We're Heating Things Up!

Student Objectives
The student:
- will explain how carbon dioxide in the atmosphere is linked to increased temperature on Earth
- will list things that individuals, families, communities and nations can do to decrease carbon dioxide emissions
- will explain what is meant by climate change.

Key Words:
ambient air
atmosphere
carbon
carbon dioxide
climate
greenhouse effect
weather

Time:
1 hour

Materials:
- quart sized mason jars with lids (2 per group)
- thermometers that fit inside the jars (2 per group)
- dark blue or brown construction paper
- tape (double sided or transparent)
- masking tape or labels
- scissors
- watch or timer
- face (dust) mask
- vehicle that runs on gasoline
- Science Journal pages

Background Information

Climate, as defined by the U.S. Global Change Research Program, is the long-term average of conditions in the atmosphere, ocean, ice sheets and sea ice as described by statistics such as means and extremes. **Climate change** refers to changes in the Earth's global climate over long periods of time–from decades to millions of years. These changes can be caused by forces inside the Earth (for example volcanos), forces from outside of the Earth (meteors, or differences in the intensity of sunlight), forces on the Earth (biology of living organisms), or the interaction of two or more of these. The Ice Ages are a well known example of climate change, although the forces that caused the Ice Ages are still not fully understood. More recent changes, especially those changes thought to be caused by human activity, have been dubbed **global warming**, however the term climate change is more accurate.

In order to understand the **climate change** that we are currently experiencing, we first

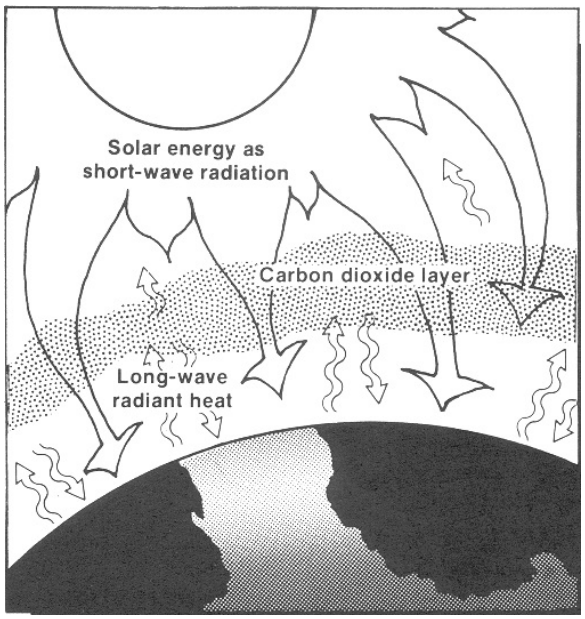
need to understand how "sunshine" works and how it plays its part in creating the **greenhouse effect**. The Sun, a medium-sized yellow star, gives off radiant energy. The radiant energy that is emitted from the Sun is called the **electromagnetic spectrum**. The electromagnetic spectrum is made up of varying wavelengths of radiant energy. The wavelength is what differentiates one type of wave from another.

Longest *(Rainbow)* *Shortest*

Radio – Radar & Microwave – Infrared – Visible light – UV – X-Rays – Gamma rays

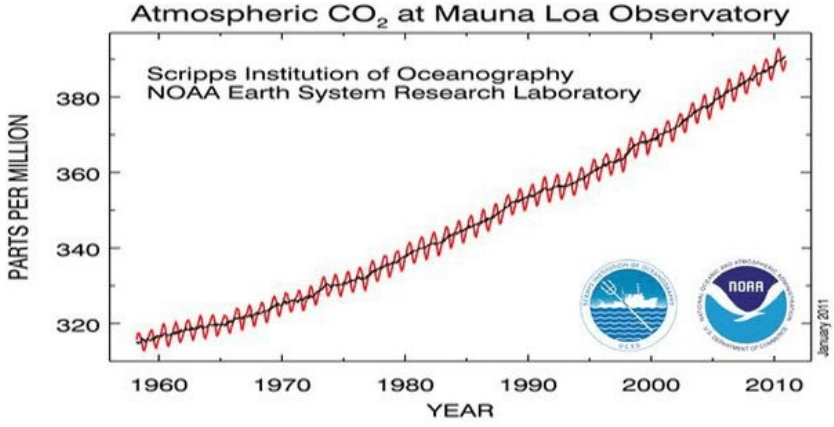
The x-ray is about one thousand time shorter than green light (in the visible range). Radio waves would be about a thousand times longer than green light. The colors that we see in the rainbow are refracted light within the visible range of the electromagnetic spectrum.

The Sun's shortwave radiation, including visible light is unstopped by molecules in the Earth's atmosphere. However, re-radiated longwave heat rays are reabsorbed and re-radiated by molecules of gases, mostly water vapor and carbon dioxide. These gases radiate heat energy so that half of it returns to Earth where it is absorbed before being re-radiated back into the atmosphere. This results in the build-up of heat energy. This is similar to what happens when your car's interior heats up on a sunny day. The Sun's shortwave energy passes through the window glass. However, the re-radiated longwave, heat-producing (infrared) energy is trapped by that same window glass and the metal structure of the vehicle, turning your car into a solar thermal collector.



Global temperatures today are averaging .74° C (1.33° F) higher than 150 years ago. Most scientists agree that the cause is the increase in atmospheric CO^2 and the greenhouse effect that this gas causes. Measurements of atmospheric CO_2 taken in locations that are far away from fossil fuel sources have shown that carbon dioxide in the atmosphere is steadily increasing. Below is the graph of CO^2 concentration collected by the National Oceanic and Atmospheric

Administration (NOAA) at the observatory on the top of Mauna Loa on the big island of Hawaii. The jagged line is the monthly averages showing the seasonal variations, and the smoother line is the yearly average. In both lines, a clear trend is obvious.



Vehicle exhausts, coal burning power plants, factories and other human activity vent about 23 billion tons of carbon dioxide into the atmosphere each year. In fact there is over 30% more CO_2 in the atmosphere now than there was in 1750 before the Industrial Revolution. Three quarters of the CO_2 that is released into the atmosphere comes from fossil fuels; the rest comes from factors such as cutting down and burning trees.

As the Earth's average temperature rises, ice at the caps will melt, and sea level will rise (from the increased water from the poles as well as the expansion of the warmer water). Weather patterns will change, probably affecting where and when food crops can be grown. Other effects are not as easily predicted; however most scientists agree that there will be extremes in the weather leading to larger storms, flooding, and droughts.

Although most scientists believe that the burning of fossil fuels is altering the Earth's climate, so far governments and policy makers are unable to agree on what to do. The Intergovernmental Panel on Climate Change (IPCC), an international group founded by the United Nations and made up of hundreds of scientists, put out a report in 2014 that stated unequivocally that humans are behind the warming of the Earth's average temperature. Rajendra Pachauri, the chairman of the IPCC stated, "...no one on this planet is going to be untouched by climate change."

Procedure

Note: Young students can easily feel helpless by overwhelming negative images, so care must be taken to balance the message and empower them. It is extremely important that discussions end with a proactive message giving the students inspiration to make changes and choices, invent, pursue science careers, and improve their future.

1. If possible, this lesson should be done on a sunny or a mostly sunny day. Although quick passing clouds will affect the data, it will not ruin the experiment.
2. Ask the students if they have heard of "climate change." Get them to tell you what they think climate change means and what could be causing it. If the students don't know, tell

them that most scientists believe that too much carbon in the atmosphere is causing the atmosphere to hold more of the Sun's heat.

3. Show the short video: *What's The Deal With Carbon* (see Internet Sites section for the link).
4. After the video lead a brief discussion to make sure that the class understood what was presented in the video. Some things to reinforce are:
   - Carbon moves around our ecosystem–in the atmosphere, in the soil, in the ocean and as part of all living things.
   - The carbon cycle has been fairly stable in the past, but some of our actions have recently altered the cycle.
   - Cutting down trees/vegetation, and burning fossilized carbon fuels has put carbon in the atmosphere faster than the trees, soil and the ocean can absorb it.
   - Carbon dioxide is a gaseous form of carbon.
5. Ask the students–according to the video, what happens when fossil fuels are burned *(carbon dioxide is released into the atmosphere)*, and according to the video, what happens when there is an increase of carbon dioxide in the atmosphere *(it acts like a blanket trapping the Sun's heat)*.
6. Tell the students that they are going to make a model of the atmosphere and use it to see if the statement in the video is correct–if an increase of carbon dioxide will lead to an increase in temperature.
7. Divide the students up into lab groups of 3 - 5 students per group. Explain to the groups that their model atmosphere will be mason jars upside down (sitting on their lids), so that sunlight can enter the jars on all sides and the top of the jars. To prepare their models they will:
   - cut a piece of construction paper (dark blue or brown) for the inside of each of their jar lids and tape it in place with either double sided tape or a tape circle. The same color paper should be used for both jar lids. (*Note: This represents either the ocean or the land, and as the students learned in the solar thermal activities, it will absorb the Sun's energy)*.
   - place a thermometer inside each jar 'upside down', with the top of the thermometer at the bottom of the jar. Tape the thermometer against the side of the glass at the top inside edge (this makes it easier to read the thermometers).
   - label each jar--one 'ambient air' and the other 'air plus car exhaust' with a piece of masking tape or label.
8. Assist them as needed in preparing their jars.
9. Take the class outside to collect the carbon dioxide for their model atmosphere. Have the students stand upwind and a few feet away from the car (or bus) being used for its' exhaust, and if possible, wear a face mask. Collect the exhaust for each of the groups:
   - Start the vehicle and let it run for a minute or two (this will decrease the amount of water vapor in the exhaust).
   - Place the jar with the mouth at (or over) the end of the exhaust tailpipe of the vehicle. This will blow exhaust into the jar and displace the ambient air. After a few seconds slip the jar lid onto the jar, remove the jar from the exhaust stream and screw the lid on tightly.
10. Since the exhaust is hotter than the ambient air, have the students take both of their jars

inside or into deep shade and watch the thermometers until both ambient and exhaust temperatures read the same.

11. When the temperatures are the same, students should then place both of their jars in a sunny location (not shading each other) and record the time and temperature in their Science Journals. Call out, "take a temperature reading!" at 5 minute intervals for 25 minutes for the students to take their temperature readings.
12. At the end of the experiment do not let the students open the jars that contain the car exhaust. That should be done outside, and preferably by an adult (you will notice the smell of exhaust when you open the jars).
13. After the groups have finished, have a few of the groups present their results to the whole class, explaining what they observed.
14. Have students graph their results in their Science Journal using a two line graph. For younger students you may wish to graph one of the sets of data on the board as an example.
15. A similar trend should be seen between groups, although the exact temperature readings will probably be slightly different between groups. Discuss with the students why this is so (*differing amounts of carbon dioxide in the test jar, different sizes/ colors of construction paper, different places the jars were set, etc*). Note: if during the experiment, clouds blocked the sunlight, students should notice a plateau or a drop in both temperatures.
16. Ask the students, since they now know that vehicle exhaust can cause an increase in temperature on the Earth, what can be done to stop it. Allow the students to brainstorm ideas, and encourage "future thinking" (new inventions, new energy sources, etc).

Key Words and Definitions

- **ambient air –** the outside air, typically measured near ground level and away from direct sources of pollution
- **atmosphere** – the whole mass of air surrounding the Earth
- **carbon –** an element found in the bodies of living things and as part of coal, petroleum and other fossil fuels
- **carbon dioxide** – a colorless, odorless, incombustible gas composed of one carbon and two oxygen atoms
- **climate** – the long-term prevalent weather conditions in the atmosphere, ocean, ices sheets and sea ice
- **greenhouse effect** – the warming of the earth's atmosphere that occurs when the Sun's radiation passes through the atmosphere, is absorbed by the earth, and is given off as radiation of longer wavelength which can be absorbed by atmospheric gases (as carbon dioxide and water vapor)
- **weather** – the current state of the atmosphere with respect to wind, temperature, cloudiness, moisture, barometric pressure, etc.

Further Research

1. Create a song about car-pooling, biking or other "green living" transportation.

2. Make posters of recycling and green living ideas – "10 Easy Things to Save the Earth", and post them around the school.
3. Hold a bike safety jamboree at school. Ask you local police department and bicycle shops to help. Suggested activities could include cone "obstacle" races, bike and helmet safety checks, and how-to maintenance seminars.

Related Reading

- ***Catch the Wind, Harness the Sun: 22 Super-Charged Projects for Kids*** by Michael Caduto (Storey Publishing, 2011)
  Twenty-two projects plus stories, background information, cartoons and photos covering solar thermal, photovoltaics, solar cooking, climate change, energy production and energy conservations–plus wind energy!
- **Energy Island: How One Community Harnessed the Wind and Changed Their World** by Allan Drummond (Square Fish, 2015)
  This book tells the true story of the Danish island of Samsø, where when the residents were confronted with ever-increasing amounts of CO_2, were able in just ten years to reduce their carbon emissions by 140% and become almost completely energy independent.
- ***The Everything Kids' Environment Book*** by Sheri Amsel (Adams Media, 2007)
  This fun guide shows students how to reduce waste, recycle materials, protect plant and animals, and more. Filled with 30 eco-friendly activities and puzzles.
- ***The Magic School Bus and the Climate Challenge*** by Joanna Cole (Scholastic, 2014)
  Ms. Frizzle shepherds her young charges on a globe-spanning tour that starts in the melting Arctic, ends back in a greener classroom and in between lays out the process and hazards of the greenhouse effect before going into eco-friendly, energy-saving technological and lifestyle changes.
- ***The New 50 Simple Things Kids Can Do to Save the Earth*** by EarthWorks Group (Andrews McMeel Publishing, 2009)
  Easy to do and kid-friendly projects.
- ***True Green Kids: 100 Things You Can Do to Save the Planet*** by Kim McKay (National Geographic Children's Book, 2008)
  This book puts and energetic spin on conservation, making environmental stewardship exciting and empowering for young students.

Internet sites (used in the lesson)

https://www.youtube.com/watch?v=2Jp1D1dzxj8

Bell Museum of Natural History (University of Minnesota), *What's the Deal With Carbon?*

Internet sites

http://climatekids.nasa.gov/

NASA's interactive student website on weather and environmental issues.

http://daily.sightline.org/2013/12/16/the-entire-ipcc-report-in-19-illustrated-haiku/

Greg Johnson, one of the scientists who was part of the Intergovernmental Panel on Climate Change (IPCC), realized that it can be difficult to communicate scientific facts and numbers in a way that all people can understand. He worked with his artist daughter to create haiku paired with watercolor illustrations to distill the 27 page 'summary' of the IPCC's 2013 climate change report into a form that is easily understood.

https://www.youtube.com/watch?v=rPqd20tdncg

Bill Nye the Science Guy explains climate change using emojis.

https://vimeo.com/69122809

Daniel Crawford of the University of Minnesota turns surface temperature data from 1880 to 2012 into a cello composition, bringing temperature data to life.

We're Heating Things Up!

Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6	.7	.8
Grade 3										
The Practice of Science	**Big Idea 1**	**SC.3.N.1**	X	X	X		X	X	X	
The Role of Theories, Laws, Hypotheses, and Models	**Big Idea 3**	**SC.3.N.3**	X	X	X					
Earth in Space and Time	**Big Idea 5**	**SC.3.E.5**		X						
Earth Structures	**Big Idea 6**	**SC.3.E.6**	X							
Forms of Energy	**Big Idea 10**	**SC.3.P.10**	X							
Grade 4										
The Practice of Science	**Big Idea 1**	**SC.4.N.1**	X	X		X	X	X	X	X
Forms of Energy	**Big Idea 10**	**SC.4.P.10**	X							
Grade 5										
The Practice of Science	**Big Idea 1**	**SC.5.N.1**	X		X	X				
The Characteristics of Scientific Knowledge	**Big Idea 2**	**SC.5.N.2**		X						
Forms of Energy	**Big Idea 10**	**SC.5.P.10**	X							
Language Arts Standards	**Third Grade:** LAFS.3.SL.1.1, LAFS.3.SL.1.3, LAFS.3.SL.2.4, LAFS.3.L.3.6 **Fourth Grade:** LAFS.4.SL.1.1, LAFS.4.SL.2.4, LAFS.4.L.3.6 **Fifth Grade:** LAFS.5.SL.1.1, LAFS.5.L.3.6									
Mathematics Standards	**Third Grade:** MAFS.3.MD.2.3 **Fifth Grade:** MAFS.5.G.1.2									

Third Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.3.N.1.1 - Raise questions about the natural world, investigate them individually and in teams through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.
- SC.3.N.1.2 - Compare the observations made by different groups using the same tools and seek reasons to explain the differences across groups.
- SC.3.N.1.3 - Keep records as appropriate, such as pictorial, written, or simple charts and

graphs, of investigations conducted.
- SC.3.N.1.5 - Recognize that scientists questions, discuss, and check each others' evidence and explanations.
- SC.3.N.1.6 - Infer based on observation.
- SC.3.N.1.7 - Explain that empirical evidence is information, such as observations or measurements, that is used to help validate explanations of natural phenomena.

Science–Big Idea 3: The Role of Theories, Laws, Hypotheses, and Models
- SC.3.N.3.1 - Recognize that words in science can have different or more specific meanings than their use in everyday language; for example, energy, cell, heat/cold, and evidence.
- SC.3.N.3.2 - Recognize that scientists use models to help understand and explain how things work.
- SC.3.N.3.3 - Recognize that all models are approximations of natural phenomena; as such, they do not perfectly account for all observations.

Science–Big Idea 5: Earth in Space and Time
- SC.3.E.5.2 - Identify the Sun as a star that emits energy; some of it in the form of light.

Science–Big Idea 6: Earth Structures
- SC.3.E.6.1 - Demonstrate that radiant energy from the Sun can heat objects and when the Sun is not present, heat may be lost.

Science–Big Idea 10: Forms of Energy
- SC.3.P.10.1 - Identify some basic forms of energy such as light, heat, sound, electrical, and mechanical.

Language Arts–Standards for Speaking and Listening
- LAFS.3.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.
- LAFS.3.SL.1.3 - Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.
- LAFS.3.SL.2.4 - Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Language Arts–Language Standards
- LAFS.3.L.3.6 - Acquire and use accurately conversational, general academic, and domain specific words and phrases as found in grade appropriate texts, including those that signal spatial and temporal relationships.

Mathematics Standards–Measurement and Data
- MAFS.3.MD.2.3 - Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step 'how many more' and 'how many less' problems using information presented in scaled bar graphs.

Fourth Grade Benchmarks

Science--Big Idea 1: The Practice of Science
- SC.4.N.1.1 - Raise questions about the natural world, use appropriate reference materials that support understanding to obtain information, conduct both individual and team investigations through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.

- SC.4.N.1.2 - Compare the observations made by different groups using multiple tools and seek reasons to explain the differences across groups.
- SC.4.N.1.4 - Attempt reasonable answers to scientific questions and cite evidence in support.
- SC.4.N.1.5 - Compare the methods and results of investigations done by other classmates.
- SC.4.N.1.6 - Keep records that describe observations made, carefully distinguishing actual observations from ideas and inferences about the observations.
- SC.4.N.1.7 - Recognize and explain that scientists base their explanations on evidence.
- SC.4.N.1.8 - Recognize that science involves creativity in designing experiments.

Science–Big Idea 10: Forms of Energy

- SC.4.P.10.1 - Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.

Language Arts–Standards for Speaking and Listening

- LAFS.4.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.
- LAFS.4.SL.2.4 - Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details, to support main ideas or themes; speak clearly at an understandable pace.

Language Arts–Language Standards

- LAFS.4.L.3.6 - Acquire and use accurately general academic, and domain specific words and phrases as found in grade level appropriate texts, including those that signal precise actions, emotions, or states of being.

Fifth Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.5.N.1.1 - Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations, experiments requiring the identification of variables, collecting and organizing data, interpreting data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
- SC.5.N.1.3 - Recognize and explain the need for repeated experimental trials.
- SC.5.N.1.4 - Identify a control group and explain its importance in an experiment.

Science–Big Idea 2: The Characteristics of Scientific Knowledge

- SC.5.N.2.2 - Recognize and explain that when scientific investigations are carried out, the evidence produced by those investigations should be replicable by others.

Science–Big Idea 10: Forms of Energy

- SC.5.P.10.1 - Investigate and describe some basic forms of energy, including light, heat, sound, electrical, chemical, and mechanical.

Language Arts–Standards for Speaking and Listening

- LAFS.5.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.

Language Arts–Language Standards

- LAFS.5.L.3.6 - Acquire and use accurately general academic and domain specific words and phrases as found in grade level appropriate texts, including those that signal contrast,

addition, and other logical relationships.

Mathematics–Geometry

- MAFS.5.G.1.2 - Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

National Next Generation Science

Third Grade Standards

Note: Related Common Core Language Arts and Mathematics Standards are listed in the Florida section above.

Fourth Grade Standards

Science–Earth and Human Activity

- 4-ESS3-1 - Obtain and combine information to describe that energy and fuels are derived from natural resources and their use affects the environment.

Note: Related Common Core Language Arts and Mathematics Standards are listed in the Florida section above.

Fifth Grade Standards

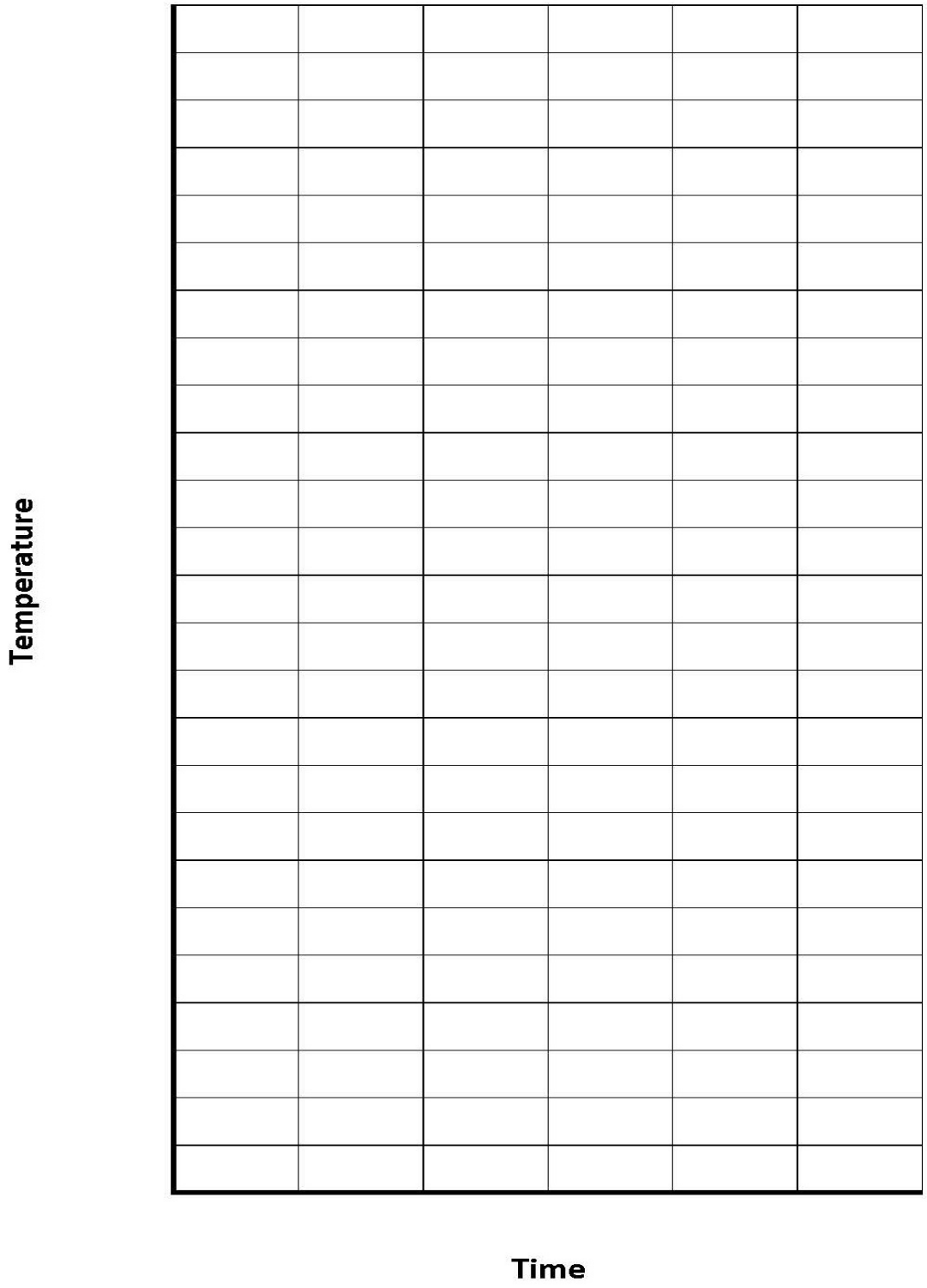
Note: Related Common Core Language Arts and Mathematics Standards are listed in the Florida section above.

We're Heating Things Up!

Place your prepared jars in the full sun. Don't let one jar shade the other. Record the starting temperature of the two jars, and record the temperatures every 5 minutes.

	Ambient air	**Air with car exhaust**
Starting temperature		
5 minutes		
10 minutes		
15 minutes		
20 minutes		
25 minutes		

Make a line graph of your data using a different color for each jar. Add temperature and time numbers on the two axes and label your colored lines.



1. What did your experiment show about air that contains extra carbon?

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2. List at least three ways we can help keep extra carbon out of the air.

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