculator: http://www.earthday.net/Footprint/english/take_action.html

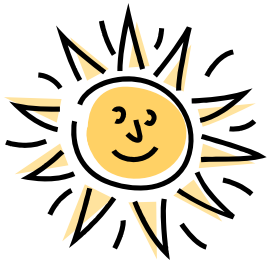
Name_____ Date:_____

Thinking About Consumption

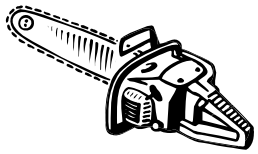
Lesson 10, Handout 1

ENERGY USE AND PRODUCT CYCE OF PAPER

START HERE

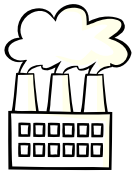


Fossil fuels used to power the chainsaw, as fuel for transportation, and energy for electricity and manufacturing.

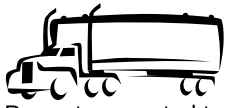


Trees cut down

Logs transported



Paper manufacturing



Paper transported to store

Paper purchased

Paper used

Recycle

OR Trash

Estimated Time: 30 - 45 minutes per day for four days

Objectives:

- List types and amount of garbage generated in the classroom and develop strategies to reduce waste.
- Understand and be able to define and implement the concepts of the 4 R's: Reduce, Reuse, Recycle, and Rot.

CA State Standard Connections:

4th Grade Investigation and Experimentation
Students will measure and estimate the weight, length, or volume of objects.

5th Grade Investigation and Experimentation
Students will classify objects (e.g., rocks, plants, leaves) in accordance with appropriate criteria.

Tool Kit Materials:

- Hanging scale to weigh waste materials
- Handout 1 (one per group)
- Handout 2 (one per student)

Additional Materials:

- A one pound weight or an object that weighs one pound(i.e. butter, bag of coffee)
- Student Journal
- Plastic gloves

Class Waste Audit

Reducing the amount of waste sent to the landfill helps protect the climate. In this four-day lesson, students will evaluate the amount of waste that they produce and develop strategies to reduce waste generation in the classroom and elsewhere.

Key Words

Waste: items thrown away and not used again.

Reduce: to use fewer products and materials in our daily lives.

Reuse: to use again.

Recycle: to collect and process products into new or different products.

Rot or Compost: natural decomposition of organic matter (grass clippings, food scraps, leaves) which can be used to enrich the soil.

Preparation

Review Lesson 11 Background material for an overview of waste and climate change. Start the lesson on a Monday. Ask the custodian not to empty your class' wastebaskets or recycling bins during the four-day lesson. At the end of each school day, have students collect the trash in a large paper or plastic bag and the recycling in a separate bag, so that it is not collected by the custodian by mistake. This also insures that the wastebaskets start empty each school day. Remind students to use only the wastebasket(s) in their classroom. Food waste should be put in a separate wastebasket and collection bag.

Make copies of Handout 1 (two sided) and Handout 2 (two sided). Complete the Setting the Stage and Activity 1 on the first day of the lesson, and on the second day begin the Waste Audit. Decide whether you will complete the activity on Friday or count and weigh Friday's trash and recycling and do final calculations on Friday or the following Monday.

Procedure

SETTING THE STAGE

- Tell students they are going to monitor the amount of trash and recycling generated by the class for one week and see if they can lower the amount of waste using the '4 R's' strategies. Since they now have a better idea of how the pathway of energy for a product, such as paper, creates greenhouse gases, they are better able to understand how their choices as a consumer can make a big difference in slowing the rate of global warming.
- Discuss the following:
  - "First of all, what is a consumer?" (Somebody who purchases material goods.)
  - "How many of you are consumers?" (Everyone.)
  - "What are some of the things you purchase, consume?" (Clothes, toys, food, entertainment i.e. tickets to movies, ballgames, transportation, books, lessons.)
  - "As a consumer, what can you do to reduce the production of greenhouse gases generated by the things you consume?" (Reduce the amount I buy, or the amount I travel. Reuse things like water bottles. Recycle paper and plastic. Compost my food scrap and lawn clippings.)

On the chalkboard draw two columns, and label as 'things we throw away', and how many. Have students make the same chart in their journals.

- During this activity students will estimate what is thrown away or recycled and how much it weighs. Pass around an object that weigh about one pound. Allow each student a few seconds to feel the weight of the object. Tell students that the object weighs one pound. This will help them estimate the weight of different objects.
- List items that might be thrown in the class wastebaskets during the week in the first column. In the 'number' column, list the estimated number that will be thrown away of each type of item on the list. After completing the chart, have them add up the estimated weight to get the estimated total weight of the trash that they think their class will generate in one week.
- If your class already recycles, still do the activity, but remember to weigh the recycling materials separate from the wastebaskets on the first day, as well as the following days.
- Ask students to share their lists with the class and compose a class list. Elicit the fact that the listed items can be put in the following categories: food scraps, plastic, paper, glass, metal, cardboard, other. Items that don't fit the other categories, such as crayons, or items made of more than one material such as pencils.
- Tell the students that the categories they have come up with are the same categories that waste disposal agencies and sites use to sort waste.

ACTIVITY 1 - Investigating our Waste

1. At the beginning of the school day on the first day of the activity, be sure to tell students to only use the classroom's wastebasket(s) this week for everything they throw out, except for food waste which will be put in a separate designated wastebasket.
2. Divide the class into groups of three. Provide each group with a copy of Handout 1. Explain that each group will write down items they remember throwing away during the day in the chart on Handout 1. They will categorize their items of trash as paper, glass, metal, plastic, food, or other for items composed of materials that cannot be easily categorized. For example, if a group threw out a total of four milk cartons, they would write the number 4 in the 'other' column, since milk cartons are made from paper infused with a wax.
3. Have students calculate the percentage for each type of waste on Handout 1 by dividing the number of items by each waste type by the total number for all waste types. For example, if a group counted 12 pieces of paper and the total number of pieces of waste was 36, then the percentage is 12 divided by 36, or 33% of the group's waste.
4. Finally, have groups answer the questions at the bottom of Handout 1.
5. Engage the class in discussion by asking them the following:
   - What does the chart tell us about our class's waste?
   - Was there anything thrown away that could have been used again? (Paper could be used on both sides before it is recycled. Plastic sandwich bags can be washed and reused.)
   - Was there anything thrown away that could have been recycled? (Paper, glass, metals, and plastics can be recycled.)
   - Was there anything that could have been composted? (Food items and paper towels can be composted. Fruit and vegetable food scraps can composted in a school or home compost bin or compost pile.)
   - Are there other ways that we can reduce the amount of waste that we throw out? (Use re-usable water bottles instead of disposable bottles, etc. Bring a handkerchief instead of using tissues.)
6. Remind students to only use the classroom's wastebasket(s) this week for everything they throw out, except for food waste which will be put in a separate designated wastebasket.

ACTIVITY 2 – Class Waste Audit

Tuesday, Day 2:

1. Distribute a copy of Handout 2 to each student.
2. Tell the students they are now going to find out how much waste their class generated on Monday. Set up the hanging scale. Take the garbage bag(s) filled with yesterday's waste and weigh them. Weigh an empty garbage bag and subtract the weight of the empty bag from the weight of the garbage bag(s) filled with yesterday's waste. Have students record the weight of the waste, minus the weight of the empty bag, on the chart in Handout 2.
3. If the classroom also collects recycling, have students repeat the above steps with the recycling container. Weigh an empty recycling container and record the weight. Weigh the recycling container with the recycling materials and subtract the weight of the empty container. Record the weight of the recycling material on the chart on Handout 2.

4. Engage students in a discussion by prompting them with the following:
   - "What does the handout tell us about our class's waste?"
   - "What are some things we can do to reduce the weight of the trash?" (Use both sides of paper before throwing it out, reuse plastic bags, set up recycling bins.)
5. Remind students to only use the classroom's wastebasket(s) for everything they throw away, except food, for the remainder of the day.

Wednesday, Day 3:

6. Analyze Tuesday's waste and dispose of it before Wednesday's waste is added to the waste bin. Repeat the steps of weighing and recording the trash and the recycling. Have students record their findings on the chart in Handout 2.
   - Ask students, "Are you doing anything differently today to reduce the amount of waste?"
7. Collect Handout 2 from students to keep until the next day's activity. Remind students to only use the classroom's wastebasket(s) today for everything they throw away except food.

Thursday, Day 4:

8. Analyze Wednesday's waste and dispose of it before Thursday's waste is added to the waste bin. Repeat the steps of weighing and recording the trash and recycling. Have students record their findings on Handout 2 and calculate an average daily weight for trash and recycling.

Friday, Day 5:

9. Analyze Thursday's waste and dispose of it before Friday's waste is added to the waste bin. Repeat the steps of weighing and recording the trash and recycling. Have students record their findings on Handout 2 and calculate an average daily weight for trash and recycling.
10. Calculations of average daily weight can be done later in the day on Friday or on the following Monday.
11. Have the students complete the questions for Handout 2.
12. Encourage discussion by asking students the following questions:
    - What was the difference in the amount and type of waste we collected on Monday compared to the waste we collected on Friday?
    - Did we reduce the amount of waste that went into the waste bin? By how much? Was it easy to do? Why or why not?
    - What can we do at home to reduce waste?

ASSESSMENT


Have students answer the following questions in their journals:

- "Do you think our class can maintain or improve on our efforts to reduce waste or do you think we will go back to the weights and numbers on the first day of the Class Waste Audit? Why or why not?"
- "What surprised you the most about our findings from the Class Waste Audit?"

- Draw a Venn diagram comparing the classroom waste with what you would expect to find from your home wastebaskets.

EXTENSIONS

1. Home Waste Audit Project - Students perform a waste audit at their homes. Provide students with a table similar to Handout 2 and allow students to conduct the audit over a week's time. Students use a bathroom scale to weigh their home's trash. At the end of the week students report their findings and share the ways they were able to reduce, re-use, recycle, and rot (compost) in their homes.

2. Learn about the Life of Garbage - Begin by leading a discussion with students about where garbage goes once it is thrown away. Ask students to use their observation skills to determine on which days garbage is picked up from the school and how much is taken away. If garbage is picked up during school hours, organize the students into teams to conduct quick spot interviews with the garbage collectors about their work, where they are going and where they have been, and the composition of school garbage. Interviews could also be conducted with custodial or janitorial staff about their work and about garbage disposal. Ask the students to report on what they have learned from their interviews. Organize a class field trip to a local dump or landfill.

Develop a School Waste Reduction Plan

Obtain for the students the school's monthly disposal fees. Lead students in conducting waste audits at different times of day for classrooms, the cafeteria, and other spaces to examine the amount and composition of the garbage. Guide students in creating a graph that charts the school's monthly garbage production/disposal over a few months. The graph can also include a pie chart illustrating the percentage of recyclable, compostable, and reuseable items that are in the trash. Ask students to develop a school waste reduction plan. Ideas include: launching salad bar programs filled with local produce from neighboring farms, school gardens, and implementing a composting program. Using the resources found in the links below, create a program appropriate for your students and school resources.
Guidelines and resources for school food projects: http://www.eecom.net/mfsp/guide.html
Waste emissions calculator:
http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html

NAME:_____ DATE:_____

Class Waste Audit

Lesson 11 Handout 1

Class Waste Analysis

What did you throw away at school today? Use the chart below to count up the number of pieces of each waste type your group threw away. Next, calculate the percentage of each waste type for the total amount of waste that you threw away. Finally, answer the two questions at the bottom.

Paper: Notebook paper, newspaper, copy paper, paper bags
Glass: Glass bottles, jars
Plastic: Bags, wrappers, bottles, containers
Cardboard: Boxes
Metal: Aluminum cans, aluminum foil, tin cans
Food items: Food scraps like apple cores or orange peels
Other: Items made of more than one material that cannot easily be separated, like milk cartons or pencils

Waste Type	Paper	Card-board	Glass	Metal	Plastic	Food	Other	Total
Number of pieces thrown out today								
Percentage of what we threw out today								**100%**

1. Which material did your group throw away the most?_____

2. Which material did your group throw away the least?_____

NAME:_____ DATE:_____

Class Waste Audit

Lesson 11 Handout 2

Record the weight of trash and the weight of recycling from each day's collection in the chart below. After you have weighed the trash and recycling for all five days, calculate the average daily weight for the trash and recycling. Then, answer the questions at the bottom of the page.

Weight of Trash and Recycling

Day	Weight of Trash	Weight of Recycling
Monday's Waste		
Tuesday's Waste		
Wednesday's Waste		
Thursday's Waste		
Friday's Waste		
Average daily weight		

1. Did the weight of the trash increase, decrease, or stay about the same throughout the five days of weighing trash?

Trash: Recycling:

2. Why do you think it increased, decreased, or stayed about the same?

Trash:

Recycling:

3. What are some things we can do to help reduce the amount of waste that we throw away at school?

Estimated Time: 1.5 hrs

Objectives:

- Know that recycling saves energy, prevents greenhouse gas emissions, and promotes resource conservation.
- Understand that products made with recycled content require less energy to produce than products without recycled content.
- Identify strategies for waste reduction through recycling.

CA State Standard Connections:

4th Grade Number Sense

4th and 5th Grade Statistics, Data Analysis:
Students organize, represent, and interpret numerical and categorical data and clearly communicate their findings.

5th Physical Science:
Each element is one kind of atom, organized in Periodic Table

Tool Kit Materials:

- Overhead of Handout 1
- Handout 1 (for half the class)

Extension Materials

- 2 plastic bins
- Junk mail or recycled office paper
- 2 small plastic grid screens
- 2 pieces of felt
- Blender
- Strainer

Recycling and the Climate

Recycling saves energy and prevents greenhouse gas emissions. In this lesson, students will learn about the benefits of recycling paper and compare the energy usage in recycling versus disposing of waste in landfills.

Key Words

Raw Material: material in its natural form that is used to make products.

Recycled Content: the amount of recycled material in a new product.

Preparation

Review Lesson 12 Background for an overview on the impacts of recycling on energy consumption and climate change. Precede this lesson with Lesson 11. Before you make paper with the class, set up the materials and do a trial run. Prepare an overhead of Handout 1. Delivering these facts without the use of additional paper will model the behavior you want and promote listening and notetaking skills.

Procedure

SETTING THE STAGE

- Begin by asking the class what kinds of things they recycle at home. (Aluminum cans, paper, plastic bottles, etc.)
- Ask the class what they think happens to each item after it is recycled. (Cans are melted down and generally made into new cans.)
- Discuss reasons why we would want to recycle items instead of just making new ones from 'new' materials. (Recycling saves energy and **raw materials**.)

ACTIVITY 1 – Benefits of Recycling

1. Project Handout 1 onto the overhead screen. Ask one student to read out loud the opening paragraph on the handout. Ask students in the class to read out loud the different facts. Discuss these as you go and ask students to write facts in their journals.


Have students answer the following question in their journal: After looking at the information about recycled paper, what surprises you the most? How much of a difference do you think recycling paper will make in climate change? Explain your thinking.

2. Engage the students in a discussion about paper recycling by reviewing the product cycle for paper done in lesson 10. Ask the following questions:
   - "Now that you have looked at some of the statistics about paper and reviewed its energy path, why do you think many people still do not recycle paper products?" (Answers will vary.)
   - "Do you think making recycled paper is easy or difficult? Why?"
   - "What can be made out of recycled paper?" (More paper can be made from recycled paper.)
3. "Paper made with recycled content needs much less energy to produce than paper from new wood material. What other benefits do we get from using recycled paper? Think in terms of greenhouse gas emissions." (Trees absorb CO_2 from the atmosphere. Cutting down less trees allows more CO_2 can be absorbed.)
4. "Besides recycling, what are some other ways we can prevent more trees from being cut down to make paper?" (We can use less paper by using computers, internet, overheads and using both sides of paper.)
5. Look at the paper cycle diagram from Lesson 10, Handout 1. "At what steps would greenhouse gas emissions be saved if recycled paper, instead of raw materials, were used to make new paper?" (Could skip cutting down trees and transporting the logs.)

ACTIVITY 2 - Making Recycled Paper

Paper-Making Project. In this project, students will make new paper from recycled paper:

- Have each student shred the equivalent of 2 to 3 pieces of used paper into thin strips.
- Take one cup of the paper and add to blender with 1 cup of water. Blend the mixture.
- Add the mix from the blender to a second large plastic bin. Dip a screen into the paper water. You can put string, confetti, or other decorative items on the screen at this point.
- Take another screen and squeeze the water out by placing it on top of the first screen and lifting it out of the bin, sandwich style.
- Next, take the sandwiched screens and place on one piece of felt; place another felt piece on top. Roll out the excess water.
- Transfer the paper onto a piece of newspaper and let dry; repeat process until there is a new piece of paper for each student.

ASSESSMENT

In their journals, have students respond to the following questions: What do you think is easiest to recycle and why? What is most difficult material to recycle and why.

In a class discussion, have students share what is most difficult and what would need to happen to make it easier to recycle those items/materials. Brainstorm additional ways to improve ease of recycling.

EXTENSIONS

1. Field Trip – Visit the local recycling center to take a tour and learn about what is and is not recycled in your area and how it is recycled.

2. Have your class collect materials and make recycled art projects.

Start a School Recycling Program

If the school does not have one yet, start a school recycling program. Guide students in communicating and working with office and custodial staff to assess current levels of solid waste. Lead students in researching the community's local recycling resources and coordinating recycling pick-ups at the school. Discuss with students ideas for other creative recycling programs such as recycling the library's unwanted books; electronic recycling for old phones, batteries, and computer parts; and encouraging the school to purchase paper and class equipment made from environmentally friendly recycled materials. Work with students to develop and implement a school outreach campaign to launch the program.

NAME:_____ DATE:_____

Recycling and the Climate

Lesson 12 Overhead

Most recycled paper is made back into paper and paper products. For example, recovered copy paper can be used to make new recycled copy paper. Recycled paper can also be molded into egg cartons, insulation, paint additives, and roofing. Even cat litter can be made from recycled paper!

Did you know[4]...

- The world's first piece of paper was made from recycled material. Around 200 B.C., the Chinese used old fishing nets to make the world's very first piece of paper.
- Americans recycle over **51%** of all the paper they use. Paper recycling now averages **346 pounds** for each person in the United States.
- In the United States, we use enough office paper each year to build a 10-foot-high wall that's 6,815 miles long, or two and a half times the distance from New York to Los Angeles.
- More than **90%** of the printing and writing paper made in the United States is from new (non-recycled) wood material.
- The paper industry is the **second largest industrial consumer of energy** in the United States.
- One ton of computer paper made from new wood material uses **24 trees.** One ton of newspaper from new wood material uses **12 trees.** One ton of magazine paper from new wood material uses a little more than **15 trees.**
- Producing recycled paper requires about **60%** of the energy used to make paper from new wood material.
- Recycling one ton of newspaper saves the equivalent of **100 gallons of gasoline** when taking into consideration the product cycle emissions of producing paper from raw materials.

[4] *The facts come from the Technical Association of the Pulp and Paper Industry (TAPPI) www.tappi.org, and from Metro, http://www.metro-region.org/article.cfm?articleid=5574.*

Composting Benefits

Estimated Time: two 45-minute lessons, 1.5 hr total

Objectives: Students will

- Describe what happens to green waste after it is collected from their home or school.
- Identify the major components of a compost bin.
- Identify the two major gases emitted from a landfill and their carbon dioxide equivalents.
- Explain the difference between a landfill and a transfer station.

CA State Standards:

4th Grade Investigation and Experimentation

5th Grade Investigation and Experimentation

Tool Kit Materials:

- Thermometers (one per group)
- Handout 1 (one per group or an overhead transparency)
- Handout 2 (one per student)
- Handout 3 (one per group or an overhead transparency)

Additional Materials:

- Scissors
- Permanent marker
- Clear packing tape or masking tape
- Green leaves/grass clippings
- Brown leaves or straw
- Spray bottle/s for water

Adapted from the Plant to the Home less in Energy for Keeps: Electricity from Renewable Energy, Energy Education Group, www.energyforkeeps.org.

Landfills generate potent greenhouse gases as waste decomposes. Composting can decompose the same waste without generating methane, a potent greenhouse gas. In this lesson, students investigate the breakdown of waste in a landfill and in a compost pile, calculate the greenhouse gas emissions from each process, and compare the relative impacts on climate change.

Key Words

Landfill: large outdoor area , usually specially constructed, where waste is dumped and buried.

Decomposition: breakdown of organic materials by bacteria and other decomposers, fungus, and insects.

Composting: process of collecting organic waste and letting it decompose naturally through aerobic decomposition.

Aerobic: decomposition in the presence of oxygen.

Anaerobic: decomposition in the absence of oxygen.

Methane: a greenhouse gas created by anaerobic decomposition.

Preparation

Review Lesson 13 Background for an overview of the cycle of waste and greenhouse gas emissions from waste disposal. Review the Handouts prior to teaching this lesson.

The Discussion section of this lesson will need to be conducted in two parts, the first part before lunch and the second part after lunch or the next day. Decide how best to collect students' lunch scraps in a bucket or a waste basket lined with a plastic bag. For example, students can bring all lunch scraps back to the classroom after lunch.

For Activity 1, students need to be comfortable calculating multiplication and division math problems.

For Activity 2 you will need to prepare and build a sample composter before teaching this lesson, if you are planning to use the soda bottle composter rather than deli containers. See Handout 3 for list of materials to collect for Activity 2.

Procedure

SETTING THE STAGE

- Begin by asking students if they know where garbage goes after we throw it away.
- "Has anyone ever been to a transfer station or a landfill? What was it like?" (Most students will call the transfer station, 'the dump,' thinking it is one and the same. Very few people are allowed at landfills anymore, except in some rural communities. However, they can take their waste to a transfer station.)

 Show students images of Landfill, Transfer Station, and Recycling Facility. Images on CD or can be printed from CD onto an overhead transparency.

- Look at the images to help students get a sense of the amount of trash/waste generated by people in their community and what a difficult problem it is to deal with.
- "Where do you think our trash goes when the landfill becomes full?" (Another landfill further away, out to the ocean.)
- In our own classroom audit, we found some food and other organic garbage that decomposes over time. How this material decomposes makes a big difference in the carbon emissions from waste. In this lesson we're going to look at why composting is especially important in reducing carbon emissions from waste disposal.

ACTIVITY 1–Greenhouse Gas Emissions From Waste

1. Project Handout 1 showing the Product Cycle of Food. Remind them that this is like the product cycles they worked on earlier for paper, but this time it is drawn for food.
2. "How do all the product cycles end?" (Landfill disposal or composting.) Pass out Handout 1 to each student. Have students look at the Landfill Stage on the handout. Discuss the following points and questions:
   - "There is a new emission on this general product cycle. The symbol CH_4 stands for methane. The symbol tells us that methane is made of what elements?" (One carbon atom and 4 hydrogen atoms.)
   - **Methane** (CH_4) is a greenhouse gas that is 21 times more effective at trapping heat in the atmosphere than carbon dioxide. Methane is produced when microorganisms break down organic wastes without oxygen, this is called **anaerobic** (without oxygen) **decomposition.**
   - There is little or no oxygen in a landfill because waste is buried under soil and other waste. The anaerobic bacteria who can live in these conditons decompose the waste and methane is created.
   - Our diagram shows that food waste could go to be composted instead of into the landfill. In a compost pile a different kind of decomposition takes place. A compost pile sits in the open air and is aerated, mixed, or turned over to allow oxygen in, which means **aerobic decomposition** can take place with oxygen by bacteria and other decomposers like worms and bugs.

- **Aerobic composting does not produce methane.** About 90% of carbon in compost remains locked up, leaving less than 10% to turn into carbon dioxide by decomposers such as worms and bacteria.


Ask questions to make sure students understand and them ask them to write these answers in their Journals.

- "At what point in the cycle of waste is methane produced?" (Methane is generated in the landfill.)
- "What are some differences between the landfill cycle and the composting cycle?" (The compost produces CO_2, not methane.)
- "How can we reduce methane emissions?" (Throw away less and compost what we can.)

3. Distribute one copy of Handout 2 to each student. Ask one student to read the handout's sidebar out loud. To ensure comprehension of key concepts, ask the following:
   - "How many times more powerful is methane to carbon dioxide in trapping heat in the atmosphere?" (Methane is 21 times more powerful than carbon dioxide.)
   - "What is the CO_2 equivalent of methane?" (The CO_2 equivalent of methane is 21.)
4. Explain to the students that after lunch they will calculate how much lunch waste the class generates. Emphasize that students will need to place all lunch food scraps in the bucket after lunch.
5. Next, weigh the bucket that you will be filling with food scraps and write that figure on the board.
6. After lunch, have all the students place their food scraps into the bucket. Once the food scraps are collected, weigh the bucket.
7. Subtract the weight of the bucket from the weight of the bucket with the food scraps to get your result. Explain to the students that this is the amount of pounds of food waste that we as a class threw away from our lunch today. Now, using Handout 2 the students are going to calculate effect of food waste on climate change in a landfill and a compost pile.
8. Have groups brainstorm a list of ways to cut down on the food waste generated by the class and share the results.
9. Share journal responses and elicit from the class that they generate much less waste if they bring only what they will eat each day. If no food waste is generated, then no carbon dioxide is emitted into the air because there is nothing to compost. Even the 10% carbon dioxide from the natural carbon cycle is not emitted.
10. To find out how much CO2e could be prevented by the entire class if they composted all food waste for one year, add up each student's answer to question #6 of Handout 2 on the chalkboard. Next, have students complete the 'Bonus Questions' at the bottom of the handout and then share the answer with the rest of the class.

ACTIVITY 2– Build a Composter

1. Divide students into groups of 2 –3 and assign a number to each group. Distribute a copy of Handout 3 to each student. Explain that to help in the investigation of landfills and composting, students will build a composter.

2. Read Handout 3 out loud so that students understand the procedure for building the composter. Pass around the composter you built prior to class as an example. Next, distribute the materials required to build the composter to each student. Have students write their group's number on the containers.
3. Have students set up a series of tests using the scientific method to find out which composts/rots the fastest, slowest, most/least completely. Brainstorm a list of variables their group might test. Remind them that only one variable can be changed for each group to ensure accurate test data. Examples of compost samples to test:
   - Container sealed and not opened until the end of the experiment (no air).
   - Container left open to air with nothing additional added over the course of the experiment (this will be your control sample).
   - Holes punched into the lid of the closed container, to enable the container to be shaken or rotated each day to aerate the contents. Nothing additional added over the course of the experiment.
   - Holes punched into the lid of the closed container, to enable the container to be shaken each day to aerate the contents. Contents sprayed with additional water every 4-5 days before the container is shaken or rotated.

Reminder: Look at Standards for Investigation and Experimentation for your grade level.

4. Students will need 5-15 minutes to build their composters depending on whether you use the plastic deli containers or build the bottle composter. Check in with students to ensure they properly complete the procedures on Handout 1.
5. Collect the composters from students and place somewhere in the classroom that does not get direct sunlight. Ask students, "What do you think will happen in the composters over the next three weeks?" (The food waste will decompose, rot.)
6. Over the next three weeks be sure to provide time for students to check on their composters and record changes.

EXTENSIONS

1. Students write a letter or create a pamphlet to show their parents or others how composting can reduce climate changing greenhouse gas emissions and/or instructions on how to start a backyard composter. If your local waste disposal district does not compost food waste, write a persuasive letter and send it along with the pamphlet to the Sanitary District Board with your recommendations, backed by facts.

 **Pack a No Waste Lunch**

Packing a lunch in reusable containers can actually be cheaper than buying packaged foods, and generates less waste. By putting on a "no-waste" lunch day, this project can inspire students and parents to creatively reduce lunchtime waste. Create a tip-sheet for parents on how to make a no-waste lunch. For example, use a lunch box with reusable containers, include a cloth napkin, don't pack plastic silverware, and use a thermos or water bottle instead of packaged drinks and soups.

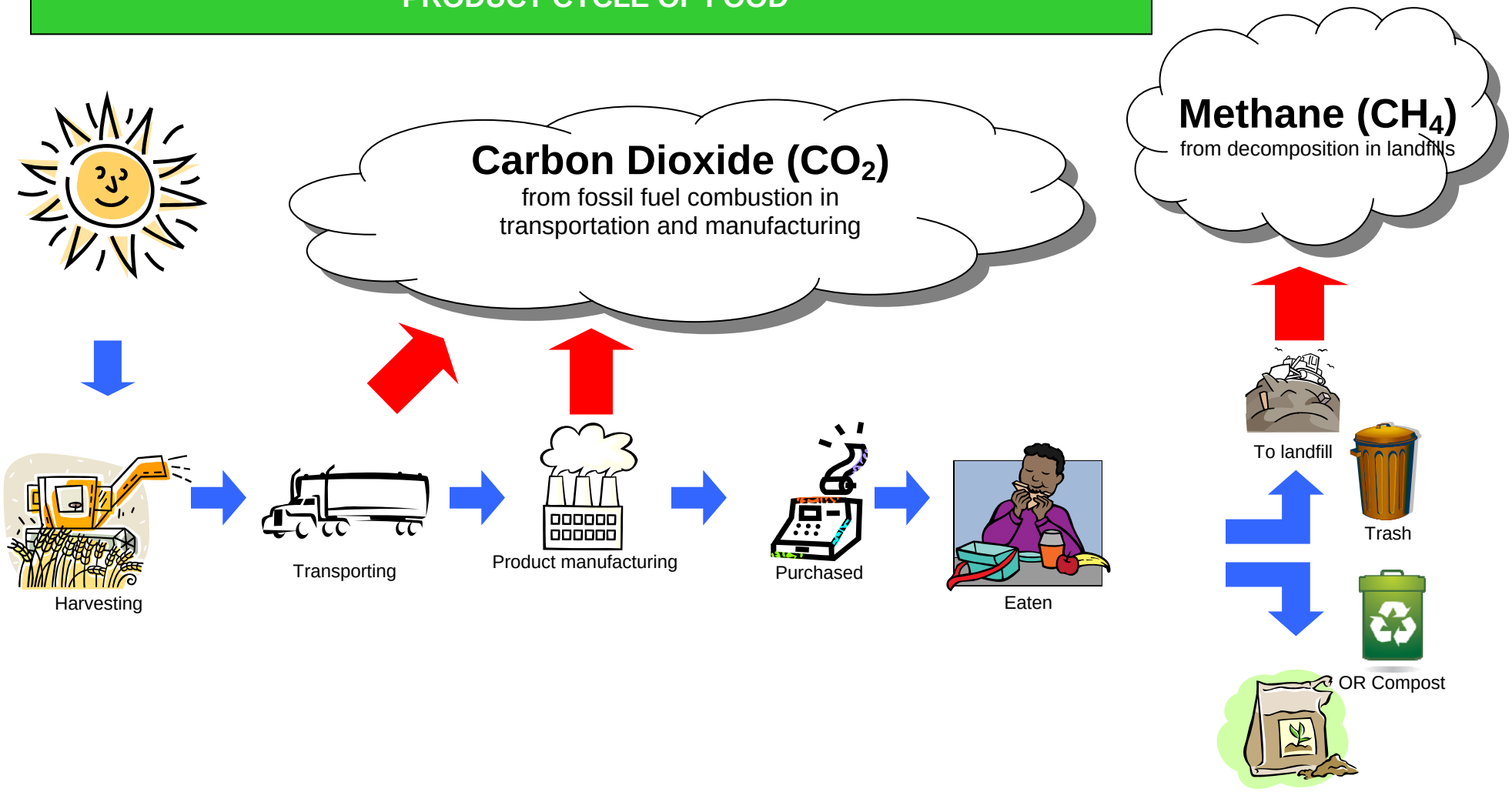
Tips for a no-waste lunch: http://www.recycleworks.org/schools/lunch.html

Name:_____ Date:_____

Composting Benefits

Lesson 13, Handout 1

PRODUCT CYCLE OF FOOD



Organic materials composted.
Compost can then be used as soil in farms.
Some Carbon Dioxide (CO_2) is created as part of the decomposition process.

NAME:_____ DATE:_____

Composting Benefits

Lesson 13, Handout 2

A byproduct of anaerobic decomposition is landfill gas, which contains approximately 50 percent methane and 50 percent carbon dioxide with small amounts of nitrogen and oxygen.

Methane is a powerful greenhouse gas. One molecule of methane traps as much heat in our atmosphere as 21 molecules of CO_2.

Scientists use a standardized unit called the carbon dioxide equivalent, or CO_2e when they measure greenhouse gases. They estimate that about 1 pound of CO_2e is released for every pound of food waste in a landfill. This number includes the impact of both methane and carbon dioxide emissions.

If the same food waste goes to a compost pile, less than 10% of the carbon will be converted into CO_2 through aerobic respiration. The rest of the carbon remains locked up in the compost. The CO_2 that is released is considered part of the natural carbon cycle.

Does your food waste affect climate change?
Read the sidebar on the left of the page and answer the following questions.

Part 1. In the Landfill

1. How many pounds of food waste did you and your class throw away from lunch yesterday?
_____ lbs

2. Multiply this number by 7 to estimate one week's worth of food waste in pounds:

$$\frac{\text{lbs}}{\text{day}} \times \frac{7 \text{ days}}{\text{week}} = \frac{\text{lbs food waste}}{\text{week}}$$

3. Scraps and peeling from preparing meals also goes to the landfill. For the purposes of this activity, we will estimate that preparation waste is approximately 1/5 of the weight of the prepared food. To find the weight of the scraps and peelings divide the number of pounds of food waste for one week by 5.

$$\frac{\text{lbs}}{\text{week}} \div \frac{5}{} = \frac{\text{lbs scraps \& peelings}}{\text{week}}$$

4. Add the weight of the food waste for one week to the weight of the prep waste (scraps and peelings) for one week to find a total weight of waste transported to the landfill.

$$\frac{\text{lbs Of lunch waste}}{} + \frac{\text{lbs prep waste}}{} = \frac{\text{lbs food waste Total}}{}$$

5. For every pound of food that is transported to a landfill and then decomposes in the landfill, 1 pound of CO2e is released. Multiply your answer in #4 by 1 lbs to find out how many pounds of CO2e are produced by one week's worth of food waste in the landfill:

$$\frac{\text{lbs food waste}}{\text{week}} \times \frac{1 \text{ lbs } CO_2e}{1 \text{ lbs food waste}} = \frac{\text{lbs } CO_2e}{\text{week}}$$

Part 2. In the Compost Pile

6. A compost pile has zero net emissions – any CO_2 emissions from aerobic composting are considered part of the natural carbon cycle and are not counted as greenhouse gas emissions. Therefore, how much CO_2 equivalent would you **keep out** of the atmosphere by composting for a week?

_____ (hint: this is the same number as your answer in #5)

7. What if your class composted every day's food waste for a year?

$$\frac{\text{lbs } CO_2e}{\text{week}} \times \frac{52 \text{ weeks}}{\text{year}} = \frac{\text{lbs } CO_2e}{\text{year}}$$

Part 3. Taking it one step Further:

8. Exchanging one standard incandescent light bulb with energy efficient CFL will prevent around 30 pounds of CO_2e from entering the atmosphere each year. Composting your food waste for one year is like changing how many light bulbs? (hint: Divide the answer for # 7 by 30 lbs).

$$\frac{\text{lbs } CO_2e}{\text{year}} \div \frac{1 \text{ CFL}}{30 \text{ lbs } CO_2e} = \text{CFLs saved each year}$$

Bonus Questions

1. How much CO_2e would the whole school prevent in a year if it composted all food waste?

_____

2. Composting the entire school's food waste for one year is like changing how many light bulbs?

_____

NAME:_____ DATE:_____

Composting Benefits

Lesson 13, Handout 3

Composter Materials:

- A piece of fruit with a seed or a peel (banana, apple, peach, orange)
- 1/2 cup of green leaves and grass cuttings
- 1/2 cup of brown leaves or straw
- 2 cups of soil
- 1 cup of newspaper or paper towels torn into small pieces, approx. 1 in. wide or less
- 1 re-useable container with top (plastic soda bottle or clear plastic container
- A permanent marker
- Scissors
- Tape
- Spoon
- Water spray bottle
- 1 thermometer

Procedure:

1. If you are using a plastic soda bottle, measure about 7 inches from the bottom of the bottle and mark with the permanent marker. Draw a line around the bottle at the 7 in. level. Use scissors to cut around this line. Do not cut all the way around! Leave about 1-1 1/2 inches to serve as a hinge for a flip lid.

2. Open the flip lid of the container and add the ingredients in the following order:
   - 1cm of soil
   - Fruit scraps from the student's eaten fruit
   - 1cm of soil
   - Green grass/leaves
   - Brown leaves/straw
   - 1cm of soil
   - Torn up newspaper
   - Fruit scraps
   - 1cm of soil

3. Once the layers have been added, give the surface a quick spray of water. This can be done throughout the experiment as the surface becomes dry over time.

4. Insert the thermometer into each container so that the temperature can be read.

5. Seal the bottle or place the lid on and tape it so it is secure. Draw small lines on the side of the container with a marker to mark the layers of the bottle. Make a note of the initial temperature inside the bottle.

6. Over the next 3 weeks monitor the bottle. Keep daily records of the temperature and changes inside the bottle. You may even start to grow types of mold and bacteria. Be sure to make notes about changes that you see, smell, etc. After 3 weeks use the compost you created as soil for a classroom plant or in your school garden, or in your backyard at home.

INSPIRING CHANGE PROJECTS

 **Calculate Your Carbon Footprint**

Students inspire their households to adopt changes to reduce emissions associated with their lifestyles. View the online footprint calculators listed below to create a handout that includes the questions from the calculators. Ask students to work with their parents to complete the handout and to use the information they've gathered to enter in the online calculator and record the results. Look over the "take action" calculator and ask students to think about which actions they could try. Have them write an ecological footprint pledge to take home and discuss with their parents about making changes.

Ecological footprint calculator: http://www.earthday.net/Footprint/index.asp

Take action calculator: http://www.earthday.net/Footprint/english/take_action.html

 **Pack a No Waste Lunch**

Packing a lunch in reusable containers can actually be cheaper than buying packaged foods, and generates less waste. By putting on a "no-waste" lunch day, this project can inspire students and parents to creatively reduce lunchtime waste. Create a tip-sheet for parents on how to make a no-waste lunch. For example, use a lunch box with reusable containers, include a cloth napkin, don't pack plastic silverware, and use a thermos or water bottle instead of packaged drinks and soups.

Tips for a no-waste lunch: http://www.recycleworks.org/schools/lunch.html

 **Develop a School Waste Reduction Plan**

Obtain for the students the school's monthly disposal fees. Lead students in conducting waste audits at different times of day for classrooms, the cafeteria, and other spaces to examine the amount and composition of the garbage. Guide students in creating a graph that charts the school's monthly garbage production/disposal over a few months. The graph can also include a pie chart illustrating the percentage of recyclable, compostable, and reuseable items that are in the trash. Ask students to develop a school waste reduction plan. Ideas include: launching salad bar programs filled with local produce from neighboring farms or school gardens and implementing a composting program. Using the resources found in the links below, create a program appropriate for your students and school resources.

Guidelines and resources for school food projects: http://www.eecom.net/mfsp/guide.html

Waste emissions calculator:
http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html

 **Start a School Recycling Program**

If the school does not have one yet, start a school recycling program. Guide students in communicating and working with office and custodial staff to assess current levels of solid waste. Lead students in researching the community's local recycling resources and coordinating recycling pick-ups at the school. Discuss with students ideas for other creative recycling programs such as recycling the library's unwanted books; electronic recycling for old phones, batteries, and computer parts; and encouraging the school to purchase paper and class equipment made from environmentally friendly recycled materials. Work with students to develop and implement a school outreach campaign to launch the program.

 **Ask Local Government to Adopt Best Practices in Waste Management**

Across the country, communities have a wide range of recycling, compost, and other waste reduction strategies. Students can take a role in pushing their community to adopt better waste management strategies. Investigate what your community is doing, what other communities have done, and prepare a presentation to your local city council on what they might change.

San Francisco's composting program: http://www.sunsetscavenger.com/composting.htm

The Bay Area Recycling Outreach Coalition: http://www.bayarearecycling.org/

Background for Lesson 14
Transportation and Air Pollution

Transportation is the network that moves people and goods from place to place. There are many different modes of transportation such as cars, trucks, buses, trains, ships, and airplanes. These transportation modes generally use fuel for power, and therefore, emit exhaust into the air. **Exhaust** emissions, typically made up of particulate matter, nitrous oxides, methane, and carbon dioxide, contribute to air pollution and climate change. Cars also emit HFCs (hydrofluorocarbons), very strong greenhouse gas emissions, from air conditioning units.

Transportation modes emit varying levels of air pollution depending on their engine and fuel usage. For example, diesel engines, found in trucks, trains, and ships, burn much dirtier than gasoline engines and emit high levels of particulate matter harmful to people's health.

Climate Change Connection: Air pollution can lead to serious public health problems like increases in respiratory illnesses and asthma attacks. Children and senior citizens are particularly vulnerable to health problems from air pollution. With climate change, California expects to have more frequent and severe heat waves in California, which will result in more air pollution and related health problems.

Background for Lesson 15
Cars and Climate Change

Cars and trucks are the biggest source of air pollution and greenhouse gas emissions in California, as well as in the San Francisco Bay Area. Vehicles burn fossil fuels for energy, gasoline in the case of most cars and diesel for most trucks, and emit carbon dioxide through their exhaust. Cars emit 19 pounds of carbon dioxide emissions for every gallon of gasoline burned.[1]

The amount of carbon dioxide that a car emits depends on its fuel efficiency. **Fuel efficiency** is the measurement of how much fuel a car needs to travel. The more fuel efficient a car is, the less fuel it needs to travel per mile than compared to other cars. Fuel efficiency is measured in miles per gallon, mpg. The fuel efficiency of a car is related to the car's weight, engine size and type, and maintenance. For example, sedans are more fuel efficient than SUVs because they weigh less and have smaller engines; however a sports car, like a Ferrari, could be less fuel efficient than an SUV because it has a big powerful engine to make it drive fast. Car maintenance, like properly inflated tires and regular oil changes can improve a vehicle's fuel efficiency. The more fuel efficient a vehicle is, the less it pollutes and emits fewer greenhouse gas emissions.

A bus is less fuel efficient than a car because it weighs a lot more and has a much bigger engine. However, a bus has a much higher passenger miles per gallon rate than a car. **Passenger miles per gallon**, pmpg, is the mpg of a vehicle multiplied by the number of people in the vehicle. A car with one person and 24 mpg equals 24 pmpg (24x1). A car with four people and 24 mpg equals 96 pmpg (24x4). A bus with 30 passengers and 4 mpg equals 120 pmpg (4x30). The higher the pmpg rate, the less greenhouse gas emissions are emitted per passenger. Therefore, a full bus outperforms a full car; and a full car outperforms a single occupant car.

Idling is another important issue surrounding vehicles and climate change. Idling is when people leave their vehicles engines running while not driving. Unnecessary idling, such as leaving car engines running while waiting for someone, wastes gas and emits greenhouse gas emissions and air pollutants into the air. Idling is an especially serious issue at schools when children breathe in the harmful pollutants of buses and cars that idle as they wait for students.

Climate Change Connection: As vehicle travel continues to grow in the United States, so do related greenhouse gas emissions. The best way to reduce emissions from cars is to use fuel efficient vehicles; never idle any engines; purchase local food and products that did not need to travel far; and most importantly, drive less. We can drive less by choosing to walk or bicycle when possible instead of driving; carpool to school and work; and use transit like buses and trains.

[1] EPA, 2005:http://www.epa.gov/oms/climate/420f05001.htm

Background for Lesson 16

City Planning

Development patterns, the way communities are organized and built, along with transportation planning, shape how people travel. For example, a person who lives in the middle of San Francisco can most likely walk to grocery stores and shops; take the bus or BART to work; and use taxis to go to special destinations. San Francisco's dense development and many transit options make it easy for a person to travel without owning a car. On the other hand, a person living in a suburban neighborhood is most likely dependent on driving because destinations are far apart from one another and few transit options exist.

Most suburban development may be described as sprawl. **Sprawl** is low-density development where residential and commercial buildings are usually located far from one another. Sprawl development generally contains roads designed for high speeds, large parking lots, and little or no pedestrian, bicycle, and transit access. Due to the far distances between destinations and limited access options, most travel in sprawl development occurs through driving, which in turn produces air pollution and greenhouse gas emissions.

With consideration to increasing fuel prices, climate change, and other environmental issues, many local governments are now placing greater priority on transit, pedestrian, and bicycling access. **Mixed use** is development that combines residential, commercial, and recreational land uses in close proximity to one another. Mixed-use development best fits around a transit station or commercial corridor to encourage accessibility by transit, pedestrian, and bicycling. This type of land use planning reduces the need for extensive vehicle travel and can reduce greenhouse gas emissions.

Urban planning, the way communities are planned, shapes the way we live and travel, even down to the school level. The development pattern around a school can determine students' travel behavior. Short distances between home and school and pedestrian friendly environments can encourage walking or biking to school. On the other hand, long distances and unsafe walking conditions discourage walking and biking to school. Urban planners are interested in improving walking and biking access to school to reduce greenhouse gas emissions from driving and promote a healthy active lifestyle.

Sustainability, only using nature's resources at a rate that they can be replenished naturally, has become a major concern in today's world. We are consuming Earth's resources faster than they can be replaced naturally and generating greenhouse gases which speed up global warming. Scientists, engineers, inventors, designers, and ordinary citizens are working on ways to conserve the Earth's limited resources by reducing consumption, generating power using renewable energy sources, and preserving trees which convert carbon dioxide into food through photosynthesis. Sustainability is being incorporated into all aspects of life from urban planning, agriculture, energy production, water usage, and construction.

Need More Information?

- Fuel efficiency
  - Department of Transportation Center for Climate Change and Environmental Forecasting. This site includes information on transportation and emissions, www.climate.volpe.dot.gov/trans.html.
  - Environmental Protection Agency and the Department of Energy provide a comprehensive listing of fuel economy ratings for most vehicles, http://www.fueleconomy.gov/
  - Air Resources Board provides vehicle fuel efficiency information, http://www.arb.ca.gov/msprog/msprog.htm

- Transit
  - The American Public Transit Association, http://www.apta.com/
  - Transit resource for the San Francisco Bay Area, http://transit.511.org/
  - Safe Routes to School, http://www.dot.ca.gov/hq/LocalPrograms/saferoutes/saferoutes.htm

- Sustainability
  - Sustainable practices website, www.howstuffworks.com

Car Tally

Estimated Time: 1 hr

Objectives:

- Understand the link between vehicle exhaust and climate change.
- Analyze data on vehicle occupancies at their school.
- Use their observations and analysis to recommend ways to reduce emissions from transportation.

CA State Standard Connections:

5th Grade Statistics, Data Analysis and Probability

Know the concepts of mean, median, and mode; compute and compare simple examples to show that they may differ.

5th Grade Visual Literacy

Identify and design icons, logos and other graphic devices as symbols for ideas and information.

Tool Kit Materials:

- Handout 1 (one per group)
- Handout 2 (one per group)

Additional Materials:

- Drawing paper (one per group)
- Clipboards (one per group)
- Timer or watch
-

Single occupant car travel is a major contributor to air pollution and climate change. In this lesson students investigate car use and driving habits at their school, and develop alternatives for the single occupant vehicle commute.

Key Words

Carpool: to share a ride with other people in one vehicle.

Traffic: the movement of cars and other vehicles on the road.

Idling: an engine running while not doing useful work, such as a car sitting still with its engine running.

Transportation: ways of moving people or goods from one place to another.

Preparation

Hold the activity during Kindergarten pick-up time. If your school does not have Kindergarten, identify a nearby street with regular vehicle traffic and with a safe location, such as a sidewalk, for students to stand and observe traffic. Review mean, median, and mode with your class or introduce them to the concepts, using the Car Tally data.

Procedure

SETTING THE STAGE

- Give each student a small piece of paper (2x3 inches, or a sticky note) and have them write or draw a picture of how they get to school on a typical day. Have them put their name on the back of the paper.
- Next, brainstorm all the categories, or ways, a student could get to school. Write these categories as sections on the bottom axis of a bar graph, either on a whiteboard or on separate chart paper. Last, have students tape their paper on the board with their means of transportation above the appropriate category, walking, car, bus, etc.
- Discuss the results of this bar graph, what was the most common means of getting to school, least common, what might be the effects on the environment?
- Ask the students what it is like in the school's parking lot or in front of the school when they arrive, specifically asking about traffic.
- Ask if most of the cars are filled with people or more often have just one or two occupants.
- Ask if students have noticed if most cars on the road or around town have multiple passengers, or more often just one.

ACTIVITY 1 – Car Tally

1. Divide the class into small groups of 3-5 students. Provide each group, or each student, with Handout 1 and a clipboard. Each group should have a pen or pencil. Explain to the groups that they will be investigating the number of people in cars after picking up Kindergarteners.
2. Escort the groups to the pick-up/drop-off area before Kindergarten is dismissed. Give groups fifteen minutes to count how many people are in each car after the driver has picked up the kindergartener.
3. Return to the classroom and help groups complete their tally sheets by adding up the total number of people inside the vehicles and finding the average, median, and mode. If this is their first experience with the concepts, you may want to integrate this part of the lesson into your math lesson, so that you have additional time to work on the math concepts.

ACTIVITY 2 – Carpool Benefits

1. Encourage discussion of Handout 1 by asking the following questions:
   - "What was the average number of people in a car?" (To find the average, add up the total number of people in the cars and divide that result by the total number of cars.)
   - "What do the median and mode numbers for people in cars tell you?" (When arranged from lowest to highest, the median is the middle number of people in the cars. The mode is the number of people in the cars that is observed most often.)

- "Did you find that the average and mode numbers for people in the cars were the same or different?" (This will depend on students' observations.)
- "Which vehicle occupancy category does the most to protect the climate?" (The 5 people in the car category is the best protector of the climate.)
- Read some of this section's background information to students including how cars and trucks are the biggest source of air pollution and greenhouse gas emissions in California.
- Cars emit 19 pounds of carbon dioxide emissions for every gallon of gasoline burned. Unnecessary idling, leaving car engines running, while waiting for someone, wastes gas and emits greenhouse gases and air pollution into the air.
- "Did all of the groups have the same answers?" (This will depend on the accuracy of students' observations.)

2. Distribute a copy of Handout 2. Have students complete the handout in their groups by developing recommendations to reduce the amount of single occupant driving at the school, and by designing a logo or symbol to remind students to drive less on the backside of the handout.

   After groups have completed Handout 2, ask students to share their responses and designs. What can students do to help? What can the school's staff and teachers do?

ASSESSMENT

Walk around while groups are working together to assess who is participating in the group discussions, and how well they understand the concepts. Collect everyone's papers, Handouts 1 and 2, at the end of the lesson to determine if students were able to collect the data required and to recommend alternatives to driving alone.

EXTENSIONS

1. Students develop a campaign to reduce car traffic at the school, which can include making posters to place around the school, writing letters to staff and to parents, and organizing carpools.

Design a Car-Free Weekend

Lead students in designing a car-free weekend for their families. Discuss with students which weekend activities require use of a car, which activities are best without cars, and which activities can be done using other modes of transportation. Students will identify how to spend the weekend without traveling by automobile and how to travel from their homes to destinations using only public transit, walking, or biking. Students can share their experiences with their classmates. Transit information for Bay Area: http://511.org/

NAMES:_____ DATE:_____

Car Tally

Lesson 14, Handout 1

1. As a group, count the number of cars you see in fife minutes. Complete the chart below. In the first column, tally the number of cars you see with one, two, three, four, or five people inside after they have picked up the kindergartener(s). Later, in the second column, multiply the tallied number of cars by the number of people in those cars.

Vehicle Occupancy	**Number of Cars (Tally)**	**Total Number of People**
2 PEOPLE IN THE CAR		
3 PEOPLE IN THE CAR		
4 PEOPLE IN THE CAR		
5 PEOPLE IN THE CAR		
CARS IDLING		
TOTAL		

2. How many cars were idling while waiting for Kindergarteners to come out?_____

3. Find the average number of people in a car at your school by dividing the total number of people in the cars by the total number of cars:

   Average number of people in a car: _____

4. Now, calculate the median number of people in the cars. Write down the number of people in each car from fewest to most, and then find the middle number. For example, if you saw four 1-person cars, two 2-people cars, and one 3-people car, those seven numbers in order would look like this: 1, 1, 1, 1, 2, 2, 3. The middle number is the fourth number, which is 1. If there is an even number of cars, add the two middle numbers and divide the total by two.

   Median number of people in a car: _____

5. Finally, calculate the mode number of people in the cars. The mode is the number that appears the most often. To find the mode, look at the row of numbers of passengers, and count how many times each number appears. The number that appears the most often is the mode. In the example above, 1 appears most often.

   Mode number of people in a car: _____

NAMES:_____ DATE:_____

Car Tally

Lesson 14, Handout 2

As a group, answer the following questions:

1. How can carpooling reduce air pollution?

_____

_____

2. What can students do to help reduce car travel and air pollution?

_____

_____

_____

3. Did you see cars idling? If so, why could this be bad for air pollution?

_____

_____

_____

4. What can teachers and school staff do to help reduce car travel and air pollution?

_____

_____

_____

5. On the back side, draw a design for a logo or symbol to remind the school or the community to drive less. For example, the logo could be a symbol for walking more and driving less.

Calculating School Trip Emissions

Estimated Time: 1 hr

Objectives:

- Determine the amount of CO_2 emitted in their travel to school.
- Calculate emissions for various vehicles and occupancies.
- Understand how transportation contributes to climate change.

CA State Standard Connections:

4th Grade Number Sense
Students solve problems involving addition, subtraction, multiplication, and division of whole numbers and understand the relationships among the operations.

Tool Kit Materials:

- Handout 1 (one per student)

Changing personal transportation choices is a critical step to protecting the climate. In this lesson, students will calculate the pounds of CO_2 released into the atmosphere from their commute to school. This exercise introduces students to the concept of passenger miles per gallon and underscores the important role that carpooling and public transportation plays in curbing air pollution and climate change.

Key Words

Miles per Gallon: the number of miles a vehicle can travel on one gallon of fuel.

Passenger Miles per Gallon: the number of miles a single vehicle can travel on one gallon of fuel multiplied by the number of passengers.

Fuel Efficient Vehicle: vehicle that requires less fuel to travel compared to other vehicles.

Preparation

Review the Background for Lesson 15 for an overview on calculating passenger miles per gallon. Prior to this lesson, ask students to collect information on the vehicles in which they get to school. Included in this information should be type of vehicle, miles per gallon, fuel type (diesel or gas), number of passengers including driver, and number of miles roundtrip to school.

For Handout 1, students need to be comfortable with calculating multiplication and division math problems.

Procedure

SETTING THE STAGE

- Ask students to describe a time they rode the bus; ask them if the bus was full of people or mostly empty?
- "Which uses more fuel, a bus or a car?" (A typical bus gets about 4 – 8 miles to the gallon, while most cars get over 20 miles to the gallon.)
- " What form of travel do you think is more fuel-efficient, a full bus or car?" "Why?"
- Explain that the bus is more fuel-efficient because it uses less fuel to transport each person compared to many cars carrying only one person each.

ACTIVITY 1 – Calculate Commute Emissions

 Bus and Transit Image on CD.

1. Explain to students that today they will learn how to calculate the amount of fuel used on their daily trips to school and the quantity of CO_2 produced. Distribute a copy of Handout 1 to each student in the class.
2. Have students look at the chart titled "Average Miles per Gallon" on the handout.
   - "Which type of vehicle gets the worst miles per gallon?" (The bus. Large trucks. Large SUVs.)
   - "Which type of vehicle gets the best miles per gallon?" (The hybrid car.)
   - "What are some things that determine how fuel-efficient a vehicle is?" (The size and type of motor help determine a vehicle's fuel efficiency. The weight of the car.)
3. Next, explain to students that **passenger miles per gallon** is a term to describe the number of miles that all passengers in a vehicle can travel on a gallon of fuel.
   - "What determines a vehicle's passenger miles per gallon?" (The number of passengers in that vehicle times the vehicle's miles per gallon.)
   - "How is a bus's miles per gallon figure different than the bus's passenger miles per gallon?" (The bus's will always get around 4 miles per gallon, but the bus's passenger miles per gallon will change depending on the number of riders.)
4. Have students complete Handout 1, providing assistance as necessary.

ACTIVITY 2 – Passenger Miles per Gallon and Climate Change

1. Once students have completed the handout, ask students
   - "Why do vehicles generate CO_2 and other forms of air pollution?" (A vehicle's engine combusts gasoline or diesel for power, and CO_2 is a byproduct of combustion.)
   - "What does CO_2 have to do with the fuel efficiency of vehicles" (The more efficient the vehicle, the less CO_2 it will produce.)

- "What does CO_2 have to do with passenger miles per gallon?" (The more people riding in a vehicle, the fewer pounds of CO_2 will be generated per person in that vehicle.)
- "Why is riding the bus or carpooling better than driving in a car alone?" (Fewer pounds of CO_2 will be emitted per person in a bus or carpool than in driving alone in a car.)

2. Discuss student results and facts about vehicle emissions in the handout. Ask students to name ways they can reduce personal travel emissions, such as, walking, cycling, carpooling, or taking the bus.

ASSESSMENT

Collect student papers to see if they were able to calculate the CO_2 emissions for various vehicles and occupancies. Look at question 10 to see if they understand the correlation between the mode of transportation and the amount of emissions produced.

EXTENSIONS

1. Calculate which vehicle gets the higher passenger miles per gallon – a minivan with six passengers or a hybrid car with two passengers? Students find the answer using the calculations in Handout 1.

2. Students keep a travel emissions log and track their emissions over a week or month. They are then asked to summarize their log and make suggestions about how they could improve their emissions.

Sponsor Bicycle Workshops!

This project inspires students to increase their safe use of bicycles as an alternative to traveling by car. Local bicycle advocacy organizations offer free classes to your students on bike safety, bike maintenance and safe riding to and from schools. These organizations will lead short bike trips around the school, teach students about proper helmet use, proper signaling and the use of bike lanes. Coordinate with an organization to hold one or more bicycling workshops at your school (e.g., for after school or lunchtime programs, or as a special assembly).
San Francisco bicycle coalition: http://www.sfbike.org/

Community Tire Check / Inflation Days!

This project can inspire community members to pay closer attention to their tire pressure and maintenance as a way to save gas and reduce air pollution. Guide students in partnering with local filling stations to host tire check and inflation events. Set up a 'tire inflation station' at the school to check tires at the end of the school day. Work with students to develop and distribute a pamphlet about proper tire inflation and vehicle maintenance.
Information on the benefits of proper tire inflation:
http://www.carcare.org/Tires_Wheels/inflation.shtml

NAME: _____ DATE: _____

Calculating School Trip Emissions

Lesson 15, Handout 1

Students travel to school in many ways. Some students walk; some ride bikes, skateboards, or scooters; most ride in a car or take the bus. This lesson will assist you in developing a way to find out how many pounds of carbon dioxide (CO_2) you create by traveling to school each day. Remember that CO_2 is one of the main greenhouse gases contributing to climate change.

Average Miles per Gallon Chart

Walk, Bike, Skate, Scoot	Food is your fuel, you can go forever!
Hybrid car	48 miles per gallon
Small compact car	30 miles per gallon
2-seater sports car	25 miles per gallon
Station wagon	25 miles per gallon
Small pick-up	22 miles per gallon
Minivan	23 miles per gallon
Small SUV	23 miles per gallon
Large pick-up	16 miles per gallon
Large SUV	15 miles per gallon
Motorcycle	50 miles per gallon
Bus	5 miles per gallon

*If your parents know the exact city mileage of your vehicle, you can enter that as A for question #2.

1. What kind of vehicle do you usually take to get to school in the morning?

_____

2. Now look at the chart above to find out how many miles the vehicle can go from burning up one gallon of fuel. What is the mileage of your vehicle? We'll call this amount A.

A = _____ mpg

3. How many people are usually in the vehicle? We'll call this amount B.

B = _____ people

4. Multiply A times B. This is your Passenger Miles per Gallon. We'll call this amount C.

C = _____ passengers mpg

5. Choose one of the next two choices. If you drive in a vehicle that uses gasoline, it creates 18.8 pounds of CO_2 gas for each gallon of fuel used. If you travel in a bus or diesel vehicle, it uses diesel fuel and creates 21.9 pounds of CO_2 gas for every gallon burned. Which is it for you? Write that below. We'll call this amount D.

   D = _____ lbs of CO_2

6. Now we will calculate the CO_2 produced per mile by the vehicle you take to school. Take amount D and divide by amount A. We'll call this amount E.

   Calculate D ÷ A E = _____ lbs

7. To determine the pounds of CO_2 per Passenger Mile for your vehicle, take amount E and divide by amount B. We'll call this amount F.

   Calculate E ÷ B F= _____ lbs

8. Determine the exact number of miles from your house to school (visit google maps or mapquest online). We will call this amount G.

   G = _____ miles

9. Multiply the distance traveled (G) x the Pounds of CO_2 per Passenger Mile (F) to know exactly how many pounds of CO_2 gas is created to commute to school each morning.

   Calculate G x F Pounds of CO_2 Gas =_____ lbs

10. What is the best way to reduce emissions from your commute to protect the climate?

_____

INSPIRING CHANGE PROJECTS

Design a Car-Free Weekend

Lead students in designing a car-free weekend for their families. Discuss with students which weekend activities require use of a car, which activities are best without cars, and which activities can be done using other modes of transportation. Students will identify how to spend the weekend without traveling by automobile and how to travel from their homes to destinations using only public transit, walking, or biking. Students can share their experiences with their classmates.
Transit information for Bay Area: http://511.org/

Sponsor Bicycle Workshops

This project inspires students to increase their safe use of bicycles as an alternative to traveling by car. Local bicycle advocacy organizations offer free classes to your students on bike safety, bike maintenance and safe riding to and from schools. These organizations will lead short bike trips around the school, teach students about proper helmet use, proper signaling, and the use of bike lanes. Coordinate with an organization to hold one or more bicycling workshops at your school (e.g., for after school or lunchtime programs or as a special assembly).
San Francisco Bicycle Coalition: http://www.sfbike.org/

Explore Food Miles in the Lunchroom

This project inspires students to examine where their food comes from and the impacts that long distance transportation of food might have on the environment. Students can map where the ingredients of particular menu items typically come from (a hamburger equals bread from Kansas, tomato from Modesto, meat from Argentina, and cheese from Vermont). On the maps, indicate the distances from these locations to the school, estimate product weight and transportation (truck, rail, air, ship) and calculate total carbon costs for items. Recommend local food options and share results with students, administration, and families.
Food miles resources: http://attra.ncat.org/farm_energy/food_miles.html

Community Tire Check / Inflation Days

This project can inspire community members to pay closer attention to their tire pressure and maintenance as a way to save gas and reduce air pollution. Guide students in partnering with local filling stations to host tire check and inflation events. Set up a 'tire inflation station' at the school to check tires at the end of the school day. Work with students to develop and distribute a pamphlet about proper tire inflation.
Information on the benefits of proper tire inflation: http://www.carcare.org/Tires_Wheels/inflation.shtml

Create a Local Bicycle / Walking Map

This project can inspire more walking and biking by providing students with maps of routes for walking and biking to school. Invite a local biking or walking organization to the classroom to share information and lead school based local excursions. Work with the art teacher to make colorful and informative maps of different bicycle and walking routes. Coordinate an event to share the maps and encourage using them to travel to school.
Marin County Bicycle Coalition Bike Map: http://www.marinbike.org/Map/Index.shtml
Safe Routes to School program site: http://www.saferoutestoschools.org/

Create a Local Green Business Guide

This project helps students understand the power of the choices they make as consumers. Work with students to collect information about local green products and businesses such as businesses that sell, manufacture, or encourage recycled carpets, EnergyStar® appliances, organic food, and green building materials. Work with students to create a guide to share with school administrators, families, and the community. San Francisco green business: http://www2.sfenvironment.org/greenbiz/where_index.htm

Designing a Clean Air City

Estimated Time: three to four 45 min. periods

Objectives:

- Describe the connection between urban planning, air quality, and climate change.
- Define sustainable and give examples of sustainable actions.

CA State Standard Connections:
4th Grade California:
A Changing State
Use maps, charts and pictures to describe how communities in California vary in land use, population density, and transportation.

Additional Materials:

- One roll of butcher paper
- Pencils with erasers (one per student)
- Crayons, colored pencils, paints
- Street maps of local town or city

Students will have a chance to apply all they have learned about climate change basics, reducing impacts from electricity use, reducing impacts from product use and disposal, and reducing impacts from transportation to create a Clean Air City. Reduction of greenhouse gas emissions from product cycles, waste disposal, transportation, and electricity production can all be a part of their dream city. In this lesson, students will map out ideal cities to learn how thoughtful land use planning and environmentally responsible choices can lead to improved air quality, through the reduction of greenhouse gas emissions, and improved quality of life.

Key Words

Urban Planner: person who helps plan communities.

Mixed Use Community: community with schools, offices, homes, stores, green space, and public spaces easily accessible to one another.

Sustainable: actions done in a manner that do not deplete natural resources faster than they can be naturally replenished.

Commute: regular travel from two destinations, such as home to work or home to school.

Preparation

Review Lesson 16 Background for an overview on the effects of land use planning on climate change. Prior to this lesson, make a chart or overhead listing the items to be included or considered in the students' planning of their Clean Air City.

Prepare map materials for pairs or small groups of students.

Procedure

SETTING THE STAGE

- Display a map of your local town, city, or the San Francisco Bay Area. Begin by having students think about where they live, play, shop, and go to school.
- Ask students "How do you usually commute to these places?"
- Explain to students that people in most cities and suburbs have to drive/commute to their destinations because the distances are too far, there is no public transit, or it is too dangerous to walk or bike.
- Ask students what would change in their lives if they could live, shop, play, and go to school in a mixed use neighborhood, with a mixture of homes, stores, parks, work, etc. all close together so a person can walk or bike between them. "What would they do that they can't do now?" "Would there be things they couldn't do that they do now?"
- Tell students that they will have the chance to become **urban planners.** Explain that their task as urban planners will be to design a sustainable Clean Air City. Explain that sustainable describes human activity that uses nature's resources at a rate that they can be replenished naturally, and that a "clean air" city is one that has no or few air pollution sources.

 Suburban and Urban City, Farms, Parks/Forest Land Images on CD.

ACTIVITY 1 – Design a Clean Air City

1. Divide the class into small groups. Explain to the groups that today they will work together as urban planners to design their own imaginary cities using their creativity and all the things they have learned about air pollution and greenhouse gases. Their goal is to design a Clean Air City. Being a city planner is very much like being one of the early settlers and pioneers in our country. They came to an area and had to decide how to use the land and where to locate all the different parts of a community. They had to deal with many issues including waste disposal, food production, power production, and water supply.

2. In their groups have students brainstorm and record a list of things they would need to include or think about in their planning. Use the ideas below to guide the discussion.
   - **Energy sources:** Non-combustion, solar, wind, hydro, biomass.
   - **Product Use:** Where does food come from? Locally grown fresher and less emissions; stores close to houses.
   - **Waste:** Transfer stations, composting, and recycling stations.
   - **Transportation:** Reduce automobile travel with bike paths, subways, walking paths. Housing close to schools, stores, places to work, access to green space.
   - **Green Space:** Plants and trees take up carbon dioxide and make your city attractive.

3. You may want to generate a set of basic map symbols, which everyone uses for common sites such as homes, schools, roads, etc. Teams may add additional symbols of their own choosing, as needed. This will help simplify reading the maps.

4. Guide students with the following instructions:

Planning a Clean Air City

- Create a name for your city, and write it at the top of your paper
- Draw the city limits and natural landmarks such as rivers or forests
- Create symbols for homes, shopping centers, schools, parks, community gardens, farmer's markets. Make a map legend showing each symbol and its meaning.
- Mark transportation routes by type, of travel (bike routes, light rail)
- Each city plan should show:
    - Transportation means and routes
    - Energy sources
    - Food sources
    - Work places
    - Homes
    - Stores, libraries, parks, and entertainment
    - Mixed use neighborhoods
    - Waste disposal area/Recycling centers
- Create a list of choices/actions which environmentally responsible citizens can make to reduce greenhouse emissions, that cannot be shown on a map, such as taking shorter showers, using less of something, and bringing their own bags when they shop. Attach the list to your map.

5. Provide each group with a large sheet of butcher paper and pencils with erasers. Markers, colored pencils, etc. can be used later when the planning is complete.

6. Circulate around the classroom and assist as needed. Once the groups have completed their maps, have each group come to the front of the class, one group at a time, to explain their map and their list of choices/actions to the rest of the class.

ASSESSMENT

Listen to students as they plan their cities. Are they using the vocabulary and ideas they have learned? Are they applying their knowledge to create something new? Are they talking about decisions and trade-offs that must be made?

Use each group's list of ideas for the Clean Air City and their final product, the map of their city and the choices and actions list to assess how well they understand the factors that influence the generation of greenhouse gases and what can be done to reduce them.

EXTENSIONS

1. Present the Clean Air City maps – Provide each group with markers, paints, etc. to label and color their Clean Air City maps. Hang maps in the classroom or in another part of the school for others to see. Invite a "buddy class" to come visit the classroom and have each group explain what makes their city a Clean Air City.
2. Research real-life clean air cities and sustainable cities – Have the student's research actual sustainable cities and clean air cities that have been or are being designed in real life. Students can search key words such as: sustainability, green city, eco-city clean air city, or mixed use city.

 **Create a Local Bicycle / Walking Map**

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San Francisco green business guide: http://www2.sfenvironment.org/greenbiz/where_index.htm