Suggested Time Frame: 3 class periods

Class Period 1

- Engage – What is "science?"
- Explore – The Carbon Game

Class Period 2

- Explore – Discuss Carbon Game results
- Explain – Climate change discussion and video

Class Period 3

- Elaborate – Take Action projects for school
- Evaluate – "What can we do?" worksheet

Lesson Objectives: Students will be able to:

1. Define the term "science."
2. List at least three impacts of climate change.
3. Describe at least two ways recycling can help slow the process of climate change.

Standards: Missouri Standards: Science

- Strand 1: Properties of Matter and Energy
  2Ca, 2Aa, 2Fa
- Strand 4: Changes in Ecosystems and Interactions of Organisms with their Environments
  1Da, 1Db, 1Dc, 2Ba, 2Bb
- Strand 7: Scientific Inquiry
  1Ca, 1Cb, 1Ea
- Strand 8: Impact of Science, Technology and Human Activity
  1Ba, 1Aa, 1Ca

Materials:

Materials Included:

- "The Carbon Games" action cards and name tags
- "Symphony of Science" guided viewing worksheet
- "What Can We Do?" worksheet
- "Helpful or Harmful?" worksheet
- Pre and Post Assessment

Teacher Provided Materials:

- Paper or journals for recording observations
- Large, open area suitable for running
- Chalk
- Bag for "The Carbon Games" cards
- Paper to graph game results

The Carbon Games

RECYCLING & CLIMATE CHANGE

Suggested Grade Level: Upper Elementary

Program Goal: Students will understand the basics of factors that increase and decrease carbon dioxide (CO_2) in the atmosphere, as well as how recycling can help lessen the effect.

Concepts Covered: Climate change; science as a process for inquiry; energy transformations—specifically light to heat, carbon dioxide (CO_2); cause and effect; graphing

Engage

Write the term "science" on the board. Ask the students to each write down their own definition of the word.

Divide the students into partners or groups and have them share each of their definitions. *Were they the same? Different? Was there something that came up in several of the definitions?* Have the group work together to come up with a revised definition based on their discussion.

Once each group has agreed on their definition, have them write it on the board. *What do they notice about the definitions? Are they similar? If so, how?*

Even though the definitions will not be exactly the same, the most important thing to draw out of the definitions that science is a process of asking questions and attempting to find the answers. *How do we find the answers?* Repeated experiments, observations and inferences.

It is also important to know that uncertainty

is an important part of the process. It allows us to continue learning more! Science rarely proves completely. Rather, it is aiming for the best approximation of reality to understand the world around us which, in turn, helps us make useful predictions and prudent recommendations.

Tell the students to keep this definition in mind, as we'll come back to it later. But first, we're going to play a game.

Explore

Adapted from "The Carbon Dioxide Game" by Sashi Kaufman, Green Teacher*, Issue 70, Spring 2003.*

Prepare an area in a large, flat space by drawing two concentric circles on the ground. One circle should be about 2 feet in diameter and a larger one about 15 feet in diameter.

Ask the students if they have ever been in a car after the car has been sitting in the sun. *How does it feel?* (Hot!) That's because the sunlight, or radiant energy, goes through the windows of the car. Once the radiant energy hits a solid surface inside the car, it turns into heat. However, once the energy is in the form of heat, it can't get back out through the window. It's trapped inside! More keeps getting trapped inside and the air inside the car warms up over time.

Tell the students that they are going to play a game that's similar to what's happening in the car, but on a bigger scale.

Take the students to the area you marked of with the circles. Explain that the smaller circle represents the earth and the larger one is the Earth's atmosphere (the gases/air that surrounds the planet).

Tell the students that the game will be played in rounds. During the first round, choose 2 students to be Carbon Dioxide (CO_2—one of the gases that naturally occur in the atmosphere that has one carbon atom and two oxygen atoms) and let them choose any place to stand within the atmosphere. However, once placed, they cannot move their feet. Give each of the students a "CO_2" name tag to wear.

The rest of the students are bundles of energy called sunbeams. They should each receive a sunlight tag to wear. Their goal is to touch the earth (with their foot or hand) where they turn from light into heat (students turn over their name tag once touching the earth), and then escape the atmosphere without getting tagged by the CO_2 molecules. Remind the students that they only need to go back and forth once. If a sunbeam is tagged, the student must stay standing still in the atmosphere. Those that avoid getting tagged will bounce back into space.

Play the first round of the game. After the round, have the "escaped" sunbeams gather around the atmosphere to see what happened. *What do they notice? What happens when some of the heat is trapped in the atmosphere?* Explain that a certain amount of CO_2 is needed in the atmosphere to

help keep the planet warm.

For the second round, remove the trapped sunbeams from the atmosphere; they will rejoin their other sunbeam buddies.

Show the students the "Carbon Games" bag. Ask the students if they have ever heard the term "**climate change**." What do they know about that term? Explain that they are going to see some of the things that can affect climate change in both good ways and bad ways.

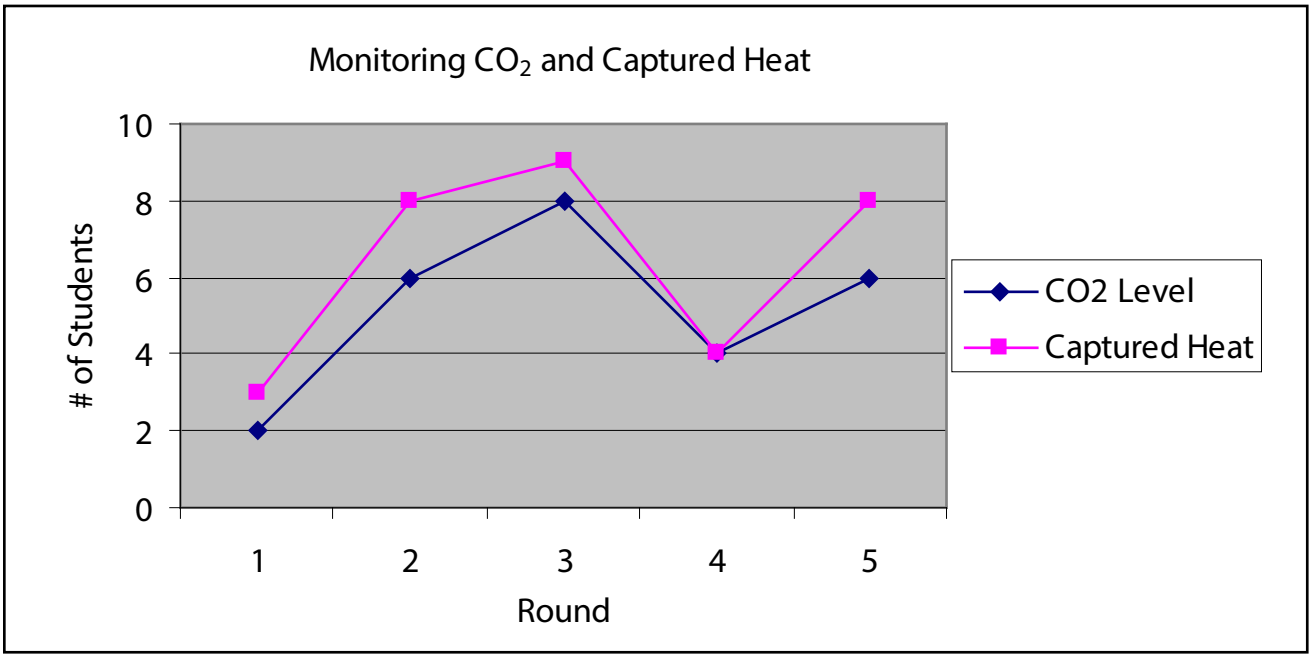
Next, increase the amount of CO_2 by reaching into the "Carbon Games" bag and pulling out an action card (for this round, use only the cards that add CO_2 to the atmosphere). Increase the amount of CO_2 in the atmosphere based on the card (by redesignating some "sunlight" students into CO_2, changing their name tags in the process) and play another round. *What happened?*

For every round afterwards, place all cards into the bag so that CO_2 levels will go up and down depending on which card is drawn. Cards include things such as:

- Drive cars
- Cut down trees
- Ride bikes
- Plant trees
- Recycle
- Use less energy
- Reduce and reuse
- Buy products made with recycled materials
- Compost
- Trash is landfilled

As the game is played, chart or graph the amount of CO_2 and how much heat is trapped. See Figure 1 below for an example of how to set up the graph.

Figure 1



Explain

After the game gather the students and ask the following questions (you may wish to refer to the graph you completed while the students played the game):

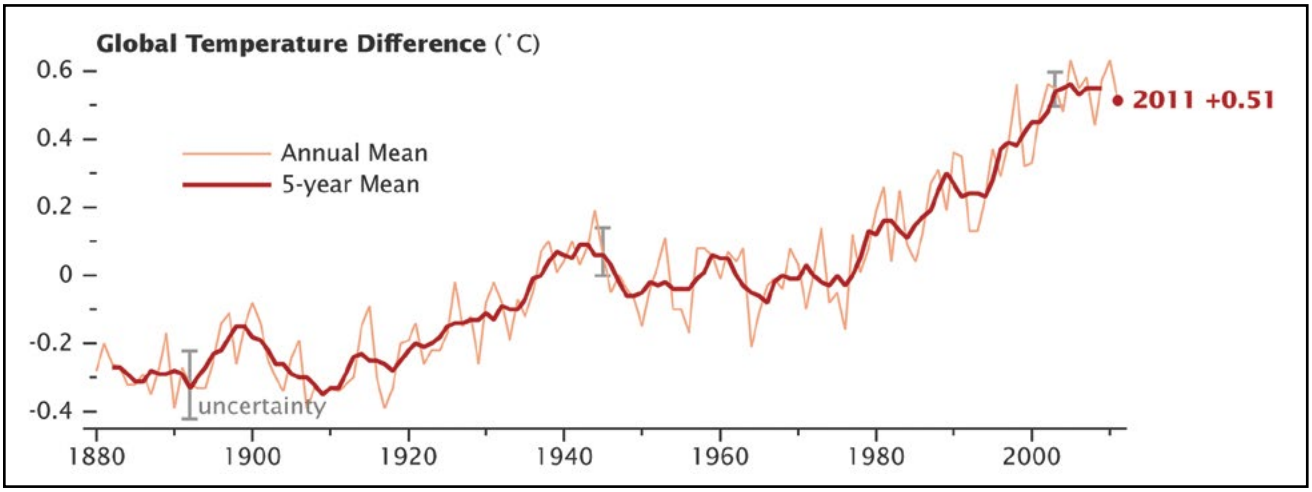
- *What do the students notice?* The heat goes up and down in relation to the CO_2 levels.
- *Do some actions have more of an impact than others? In what way?* Yes, they cause more or less CO_2 to be released.
- *Why do they think that some things have more of an impact?* Some actions release more CO_2 into the atmosphere because they contain more stored carbon that can be released, such as fossil fuels.
- *Do the students think it is only CO_2 that traps the heat?* No, there are other gases and particles in the atmosphere, such as water vapor, chlorofluorocarbons (CFCs), and methane gas that will also trap the heat.
- *How will having additional gases and particles trap heat affect the planet?* Things will heat up even faster.
- *How could this affect the planet?* The extra trapped heat can cause changes in the temperatures around the world.
- *Is this something that is actually occurring on Earth?* Yes, it's called the "**greenhouse effect**" and the gases that trap the heat in the atmosphere are called "**greenhouse gases**."
- *Do the students know the difference between "weather" and "climate?"* Weather refers to what's happening (weather-wise) at this moment. Is it hot? Cold? Rainy? Windy? The climate of an area reflects the typical weather trends in that area over a long period of time. Therefore climate change is a change in long-term weather patterns. Most scientists agree that the climates are changing. The debate comes in regarding the causes of those changes, be they natural or man-made and the extent of each. The challenge we face is, that regardless of the cause, the climate is changing and how will we deal with or try to slow some of those changes.
- *What are some of the results of climate change*? Take answers from the students.The following information may be beneficial to help add to your discussion.

CLIMATE CHANGE DISCUSSION GUIDE

Temperatures are increasing

According to NASA scientists, the global average surface temperature in 2011 was the ninth warmest since 1880. The finding continues the trend in which nine of the ten warmest years in the modern meteorological record have occurred since the year 2000. The August 2012 global temperatures were the fourth highest on record. View an animation of how global temperatures have changed since 1880 at *http://www.nasa.gov/topics/earth/features/2011-temps.html*.

Figure 2



From http://www.nasa.gov/topics/earth/features/2011-temps.html.
Image credit: NASA Earth Observatory, Robert Simmon.

Glaciers are shrinking

Warmer temperatures cause the glaciers to melt. As these white surfaces get smaller, less light is reflected back into the atmosphere, causing more heat to be absorbed by the land and water around them. As the ice melts, ocean currents are slowing.

Sea levels are rising

Sea levels have risen about eight inches in the past 100 years, and the rate of increase is accelerating. This is caused mostly by ocean water expanding as it gets warmer and, to a lesser extent, glacial ice melt. This rise in sea levels has multiple affects on people, plants and animals living along the coastlines.

Changes in weather patterns

As precipitation patterns and amounts change, some places are getting more rainfall and other are getting less, which affects plants and crops (therefore income!) growing in that area, as well as amounts of water available to people.

Blooming times are changing

As temperatures rise, plant blooming times are now earlier than ever. This can drastically affect animals that migrate to an area at a specific time so they have access to that specific plant for food or reproduction.

Animals are changing migration patterns

Animals are adapted to live in areas with particular temperatures or climates. As the climates and food sources change, animals are shifting their range and/or migration timing in response to those changes. If they cannot find suitable new locations and food sources, or if they are sedentary organisms such as plants, trees, and coral, they could go extinct.

Show the students the YouTube video "Symphony of Science, Our Biggest Challenge" available at http://www.youtube.com/watch?v=HHP9Rh-ooh0. Give students the worksheet and have them answer the questions as they watch the video. Review the students' answers, helping to fill in the blanks as needed.

Based on our earlier discussion about science, how do you think science can help us with the issue of climate change? Science not only gives us a way to observe and measure these effects, it helps us make useful predictions and recommendations based on the information we gather.

What can you do to make things better? Do some of the things from the game that helped reduce the amount of CO_2 and other gases such as recycling, composting and buying recycled-content products!

Elaborate

Review the discussion from the prior activities. Can the students remember what we can do to help lessen the effects of climate change? Give students a copy of the "Helpful or Harmful" worksheet to review.

Get the student started by discussing the first line in the chart. Ask, "Is recycling helpful or harmful? How might recycling help?" By recycling, we don't need to start at the beginning to extract the raw products and create a new product from scratch. This saves energy, and CO_2 emissions in the atmosphere. Also, by recycling and composting, we keep products out of a landfill, which help reduce the amount of greenhouse gases produced at the landfill.

As a class, or in teams, have the students complete the rest of the worksheet.

Once the worksheet is completed, have each group take one of the actions and develop a poster, advertisement, slogan or announcement to let other students know how that action can be helpful or harmful, and what people can do at school and at home to help out.

Share the students' completed projects with the rest of the school.

Evaluate

Show students the "What Can We Do?" table. Work together as a group to discuss answers or have students complete on their own.

Pre & Post Assessment

These questions can be used to assess the students' understanding of the topics discussed in this lesson. Ask the students the same questions before and after the unit using the Student Copy Page. Answers are provided on the Teacher Answer Page.

Name:_____

Student Copy Page

Pre and Post Assessment Questions for *The Carbon Games*

Short Answer Questions

1. List at least three greenhouse gases. (3 points)

2. List two actions that can increase the amount of CO_2 in the atmosphere. (2 points)

3. List at least three impacts of climate change. (3 points)

4. Describe at least two ways recycling can help slow the process of climate change. (2 points)

Teacher Answer Page

Pre and Post Assessment Questions for *The Carbon Games*

Short Answer Questions

1. List at least three greenhouse gases. (3 points)
   - CO_2
   - Methane
   - Chlorofluorocarbons (CFCs)
   - Water Vapor

2. List two actions that can increase the amount of CO_2 in the atmosphere. (2 points)
   - Cutting down trees
   - Driving cars
   - Trash is landfilled
   - Leaving lights on/wasting energy

3. List at least three impacts of climate change. (3 points)
   - Temperatures are increasing
   - Glaciers are shrinking
   - Sea levels are rising
   - Changes in weather patterns
   - Blooming times are changing
   - Animals changing migration patterns

4. Describe at least two ways recycling can help slow the process of climate change. (2 points)
   - Recycling saves energy, and therefore CO_2 emissions
   - Recycling keeps products out of landfills, which helps reduce the amount of greenhouse gases produced at the landfill

Teacher Resource Page

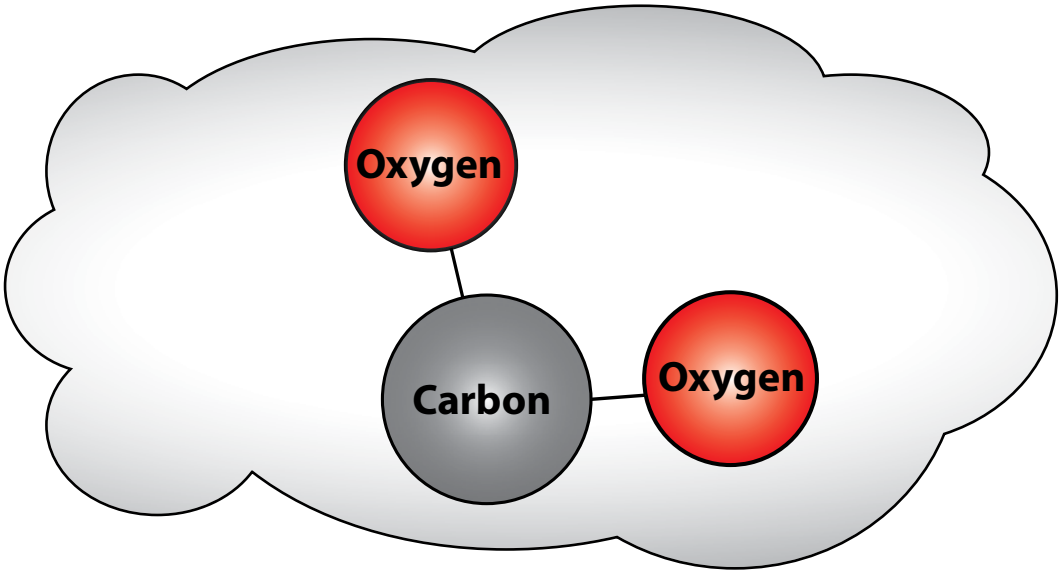
The Carbon Games

The Carbon Games Action Cards	
DRIVE CARS — Every gallon of gas (made from petroleum, a fossil fuel and non-renewable resource) used puts 18.8 lbs of CO_2 into the atmosphere. (Add four CO_2 molecules)	**REDUCE AND REUSE —** Using fewer products and reusing items when possible reduces the amount of CO_2 produced. **(Remove four CO_2 molecules)**
CUT DOWN TREES — Trees remove CO_2 from the atmosphere during photosynthesis. Fewer trees means more CO_2 in the atmosphere. **(Add four CO_2 molecules)**	**BUY MORE STUFF (LIKE TOYS AND GAMES) —** Every new product made requires more energy and resources to make them. Also, the product will probably need to be discarded in the future. All of these steps can release CO_2 into the atmosphere. **(Add four CO_2 molecules)**
RIDE BIKES — Riding a bike is a very energy efficient form of transportation. Plus it's good for you! **(Remove two CO_2 molecules)**	**PLANT TREES —** Trees remove CO_2 from the atmosphere during photosynthesis. More trees means less CO_2 in the atmosphere. **(Remove four CO_2 molecules)**
USE ENERGY EFFICIENT TECHNOLOGY — Using more efficient cars and appliances means that you get the same results while using less energy! **(Remove two CO_2 molecules)**	**RECYCLE —** Recycling saves energy, which means we use fewer fossil fuels. **(Remove two CO_2 molecules)**
USE LESS ENERGY — Most of our energy comes from fossil fuels. When we remember to turn off lights and other appliances when we're done using them means that we're saving energy and using fewer fossil fuels. **(Remove two CO_2 molecules)**	**COMPOST —** When we compost our food scraps and yard waste, we keep these items out of landfills where they create methane gas – another greenhouse gas. **(Remove four CO_2 molecules)**
TRASH IS LANDFILLED — When you throw away "trash", it is sent to a landfill where it breaks down or decomposes. Decomposition generates the greenhouse gases CO_2 and methane. 70% of what is sent to a landfill can actually be recycled. **(Add two CO_2 molecules)**	**BUY PRODUCTS MADE WITH RECYCLED MATERIALS —** When you buy things made out of recycled materials, like paper, you create a demand for that product. This gives companies reasons to keep making products with recycled materials. **(Remove two CO_2 molecules)**
USE RENEWABLE ENERGY — Renewable resources such as wind, water and the sun generate no carbon emissions when used to provide energy. **(Remove four CO_2 molecules)**	**LEAVE THE LIGHTS ON WHEN YOU LEAVE A ROOM —** Most of our energy comes from fossil fuels. When we use more energy we're releasing more CO_2 into the atmosphere. **(Add two CO_2 molecules)**

Teacher Resource Page

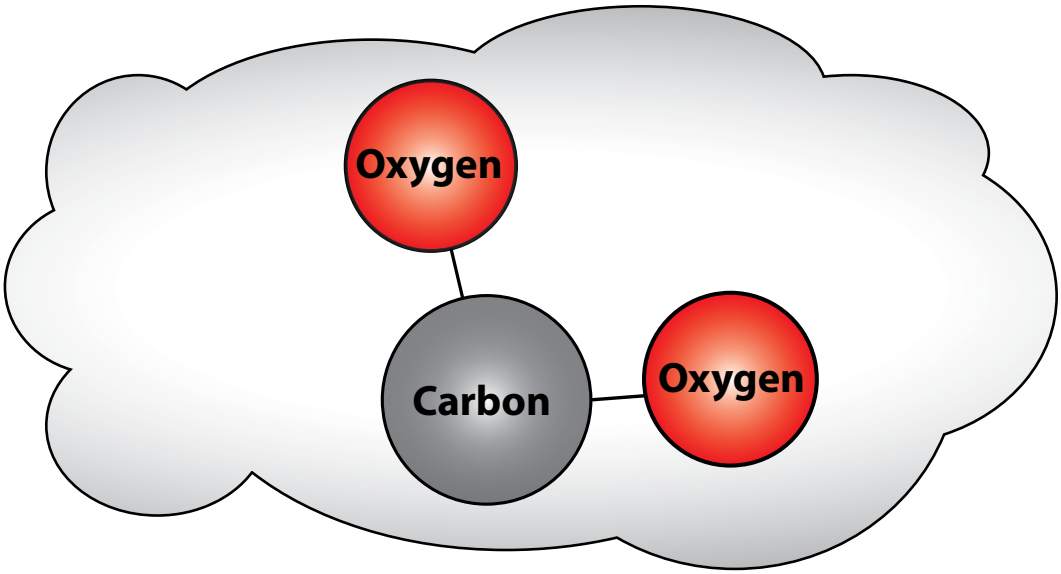
The Carbon Games

The Carbon Games Name Tags



Carbon Dioxide = CO_2

(Molecule made from 1 carbon atom and 2 oxygen atoms)



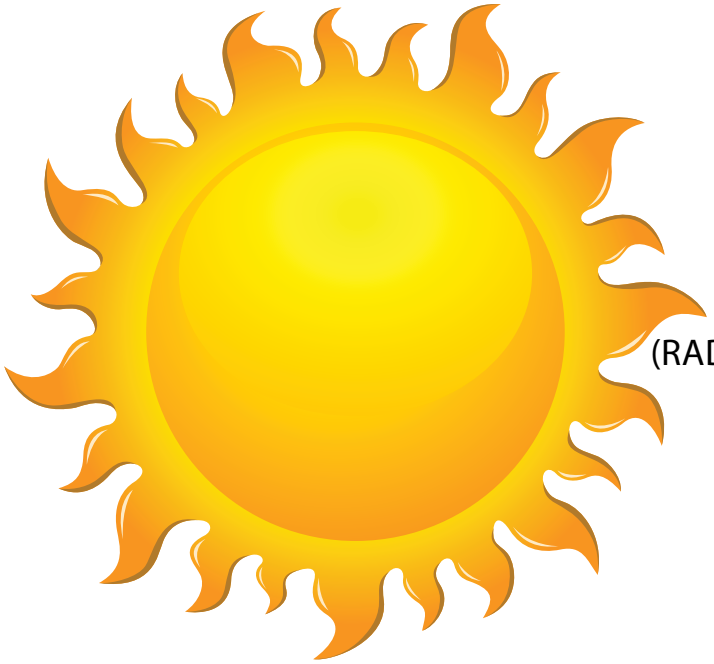
Carbon Dioxide = CO_2

(Molecule made from 1 carbon atom and 2 oxygen atoms)

Teacher Resource Page

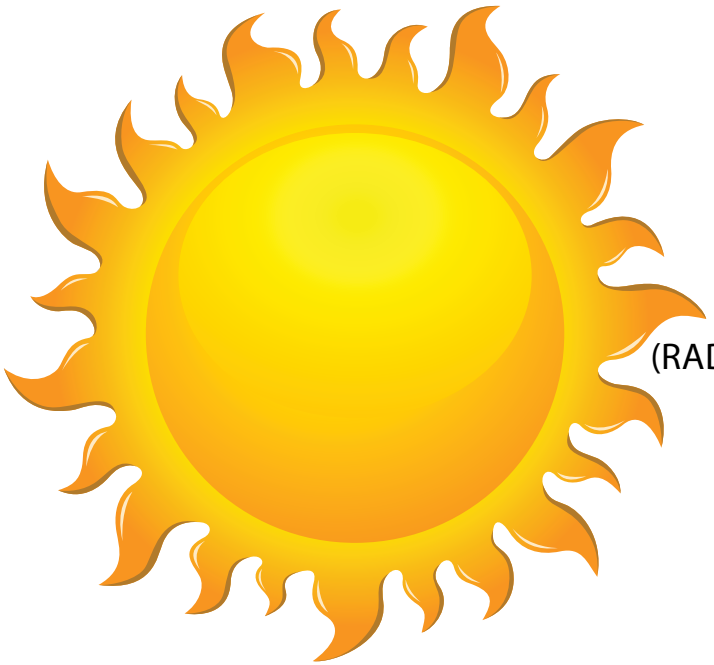
The Carbon Games

The Carbon Games Name Tags



Sunlight

(RADIANT/ELECTROMAGNETIC ENERGY)



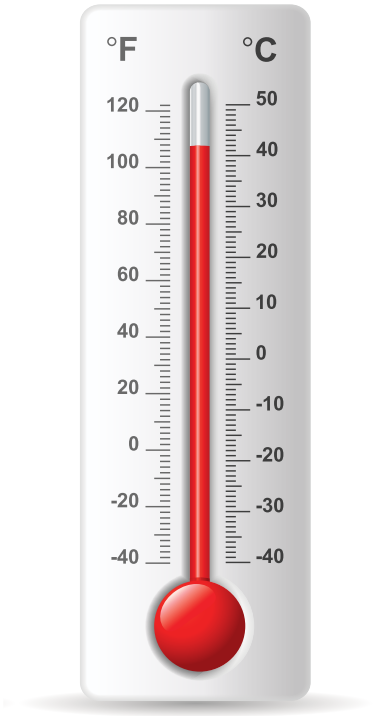
Sunlight

(RADIANT/ELECTROMAGNETIC ENERGY)

Teacher Resource Page

The Carbon Games

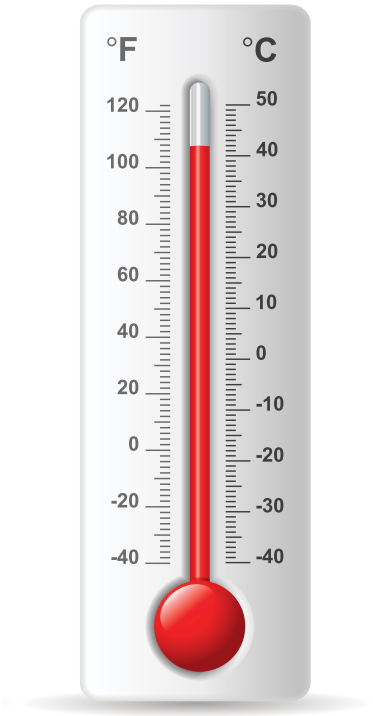
The Carbon Games Name Tags



Heat

(THERMAL ENERGY)

(Sunlight turns into heat when it hits a solid surface.)



Heat

(THERMAL ENERGY)

(Sunlight turns into heat when it hits a solid surface.)

Name:_____

Student Copy Page

Guided Viewing Worksheet: "Symphony of Science, Our Biggest Challenge"

As you watch the video, answer the questions below to the best of your ability.

1. What's the biggest challenge we have faced?

2. What keeps the earth warm?

3. What is another thing that also traps heat along with CO_2?

4. Fill in the blank: "One global _____"

   What does that phrase mean?

   Every single _____ every one of us does _____ everybody all over the _____.

5. Where does climate start?

6. How are CO_2 and temperature related?

7. Fill in the blank: "Science offers us _____"

8. A big cause for the rise in CO_2 in the atmosphere comes from what?

9. What does climate change affect?

Teacher Answer Page

Guided Viewing Worksheet: "Symphony of Science, Our Biggest Challenge"

As you watch the video, answer the questions below to the best of your ability.

1. What's the biggest challenge we have faced?

   Climate Change

2. What keeps the earth warm?

   CO_2

3. What is another thing that also traps heat along with CO_2?

   Could be any one of the following: methane, chlorofluorocarbons, water vapor

4. Fill in the blank: "One global _____ecosystem_____"

   What does that phrase mean? Every single _____thing_____ every one of us does _____affects_____ everybody all over the _____world_____.

5. Where does climate start?

   In the skies

6. How are CO_2 and temperature related?

   They move together (as one rises or goes down, so does the other)

7. Fill in the blank: "Science offers us _____answers_____"

8. A big cause for the rise in CO_2 in the atmosphere comes from what?

   Burning fossil fuels

9. What does climate change affect?

   The earth/everyone!

Name:_____

Student Copy Page

Helpful or Harmful?

Complete the following table, explaining if the actions listed are helpful or harmful to climate change, either by increasing (= harmful) or decreasing (=helpful) the amount of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere.

Action	Helpful or Harmful	Comments
Recycling		
Drive Cars		
Reduce and Reuse		
Cut Down Trees		
Use Energy Efficient Technology		
Use Less Energy		
Trash is Landfilled		
Use Renewable Energy		
Buy More Stuff!		
Plant Trees		
Compost		
Buy Products Made with Recycled Materials		
Leave Lights On When You Leave Room		

Name:_____

Student Copy Page

What Can We Do?

Complete the table below.

Action	How would it affect the things around me?	How would it affect me?	What do I pledge to do?
Buy less stuff			
Fix something when it's broken instead of throwing it away			
Reuse items			
Recycle			
Compost			
Walk or ride a bike instead of driving			
Plant a garden			
Add your own idea			

Activities for this lesson were composed by the EarthWays Center of the Missouri Botanical Garden (*http://www.missouribotanicalgarden.org*), 2012.

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