# Project GLACIER

Global Change Initiative: Education and Research

# An Educator's Guide to the Causes, Effects, and Mitigation of Global Warming

2014-2015 Model Curriculum Unit for Grades 6-8 *Draft*

Sponsored by the NSF GK-12 Program

BOSTON UNIVERSITY

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# ACKNOWLEDGEMENTS


## *WRITERS*

Ben Thompson and Djems Domerson, Runkle School, Brookline, MA

JanMarie Andersen and Stephanie Pottinger, Davis Leadership Academy, Dorchester, MA

Dustin Hickey and Wendy Hanlon, Atlantic Middle School, Quincy, MA

Swati Banerjee and Marianne Marks, Oak Hill Middle School, Newton, MA

Chris Theissen and Donna Glynn, Atlantic Middle School, Quincy, MA

Andrew Christ and Eric Hazlinsky, Driscoll School, Brookline, MA

## *GRAPHICS AND LAYOUT*

Stephanie Pottinger, Boston Public Schools Science Teacher

Donna Glynn, Quincy Public Schools Science Teacher

Model Curriculum Unit and Lesson Plan Template adapted from MA DESE Curriculum and Instruction


*NOTE: This is a working draft. Please direct any questions, comments, suggestions etc. to Stephanie Pottinger or Donna Glynn.*

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# Preface

In this unit, students will examine global climate change with specific emphasis on areas that are accessible, achievable, and relevant to middle school students. The overarching goal is for students to explore issues within climate change, specifically addressing the natural functioning of climate, the causes and effects of human induced global climate change, and possible solutions to slowing such change. Broken up into six distinct lessons, this unit encompasses varying themes within the broad area of global climate change. Each lesson is designed to stand on its own, exist as part of the unit, or to be expanded, with suggestions and resources provided for teachers to tailor the topic to their own curriculum and student needs. Lessons within the unit address various learning styles through different teaching strategies, accommodating for English Language Learners, as well as students who are differently abled.

In Lesson one, *The Carbon Cycle: Jurassic Whirled,* students will simulate the journey of life's essential element from Jurassic times to today. Through hands-on experimentation, students will utilize laboratory and measurement skills to demonstrate the natural carbon cycle, and be able to explain how a carbon atom exhaled 200 million years ago could be floating around your classroom. Further examination will allow students to use their knowledge of the carbon cycle to defend the claim that human disruption of the natural cycle has a direct impact on climate change.

*Glacier World Tour,* Lesson 2 in the unit, allows students to visit worldwide glaciers virtually using Google Earth. Students will utilize mapping skills to locate specific glaciers, then collect, graph, and analyze the data. Specific attention will be paid to the relationship between the elevation and latitude of glaciers. Trends should be recognized, allowing for a connection to global climate change and its impact on glaciers. Students will be expected to make claims about the location of glaciers, defending why glaciers are in determined locations as is evidenced by collected elevation and latitudinal data. Defense of claims will be supported by collected data to emphasize the effects of global temperature rise on glaciers.

Lesson 3 examines the global and local consequences of sea level rise. Students will utilize topographic mapping skills to create 3D contour models of a coastal area, projecting anticipated sea level rise. To gain an understanding of the impact of sea level rise, students will research and collect information on coastal cities by completing a webquest. Students will learn how to determine

the elevation of any location and calculate how much rise needs to occur to flood cities. Through various in class activities, students will acquire the when, where, and how of sea level rise, with particular emphasis on local impact. Contributing factors will be identified and possible solutions determined as students explore adaptations to living with rising seas and design solutions to mitigate such change. At the conclusion of the lesson, students will be able to write confidently about the causes and effects of sea level rise and offer potential viable solutions as well as describe the direct connection between global warming and sea level rise.

Lesson 4 is a long-term study in Phenology. Over the course of 8-10 weeks in the fall, students will observe and collect data from a self-selected tree. Tracking leaf loss is conducted visually with photography, and by estimating percentage of remaining leaves. Comparisons will be made with historic data obtained through a national phenology database. Students will write a formal lab report for which they Test a hypothesis and observe evidence of climate change in their native location.
This project culminates in a final poster and presentation project in which students will draw conclusions and explore the implications of early leaf loss and re-budding, and be able to defend this phenomenon as evidence for global temperature rise.

*The Home and Family Energy Audit* in Lesson 5 allows students to examine the human impact of climate change on a personal level. Students will evaluate individual and family energy choices by conducting and analyzing a full home energy audit. This process includes reviewing types of energy and their efficiencies, and a comparison of fossil fuels and sustainable energy. Online research will be conducted to determine and reduce one's own carbon footprint. A modeling activity requires students to identify all sources of carbon dioxide gas currently added to the atmosphere. Also, they must consider the contribution of carbon dioxide gas by industrial nations and be able to explain how the use of carbon-based fossil fuels contribute to the greenhouse effect and climate change. In short, students should be able to use information gained in this lesson to affect real and immediate change.

The final lesson in the unit explores solutions to mitigate the negative impacts of global climate change through a fun, hands-on activity while also promoting math practice. Students begin by modeling a fishery using M&Ms, with the fishery serving as an example of general environmental problems. Through this activity, students will collect data, and construct and analyze line graphs and pie charts. The importance of quantification and graphing in policy analysis is emphasized. Students will also examine the concept of the global carbon budget. Discussion includes various ways to address climate change and recognizing the importance of cooperation in addressing climate change.

Upon completion of this unit, students will have participated in an engaging and challenging scientific experience, but should also leave feeling empowered. Used in part or in its entirety, the unit encompasses skills critical to the scientific method such as observation, surveying, research, measurement, and analysis. Additionally, it promotes effective scientific communication by applying essential Common Core reading and writing skills. Ultimately, students should leave this unit equipped and inspired to slow the effects of global climate change. They can do this not only by reducing their own planetary impact but also by being prepared to educate and encourage others to do the same.

# Unit Outline

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">ESTABLISHED GOALS G<br><br>To ensure students gain an intricate understanding of the causes, effects, and slow-up of global warming. This includes the following educational standards:<br><br>Science, Technology and Engineering<br>[NOTE: These are draft revised STE standards (as of 10/22/13); final adopted STE standards may be slightly different.]<br><br>MS-ES 3.2 Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events.<br>MS-ES 3.4 Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per capita consumption of natural resources on the environment.<br>MS-ES 3.5 Examine and interpret data to describe the role that human</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to T<br>Promote the slow up of global warming by reducing their own impact on the Earth and educating and encouraging others to do the same.</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS U<br>Students will understand that<br><br>U1 Carbon is a necessary component that supports all forms of life on Earth;<br>U2 Human activity influences the natural carbon cycle;<br>U3 Glaciers are located worldwide as determined by elevation and latitude;<br>U4 Sea levels are rising, directly impacting coastal areas;<br>U5 There is evidence of Climate change happening everywhere, even where they live;<br>U6 Types of energy impact climate differently, determined by their efficiencies;<br>U7 Policy analysis involves the quantification of data and graphs.</td><td>ESSENTIAL QUESTIONS Q<br><br>Q1 What is the role of human activity in the carbon cycle?<br>Q2 What is contributing to the rising of sea levels?<br>Q3 What evidence is there of climate change?<br>Q4 How are energy use choices impacting Earth's climate?<br>Q5 How can human activities negate the negative impact on natural resources?</td></tr>
</table>

| | | |
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| activities have played in causing the rise in global temperatures over the past century.<br>**MS-LS 2.1** Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth and number of organisms., Collect and compile a data set for comparison against historic climate data sets.<br>**MS-LS 2.3** Develop a model to describe the cycling of matter among living and nonliving parts of an ecosystem including through the process of photosynthesis and cellular respiration.<br><br>*English Language Arts and Literacy*<br>**RST.6-8.2** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.<br>**RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.<br>**RST.6-8.4** Determine the meaning of symbols, key terms, and other | Acquisition | |
| | *Students will know* K<br><br>K1 How human activity is influencing the carbon cycle and why engineers are working to understand and rebalance the carbon cycle;<br>K2 Where glaciers are located and what determines that location;<br>K3 Causes of sea level rise and how to calculate the amount necessary for flooding to occur;<br>K4 The difference between climate and weather;<br>K5 The different types of energies and their efficiencies;<br>K6 How to conduct an energy audit;<br>K7 Several approaches to addressing climate change. | *Students will be skilled at* S<br><br>S1 Designing and/or conducting an experiment to test a hypothesis using the scientific method;<br>S2 Making claims utilizing evidence obtained during an experiment;<br>S3 Collecting, organizing, and analyzing data then comparing it to another data set;<br>S4 Constructing graphical displays of data to identify relationships;<br>S5 Considering limitations of data analysis;<br>S6 reading and creating topographic and two dimensional maps;<br>S7 Generating models to predict or show unobservable phenomena. |

| | | |
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| domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.<br>**RST.6-8.7** Integrate quantitative or technical info expressed in words in a text with a version of that info expressed visually (e.g., in a flowchart, diagram, model, graph, or table).<br>**RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.<br>**WHST.6-8.1** Write arguments focused on discipline-specific content.<br>**WHST.6-8.2** Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.<br>**WHST.6-8.6** Use technology, including the Internet, to produce | | |

| | | |
|---|---|---|
| and publish writing and present the relationships between information and ideas clearly and efficiently.<br>**WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research.<br><br>*Mathematics*<br>**Math.Practice.MP2** Reason abstractly and quantitatively. | | |

| Stage 2 - Evidence | |
|---|---|
| Evaluative Criteria | Assessment Evidence |
| See CEPA Rubric | CURRICULUM EMBEDDED PERFORMANCE ASSESSMENT (PERFORMANCE TASKS) PT<br><br>**Lesson 1: Carbon Cycle, Jurassic Whirled**<br>Lab experiment response summary and CER defense writing<br><br>**Lesson 2: Glacier World Tour**<br>Data collection, graphing and CER writing<br><br>**Lesson 3: Sea Level Rise**<br>3D model and map, Expository Essay<br><br>**Lesson 4: Phenology**<br>Formal Lab Report and Poster/Powerpoint Presentation<br><br>**Lesson 5: Energy Audit** Conducting/analyzing full energy audit and Reducing Our Carbon Footprint research and writing assignment, |

| | |
|---|---|
| | **Lesson 6: Climate Solutions**<br>Constructed graphs from activity with a data analysis of the data |
| | OTHER EVIDENCE: OE<br>L1-OE: Think-Pair-Share small group discussions; Dinosaur Breath worksheet; Formative assessments include group discussions and Carbon cycle graphic organizer exit ticket.<br>L3-OE: Design solutions to mitigate effects of sea level rise.<br>L4-OE: Answer Essential Questions.<br>L5-OE: Open Response Question; Formative assessments include group discussions. |

## Stage 3 – Learning Plan

Summary of Key Learning Events and Instruction:

Suggested Text: Climate Literacy Principles with Text Dependent Questions

**Lesson 1: Carbon Cycle, Jurassic Whirled** (two-three 50-minute instructional periods)
Investigate the role of animals, from dinosaurs to humans, in the carbon cycle, and examine their impact on global climate change.

**Lesson 2: Glacier World Tour** (two 50-minute instructional periods)
Employ mapping and graphing skills to locate, compare, and analyze glaciers worldwide, emphasizing the relationship between elevation and latitudes of glaciers.

**Lesson 3: Sea Level Rise** (five 50-minute instructional periods)
Utilize topographical mapping and 3D modeling skills to investigate the effects of global sea level rise.

**Lesson 4: Phenology** (8 weeks)
Demonstrate local evidence of climate change through collection and comparison of leaf drop data, connecting the effects of earlier leaf loss with a change in $CO_2$ cycling.

**Lesson 5: Energy Audit** (five 50-minute instructional periods)
Analyze personal and home energy use, examining individual and familial impact on the greenhouse effect and climate change.

**Lesson 6: Climate Solutions** (two 60-minute instructional periods)
Construct and analyze line and pie graphs, and examine their relevance in policy analysis and addressing climate change.

Possible Extension to Communicate Info: Reflection in Action Science without Borders Challenge Ocean Awareness Student Contest American Geosciences Institute Contests Youth and Climate Change Music Contest

# Lesson 1: The Carbon Cycle

Jurassic Whirled: Breath of a Dinosaur

By Fellow Christopher A. Theissen and Teacher Donna J. Glynn, SY2014-2015

**Brief Overview of Lesson (what this lesson is about):** Students will investigate the role of living things in the carbon cycle and their effect on global climate change.

## Prior Knowledge Required:

- *Understanding* of the processes of weathering, erosion, photosynthesis, and respiration.
- Prior *introduction* to the geologic carbon cycle processes of subduction and volcanic activity.
- *Familiarity* with the impact of human activity on global climate change.

**Estimated Time (minutes):** One-three 50 minute class periods.

## Resources for Lesson (list resources and materials):

- Handouts: Student Background Reading: *Life of a Carbon Atom* and Dinosaur Breath Worksheet (Univ. of Colorado)
- chalk (NOT dustless chalk)
- rolling pin/hammer and hard surface to crush chalk
- 1 small sandwich bag in which to crush chalk
- ¼ cup white vinegar
- 2 small beakers, graduated cylinders, or small glass jars
- General classroom supplies: splash-proof goggles, digital scales, paper towels

# MA Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson #1: The Carbon Cycle: Jurassic Whirled, Breath of a Dinosaur
By Fellow Christopher A. Theissen and Teacher Donna J. Glynn, SY2014-2015

**Time (minutes):** 1-3 Fifty minute class periods. *NOTE: This activity can easily be modified as a class demonstration.*

**Overview of the Lesson:** Students will investigate the role of dinosaurs in the ancient geologic carbon cycle through reading, discussion, and hands-on experimentation. Their understanding of the carbon cycle may be extended to include its role in global climate change, as well as what can be done to reduce contributing $CO_2$ emissions.
*NOTE: This activity was adapted from various carbon cycle lessons, the most complete of which was done by the Integrated Teaching and Learning Program at the University of Colorado Boulder, College of Engineering: Hands-on Activity, Dinosaur Breath. (https://www.teachengineering.org/)*

## Standard(s)/Unit Goal(s) to be addressed in this lesson:

Standards/Unit Goal: SCIENCE

MS-ES 3.4 Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per capita consumption of natural resources on the environment.
MS-ES 3.5 Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.
(MS-LS 2.3 Develop a model to describe the cycling of matter among living and nonliving parts of an ecosystem including through the process of photosynthesis and cellular respiration.)

Standards/Unit Goal: READING

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, performing technical tasks.
RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
RST.6-8.7 Integrate quantitative or technical info expressed in words in a text with a version of that info expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Standards/Unit Goal: WRITING

WHST.6-8.1 (A, B, E) Write arguments focused on discipline-specific content.
WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

**Essential Question(s) addressed in this lesson:**

- Which element is the essential building block to all life on Earth?
- What is the carbon cycle?
- What are the effects of the four main processes of the geological carbon cycle?
- What is the role of human activity in the carbon cycle?
- How can a carbon atom expelled by a dinosaur as $CO_2$ during the Jurassic Period exist and be relevant today?

- Why are scientists and engineers working to understand and rebalance the carbon cycle?

## Objectives:

Science Skill Objectives:

- Illustrate the carbon cycle
- Make a claim utilizing evidence obtained during the experiment

Content Knowledge Objectives:

Upon completion of this lesson, students should be able to:

- Define carbon as a necessary component that supports all forms of life on Earth.
- Describe how it is possible for a carbon atom in a Jurassic dinosaur's breath to be present in a piece of chalk today. (Trace the movement of a carbon atom through the cycle/time)
- Identify and explain ways in which human activity is influencing the carbon cycle.
- Explain why engineers are working to understand and rebalance the carbon cycle**.**

**Language Objectives:** During and upon completion of this lesson, students should be able to:

All Students: CCSS.ELA-Literacy.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.

Levels 1-3:

- With a partner, identify key vocabulary connected to this content area.
- Identify carbon as the element essential to all life on Earth.
- State and/or illustrate the carbon cycle.
- Define and/or provide evidence of global climate change.

Levels 2-4:

- Appropriately use key vocabulary from the reading during the activity with the help of visuals and/or word banks and glossaries.
- Explain how all animals, including humans, are naturally connected to the carbon cycle.
- Explain how human actions affect the carbon cycle beyond their natural connectedness. (How do humans release carbon?)

Levels 3-5:

- Appropriately use key vocabulary from the reading during class discussion.
- Describe how it is possible for a carbon atom in a Jurassic dinosaur's breath to be present in a piece of chalk today.
- Connect, orally and through writing, the effect of human activity on the carbon cycle with the current carbon cycle imbalance that is so concerning to scientists. (How is human disruption of the carbon cycle directly impacting global climate change?)

### Targeted Academic Language:

| Tier 1 | Tier 2 | Tier 3 |
|---|---|---|
| Atom | Atmosphere | Carbon cycle |
| Carbon | Erosion | Carboniferous period |
| Chalk | Global Warming | Fossil Fuels |
| Climate | Product | Jurassic Period |
| Cycle | Reactant | Photosynthesis |
| Element | Respiration | Subduction zone |
| Molecule | (Subduction) | Volcanic activity |
| Oxygen | Weathering | |

### What students should know and be able to do before starting this lesson?

Students should have some familiarity with the *impact of human activity on global climate change.* They should also have been previously introduced to the geologic carbon cycle processes of *subduction and volcanic activity.* It is expected that students have

knowledge of other contributing processes such as *weathering and erosion,* as well as a solid understanding of *photosynthesis and respiration*.

### Anticipated Student Pre-conceptions/Misconceptions:

- Carbon is NOT the element essential to life (Oxygen or water molecules expected responses)
- Their own, individual actions do not contribute to 1) a cycle 2) climate change
- Global Warming may not be/is not happening (that it may still be open to debate)

**Instructional Materials/Resources/Tools :** Note: This exercise requires the expendable materials, estimated cost is ~$1 per student.

One per student:

- splash-proof goggles
- Student Background Reading: *Life of a Carbon Atom* and Dinosaur Breath Worksheet (Univ. of Colorado)

Per group:

- chalk (NOT dustless chalk)
- rolling pin/hammer and hard surface to crush chalk
- 1 small sandwich bag in which to crush chalk
- ¼ cup white vinegar
- 2 small beakers, graduated cylinders, or small glass jars
- baking soda

Shared classroom equipment and supplies:

- digital scales
- paper towels

### Advanced Preparation for Teachers:

- Keep key vocabulary posted in the room as a word bank.
- Prepare sandwich bags in advance by placing 3-4 pieces of regular chalk in each bag.
- Make copies of the reading and activity worksheets, one per student.

- Assign the reading *Life of a Carbon Atom* and have students answer associated questions prior to the activity.
- Pre-assign student working groups (ideally 2-3 students/group but can be managed with 4-5)
- Package the materials for each group in a plastic container to facilitate distribution.

**Instructional Tips/Strategies/Suggestions for Teacher:**

- Do not use dustless chalk.
- Thicker sandwich bags may be better; be prepared for cheaper bags to tear a little.
- Red vinegar will work but may be more likely to stain if spilled.
- A second adult present is suggested when students use hammers/rolling pins.
- A mortar and pestle may be useful, but the chalk should remain in the bag.
- Walk students through the calculation portion of the experiment as needed.
- If scales are too few, stagger the experiment: some students find container mass while others are crushing chalk and vice versa.
- The University of Colorado lesson "Dinosaur Breath" suggests adding sodium bicarbonate to produce a more noticeable reaction (in both the chemistry and the students), but it is not necessary. See their explanation at: teachengineering.org.

**Assessment:**

- The Life of a Carbon Atom and Dinosaur Breath *worksheets* should be completed during and upon completion of the activity.
- Students will conduct a *Think-Pair-Share* discussion within their group, with a *written summary response* to share with the class.
- The teacher will facilitate a *whole class discussion* following group responses. The teacher should also be sure to review the correct answers to the Dinosaur Breath worksheet. Students should take notes and correct any inconsistencies.
- Students will complete a small carbon cycle graphic organizer Exit Ticket as an informal assessment.
- Homework, CER writing: Using the essential questions as a guide, students create a CER connecting the carbon cycle to global climate change. Students should defend writing with evidence from research and experimentation. (See CEPA for details).

**Lesson Details (including but not limited to):**

Lesson Prerequisites: Day 1

- Review Language Objectives with students.

- Pre-assessment - conduct a Write Around: "The carbon cycle is ..."
- See Advanced Preparation for Teachers: students should complete the reading and associated questions prior to activity.
- If time allows, discuss the reading and questions, correcting misconceptions as needed.

**Lesson Opening:** Day 2

- Review Content Knowledge and Science Skills Objectives with students.
- Do Now: MCAS style practice question on the Carbon Cycle
- Review tiered vocabulary as appropriate (Tier 1 & Tier 2 Cross-Curricular terms) with a Sentence Frame Admit Ticket. Students may use posted word bank terms.
- Remind students of the reading and questions from the *Life of a Carbon Atom* handout.

**During the Lesson:** Activity, Day 2

Conduct the experiment to examine how carbon changes form, and to calculate how much is released into the atmosphere.

- Distribute the Dinosaur Breath worksheet. Together with students, read instructions.
- Distribute experiment materials: goggles, chalk, rolling pin, hammer, glassware.
- At teachers cue, students should begin the experiment, following the instructions on the worksheet:

1. Label Container #1 and Container #2, and illustrate set up on the worksheet.
2. Using a hammer or rolling pin, smash the chalk into small bits within the bag, first making sure the bag is sealed.
3. Add 1 tablespoon of baking soda into the bag and mix with the chalk bits.
4. Measure the mass of both glass containers and/or graduated cylinders while they are empty, making sure to record.
5. Fill Container #1 with the chalk/baking soda mixture, find the mass, and record.
6. Fill Container #2 with ¼ c vinegar, find the mass, and record.
7. Subtract the mass of Container #1 empty from the mass of Container #1 filled with the chalk/baking soda mixture to obtain the mass of just the chalk/baking soda mixture. Record.

8. Subtract the mass of Container #2 empty from the mass of Container #2 filled with vinegar to obtain the mass of just the vinegar. Record.
9. Add the mass of chalk/baking soda mixture and vinegar to get the mass of the products before the reaction. Record.
10. Pour the vinegar in Container #2 into the chalk/baking soda mixture and mix. Allow a minute or so for the reaction to take place. (Note: chalk + vinegar = CO2 [exhaled dinosaur breath] + water + calcium compound.)
11. After about a minute has passed, measure the mass of the reactant products.
12. Record the mass of the reaction products (water + calcium carbonate in Container #1). Remember to subtract out the mass of Container #1 when empty. (Note: the mass of the reaction products should be less than the original combined mass of Container #1 and Container #2. This is because the chemical reaction between the calcium carbonate and the vinegar released some of the carbon that was stored in the chalk into the atmosphere.)
13. Subtract the mass of the reactant products from the combined mass of the products before the reaction to estimate how much of the carbon was converted to gas. Record.

**Lesson Closing:**

- Complete the Dinosaur Breath worksheet (see Assessment).
- Think-Pair-Share group discussions (see Assessment).
- Teacher led class discussion and review of answers.
- Exit Ticket: fill in small graphic organizer of the carbon cycle.

**SUGGESTED ACTIVITIES**:

Extensions and Reinforcement:

- Determine prior knowledge: Write Around questions, i.e. What is the carbon cycle?
- Review Carbon Cycle: Class discussion and create graphic organizer/study guide.
- Technical Writing: Design a stepwise lesson plan and explanation of the carbon cycle that could be used to instruct elementary school students.

- Creative Writing: story/journal of time travel through the life of a carbon atom.
- Intercurricular Connections: Construct a "Timeline of Earth's History" with skills and content in math, history, science, technology, engineering, and art highlighting key events that involve the presence of carbon, the development of the carbon cycle, the introduction of oxygen, and the beginning of life on Earth.
- Advanced connections: Create a Venn diagram comparing the geologic vs. biologic carbon cycles. Use the collected information to write an explanation of their roles.
- Reading: Student Science News, *Recycling the Dead* (with Word Search and Questions)
  Student Science News, *How People Have Been Shaping the Earth*
- Video: Crash Course with Hank Green, The Global Carbon Cycle, Crash Course #46
  NASA: Keeping Up With Carbon
  An Inconvenient Truth, Davis Guggenheim, 2006.

# List of Lesson Resources

**List and include resources by lesson sequence:**

*Prior Knowledge required:* Life of a Carbon Atom reading, questions, and answers .doc and .pdf formats.

*Lesson Opening:* Do Now: Sample MCAS Test Item, (Grade 10 Biology, Feb. 2011)

Cellular respiration, decomposition, combustion, and photosynthesis are processes that drive which of the following cycles in ecosystems?

A. the carbon cycle
B. the nitrogen cycle
C. the phosphorus cycle
D. the water cycle

*Lesson Materials/Activity:* Dinosaur Breath activity with worksheet, questions, and answers .doc and .pdf formats.

*Lesson Closing:* Sample Exit Ticket

Sample Carbon Cycle Graphic

*Homework:* Sample CER
Sample CER Rubric, See Boston University Project Glacier, Forest to Sea Curriculum, page 32.

Resources for Extension/Reinforcement:

- Integrated Teaching and Learning Program at the University of Colorado Boulder, College of Engineering: Hands-on Activity, Dinosaur Breath. (https://www.teachengineering.org/)
- Boston University Project GLACIER, Global Change Initiative: Education and Research Resources
- Student Science News, *Recycling the Dead* (with Word Search and Questions)

- Student Science News, *How People Have Been Shaping the Earth*
- Crash Course, The Global Carbon Cycle, Crash Course #46
- NASA: Keeping Up With Carbon
- An Inconvenient Truth, Davis Guggenheim, 2006.

# Curriculum Embedded Performance Assessment (CEPA)

**A. CCSS.ELA-Literacy.SL.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.

a. Pre-assessment - conduct a Write Around: "The carbon cycle is ..."
b. Completion of Dinosaur Breath lab activity.
c. Think-Pair-Share group discussions.
d. Teacher led class discussion and review of answers.

**B. CCSS.ELA-Literacy.RST.6-8.2** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

a. Read the background information and answer the associated questions prior to the activity. Answer key attached.
b. Complete the Dinosaur Breath worksheet. Answer Key attached.

C. **CCSS.ELA-Literacy.RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
    **a.** Complete the Dinosaur Breath worksheet. Answer Key attached.
D. **CCSS.ELA-Literacy.RST.6-8.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
    a. Read the background information and answer the associated questions prior to the activity. Answer key attached.
    b. Sentence Frame Admit Ticket.
E. **CCSS.ELA-Literacy.RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
    a. Exit Ticket: carbon cycle graphic organizer/diagram.
F. **CCSS.ELA-Literacy.WHST.6-8.1** Write arguments focused on discipline-specific content. This includes :

    **CCSS.ELA-Literacy.WHST.6-8.1A** Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

    **CCSS.ELA-LITERACY.WHST.6-8.1.B** Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

    **CCSS.ELA-LITERACY.WHST.6-8.1. E** Provide a concluding statement or section that follows from and supports the argument presented.

    a. Homework: Upon completion of this activity, students create a CER connecting the carbon cycle to global climate change. They will use the information gathered through reading and research to make a Claim about the carbon cycle as it relates to global climate change, provide Evidence from their experience and/or additional research, and defend their Reasoning with scientific argument. Written discussion should include lesson essential questions such as why scientists are working to rebalance the carbon cycle and the connection between the natural role of humans in the carbon cycle as compared to those human activities contributing to the atmospheric imbalance. The teacher should remind students of these essential questions, as well as the curriculum content and language objectives. This assignment will serve as a study guide for future traditional open response assessment and standardized test preparation.

**G.** **CCSS.ELA-Literacy.WHST.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

a. Life of a Carbon Atom worksheet portion: questions/open response writing. Answer Key attached.
b. Complete the Dinosaur Breath worksheet. Answer Key attached.

**H**. **CCSS.ELA-Literacy.WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research.

a. *Life of a Carbon Atom* questions/open response writing. Answer Key attached.
b. Complete the Dinosaur Breath worksheet. Answer Key attached.
c. Think-Pair-Share group discussions and written summary responses.
d. Homework: CER Writing. (See F-a above).

# Lesson 2: Glaciers

By Fellow Andrew Christ and Teacher Eric Hazlinsky, SY2014-2015

**Brief Overview of Lesson (what this lesson is about):** Students will explore the relationship between elevation and latitude of glaciers using Google Earth.

**Prior Knowledge Required:** Familiarity with metric units, latitude and longitude, and Google Earth.

**Estimated Time (minutes):** Two 50 minute class periods.

**Resources for Lesson (list resources and materials):**

- The Glacier World Tour Handout
- Computer/Internet access
- Glacier World Tour KMZ file (contact Andrew Christ)

## Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson #2: Glacier World Tour

By Fellow Andrew Christ and Teacher Eric Hazlinsky, SY2014-2015

**Time (minutes):** 2 days

**Overview of the Lesson:** In this exercise, students will travel to the various environments on Earth where glacial ice exists using Google Earth. Students will import a file of locations on Earth where glaciers can be found and will have to use Google Earth to find the elevation and latitude of each glacier. Then the students will graph elevation vs. latitude to look for trends where glaciers can be found and why.

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

Standards/Unit Goal: SCIENCE

MS-ES 3.2 Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events.

Standards/Unit Goal:  READING

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Standards/Unit Goal: WRITING

WHST.6-8.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

### Essential Question(s) addressed in this lesson:

- Where on Earth can you find glaciers?
- What about these locations allow glaciers to form?

### Objectives:

Science Skill Objectives:

- Students will use Google Earth to acquire data.
- Students will graph the data.
- Students will analyze the data.
- Students will make a claim about the data.

Content Knowledge Objectives:

Upon completion of this lesson, students should be able to:

- Understand that glaciers can be found throughout the world, as long as conditions are correct. At low latitudes they are found only at high elevations and as latitudes get higher glaciers can be found at all elevations.

**Language Objectives:** During and upon completion of this lesson, students should be able to:

Levels 1-3:

· Writing: Label pictures and graphs.

· Reading: Match content–related objects/pictures to words.

Levels 2-4:

· Listening:

- Follow multi-step oral commands/instructions.
- Sequence visuals per oral directions.

· Writing:

- Connect simple sentences.
- Complete graphic organizers/forms with personal information.

Levels 3-5:

· Reading:

- Differentiate between fact and opinion.
- Answer questions about explicit information in texts.

- Use English dictionaries and glossaries.

· Writing:

- Produce short paragraphs with main ideas and some details (e.g., column notes).
- Create compound sentences (e.g., with conjunctions).
- Explain steps in problem-solving.

**Targeted Academic Language:**

| Tier 1 | Tier 2 | Tier 3 |
|---|---|---|
| Gentle | Elevation | Latitude |
| | Moderate | Longitude |
| | Slope | |
| | Steep | |
| | Variable | |

**What students should know and be able to do before starting this lesson?**

· Students should have a basic understanding of Google Earth.

· Students should be familiar with latitude and longitude.

· Students should follow directions to make sure everything is in the correct units.

**Anticipated Student Pre-conceptions/Misconceptions:**

· Students tend to assume that glaciers can only be found near the poles.

**Instructional Materials/Resources/Tools :**

- The Glacier World Tour Handout, one per student
- Computer/Internet access
- Glacier World Tour KMZ file (contact Andrew Christ)

**Instructional Tips/Strategies/Suggestions for Teacher:**

Quick Tips on how to use Google Earth.

- Zoom in/out: scroll up/down on the track pad. You can also double click.
- Coordinates (longitude/latitude) & Elevation: these can be found in the lower right-hand corner of the Google Earth window.
- Change viewing angle: Shift + up/down arrow or Ctrl + up/down arrow.
- Google Earth Tour: expand the folder labeled "Glacier World Tour." A list of yellow thumbtacks and locations will appear.

**Assessment:**

- The Glacier World Tour Handout
  - -Data collection
  - -Graphing
  - -CER writing
- Completion of the entire three-part Glacier Unit culminates in a student presentation.

**Lesson Details (including but not limited to):**

Lesson Opening: This mapping activity is the second lesson of a three-part glacier unit. For a more in depth exploration of glaciers, refer to the Boston University GLACIER website of Andrew Christ.

- Part I: Power Point lecture on glaciers : note taking activity including definition, formation, flow, dynamics, and landscapes.
- **Part II: Glacier World Tour: Locating glaciers on the globe, plotting latitude vs. elevation for glaciers, navigating Google Earth as a digital learning tool.**
- Part III: Glacier Modeling Lab: modeling glacial flow with gak - a hands-on activity exploring factors that affect glacial flow. Culminates in a class presentation.

Activity:

Glacier World Tour:

- Review the use of latitude and longitude in mapping.
- Instruct all students on setting Google Earth to metric units: In the menu bar navigate to Tools -> Options -> select decimal degrees for latitude/longitude and Meters/Kilometers for units of measurement.
- Distribute The Glacier World Tour handout, one per student.
- Following the directions on the Glacier World Tour handout and suggestions above, walk students through finding the first few glaciers using Google Earth.
    - Click the yellow thumbtacks to travel to the location.
    - Once the program has zoomed and steadied on the first location press "pause".
    - Explore the area! Look at pictures posted on Google Earth in the area.
- Once you have the information for a location, click on the next thumbtack.
- Have students complete the table for each location using information found and observed using Google Earth. Collect:
    - Latitude
    - Elevation
    - Continent
- Have students make a scatter plot of the latitude (x-axis) and elevation (y-axis) for each glacier.

Lesson Closing:

Students should complete The Glacier World Tour Handout by writing a CER on the relationship between the elevation and latitude of glaciers.

# List of Lesson Resources

**List and include resources by lesson sequence:**

*Prior Knowledge required:* Review Latitude/Longitude, and complete glacier note taking activity.
See Boston University GLACIER website of Andrew Christ.

*Lesson Materials/Activity:* The Glacier World Tour Handout
Glacier World Tour KMZ file (contact Andrew Christ)

*Lesson Closing:* The Glacier World Tour Handout

Resources for Extension/Reinforcement:

- Lesson Extensions, Boston University GLACIER website of Andrew Christ
- Earth Labs: Make a Glacier
- The Boston Globe: *Watch the Arctic get smaller via National Geographic Maps*
- Student Science News, *Glaciers on Ice - For Now*

# Curriculum Embedded Performance Assessment (CEPA)

A. **CCSS.ELA-Literacy.RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
    a. Graphing

B. **CCSS.ELA-Literacy.WHST.6-8.6** Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.
    a. Data collection
    b. Graphing
    c. CER writing

# Lesson 3: Sea Level Rise

By Fellow JanMarie Andersen and Teacher Stephanie Pottinger, SY2014-2015

**Brief Overview of Lesson (what this lesson is about):** Global and Local consequences of sea level rise.

**Prior Knowledge Required:** Causes of global warming and sea level rise

**Estimated Time (minutes):** 5 days

**Resources for Lesson (list resources and materials):**

1. Causes of Global Warming and Sea Level Rise
    a. New England Aquarium Blue Impact Videos
        i. Thermal Expansion
    b. Thermal Expansion Lab Activity
    c. EPA Melting Glaciers
    d. Sea Level Rise Demonstration

2. Global Sea Level Rise
    a. Elevation of any place on Earth

3. Local Sea Level Rise
    a. Topographic Map of nearest coastal area

# Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson 3: Sea Level Rise

By Fellow JanMarie Andersen and Teacher Stephanie Pottinger, SY2014-2015

**Time (minutes):** 5-7 days

**Overview of the Lesson** Students investigate the effects of sea level rise globally- by performing a webquest on various coastal cities and then locally- by constructing a 3D model from a topographic map of a coastal area and predicting sea level rise.

## Standard(s)/Unit Goal(s) to be addressed in this lesson:

Standards/Unit Goal: SCIENCE

MS-ESS 3.5 Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

Standards/Unit Goal: READING

RST.7 Integrate quantitative or technical info expressed in words in a text with a version of that info expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Standards/Unit Goal: WRITING

RST.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

### Essential Question(s) addressed in this lesson:

- What is contributing to the rising of sea levels?
- How will sea level rise affect me?
- What are possible ways to live with sea level rise?

### Objectives

Delineate the causes of sea level rise,  how it will affect coastal communities, and ways to mitigate the effects.

### Language Objectives

**(1-3)** State how sea level rise will affect an area because of global warming using illustrated word banks and sentence frames in pairs.

**(2-4)** Explain how sea level rise will affect a coastal community  because of global warming using sentence frames in pairs.

**(3-5)** Describe global warming and sea level rise and how it will affect coastal communities using graphic organizer in pairs.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Targeted Academic Language** | **Tier 1** | sea | land ice | rise | map | global warming |
| | **Tier 2** | coast | contour map | glacier | temperature | |
| | **Tier 3** | density | water displacement | kinetic energy | thermal expansion | alpine |

### What students should know and be able to do before starting this lesson

- How to read a topographic map
- Be familiar with density and water displacement

- Understand temperature defined as the kinetic energy of molecules- the more energy it has, the more space it will take up

### Anticipated Student Pre-conceptions/Misconceptions

Sea level rise is occurring due to all glaciers- density of ice in water and displacement.

### Instructional Tips/Strategies/Suggestions for Teacher

Thermal expansion and Land Ice could be done as a demonstration or as a separate lesson to ensure prior knowledge acquired as well as New England Aquarium's *Blue Impact* videos.

### Assessment

3D model and map with anticipated Sea Level Rise
Rubric on Project and Expository Essay

### Lesson Details (including but not limited to:)

#### Lesson Opening

1. Prior Knowledge via KWL
2. Go over Tiered vocabulary as do now- matching
3. Fill in the blank/questions on causes of sea level rise

#### During the Lesson

**Part 1 Global Effects**

1. VIDEO: Sea-Level Rise and Coastal Hazards fill out worksheet and read "Further Investigations"

2. Pairs- Activity to find the elevation of any place
3. Calculate how much the sea would have to rise to flood the cities.
4. Discussion
    a. Ask why most cities are located along coasts or rivers
    b. Implications on deltas, marshes, estuaries, and freshwater
    c. Consequences during storm surges
    d. Climate Refugees- populations most affected ie: Hurricane Katrina

**Part 2 Local Effects**

1. Have students choose coastal area from larger contour map and have them "zoom" in and trace on another piece of paper.
2. If students are familiar with the area, have them identify schools, buildings, and streets on the map.
3. Create a 3D Contour Map by cutting out foam pieces, gluing it together. Add the landmarks and place it into a plastic container.
4. Add water in increments of 1cm to represent a 2ft sea level rise; Color it in on the traced map with different colors and add color coded legend.
5. Complete Table summarizing what was affected at each stage of sea level rise and answer questions

**Lesson Closing**

1. Complete -L- on KWL chart
2. Create design solutions to mitigate effects of sea level rise- suggest www.bostonlivingwithwater.org for ideas
3. Writing- Expository essay on Causes and Effects of Sea level Rise and Possible Adaptations

# List of Lesson Resources

**List and include resources by lesson sequence**

*Prior Knowledge required:*Causes of Global Warming and Sea Level Rise

a. New England Aquarium Videos
    i. Thermal Expansion video
b. Thermal Expansion Lab Activity
c. Melting Glaciers
d. Sea Level Rise Demonstrations

*Lesson materials*

A. Global Sea Level Rise worksheet
    a. Go to www.altitude.nu and accompanying worksheet
B. Local Sea Level Rise
    a. Topographic Map of nearest coastal area
    b. Foam, plastic tray, ruler, markers
    c. Follow up table and questions
C. Project and Essay- www.bostonlivingwithwater.org

# Curriculum Embedded Performance Assessment (CEPA)

C. **CCSS.ELA-Literacy.WHST.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

   a. **Explanatory Essay Prompt-** Discuss the causes, effects, and possible solutions to sea level rise.
   b. Electronic Essay Map
   c. Expository Essay Rubric

A. **CCSS.ELA-Literacy.SL.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.
   a. **Socratic Seminar-** Is it the moral obligation of developed countries to take care of climate change?
      i. Suggested text- NY Times Opinion Pages- Global Warming and the Developing World
   b. Socratic Seminar Outline and Rubric

# Lesson 4: Phenology

By Fellow Swati Carr and Teacher Marianne Marks, SY 2014-2015

**Brief Overview of Lesson (what this lesson is about):** Studying Phenology through Leaf Drop Dates

**Prior Knowledge Required:** Understand the importance of data collection over time; Estimate percentages; Identify local trees in broad groups (oak, maple etc.)

**Estimated Time (minutes):** 8 weeks (10 mins each week for student and 10 mins for class check-in)

**Resources for Lesson (list resources and materials):**

A. Climate vs Weather worksheet
B. Phenology Introduction Worksheet
C. Walden Warming Excerpt
D. Procedure
E. Data Collection Tracking
F. national phenology database

# MA Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson 4 Phenology

By Fellow Swati Carr and Teacher Marianne Marks, SY 2014-2015

**Time (minutes):** Oct-November (leaf drop times in North America/northern hemisphere)- Two days for introduction and project instructions; 8-10 weeks (5-10 minutes each week of data collection each week) for project.

**Overview of the Lesson** Students pick one tree in the fall and track its loss of leaves by visual estimation (photographing and estimating percentage of leaves still on the tree) each week for 8-10 weeks to see when the tree loses all its leaves (or they are all dead on the tree). This is then compared against historic data sets by submitting to a national phenology database.

## Standard(s)/Unit Goal(s) to be addressed in this lesson:

Standards/Unit Goal: SCIENCE

MS-LS 2.1 Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth and number of organisms., Collect and compile a data set for comparison against historic climate data sets.

Standards/Unit Goal: READING

RST.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Standards/Unit Goal: WRITING

RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

## Essential Question(s) addressed in this lesson:

- How do scientists even know that our climate is changing…that the Earth is getting warmer?
- As a general trend, if trees lose all their leaves earlier in the year than they did 150 years ago before the Industrial Revolution, what conclusions can we draw about our climate?
- How would trees losing their leaves earlier and re-budding earlier in the year change the cycling of atmospheric CO2 in the Northern Hemisphere?

## Objectives

Skill Objectives

- Utilize data collection techniques and compare to another data set
- Test a hypothesis and observe evidence of climate change in their native location (as opposed to the poles which they cannot really relate to)

Knowledge Objectives

- Differentiate between climate and weather.
- Testing a hypothesis by data set comparison
- Understand that Climate change is happening everywhere, even where they live

## Language Objectives

**(1-3)** Identify evidence of warming of the Earth by the leaf drop date through graphic representations and narrative support in groups.

**(2-4)** Describe the importance of carbon and its influence in climate through sentence frames and vocabulary word banks in groups.

**(3-5)** Explain the comparison of trends in phenological data and graphs as evidence of a changing climate with a graphic organizer and rubric in pairs .

**Targeted Academic Language** **Tier 1** data leaf/leaves seasons weather warm

**Tier 2** climate weather carbon evidence average

**Tier 3** phenology percent climate change trend procedure

**What students should know and be able to do before starting this lesson** Estimate percentages, identify local trees in broad groups (oak, maple etc.)

**Anticipated Student Pre-conceptions/Misconceptions** (1) Weather and Climate mean the same thing
(2) All trees drop their leaves at the same time
(3) Trees drop their leaves at the same time of the year in a place irrespective of climate
(4) Only scientists can collect useful data

**Instructional Materials/Resources/Tools** A cell-phone camera or similar

**Instructional Tips/Strategies/Suggestions for Teacher** (1) Take them outside to practise estimating the percentage of leaves of a tree (2) Have the student put in their own data into a national phenology database during class.

### Assessment

- Answer Essential Questions
- Formal Lab Report
- Poster/Powerpoint Presentation

### Lesson Details (including but not limited to:)

#### Lesson Opening

G. Climate vs Weather worksheet

a. How do scientists even know that our climate is changing…that the Earth is getting warmer? Warmer than what? If you had two cups of coffee — one hotter than the other — and you had to tell by how hotter the first was compared to the second, how would you find out? What would you do? What information do you need?

b. (Allow the students to suggest that they would compare temperatures. Use the board to help students keep track of the process.)

c. Now take a look at the picture below. What time in the year do trees look like they have absolutely no leaves? When do trees have flowers and new leaves? How is the temperature different at these four times of the year?

d. Data Analysis of Graphs- The Cycling of C02 levels in the atmosphere by month of year

**During the Lesson**

A. Phenology Introduction Worksheet

a. Can you think of something else in nature that changes when seasons change (class discussion; teacher should lead with an example (bird migration or animal life cycles, for example).

i. How do trees know when to drop their leaves? How do birds know when to migrate, or animals when to go into hibernation or when to reproduce? (Drive home the point that these changes take place because plants, animals and birds respond to temperature.)

b. **Definition:** Phenology is the study of how plant and animal life cycles change with the changes in climate, especially seasonal variations in temperature. (Have the students mark this as important.)

c. Look at some examples of phenology together (use Phenology Student worksheet)

d. To find evidence that the climate is changing, scientists have to do what you just did a little while ago. They have to compare. To see if the Earth is getting warmer, scientists find old records of temperature from 100 years ago and compare it to temperatures today. To compare if climate is changing, scientists track when the seasons change now and compare it to when seasons changed more than 100 years ago.

i. How do scientists know when seasons are changing?

1. Observations of trees have dropped all their leaves (season goes from fall to winter) or when flower buds first appear on trees/plants (winter to spring).
2. Observations of bird migration or when animals go into hibernation or when they come out of hibernation and start reproducing.

ii. Why is it not enough to collect evidence for just 1 year?

1. Read Walden Warming Excerpt
2. Remind students about weather vs climate and how one winter can be much colder or warmer than the next so reliable comparisons can only be made when several years' worth of data is collected and averages are taken.

B. Phenology Project

a. Students pick one tree in the fall and track its loss of leaves by visual estimation (photographing and estimating percentage of leaves still on the tree) each week for 8-10 weeks to see when the tree loses all its leaves (or they are all dead on the tree).

i. Procedure

ii. Data Collection Tracking

iii. Compare it against historic data sets by submitting to a national phenology database.

## Lesson Closing

A. Answer Essential Questions

B. Write Formal Lab Report

C. Create presentation explaining results (poster session)

# Curriculum Embedded Performance Assessment (CEPA)

A. **CCSS.ELA-Literacy.WHST.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
   a. **Formal Lab Report-** On Drive, create a formal lab report
   b. Formal Lab Report Rubric

A. **CCSS.ELA-Literacy.SL.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.
   a. Create a Poster/Powerpoint about this project using the rubric as a guide
   b. Poster/Powerpoint Rubric

# Lesson 5: Energy Audits

By Fellow Dustin Hickey and Teacher Wendy Hanlon, SY2014-2015

**Brief Overview of Lesson (what this lesson is about):** Students will analyze personal and family energy usage and conduct a home energy audit. Topics include energy, energy choices, greenhouse gases, and carbon footprints as they pertain to climate change.

## Prior Knowledge Required:

- *Define and describe* energy and energy transformation.
- *Interpret* graphed data.
- *Familiarity* with the impact of human activity on global climate change.

**Estimated Time (minutes):** Five 50 minute class periods (1 week)

## Resources for Lesson (list resources and materials):

- Thermometers
- Lamps (for heat demonstration)
- Various types of light bulbs
- Student/Family Letter sample and Types of Light Bulbs handouts (See Resources).
- Online mapping tool/map of the school neighborhood.
- Student access to home energy use documents is helpful.
- Computer/internet access.
- Robert Kaufmann, Boston University, 2014 Power Point: *Bringing Energy Into the Classroom*.

# MA Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson #5: Energy Audits
By Fellow Dustin Hickey and Teacher Wendy Hanlon, SY2014-2015

**Time (minutes):** Five 50 minute class periods (1 week).

**Overview of the Lesson:** Students will be conducting a home energy audit after analyzing personal and family energy usage as review of energy and as an introduction to energy choices, greenhouse gases, & carbon footprints as they pertain to climate change.

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

Standards/Unit Goal: SCIENCE

MS-ES 3.4 Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per capita consumption of natural resources on the environment.
MS-ES 3.5 Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

Standards/Unit Goal: READING

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, performing technical tasks.
RST.6-8.7 Integrate quantitative or technical info expressed in words in a text with a version of that info expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Standards/Unit Goal:  WRITING

WHST.6-8.1 Write arguments focused on discipline-specific content.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

## Essential Question(s) addressed in this lesson:

- What makes things hot?
- How can individuals monitor and modify their energy use choices?
- How are energy use choices impacting Earth's climate?

## Objectives:

Science Skill Objectives:

- Evaluate energy choices made by themselves and their family through an energy audit.
- Describe the greenhouse effect and its implications on global climate change.
- Communicate multiple changes they can make to reduce their carbon footprint.

Content Knowledge Objectives:

Upon completion of this lesson, students should be able to:

- Understand different types of energy and their efficiencies: Compare and contrast fossil fuels vs. sustainable energy.
- Explain how the use of carbon-based fossil fuels contribute to the greenhouse effect and climate change.
- Know that industrial nations contribute the most $CO_2$ to the atmosphere resulting in increased global changes.  Students should be able to identify some of these nations.
- State that an energy audit is an analysis of energy use that can be used to inform future energy use choices.  Students should be able to describe the process of conducting an energy audit, and provide real examples of how it can be useful.
- Understand and explain what options they have to reduce energy use by themselves and with their family.

**Language Objectives:** During and upon completion of this lesson, students should be able to:

All Students: CCSS.ELA-Literacy.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.

Levels 1-3:

- With a partner, identify key vocabulary connected to this content area.
- In their own words, define "heat."
- List/identify fossil fuels used in their own home, including how to monitor usage (i.e. read the electric bill).
- Identify two industrial nations that contribute the most $CO_2$ to the atmosphere.
- State and/or illustrate the greenhouse effect.

Levels 2-4:

- Appropriately use key vocabulary from the reading during the activity with the help of visuals and/or word banks and glossaries.
- Demonstrate the process of heat transfer through writing and/or illustration.
- In a small group, identify types of fossils fuels and sustainable energy sources.
- State two personal behaviors they could change to reduce energy use.
- Communicate the concept, value, and process of conducting a home energy audit to their families using visuals, handouts, and physically identifying energy sources at home.

Levels 3-5:

- Appropriately use key vocabulary during class discussion and while conducting the energy audit.
- Orally and in writing, compare and contrast fossil fuels vs. sustainable energy using word banks, visuals, and glossaries as needed.
- Evaluate and compare the energy usages of the world's largest $CO_2$ producing nations.

- Describe, orally and through writing, the concept, value, and process of conducting a home energy audit.
- Connect, orally and through writing, the affect of human activity on the greenhouse effect.
  (How is human energy use directly impacting Earth's climate?)

**Targeted Academic Language:**

| Tier 1 | Tier 2 | Tier 3 |
|---|---|---|
| Climate | Audit | Carbon-based fossil fuels |
| Option | Efficient | Thermodynamic |
| Renew | Evaluate | |
| | Greenhouse | |
| | Industrial | |

**What students should know and be able to do before starting this lesson?**

Students should be able to define energy prior to this activity. They should also be able to describe energy transformation and interpret graphed data.

**Anticipated Student Pre-conceptions/Misconceptions:**

Students may have preconceptions/misconceptions about climate change, specifically:

- Is Earth's overall temperature is rising?
- Confusion about greenhouse gases ($CO_2$ vs. ozone)
- What fossil fuels are and their role in climate change

- Options to reduce carbon footprint

### Instructional Materials/Resources/Tools:

- Thermometers
- Lamps (for heat demonstration)
- Various types of light bulbs
- Student/Family Letter sample
- Types of Light Bulbs handout
- Online mapping tool/map of the school neighborhood.
- Student access to home energy use documents is helpful.
- Computer/internet access.
- Robert Kaufmann, Boston University, 2014 Power Point: *Bringing Energy Into the Classroom*

### Advanced Preparation for Teachers:

- Copy handouts in advance.
- Send home the Student/Family letter at least a week before beginning the activity.
- Begin to accumulate types of bulbs for demonstration/identification.
- Set up lamp with thermometer attached.

### Instructional Tips/Strategies/Suggestions for Teacher:

- Engage students and families via a letter informing and requesting information for the home energy audit.
- Include activities/assignments that require family engagement throughout the lesson.

**Assessment:**

1. Reducing Our Carbon Footprint assignment:

For this assignment students are given the definition for carbon footprint from the Time for Change website, then are asked to respond to the following prompt:

Identify 10 ways you individually and as a family could reduce your carbon footprint. Use detailed sentences that identify the actions you will take and describe how the actions would result in the reduction of your carbon footprint.

(Optional addition to the directions: If you are unable to identify 10 ideas on your own and by discussing this assignment with your family you may use the internet as a resource BUT you must include the citation for sources used.)

2. Open-Response Question:

Mrs. _____likes Hawaiian pineapple and drives to her local grocery store to purchase one. Draw the path of fossil fuel use that will contribute to her carbon footprint (emissions) as a result of her decision to buy the pineapple in _____(your hometown).

3. Create a model that includes images and detailed captions to clearly identify all sources of $CO_2$ gas being added to the atmosphere.

**Lesson Details (including but not limited to:)**

**Lesson Opening:**

A. What Makes Things Hot? Light Bulbs and Efficiency

- Introduction to Forms of Energy - renewable vs. non-renewable
  Through demonstration and investigation students compare the efficiency of traditional incandescent, compact fluorescent (CFL), and light-emitting diode (LED) light bulbs.
- Students identify which bulb gives off most heat. A thermometer will be attached to a lamp to collect quantitative data. Focus should be paid to the heat emitted by the bulbs as well as the light quality.
- The teacher will lead a discussion on energy transformation and efficiency. Ask students, "What does heat given off by the light bulb tell us about the energy use if all 3 bulbs give off the same amount of light?"
- Identify properties of 3 bulb types. Provide the *Types of Light Bulbs* handout with specifications for the light bulb types for use during follow-up analysis of investigation results.
- Use Power Point or other visuals to review concepts:
  - What is energy?
  - Types of energy
  - Energy transformation
- Introduce renewable vs. non-renewable energy sources, problems caused by fossil fuel use, greenhouse gases, and the greenhouse effect.

B. Modes of Transportation: calculating the ecological footprint of transportation.

- Present *Bringing Energy Into the Classroom,* Robert Kaufmann, Boston University, 2014 Power Point.
- Display a close-up map of school with a 5-mile radius for use with this activity. Have students estimate the distance from home to school via roads.
- Guide students through the completion of this part of the audit worksheet to calculate their energy use traveling to and from school each day. Encourage students to share their work with family members who can then calculate the family transportation footprint.

## During the Lesson

C. CAS Home Energy Audit:

- Present *Bringing Energy Into the Classroom,* Robert Kaufmann, Boston University, 2014 Power Point.
- Review of this homework assignment will reveal areas where families could reduce energy consumption and save money. Focus on the monetary savings as an incentive to be environmentally responsible.
- Homework: Students and their families work together to complete Home Energy Audit (simple audit). This document from the California Academy of Sciences is available in English and Chinese. See additional options below in "Resources."

D. Home Energy Audit- data entry and analysis:

- Guide students through the entry of information provided by students/families or a set of data provided by teacher (gas, electric, home heating bills, & home square footage) on a paper copy of the Home Energy Audit paper format.
- Enter information to excel spreadsheet of Home Energy Audit for automatic calculation. Print copy for students to take home.
- Homework: Share results with family. Family discussion of changes that could influence carbon-based fuel use/dependency, as well as save money.
- Analyze and discuss the results of sample data, what each piece of information represents.
- Guide a discussion on how it might help inform family energy decisions for the future, EX: choice for lighting, solar energy availability, electronic use, etc.
- Reading Comprehension Assignment -Greenhouse Effect & Global Warming.

E. Greenhouse Effect & Carbon Footprint Calculator

- What is the Greenhouse Effect? Discussion, follow-up on reading assignment, and lecture with visuals (there are many resources for visuals located online).
- Who produces the most $CO_2$ emissions?
- List the top five $CO_2$ producing nations. Lead off with a small group/table group discussing and recording on paper/white board. Groups will share results on the board while projecting a map of the world.
- Follow-up discussion: Why were these countries the top 5? What do they have in common?
- YouTube videos & discussion:
  - What's the Deal with Carbon?
  - simpleshow explains the Carbon Footprint.
- Students explore Carbon Footprint Calculators: Direct students to specific calculator(s) of your choice from the multiple sources on the internet.

**Lesson Closing:**

F. Wrap- Up:

- What have we learned and what can we do?

**SUGGESTED ACTIVITIES:**

Extensions and Reinforcement:

- Determine prior knowledge: Write Around questions, i.e. What is the heat?
- Review the Greenhouse Effect: Class discussion, create graphic organizer/study guide.
- Technical Writing: Draft a contract proposal to parents showing calculated projected savings with home energy conservation. What could a family do with that money?
- Creative Writing: story/journal of energy through time.
- Intercurricular Connections: Construct a "Timeline of Earth's History" with skills and content in math, history, science, technology, engineering, and art highlighting key events on the evolution of energy use before and after human existence.

- Advanced connections: Perform an energy audit of the classroom or entire school.
- Reading: Student Science News, *Cold House, Hot House, Green House* (with Word Search, Questions, and Additional Information).
- Video: Crash Course World History with Stan Muller (for Hank and John Green), *Humans and Energy*, #207

# List of Unit Resources

**List and include resources by lesson sequence:**

There are many resources available online. Below are a few that you may find helpful.

*Prior Action required:* Student/Family Letter sample

*Lesson Opening:* Types of Lightbulbs handout

Boston University Project GLACIER, Global Change Initiative: Education and Research Presentations
- Robert Kaufmann, Boston University, 2014 Power Point: *Bringing Energy Into the Classroom*

Online mapping tool

*Lesson Materials/Activity:* Boston University Project GLACIER, Global Change Initiative: Education and Research http://gk12glacier.bu.edu/pages/resources/presentations.php
- Robert Kaufmann, Boston University, 2014 Power Point: *Bringing Energy Into the Classroom*

What's the Deal with Carbon? By Bell Museum

simpleshow explains the Carbon Footprint by simpleshow

*Assessment:* Research for Writing Prompt, Time for Change: Carbon Footprint

Resources for Extension/Reinforcement:

Boston University Project GLACIER, Global Change Initiative: Education and Research Presentations

- Michael Gevelber, Boston University, 2014 Power Point: *Achieving Energy Efficiency in Buildings*

California Academy of Sciences Home Energy Audit and associated energy lesson plans by The Green Ninja

Alternative Home Energy Audit: Energy Quest, California Energy Commission

Student Science News, *Cold House, Hot House, Green House* (with Word Search, Questions, and Additional Information).

Energy Hog Home Scavenger Hunt. Also see Energy Hog's games, activities, and other resources for kids and educators.

# Curriculum Embedded Performance Assessment (CEPA)

A. **CCSS.ELA-Literacy.RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
B. **CCSS.ELA-Literacy.RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
C. **CCSS.ELA-Literacy.SL.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly.
    a. Light bulb data collection and class discussion.
    b. Map calculations and travel audit, home and school discussions.
    c. Home Energy Audit.
    d. $CO_2$ producing nations, YouTube video discussions.
    e. Wrap Up - review.
D. **CCSS.ELA-Literacy.WHST.6-8.1** Write arguments focused on discipline-specific content.
E. **CCSS.ELA-Literacy.WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research.

# Lesson 6: Climate Solutions

By Fellow Ben Thompson and Teacher Djems Domerson, SY 2014-2015

**Brief Overview of Lesson (what this lesson is about):** Students will be modeling a fishery with MnMs, as an example of a general environmental problem and learn the importance of data analysis via graphs to encourage policy making.

**Prior Knowledge Required:** Familiarity with Climate Change

**Estimated Time (minutes):** Two 60 minute class periods

**Resources for Lesson (list resources and materials):**

- Projector (or you could print out the graphs, the most important part of the presentation)
- Plates
- Cups
- Straws
- MnMs

- Powerpoint

## MA Model Curriculum Lesson Plan

**Lesson Number and Name:** Lesson 6: Climate Solutions

By Fellow Ben Thompson and Teacher Djems Domerson, SY 2014-2015

**Time (minutes):** 2 Class Periods

### Overview of the Lesson

Students will look at the concept of the global carbon budget. They will then learn how to make, read, and interpret a graph, determine what makes a good graph, and look at various ways to address climate change.

### Standard(s)/Unit Goal(s) to be addressed in this lesson:

Standards/Unit Goal: SCIENCE

MS-ESS 3.4 Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per capita consumption of natural resources on the environment.

Standards/Unit Goal: MATHEMATICS

CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.

**Essential Question(s) addressed in this lesson:** How can graphs be used to represent data? How can graphs be used as evidence of climate change?

## Objectives

- Analyze and construct line and pie graphs.
- Appreciate the importance of quantification and graphs in policy analysis.
- Identify several approaches to addressing climate change.
- Recognize the importance of cooperation in addressing climate change.

## Language Objectives

**(1-3)** State  a way humans activities can ease the negative impact of natural resources using oral language and pictures in groups of L1.

**(2-4)** Verify the importance of human activities can ease the negative impact of natural resources using pictures and a graphic organizer with a word bank.

**(3-5)** Rationalize the importance of human activities can ease the negative impact of natural resources using a graphic organizer.

| | | |
|---|---|---|
| **Targeted Academic Language** | **Tier 1** | fishing fish population natural nature resource |
| | **Tier 2** | natural resource environment data technology |
| | **Tier 3** | globalization policy climate change |

## What students should know and be able to do before starting this lesson

- Some background on climate change and importance of mitigating it.
- Familiarity with interpreting data from a graph.

## Anticipated Student Pre-conceptions/Misconceptions

There is an infinite, discrete amount of GHGs that can be released this century, when there is a finite amount.

### Instructional Materials/Resources/Tools

### Instructional Tips/Strategies/Suggestions for Teacher

Test out the straws and suction of the MnMs beforehand then adjust the parameters to achieve the desired results.

### Assessment

Constructed graphs from activity with a data analysis of the data.

### Lesson Details (including but not limited to:)

#### Lesson Opening

A. Do Now- Round Robin of graphs that are on presentation
    a. Have students note down various observations of graphs
    b. Then have students circulate to see other groups' analysis and note down comments
B. Run through this presentation with the students along with printed out graphs
    a. There are notes in the presentation describing what to say (and ask!) about for each slide.
    b. The presentation emphasizes the importance of a quantitative approach to solving problems, how to read and critique graphs, and several approaches to addressing climate change.

## During the Lesson

A. Students will work in pairs to "fish" MnMs from their plate.
B. On each plate put 10 MnMs. Give the students 1 min. to fish as many as they can. They are not allowed to use their hands. Tell them they must use the straw and their mouths to suction the MnMs off their plates and into the cups. Some students will realize that by working together two straws can much more easily pick up the MnMs.
C. Have the students record how many MnMs there are, and how many they captured this round, and how many they have captured total. Explain that there is a new fishing season and that the fish have reproduced. Add 2 MnMs to each plate plus two more for each MnM currently on the plate (you may want to put some sort of a max on how many can be on a plate, as there are going to be several iterations of this and if students were really clever they could end up with hundred of MnMs). Additionally add one gummy (fish, worm, bear), but explain that since it is much larger, each gummy will only produce one additional gummy the next round. Give the students another minute. Have them record how many fish and wales (aka gummys) there are, how many they have captured this round, and total. Explain that in the new season fishing technologies have improved and that they may now use their hands. Replenish the fishing stock on each plate and give the students another minute. Have them record their results.
D. If the parameters have been set correctly, students will have realized that they need to show restraint as they fish, so that they can have a good catch next year. We will now try to simulate a "tragedy of the commons" scenario.
E. Explain that technology has advanced even further and that now we can travel the globe to go fishing. Pair up the pairs of students so that they mix their fisheries. Make clear that they are still working separately (aka don't mix the cups).
F. Run through a number of fishing cycles, having the students recording their capture along the way. After each of the cycles you can combine more and more fisheries, increasing the number of people the students will have to negotiate with.

## Lesson Closing

A. Have the students discuss what kind of graph would be most appropriate for the data.

B. Have them make two line graphs one for the gummys and one for the MnMs (this could be for homework)
    a. On each line graph there should be three lines: Population, seasons catch, and total catch.
    b. Discuss with the students how graphs should have titles, a key, and properly labeled axes.
    c. Discuss the different strategies used
C. Talk about how cooperation worked in the later seasons after "globalization." Note the importance of the parameters.
D. Ask-How did the parameters being different for the fish and the wales affect their strategies? Make sure they know that we chose the parameters carefully to try and produce the results we wanted, but that if the parameters had been different, wildly different results could have occurred.

# Curriculum Embedded Performance Assessment (CEPA)

# Climate Resources for Middle School Teachers

Facing the Future's Climate Change: Connections and Solutions is free for download. This free two-week lesson plan PDF encourages students to think critically about climate change and to collaborate to devise solutions.

Here are several freely downloadable climate change lesson plans developed by middle school teachers for middle school:
http://cimss.ssec.wisc.edu/climatechange/nav/lessonplans/index.html

Lehigh University has developed an Environmental Literacy and Inquiry Climate Change middle school curriculum and support materials. The curriculum is freely available at:
http://www.ei.lehigh.edu/eli/cc
The support materials section has different climate change topic background sections. See:
http://www.ei.lehigh.edu/eli/cc/support/index.html

To access the curriculum assessment materials, use:
User ID: eliteacher
Password: 87dja92

Climate.gov's Teaching Climate (formerly 'Education' )offers learning activities and curriculum materials, multi-media resources, and professional development opportunities for formal and informal educators who want to incorporate climate science into their work.

The site provides more than 480 ready-to-use middle school climate education resources that education and subject-matter experts have screened for scientific accuracy, pedagogical soundness, and usability by the CLEAN Review process. These resources are tagged according to grade ranges, science education standards, and climate concepts.

Additionally, the section has a Guide to Teaching Climate Science, the following climate literacy principles are found in the Climate Literacy Framework, and provide scaffolding for teaching climate science. Each principle listed below links to a more detailed description of the topic, as well as a discussion of what makes the topic important, why it can be challenging to teach, suggestions for grade-level specific teaching strategies, and links to relevant teaching materials.

Here's a link to a unit we developed: http://climatechangeandforests.org/curriculum

Our resources at Climate Generation are designed for grades 3-12 and are free to download. We also offer professional development throughout the year for teachers.
http://www.climategen.org/what-we-do/education/

Challenger.org includes lesson plans and an interactive climate modeler that can be used with middle school students.

http://www.challenger.org/sciencechallenges/cc-earth-4-u-online-interactives/

The Challenger Center put out some curriculum and an online carbon cycle interactive a few years ago as part of a NASA grant. Some of the curriculum is on CLEAN.net and all of it is on http://www.challenger.org/resources/for-students/.

Like the ELF resources, they are "sphere" oriented.

Climate Kids (and it has a teacher section on it as well) — http://climatekids.nasa.gov

The CLEAN network and others developed learning pathways based on the National Climate Assessment:
http://www.climate.gov/teaching/2014-national-climate-assessment-resources-educators.

You can browse our recommended educational resources: https://www.climatecommunication.org/resources/#educational-resources Not necessarily specific to middle school, but there are some valuable resources here.

BOOKS AND E-BOOKS

The Story of Climate Change is a Digital Textbook for Middle School (6-8th Grade) Students that is aligned with Next Generation Science Standards and Climate Literacy Science Standards. It is available for download on iTunes:
https://itunes.apple.com/us/book/the-story-of-climate-change/id982104376?mt=13

Climate Change: Discover How It Impacts Spaceship Earth
Examines real studies concerning planetary science, Arctic ice bubbles, and migratory patterns. Kids explore the history of human impact from the Industrial Revolution to our modern-day technology, as well as the innovations underway around the world to address global climate change.

Another resource is a book developed with funding from a NOAA Environmental Literacy grant has hands-on activities organized within the "spheres": atmosphere, biosphere, geosphere, hydro- & cryo-spheres, and energy as the driver within and between the spheres. Titled: *Environmental Literacy with a focus on climate change* (nicknamed the "ELF"), the activities have been field tested by hundreds of teachers and checked for accuracy by scientists. Freely downloadable at http://andrill.org/education/elf_activities.html

How We Know What We Know About Our Changing Climate is a book written for middle school students by Lynne Cherry, the leading children's environmental writer/illustrator and author of *The Great Kapok Tree*, and Gary Braasch, award-winning photojournalist and author of *Earth Under Fire: How Global Warming is Changing the World*. It has 1won 15 awards for kids science lit, and has teacher guide. Not only science, but examples of how some schools teach science, local observations, and climate.

www.dawnpub.com/our-books/how-we-know-what-we-know-about-our-changing-climate/