My Carbon Footprint Middle School Curriculum

New York Hall of Science

About the New York Hall of Science

The mission of the New York Hall of Science (NYSCI) is to bring the excitement and understanding of science and technology to children, families, teachers and others by galvanizing their curiosity and offering them creative, participatory ways to learn. As the City's only hands-on science and technology center, NYSCI serves close to a half-million annual visitors, offering an unparalleled range of 450 interactive exhibits, discovery labs, a science and technology library, and the largest outdoor science playground in the nation. NYSCI's educational programs are designed to engage diverse audiences in the exploration of STEM (science, technology, engineering and math) by offering immersive experiences that promote hands-on investigation and discovery. Some of NYSCI's longest-running and most successful programs provide STEM professional development, classroom support and resources to K-12 teachers.

About DB Climate Change Advisors

DB Climate Change Advisors (DBCCA) is the climate change research business of Deutsche Asset Management (DeAM). DeAM is one of the leading climate change investors in the world. With a world-class in-house research team focusing on this theme, DBCCA is an investment industry thought leader on a broad range of clean-tech dynamics.

With approximately $758 billion in assets under management globally as of 30 June 2011, Deutsche Bank's Asset Management division is one of the world's leading investment management organizations, not just in size, but in quality and breadth of investment products, performance and client service. The Asset Management division provides a broad range of investment management products across the risk/return spectrum. In addition, DeAM has approximately $7 billion of AuM in green investment strategies, which is supported by DBCCA's extensive research.

NYSCI's *My Carbon Footprint* is presented by

Deutsche Bank Group
DB Climate Change Advisors

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Introduction

With support from Deutsche Bank Climate Change Advisors (DBCCA), the New York Hall of Science created *My Carbon Footprint*, an educational initiative designed to build awareness about climate change science among New York City's schoolteachers and students. The curriculum for *My Carbon Footprint* is geared towards middle schools and was inspired by The Carbon Counter in New York City. Developed by DBCCA, The Carbon Counter is the world's first real-time carbon counter that displays a current count of greenhouse gases in the atmosphere. *My Carbon Footprint* incorporates hands-on learning opportunities, digital tools, and new technology to engage students and teachers

Each student-centered lesson in *My Carbon Footprint* maps to science standards and focuses on one or two key scientific concepts related to global climate change. Taken as a whole, *My Carbon Footprint* gives students the foundation they need to understand climate change and its related issues. The curriculum contains three modules — Climate Basics, My Carbon Footprint, and Taking Action. The modules can be taught in whichever order is most effective for your classroom.

We hope you'll find this curriculum valuable. Thank you for helping to teach the next generation about climate change.

Curriculum Modules

The scientific community agrees that climate change is happening, and it is happening here and now. The New York Hall of Science (NYSCI) created the *My Carbon Footprint* curriculum to educate youth about the science of climate change as well as empower students to examine the environmental impact of their actions.

The *My Carbon Footprint* curriculum contains three modules: Climate Basics, My Carbon Footprint, and Taking Action. The modules and lessons can be implemented in any order.

In the first module, Climate Basics, students explore fundamental aspects of what climate change means and how scientists know climate change is happening.

Key ideas include:

- The difference between weather and climate can affect the way the public understands climate change.
- Carbon dioxide and the greenhouse effect play important roles in natural processes, but when humans add too many greenhouses gases to the atmosphere the greenhouse effect becomes intensified.
- Earth's climate has changed before, but current climate change has features that make it different from past climate changes.

In the second module, My Carbon Footprint, students discover how humans can affect their environment.

Key ideas include:

- Every action an individual takes has the potential to impact the environment in the form of greenhouse gas emissions. These impacts added together comprise a person's carbon footprint.
- The products people buy have life cycles just like plants or animals, and by being smart consumers individuals can lessen the impact that product life cycles have on the environment.

Finally, the third module, Taking Action, presents strategies to fight and prepare for climate change.

Key ideas include:

- Carbon trading systems are an economic approach to fighting climate change.
- Mitigation refers to actions that reduce the amount of greenhouse gases entering the atmosphere in order to reduce the effects of climate change. Adaptation refers to actions or strategies that help humans cope with changes that will be caused by or have been caused by climate change.
- Scientific modeling helps scientists understand climate change and its potential impacts. When presented creatively, information from scientific models help raise awareness about climate change.

The flexibility of *My Carbon Footprint* ensures that this standards-based curriculum fits seamlessly into your classroom.

Module 1: Climate Basics

Weather and Climate

Introduction

During a cold day in January, you may hear people ask, "If it is so cold, how could climate change possibly be real?" This type of question highlights the importance of recognizing the difference between climate and weather. This distinction is fundamental in understanding climate change, yet many people confuse the two terms. Weather refers to the state of the atmosphere on a day-to-day basis, whereas climate refers to the average weather found in a particular region at a particular time of year. In other words "climate is what you expect, weather is what you get."

In this activity, students will explore the relationship between climate and weather using weather records from a fictional planet.

Key Terms

Weather: The state of the atmosphere on a day-to-day basis.

Climate: The average weather found in a particular region at a particular time of year.

Time to Complete: One class period.

Standards Addressed

National Science Standards:
NS.5-8.1, NS.5-8.4, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 7.2, PS 2.1a, 2.2i, 2.2j

New York City Scope and Sequence
Grade 6: Unit 2, Unit 4
Grade 7: Unit 1
Grade 8: Unit 3

Materials

Sandwich bags
Labels
Candies of different colors such as M&Ms, Skittles, etc.
(Colored marbles or beads work just as well.)
Chart paper
Markers
Paper and pencils/pens
Worksheet (found at the end of this lesson)

Preparation

Before implementing this lesson, the teacher will need to prepare bags of candy. Each bag of candy represents a different year, and each candy represents the weather for a particular day in March of that year.

Each bag should have five pieces of candy in it. Depending on the number of students, prepare one bag for each student or have students work together. The more bags prepared, the more data available.

The following set-up is designed for 36 students and uses Skittles, but the type of candy and number of bags can be modified for classes of different sizes. This set-up includes bags for four different decades so that students can gather weather information over an extended period of time. Label each bag with the year, and place the Skittles inside as directed below:

1920–3 yellow, 1 purple, 1 red
1921–3 yellow, 2 orange
1922–5 yellow
1923–4 yellow, 1 green
1924–2 yellow, 1 orange, 1 red, 1 green
1925–3 yellow, 1green, 1 orange
1926–3 yellow, 1 red, 1 orange
1927–4 yellow, 1 green
1928–2 yellow, 1 orange, 2 red

1940–2 orange, 2 yellow, 1 red
1941–3 orange, 1 yellow, 1 green
1942–4 orange, 1 green
1943–2 orange, 1 green, 1 purple, 1 red

1944–3 orange, 2 yellow
1945–3 orange, 1 green, 1 yellow
1946–2 orange, 1 purple, 2 red
1947–3 orange, 1 yellow, 1 green
1948–2 orange, 2 green, 1 yellow

1960–2 green, 2 orange, 1 yellow
1961–3 green, 1 orange, 1 purple
1962–3 green, 2 orange
1963–2 green, 1 red, 1 purple, 1 yellow
1964–3 green, 2 orange
1965–2 green, 2 red, 1 orange
1966–2 green, 1 yellow, 1 purple, 1 orange
1967–3 green, 1 orange, 1 red
1968–2 green, 2 red, 1 orange
1980–3 red, 2 green
1981–2 red, 2 purple, 1 green
1982–2 red, 1 yellow, 1 orange, 1 green
1983–3 red, 1 purple, 1 orange
1984–4 red, 1 green
1985–2 red, 2 green, 1 purple
1986–3 red, 1 green, 1 orange
1987–3 red, 1 orange, 1 yellow
1988–3 red, 1 purple, 1 green

Trends start to emerge. For example, the 1920s have a mixture of colors, but in general have more yellow candies than any other color. The 1940s still have lots of yellow, but have more orange than any other color.

Procedure

1. Ask students what they already know about climate and weather. After some discussion, explain that weather is what you observe on a day-to-day basis, while climate is the weather you'd expect to see in a particular area based on past averages. Write the definition on the board so the students can refer to it during the activity.
2. After distinguishing between these two concepts, tell students that they will investigate the weather and climate on an alien planet. As a class, come up with a name for the planet. Pass out the worksheet and have the students record the planet's name.
3. The class should then come up with a type of weather for each color candy. For instance, a red Skittle may represent very hot while a green Skittle might represent rain. As the facilitator, decide if certain suggestions don't make sense for this activity and prompt students to select something else. For example, if a student says volcano, explain that this is not a type of weather and prompt the class to make another suggestion.
4. Students should now create a key on their worksheet using the suggestions for each colored candy.
5. Pass out one of the labeled bags to each student. Each student should have a different year.
6. Tell students that the bag they have represents the weather on an alien planet during the first five days in March. Each bag represents a different year. Each candy will represent a different day.
7. Ask them to randomly remove one piece of candy from the bag. This is the weather on March 1. Tell each student to record this information on their worksheet. Repeat this procedure for the next four candies (March 2–5).
8. Instruct students with bags labeled with the same decade to work together to create a visual representation of the weather for that decade using chart paper

and markers. They could create a bar graph, they could draw out each piece of candy, etc. Alternatively, students could use graphing software to create their visualizations. Students should also calculate the average number of each color candy for their decade.

9. Each decade group should bring their chart paper to the front of the room, so students can compare as a class. Make sure that students understand that each individual candy represents weather while the bags of candy taken together represent climate.

10. Since the bags were designed to show changes in decades, students will notice changes over time. Also, help them notice that while there may have been similarities in bags, no decade had completely uniform weather. Based on the averages they recorded and the trends they have noticed, ask students what they would predict the weather to be like on March 6 for the different years. What about any years that might be missing from the decade? What would we need to be more confident in our predictions?

11. Lead a class discussion using some of the following thoughts:

- Now that you know more about weather and climate, how would you respond if you heard someone say, "Last week was so cold, how could we have global warming?"
- This is a fictional planet. Do the results we found make sense for where we live? Why or why not? What is the weather today? What is the climate like in our area?
- Present students with information on global annual mean surface air temperature change:

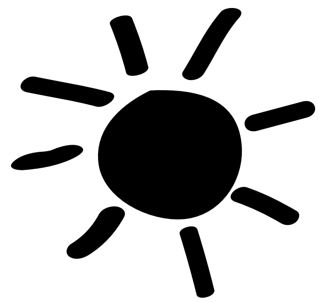
  http://data.giss.nasa.gov/gistemp/graphs/

  Have any aspects of the climate in the local area changed over time the way it did on the alien planet? How might scientists use past weather records to inform predictions about climate change?

Additional Websites

www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

www.ncdc.noaa.gov/faqs/index.htm



nysci Weather and Climate Worksheet

____
Name

____
Name of the alien planet | Year noted on your bag

Key for Weather

Color of Candy	*Weather*

Weather for March 1: ____________________

Weather for March 2: ____________________

Weather for March 3: ____________________

Weather for March 4: ____________________

Weather for March 5: ____________________

Observations for weather during your decade:

____

____

____

____

Influences on the Carbon Cycle

Introduction

With so much talk about carbon dioxide in relation to climate change, there is a common misconception among students that all carbon dioxide is bad. Understanding both the carbon cycle and the greenhouse effect is key to understanding climate change. To reinforce the idea that carbon dioxide is a natural and important part of life cycles on Earth, students begin the lesson by performing an experiment to demonstrate that humans exhale carbon dioxide.

Key Terms

Carbon Cycle: The process by which carbon gets exchanged among land, sea and air.

Greenhouse Effect: The process by which specific gases in the atmosphere absorb and reradiate energy from the sun helping to regulate a planet's temperature.

Carbon Sink: Things that can absorb carbon. Sometimes they are natural like trees or algae, and other times they are man-made, like systems that allow humans to pump extra carbon into rocks in the bottom of the ocean.

Time to Complete: One or two class periods.

Standards Addressed

National Science Standards:
NS.5-8.1, NS.5-8.2, NS.5-8.3, NS.5-8.4, NS.5-8.5, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 6.1, 7.2 PS 2.1, 2.2

New York City Scope and Sequence
Grade 6: Unit 4
Grade 7: Unit 1, Unit 4
Grade 8: Unit 4

Materials

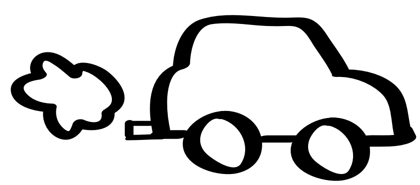
Bromothymol blue pH indicator solution (Available for purchase from any science supply company.)
1 small cup of water for each student
1 straw for each student
Pipette
Paper towels
Goggles for each student

Preparation

Directly before the lesson, place 4-5 drops of the indicator solution in a small cup of water. The water should be noticeably blue in color. Prepare one cup for each student.

Procedure

1. Direct students to put on goggles.
2. Ask students to take note of the color of the liquid in their cup.
3. Tell them that they will use the straws to blow into the blue liquid for 30 seconds. Some of the water might overflow onto the table, but they should try to be neat.
4. Instruct students to blow into the straw and time them for 30 seconds. After 30 seconds, direct students to put their straws down. Students can now remove their goggles.
5. Again, ask students to notice the color of the liquid in their cup. They will notice that the liquid has turned yellow.



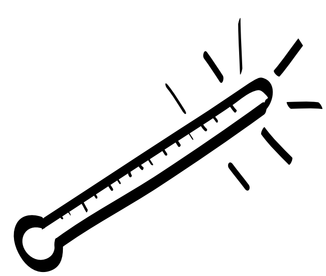
6. Ask students to hypothesize why the liquid changed color and what liquid they think was in the cup.
7. After a short discussion, explain that the cup contained water with a few drops of a pH indicator solution. If needed, explain the concept of pH. Now that they have this information, do they have a different idea of why their liquid turned color? You can prompt them by asking what they were exhaling into the cup.
8. Explain that students exhaled carbon dioxide into the cup, which made the water slightly more acidic causing the indicator solution to change color. As students can see, carbon dioxide plays a natural part in our biological processes.
9. Review the carbon cycle and discuss natural sources of carbon (animal respiration, breakdown of organic materials, volcanoes) as well as natural carbon sinks (trees, ocean, algae, etc.).
10. Tell students that although carbon dioxide occurs naturally and helps support life on Earth, carbon dioxide is also a major cause of global climate change. How can this be the case? Carbon dioxide is a greenhouse gas that is found in the Earth's atmosphere. Carbon dioxide and other greenhouse gases such as water vapor, methane and nitrous oxide help regulate the temperature of Earth by absorbing infrared radiation from the sun and then reradiating this heat energy back to Earth's surface. When unnaturally high levels of carbon dioxide get released into the atmosphere, more heat gets trapped and the Earth warms too much.
11. At this point, it may help to discuss the relationship between global climate change and the hole in the ozone layer. Students often have the misconception that one problem causes the other. Although both issues deal with the atmosphere, and some of the things that deplete stratospheric ozone levels can also contribute to climate change, they are distinct issues. Climate change relates to too many greenhouses gases being added to the atmosphere while the hole in the ozone layer deals with depletion of ozone gas in the stratospheric level of the atmosphere. In short, climate change and the ozone hole are two discrete but related problems.

Extension

1. The carbon cycle on Earth is in a delicate balance, and when humans create too much carbon dioxide or other greenhouses gases, it can cause this balance to be thrown off. Tell students that they will brainstorm ways to help keep the carbon cycle in balance.
2. Split the class into 4-6 small groups. Assign each group actions that either limit sources of carbon or increase the absorption of carbon. Examples include:

   Planting more trees.
   Reducing the number of cars on the road.
   Creating an artificial carbon sink.
   Cultivating algae.
   Limiting pollution from factories.
   Developing fossil fuel alternatives.

3. The groups will have 20 minutes to brainstorm the pros and cons of the action and put together a presentation to "sell" their idea to the rest of the class. Each group will then have two minutes to present and the presentation must tie back to the science concepts covered in Part 1.



Natural Climate Variability vs. Man-Made Climate Change

Introduction

Earth's climate has changed in the past due to natural factors such as small changes in Earth's orbit or volcanic activity. An increasing rate of change, however, differentiates current climate change from past changes in climate. Earth's climate is changing much faster than it has in the recent past, and evidence indicates a link between these changes and man-made factors like greenhouse gas emissions from cars and factories.

In this lesson, students will explore how scientists study past climate change and will learn that although Earth's climate has changed before, the current climate change differs from natural climate variability.

Key Terms

Natural Climate Variability: Changes in climate caused by natural factors like volcanoes or slight changes in Earth's orbit.

Anthropogenic (man-made) Climate Change:
Changes in climate caused by human activities such as the use of fossil fuels.

Time to Complete: One class period.

Standards Addressed

National Science Standards:
NS.5-8.1, NS.5-8.4, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 7.2, PS 2.1a, 2.2i, 2.2j

New York City Scope and Sequence
Grade 6: Unit 2, Unit 4
Grade 7: Unit 1
Grade 8: Unit 3, Unit 4

Materials

Worksheets (found at the end of this lesson)
Soil
5 different colors of sand
8 clear containers
Labels
Tweezers, scoops, etc.
Hand lenses
Chart paper
Colored pencils or markers that match the colors of sand

Preparation

Prepare the sediment samples in advance. The following set-up works for 32 students split into four groups. Clearly label samples. Add enough *packed* soil and sand to the container so that the layers are obvious and do not shift. Layers should be of the same thickness. In order to increase the opportunity that each student will get with the materials, multiple identical samples can be created and distributed *within* a group.

Group 1: layer of soil, layer of white sand, layer of soil, layer of purple sand, layer of soil

Group 2: layer of soil, layer of blue sand, layer of soil, layer of orange sand, layer of soil

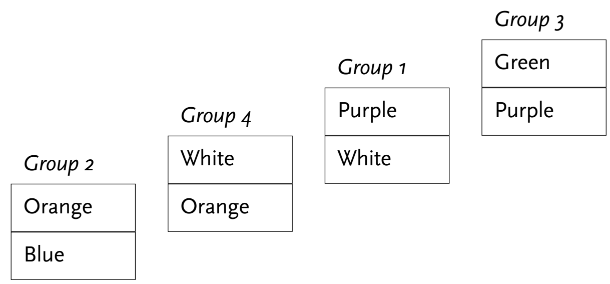
Group 3: layer of soil, layer of purple sand, layer of soil, layer of green sand, layer of soil

Group 4: layer of soil, layer of orange sand, layer of soil, layer of white sand, layer of soil

The sand in this activity represents pollen, and the data is simplified. In reality, the pollen grains of various plant species would be mixed in with the soil, and scientists would use microscopes and other equipment to study the pollen. As an added challenge, students could prepare slides of their samples and then look at the slide under a microscope.

Procedure

1. Begin with a class discussion of different ways that scientists learn how the climate has changed in the past. These include looking at ice cores, tree rings, and sediment samples that contain pollen. This study of past climates is known as paleoclimatology.
2. Tell students that today they will look at different layers of "pollen" trapped in soil. If we know that certain types of pollen are found in certain conditions we can begin to figure out how the climate has changed over time. Split the class into four groups and pass out worksheet #1, but not worksheet #2.
3. Have students work with their group to observe their sediment samples. Have them record only the layer of colored pollen on the worksheet. They do not need to record or draw the layers of plain soil. Additionally, have students create a large picture of their sample on chart paper.
4. Once students have observed and recorded their observations, they can dig through the sediment sample using tweezers or small scoops.
5. After all groups have completed their drawings, have them bring the chart paper up and tape each picture to the board.
6. Using the drawings of each sample, ask students how they can figure out which order the samples go in. Which sample is the oldest? Which is the newest? Remind students that when looking at layers in the context of earth science, the oldest layer is on the bottom and the newest layer is on the top.
7. After students have had time to think and discuss for a few moments, prompt them by asking if they see any overlap between samples. Do two different samples contain the same color? What can we infer by that overlap (Answer: The layers came from the same time period). Move the chart paper so that overlapping layers are next to each other.
8. Once all of the overlapping layers are displayed next to each other, students will see that the papers are staggered (see below). The blue layer of pollen is on the bottom so it is the oldest.



9. Pass out worksheet #2. Now that students can put the samples in order, they can figure out how climate conditions have changed over time. Remind them to use the key on worksheet #1 to figure out what climate conditions each type of pollen could be found in.
10. After the worksheet has been filled, ask students to report how the climate changed over time.
11. Tell students that just like in this activity, the climate has changed before. Natural factors such as volcanoes and even small changes in the Earth's orbit contributed to past changes. The current changes in climate, however, are not just natural variability. The change is happening much faster than it has in the past 1,300 years, and scientific evidence suggests that the change coincides with human industrial activity. Show students these images of changes in carbon dioxide levels and surface air temperate to help reinforce the idea that the most recent climate change is happening quickly and matches up with man-made factors:

    http://climate.nasa.gov/evidence/
    http://data.giss.nasa.gov/gistemp/graphs/

Sediment Analysis: Worksheet 1

Blue pollen: Found in cool conditions.

Orange pollen: Found in cold, dry conditions.

Green pollen: Found in temperate conditions.

Purple pollen: Found in cool, wet conditions.

White pollen: Found in warm, wet conditions.

Observe your sample. Do you see colorful layers of pollen? Write or draw only the layers of pollen in the chart below. Some layers might be clearer than others. Then, use your tweezers and hand lenses to learn more.

Soil Analysis: Worksheet 2

As a class, compare observations and put the samples in order.

Group #

Group #

Group #

Group #

Now that you have discovered which order the pollen was found in, you can use the key from worksheet one to describe how the climate has changed over time.

Oldest pollen found in ____ conditions.

Next type of pollen found in ____ conditions.

Next type of pollen found in ____ conditions.

Next type of pollen found in ____ conditions.

Newest type of pollen found in ____ conditions.

Module 2: My Carbon Footprint

Carbon Footprint Calculator

Introduction

A person's carbon footprint is a measurement of the greenhouse gases released into the atmosphere as a result of that person's individual actions. Energy use, food choices, and clothing purchases all contribute to this total. Carbon footprint calculators are tools that help individuals become more aware of their impact on the environment and may even give suggestions on steps to minimize their carbon footprint.

Carbon footprint calculators serve as an opportunity for people to learn how their choices impact the environment. Many carbon footprint calculators for kids, however, apply more to adults than children. By asking students to generate their own calculators, students will not only think about their own choices but will also create a tool to share with others.

In this lesson, students will explore online carbon footprint calculators geared towards young adults, and will use their findings to create their own youth-oriented carbon footprint calculators.

Key Terms

Carbon Footprint: The total amount of greenhouse gases released due to an individual's actions.

Carbon Footprint Calculator: A tool used to determine the amount of greenhouse gases an individual's actions release into the atmosphere.

Time to Complete: Two class periods.

Standards Addressed

National Science Standards:
NS.5-8.1, NS.5-8.2, NS.5-8.3, NS.5-8.4, NS.5-8.5, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 6.1, 7.2 PS 2.1, 2.2

New York City Scope and Sequence
Grade 6: Unit 4
Grade 7: Unit 1, Unit 4
Grade 8: Unit 4

Materials

Computers
Pen and paper

Preparation

Visit each of the websites included in the procedure to pick out questions that will spark discussion and to prepare for questions students may ask. For example, a person's carbon footprint is usually reported as metric tons of carbon dioxide, and students may have trouble understanding their results because they are unfamiliar with this unit of measurement.

Some of the sites require students to create a free account. Other carbon footprint calculators can be substituted as desired.

Procedure

1. Ask students what the term "carbon footprint" means. Why do we care about our carbon footprints?
2. Tell students they will use online carbon footprint calculators designed for young adults. Ask them why a tool like a carbon footprint calculator might be important. (Sample answers: To educate, to raise awareness, etc.) Instruct students to take notes while they visit each site. Which questions do they like? What questions are difficult for young people to answer? Would their friends want to use these sites? They should also record their results for each site.

3. Have students visit the following carbon footprint calculators:

   www.epa.gov/climatechange/kids/calc/index.html#calc=bus

   www.cooltheworld.com/kidscarboncalculator.php

   meetthegreens.pbskids.org/features/carbon-calculator.html

4. As a class, have students share which calculators they tried and compare their footprints to those of their fellow classmates. What were some of the actions or behaviors that might have resulted in larger footprints?

5. Were there questions that students had difficulty answering? What activities might have been missing? Did students understand what their results meant?

6. Working in groups, have students come up with their own questions to ask. They can include some questions they liked from the other calculators but should also include new questions that they think will appeal to their friends. Prompt them with questions such as:

- Does your list include things that you purchase?
- What about how often you buy new electronics like phones or iPods?
- What about things you do for fun?

7. Additionally, students should create a key to explain what their results mean. This may require them to research the amount of carbon emissions associated with the activities included in the calculator. Sites like this may help:

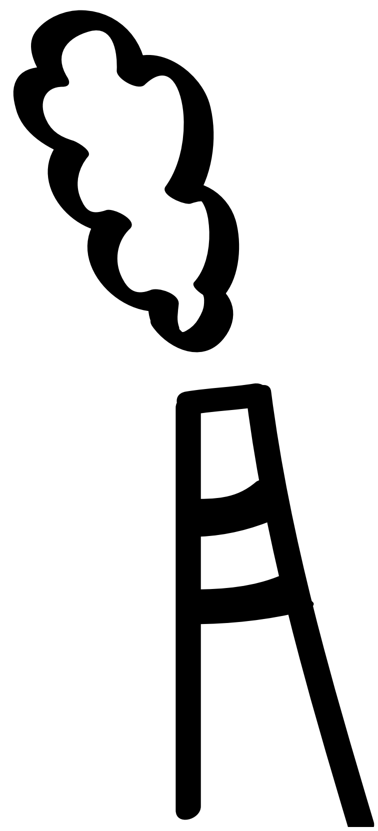
   www.carbonfund.org/site/pages/carbon_calculators/category/Assumptions

8. Alternatively, students can create a rating system such as: Mostly A's — You are taking steps to reduce your footprint, Mostly B's — You need to make some changes, Mostly C's — Your footprint is too big, etc.

9. The Deutsche Bank Climate Change Advisors Carbon Counter can be used as another example of how to raise awareness about carbon emissions. In effect, the Carbon Counter represents a collective carbon footprint.

   www.dbcca.com/dbcca/EN/

10. As a homework assignment, have students keep track of their daily activities for several days. Which of these activities should be included in the carbon footprint calculator?



Life Cycles of Electronics

Introduction

The electronics industry is often perceived as a "green" industry because the technology appears clean or sleek, and computers don't seem to produce obvious pollutants such as smoke. In reality, electronic products require many types of natural resources from all over the world. This industry also lacks a viable system for ensuring that electronics get disposed of properly.

Students will deconstruct electronic products to learn how the items they use everyday may affect the environment. The lesson also prompts class discussion about what consumers can do to make better choices when it comes to the items they buy.

Key Term

Product Life Cycle: The stages a product goes through from initial harvesting of raw materials through disposal and breakdown.

Time to Complete: One or two class periods.

Standards addressed

National Science Standards:
NS.5-8.1, NS.5-8.2, NS.5-8.5, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 6.1, 7.2,

New York City Scope and Sequence
Grade 6: Unit 4
Grade 7: Unit 1, Unit 4
Grade 8: Unit 4

Materials

Goggles
Gloves
Screwdrivers
Hammers
Electronics to take apart
Product life cycle worksheet (included at the end of the lesson)
World map

Preparation

In the weeks leading up to this activity, ask students to bring in any old or broken electronics they may have around the house. Additionally ask other teachers and classrooms to donate electronics. Students will work in groups, so 4-6 larger items such as toasters, printers, alarm clocks etc. and 5-10 smaller items like computer mice, old cell phones, etc. are needed for each class.

Have a plan for the disposal of the materials. This site includes resources on correct disposal of e-waste:

www.epa.gov/osw/conserve/materials/ecycling/

Some of the items may have many small parts and putting paper on the tables will aid with easier clean-up.

SAFETY NOTE: Computer monitors and TV screens are not suitable for this activity. They contain dangerous materials that could be disturbed if disassembled.

Procedure:

1. Start a class discussion. We all use electronic products. Can anyone name some of the items they use everyday?
2. Products have a life cycle just like a plant or animal has a life cycle. What steps make up an animal's

life cycle? What steps does a product's life cycle include? (Sample answer: Harvest metals from the ground to make the product. Transport the raw materials to a factory where the machines transform the materials into a final product. The product travels from a factory to a store where an individual buys it. The individual takes it home, uses it, and either recycles it or throws it away. It may take hundreds of years to break down).

3. Each part of the life cycle uses energy and may include greenhouse gases being released into the environment. Also, tiny parts of the product that we don't even see from the outside make it difficult to determine the different steps in the product's life cycle. For example, computer chips are created using rare, raw materials mined from the Earth, and these materials must travel all across the world to make it into our computers, and yet we don't even see them!

4. Split students into small groups. Each group will receive one large electronic item and one or two smaller items. Tell students that they should try to get a general count of the number of individual parts in each electronic item. They must also keep track of where in the world each piece came from. Not every piece will have a label, and some of the labels will be small, so they should use their worksheet and world map to record as much information as possible.

5. Allow students to work for about 20 minutes or until they've had enough time to get the sense that parts vary and originate in different parts of the world.

6. As a class, compare world maps. Did different products have parts from different countries? Where in the world do the labeled parts come from? If these parts come from different countries, how do they get to stores in the United States?

7. Now that students have gotten a closer look at what exactly the product is made of, what can they say about the life cycle of the product?

8. Wrap up the class discussion using the following points:

- What will happen to this product when we're done with this activity? The product should not go to a landfill. It won't break down, and could release harmful chemicals. To dispose of the item properly, we will contact an agency to pick it up and dismantle the product safely.
- One thing that can lessen the impact electronics have on the environment is to only buy new things when we need them. Companies constantly create new products and encourage people to buy them because they want to make a profit. We feel pressure to buy the shiny new cell phone or the cool new computer, but that means we throw away electronics that still work creating more waste and causing more natural resources to be used for the creation of new items.
- Who is responsible for making sure electronics are disposed of properly? Is it the manufacturer of each individual part? Is it the company that created the final product? Although certain countries may have laws in place to deal with these questions, the electronics industry is global, making it difficult to enforce these laws. Many times harmful electronic waste ends up being discarded in developing nations.
- Be mindful of what you buy and where it comes from. By being responsible consumers, we can cut down on waste and reduce greenhouse emissions.

9. As a possible extension or homework assignment, have students research and investigate the life cycle of one specific part of one of the products. For example, what material makes up a keyboard key? Where is it made? Where is it added to the rest of the computer? How does it reach stores in the United States? What type of greenhouse gas emissions are associated with the production of the product?

nysci Life Cycles of Electronics Worksheet

____
Name

____
Type of Product

List or describe the different parts you find:

1. ______________________ 2. ______________________

3. ______________________ 4. ______________________

5. ______________________ 6. ______________________

7. ______________________ 8. ______________________

What are some steps in the life cycle of this product? Include where in the world the different materials must travel.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

Module 3: Taking Action

Adaptation and Mitigation: Sea Level Rise

Introduction

Warming oceans and melting landlocked ice caused by global climate change may result in rising sea levels. This rise in sea level combined with increased intensity and frequency of storms will produce storm surges that flood subways, highways and homes.

In this activity, students learn the difference between mitigation and adaptation, and explore design adaptations to prepare for flooding caused by sea level rise.

Key Terms

Climate Change Adaptation: Actions or strategies that help humans to cope with changes that will be caused by or have been caused by climate change.

Climate Change Mitigation: Actions that reduce the amount of greenhouse gases entering the atmosphere in order to reduce the effects of climate change.

Storm Surge: An atypical rise of water created by a storm.

Time to Complete: Two or three class periods.

Standards Addressed

National Science Standards
NS.5-8.1, NS.5-8.2, NS.5-8.3 NS.5-8.4, NS.5-8.6

New York State Core Curriculum
Standards 1,6,7, LE 3.2, 7.2 PS 2.1, 2.2, 3.1, 3.2, 4.2

New York City Scope and Sequence
Grade 6: Unit 2, Unit 4
Grade 7: Unit 2, Unit 4
Grade 8: Unit 3, Unit 4

Materials

10" x 12" aluminum tray (one for each group)
Playground sand (can be purchased at Home Depot, etc.)
Clay
Water
Beaker that can hold at least 500 ml
Ruler
Materials for student designs. These may include:
- *Cotton balls*
- *Beads*
- *Styrofoam*
- *Pipe cleaners*
- *Sand*
- *Sandwich bags*
- *Toothpicks*
- *Popsicle sticks/craft sticks*
- *Tape*
- *Packing peanuts*

Preparation

The instructor should create a materials list for the students to select from during the design stage of the lesson.

Procedure

1. Begin with a discussion about sea level rise. Key points that students should be aware of by the end of the discussion include:
   a. As temperature rises, the water molecules in the ocean actually expand, thereby increasing the sea volume and level.
   b. Landlocked ice melting may cause the sea level to rise. Ice already floating in the ocean will not significantly contribute to sea level rise.
   c. Storm surges and increased flooding are a major concern associated with sea level rise.
2. Explain the difference between climate change mitigation and climate change adaptation. Mitiga-

tion is when people try to reduce the likelihood of changes by reducing greenhouse gas emissions or increasing the absorption of greenhouse gases. Examples of mitigation include riding a bike instead of driving a car or planting a tree. Adaptation is when people make changes to live in a world where the climate has changed or will change. Examples include building wastewater treatment plants farther from shore to prepare for greater storm surges. Storm surges are produced by weather patterns that cause water to pile up or rise higher than normal, and these surges can cause substantial coastal flooding. Humans have already started to see effects of climate change, so a combination of mitigation and adaptation is needed.

3. Split students into five smaller groups. Each group will be assigned a major coastal city to research either in the classroom or as homework. They should find projections for sea level rise in those cities as well as identify ways that the city plans to adapt to sea level rise. The end of this lesson includes links to resources related to each city that will help guide students if they have trouble. The cities are:

   Boston
   Los Angeles
   New Orleans
   New York
   San Francisco

4. The next class period, have students share what they've learned. Now that they have gotten some ideas about how cities actually adapt to sea level rise, they will apply their knowledge to a design challenge.

5. Have groups set up their design challenge. Half of the aluminum tray should have an inch of playground sand packed in leaving one-fourth of an inch lip around the top edge. Students should wet the sand to make it pack easier, but add just enough water to wet the sand. The sand should not be runny. This will serve as land upon which to place a model house. The other half of the tray should be filled with just enough water to cover the bottom. (If the sand absorbs the water, keep filling until there is a layer of water covering the bottom.)

6. Students will also create a house out of clay. The house should be no wider or higher than one-and-a-half inches. Place the house somewhere on the sand.

7. Have students examine the set-up and brainstorm what types of adaptations they might want to make to prevent their home from being damaged by a storm surge of 500 ml of water. Prompt students to think about more than just raising the home and tell them the house can be no higher than three inches with modifications. (Some ideas: a wall, stilts, digging a channel, sand bags, restoring wetlands, different building materials to fortify the house, floating home.)

8. Have students create a list of materials they need, or allow them to select from a list of available materials.

9. After students have shown a clear adaptation plan, like a blueprint, allow them to build.

10. Once all groups finish building, each group should test their design while the rest of the class observes. Add the extra 500 ml water by vigorously pouring it into the tray. This added water represents a storm surge. Instruct students to record their observations.

11. What designs were successful? Which weren't? Would the house withstand another storm surge? What are some of the challenges to adaptation in real life (cost, can't just put houses on stilts or dig trenches, etc.)

Information About Cities' Sea Level Rise Projects and Adaptation Plans

Boston
www.cityofboston.gov/climate/adaptation/
www.cityofboston.gov/climate/bostonsplan/

Los Angeles
http://cal-adapt.org/sealevel/
www.ci.la.ca.us/ead/ead_climatechange.htm

New Orleans
www.nola.gov/en/RESIDENTS/Environmental-Affairs/Climate-Protection
www.nola.gov/RESIDENTS/Environmental-Affairs

New York
www.nyc.gov/html/planyc2030/html/theplan/the-plan.shtml
www.dec.ny.gov/energy/75794.html
www.dec.ny.gov/energy/45202.html

San Francisco
http://cal-adapt.org/sealevel/
www.bcdc.ca.gov/planning/climate_change/climate_change.shtml

All
www.epa.gov/climatechange/kids/impacts/effects/coastal.html
www.epa.gov/climatechange/kids/solutions/prepare/seas.html

Carbon Trading Game

Introduction

Industries create large amounts of greenhouse gases that cause global climate change. Carbon trading is one proposed mechanism for forcing businesses to reduce their greenhouse gas emissions. Carbon trading works as part of a cap and trade scheme in which the government decides to limit, or cap, the amount of carbon industries may produce. At the start of this type of system, companies either receive an allotted number of carbon credits, or an auction takes place and companies bid on these credits. Each credit represents a certain amount of carbon that the company may emit, or release into the atmosphere. If they go over, they either need to buy credits from other companies, or pay a fine.

This game introduces students to the idea of a carbon trading system, and requires students to use their critical thinking skills. The game highlights many of the problems and complexities associated with this type of scheme. For instance, companies may wish to invest money in research and development to design new, greener technologies in order to reduce their emissions in the hope that they will make a profit by selling their extra credits, but this profit is not guaranteed. Similarly, if the fines for going over emissions allowances are not high enough, companies may not invest in research and development but instead decide to just pay the fine. Additionally, if the government sees that companies routinely come in under their allotment, the government may decide to lower the cap. By not limiting their pollution levels, companies may ensure that the government does not lower the cap.

Finally, monitoring how much pollution each individual company may release is difficult, and companies can get away with producing more than their share without having to pay for it.

Key Terms

Carbon Credit: A permit to release a certain amount of carbon dioxide into the atmosphere.

Cap and Trade: A system in which an upper limit is put on the amount of pollution that may be emitted by members of the system. Each member is allotted a certain number of credits, and members may buy credits from one another in order to comply with the limit.

Carbon Trading: A cap and trade system dealing specifically with carbon dioxide.

Time to Complete: One class period.

Standards Addressed

National Science Standards
NS.5-8.1, NS.5-8.4, NS.5-8.6

New York State Core Curriculum
Standards 1,6,7, LE 7.2, PS 2.1

New York City Scope and Sequence
Grade 6: Unit 4
Grade 8: Unit 4

Materials

Die
Play money
Carbon Trading Game cards (included at the end of this lesson)
Poker chips, Jenga blocks, etc. to act as carbon credits
Clock or timer to keep track of trading time

Preparation

This game presents a simplified version of complex carbon trading systems, and the rules of the game can be changed to reinforce different content. After students have become more familiar with the carbon trading system, they can generate their own game cards. Some of the game cards do not have a direct link to the carbon trading system, but can inspire class discussion about sources of greenhouse gases and offsetting carbon emissions. Be sure to read through all of the cards to facilitate this discussion.

Procedure

1. Introduce the idea of a cap and trade and a carbon trading system. Tell students that the cap is on an entire industry rather than on a specific company. (For example, as a whole group, auto manufacturers can only release 80 metric tons of carbon per year. That means one company might release 10 metric tons while another might release 20 metric tons, and everything is acceptable as long as the group total stays under 80 metric tons.)
2. As a class, decide on an industry (i.e. auto manufacturers, coal plants, something fictional, etc.)
3. Split the class into groups. Each group will be a business. They can pick a business name if they like.
4. At the start of the game, each business will start with $1,000.
5. At the start of the game, each business will start with 20 one-metric ton carbon emission credits, represented by poker chips, Jenga pieces, etc. This means that the business can emit 20 metric tons of carbon without getting fined. The class will play four rounds. If they go over 20 metric tons at the end of the four rounds they will be fined $300. Each round represents one year.
6. To see how much carbon a business emits, they will roll a die. The teacher will act as a banker/the government. For example, if a group rolls a four, the teacher will collect four chips.
7. After rounds one, two and three, companies will have four minutes to trade with each other. For example, if in the first round a group rolls a low number, they may choose to sell some of their credits to another business who may be in danger of going over. Or they can choose to keep their credits. The group selling the credits can charge as much as they like. (To facilitate trading rounds, it may be best to have one representative from each group be the spokesperson and announce the deal their company is willing to make. Additionally, the teacher may wish to prompt companies to make counteroffers.)
8. If a group rolls a 1 or a 6 they will pull a card. These cards can either be good or bad for the business and may involve choices.
9. It may help to designate one student as the recorder. This student can use the whiteboard to keep track of the amount of credits and money each company has after each round. This will help students visualize the teams that might be selling credits and those that might be buying credits.
10. The group with the most credits **and** the most money wins. If there is a group that has the most money and another with the most credits, a class discussion/vote will decide upon the winner. Is it better to have credits or money? Alternatively, keep track of how much companies are selling carbon for, and use that as the value of a credit to calculate the winner.
11. After the four rounds, discuss the fine. Was $300 enough to make the business worried about going over? What cards did companies get, and what did those cards tell us about how successful a system like this could be in encouraging companies to reduce the amount of pollution they create.
12. Now, play four rounds with a fine of $700. How does this compare to the game when there was a $300 fine?
13. Sometimes the government sees that an industry regularly comes in under their allotment so they choose to lower the cap. You can choose to play another four rounds where companies are only allowed 15 credits. Alternatively, play with two dice, so that companies emit more pollution, making it more difficult to come in under the cap.

nysci Carbon Trading Game Cards

You have the option of investing in research and development. You can choose to pay $100 to the banker right now. If you pay $100, for future turns, if you roll a 5 or 6 you will still only pay three credits. Or you can choose not to invest.

The public likes that you are trying to be a cleaner company, and they start buying more of your products. Get one credit back.

You start an education campaign to help the community become aware of climate change. Get two credits back.

You plant trees to offset your emissions. Get one credit back.

Your CEO decides to stop taking long flights to business meetings. Get one credit back.

There is an accident at your business and you release extra pollution. Pay three credits.

You have the option of investing in research and development. You can choose to pay $200 to the banker right now. If you pay $200, for future turns, if you roll a 4, 5 or 6 you will still only pay three credits. Or you can choose not to invest.

A rival company is willing to give you a deal. Pay $200 to get two credits back.

You cut down trees to build a new factory. Lose two credits.

You have not been properly reporting your carbon emissions data. Pay a $200 fine and lose two credits.

The Carbon Counter

Introduction

The scientific community agrees that climate change is happening. To learn more about climate change, researchers use information about past and current climate conditions, greenhouse gas emissions, and other relevant factors to create very complex models. Data from these models can help the public better understand the potential impacts of climate change and raise awareness about the role humans play in global climate change.

For example, Deutsche Bank Climate Change Advisors (DBCCA) worked with scientists from the Massachusetts Institute of Technology to create a Carbon Counter that displays a real-time total of long-lived greenhouse gases in Earth's atmosphere. This Carbon Counter serves as a constant reminder that climate change is a problem that won't just go away. As the text on the Carbon Counter says, "Climate Change Affects Everyone."

In this lesson, students are introduced to the science and motivation behind the DBCCA Carbon Counter. They then use the Carbon Counter as inspiration to create their own way of educating their friends and family about greenhouse gas emissions.

Key Terms

Climate Modeling: The use of equations and other quantitative information to create representations of how Earth's atmosphere, land and water interact.
These models help explain past, current and future climate conditions.

Time to Complete: Two class periods.

Standards Addressed

National Science Standards:
NS.5-8.1, NS.5-8.2, NS.5-8.3, NS.5-8.4, NS.5-8.5, NS.5-8.6

New York State Core Curriculum
Standards 1, 6, 7, LE 6.1, 7.2 PS 2.1, 2.2

New York City Scope and Sequence
Grade 6: Unit 4
Grade 7: Unit 1, Unit 4
Grade 8: Unit 4

Materials

Computer
Art supplies

Preparation

The instructor should create a materials list for the students to select from during the design stage of the lesson.

Procedure

1. Show students the web version of the Deutsche Bank Climate Change Advisors (DBCCA) Carbon Counter.

   www.dbcca.com/dbcca/EN/

2. Ask students to share their reaction to the Carbon Counter. Do they find the number surprising? Can they easily interpret the number displayed by the Carbon Counter?

3. Then tell students that the web version matches up to a large version that stands over two-stories tall and is located in midtown Manhattan. Show a photo or video:

   www.dbcca.com/dbcca/EN/carbon-counter.jsp

   The Carbon Counter shows a real-time count of the long-lived greenhouse gases in Earth's atmosphere.

Ask students why they think DBCCA created the Carbon Counter. Draw students' attention to the slogan on the Carbon Counter that says "Climate Change Affects Everyone".

4. Can you measure all of the greenhouses gases being emitted at all times? (No) Ask students where they think the number for the Carbon Counter comes from.

5. Explain that the number comes from a model. Using actual observations or measurements to build the model is vitally important in understanding many scientific phenomena, and data from models helps researchers communicate accurate scientific data to the public. To create the Carbon Counter, scientists at the Massachusetts Institute of Technology (MIT) used observations from all over the globe. They put information from the observations into different equations that helped them to understand and even predict levels of greenhouse gases in the atmosphere.

   John Riley, co-director of the MIT Joint Program on the Science and Policy of Global Change, Senior Lecturer, Sloan School of Management, explains the process of calculating the number in the following way:

   "We used measurements from an extensive global network and brought those together. The challenge of making this a real time measurement was to have an index that pulls together the many different GHGs (greenhouse gases) into a single measurement that makes sense.

   These measurements lag real time a bit because of the time it takes to measure the concentrations. So we needed to forecast forward a little bit in order to get the real time measure."

   Ron Prinn, Co-Director, MIT Joint Program on the Science and Policy of Global Change; Director, CGCS; TEPCO Professor of Atmospheric Science, goes on to explain:

   "It's useful to come up with a single number that encapsulates the rise of all of the GHGs (greenhouse gases), because there are 40 or 50 of them (to give you a sense) that we've already recognized. So that combined number is called CO_2 equivalent. And that is what is being depicted in the carbon counter. It is only an approximation to the real forcing of climate change by these gases, but it's good for communication purposes. It helps to communicate the changing nature of our atmosphere in a way that's fairly easy to understand, for the non-expert."

6. Now that students know the purpose and the science behind the counter, they can use it as an inspiration to create their own way to raise awareness and educate their school and their families.

7. Students can work alone or in groups. Students should think of a creative way to use the Carbon Counter to draw awareness to the issue of global climate change. They should select materials from a list that you provide to them.

8. Groups should have a few minutes to brainstorm and then come back together as a large class to share their ideas and get feedback.

9. Students can now create a model, blueprint, script or drawing of their idea. (Sample ideas: sculptures that include the Carbon Counter; technology such as car dashboards that incorporate the number; a running total on popular sites such as Google or Facebook; commercials or movie advertisements, etc.)

10. Make sure that students tie their ideas back to the idea of greenhouse gases rather than just a general "going green" theme.