CLIMATE, THE CRYOSPHERE, AND THE CARBON CYCLE
Final Project Overview:

Plan Title: Climate, the Cryosphere, and the Carbon Cycle

Introduction: I have utilized many of the resources from this class as well as a few suggested by other students. I plan to:

1. Introduce students to the cryosphere, specifically glacial retreat in Antarctica.
2. Have students conduct a mini-lab to model the fact that ice lost from land raises water levels.
3. Give students exposure to the extended carbon cycle.
4. Expose them to a simple climate model program.
5. Allow them to find individual related resources on the internet.
6. Have them share this information by creating posters.
7. Have them consider the effects of carbon dioxide as a greenhouse grass contributing to climate change.

Define Learners: The audience will consist of approximately 36 to 40 freshmen students in one section of Earth/Space Science. At one sample school we teach three classes of 90-minute blocks lasting one 18-week semester, both fall and spring semesters. My students will be lower-level in terms of math and English skills, with many ELL, and probably include 6 – 8 with special needs in this one class.

Standards: See daily lesson plans for specific Arizona Science Standards.

Topic: As stated in the title, my topic focuses on the Cryosphere, the Carbon Cycle, and their relationship to climate change.

Curriculum Links: I see this topic as a good wrap-up for the Earth/Space course as it will build on concepts covered throughout the semester and put a nice cap on the current curriculum. For example: This will piggy-back well with what students have already learned about forms of energy transfer (conduction, convection, and radiation), weather (including basics of the Greenhouse Effect, plate tectonics, basic chemistry, glaciers, and albedo.

Objectives: See daily lesson plans.

Materials: See daily lesson plans.

Time: One week in duration (five daily lessons).

Scope and Sequence: These are spelled out in detail in the lesson plans but here are the daily lesson titles:

1. **THE CRYOSPHERE AND CLIMATE CHANGE**
2. **THE CARBON CYCLE & CLIMATE CHANGE**
3. **WORKING WITH A SIMPLE CLIMATE MODEL**
4. **CLIMATE POSTER PROJECT**
5. **POSTER PRESENTATIONS & SUMMATIVE EVALUATION**

Supplementary Materials: All materials I have created and those from other resources are listed at the bottom of daily lesson plans with copies attached to the lesson plan document (PDF) where possible.

Assessment of Students: Assessment materials include worksheets, group responses to the mini-lab, successful location and printing of an appropriate scientific climate change article, posters, and finally a summative evaluation/quiz that involves interpreting the AMNH Carbon Cycle and giving thoughtful answers to reflection questions.

Evaluation of the Lesson: I will evaluate the success of this unit lesson by noting whether students meet daily objectives. Additionally I will assess student responses on the summative evaluation instrument to see if they show a better understanding of climate change than they demonstrate in earlier discussions and formative assessments.

CLIMATE, THE CRYOSPHERE, AND THE CARBON CYCLE

Cite Resources:

1. Ice Inquiry Lab Procedure
   - 50 ml beakers
   - 100 ml or 50 ml graduated cylinders
   - Water
   - Ice Cubes
2. http://www.bbc.com/news/science-environment-20804192
3. http://ehp.niehs.nih.gov/119-a20/
4. http://amnh.mrooms.net/mod/page/view.php?id=16930
5. http://www.nbcnews.com/watch/nightly-news/antarctica-ice-sheet-is-disintegrating-254261827888
6. http://www.nbcnews.com/video/nightly-news/23812562#23812562
7. http://www.youtube.com/watch?v=t8SPrR4K-tM
8. http://www.esrl.noaa.gov/gmd/obop/mlo/
9. http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_data_mlo.png
10. http://amnh.mrooms.net/mod/page/view.php?id=16931
11. Carbon Cycle Guided Notes
12. http://www.windows2universe.org/earth/climate/carbon_cycle.html
13. Carbon Cycle Game Response Sheet
14. http://ngm.nationalgeographic.com/img/big-idea/carbon-bath.jpg
15. Carbon Bathtub and Climate Model Reflection Questions
16. http://scied.ucar.edu/simple-climate-model
17. Student Research Articles
18. Butcher Paper of various colors and sizes
19. Colored pencils, markers, and crayons.
20. AMNH Carbon Cycle
21. Summative Unit Evaluation Instrument

Conclusion: This was a challenging but worthwhile project. But once I figured out a mini-lab to model rising sea level as glacial ice is lost with warming the rest fell into place nicely. I had thought to have them propose local solutions but the recent research regarding loss of West Antarctic ice sheets makes for a more compelling use of time and an eye-catching beginning. One weakness I did note was my not addressing the actual greenhouse effect directly here but we will have covered it at least briefly earlier in the semester. This unit fits very well with Earth/Space but not so well with my other five sections of Forensics. I look forward to teaching this unit in the coming school year.

UNIT LESSON PLAN: DAY 1 ~ THE CRYOSPHERE AND CLIMATE CHANGE

NAME: **SUBJECT:** Science **COURSE**: Earth/Space Science

UNIT: Climate, the Cryosphere, and the Carbon Cycle

State Standards and Academic Strands: (Essentials Skills and Instructional Focus)

AZHS-S1-C1-PO4 Predict the outcome of an investigation based on prior evidence, probability, and/or modeling
AZHS-S1-C4-PO3 Communicate results clearly and logically.
AZHS-S1-C4-PO4 Support conclusions with logical scientific arguments.
AZHS-S6-C1-PO4 Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
AZHS-S6-C2-PO16 Explain the causes and/or effects of climate changes over long periods of time
9-10.WHST.2 Write informative/explanatory texts, including scientific procedures/experiments, or technical processes.

STUDENT GOALS (STUDENT LEARNING)

Student will be able to…

- Make predictions based on given conditions
- Perform an experiment simulating melting of glaciers and sea ice
- Identify the cryosphere and its links to the hydrosphere and atmosphere
- Recognize the effects of climate changes on glaciation
- Make scientific conclusions about sea levels resulting from climate change.

PERFORMANCE TASKS

A. Ice Inquiry Lab[1] Part 1
B. Story/Hook: Show the four sequential images of Larsen B Ice Sheet collapse of 2002 from BBC[2] (larger) and/or EHP[3] links and explain the sequence. Ask students what could cause this and discuss their responses.
C. Introduce or remind students that the cryosphere is the Earth's frozen water on land and sea. Show the NASA Video[4]: **A Tour of the Cryosphere** (2009).
D. Ice Inquiry Lab[1] Part 2
E. Show the NBC video clips[5,6] describing recent research on West Antarctica ice shelves, inviting comments and discussion between each video. Give a brief explanation of how scientists model ice sheet melting and use of computer projections to help prepare students for the next video. Use this opportunity to tell them that we will be trying a simple climate model ourselves later in the week. Show YouTube Clip: **Irreversible Collapse: APL-UW Research Suggests Melt of West Antarctic Glaciers**[7]
F. Ice Inquiry Lab[1] Part 3

RESOURCES

1. Ice Inquiry Lab Procedure
   - 50 ml beakers
   - 100 ml or 50 ml graduated cylinders
   - Water
   - Ice Cubes
2. http://www.bbc.com/news/science-environment-20804192
3. http://ehp.niehs.nih.gov/119-a20/
4. http://amnh.mrooms.net/mod/page/view.php?id=16930
5. http://www.nbcnews.com/watch/nightly-news/antarctica-ice-sheet-is-disintegrating-254261827888
6. http://www.nbcnews.com/video/nightly-news/23812562#23812562
7. http://www.youtube.com/watch?v=t8SPrR4K-tM

Ice Inquiry Lab

Part 1:

Setup: Each group gets a 100 ml beaker with an ice cube floating in water with a current level of 40 ml. They also get a 50 or 100 ml graduated cylinder and are asked to fill that with 40 ml of water. Then they are given another ice cube to set on top of the graduated cylinder. (Warmer water can be used to speed up the process after testing the time required but should be consistent for both containers).

Groups are then asked to respond to the following prompts on one lined piece of paper per group with the names of all students in the group:

1. Predict what will happen to the water levels in each container as the ice melts.
2. Identify which container represents ice on land (glaciers) and which represents ice in the ocean.

Part 2:

3. What do we call all the Earth's zones of fresh water?
4. Which of the containers is more like the Arctic (North Pole) area?
5. Which of the containers is more like the Antarctic or Greenland?

Part 3:

6. Has the melting of the ice changed either of the two water levels? Explain your results.
7. If the water represents the ocean, what can you conclude regarding various ice regions and sea levels if the average global temperature continues to rise?
8. What element or compound (not H_2O) do you think might have the most impact on climate change?

Finally: please clean up your lab stations by pouring water in sinks and cleaning any spills. Then, return all items to their proper locations.

UNIT LESSON PLAN: DAY 2 ~ THE CARBON CYCLE & CLIMATE CHANGE

NAME: **SUBJECT:** Science **COURSE**: Earth/Space Science

UNIT: Climate, the Cryosphere, and the Carbon Cycle

State Standards and Academic Strands: (Essentials Skills and Instructional Focus)

AZHS-S4-C3-PO2 Describe how organisms are influenced by a particular combination of biotic (living) and abiotic (nonliving) factors in an environment.
AZHS-S4-C5-PO2 Describe the role of organic and inorganic chemicals important to living things.
AZHS-S6-C1-PO1 Identify ways materials are cycled within the Earth system
AZHS-S6-C2-PO3 Distinguish between weather and climate.
AZHS-S6-C2-PO16 Explain the causes and/or effects of climate changes over long periods of time

STUDENT GOALS (STUDENT LEARNING)

Student will be able to…

- Identify the importance of carbon dioxide as a greenhouse gas product of burning fossil fuels.
- Identify the importance of the carbon cycle to life on earth.
- Explain the relationship between atmospheric carbon dioxide levels and climate change.
- Explain threats to ocean ecosystems due to increased acidification.

PERFORMANCE TASKS

A. Story/Hook: Explain who Charles Keeling was and his role in establishing the Mauna Loa Carbon Dioxide Monitoring Station[1].
B. Project the Keeling Curve[2] and explain what the graph shows, then discuss the seasonal CO_2 shifts briefly with students.
C. Show the Carbon Cycle Video[3] two or three times so students can complete the guided notes[4]. Collect students' guided notes and transition to computer lab.
D. Have students go to the Carbon Cycle Game website[5], play through the Carbon Cycle Game several times while completing the Carbon Cycle Game Response Sheet[6].

RESOURCES

1. http://www.esrl.noaa.gov/gmd/obop/mlo/
2. http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_data_mlo.png
3. http://amnh.mrooms.net/mod/page/view.php?id=16931
4. Carbon Cycle Guided Notes
5. http://www.windows2universe.org/earth/climate/carbon_cycle.html
6. Carbon Cycle Game Response Sheet

AMNH Carbon Cycle Video Name:_____ Hour: _____

Earth/Space Science

Instructions: Fill in the guided notes as you watch the video. We will watch the video at least two times.

Carbon is the basic building block of_____.

Carbon is stored in the _____, the _____, and the _____.

A carbon atom could spend _____ of years moving through the Earth in a complex cycle.

Understanding the carbon cycle and how it is changing is key to understanding Earth's changing _____.

On land, _____ remove carbon from the atmosphere through photosynthesis.

Animals eat plants and either breathe out carbon or the carbon moves up the food chain.

When plants and animals die and decay, they transfer carbon back to the _____.

The ocean holds huge amounts of carbon, about _____ times the amount we find in the atmosphere.

The ocean is sometimes called a _____ _____, meaning that it absorbs carbon from the atmosphere.

The ocean takes up carbon through _____ and _____ processes.

At the ocean surface, carbon dioxide from the atmosphere _____ into the water.

Tiny marine plants called _____ use this carbon dioxide for _____.

Phytoplankton are the base of the _____ food web.

After animals eat the _____, they breathe out the carbon or pass it up the food chain.

Sometimes phytoplankton die, decompose, and are _____ in the surface waters.

Phytoplankton can also sink to the _____ _____, carrying carbon as they descend.

Over long time scales, this process has made the ocean floor the largest _____of carbon on the planet.

Most of the ocean's _____ are in cold, deep water.

In a process called _____, currents bring nutrients and carbon up to the surface.

Carbon can then be released as a gas back into the _____, continuing the carbon cycle.

By cycling huge amounts of carbon, the ocean helps _____ climate.

Oceans are actually a great a regulator, a _____ of the Earth's climate.

The balance between incoming _____ and outgoing _____ determines the Earth's climate.

_____ gases act like a blanket and trap heat in the atmosphere.

AMNH Carbon Cycle Video – Page 2

Earth/Space Science

_____ _____ is a greenhouse gas.

In the past two centuries, humans have increased atmospheric carbon dioxide by more than _____ by burning _____ _____ and cutting down forests.

The Earth has not experienced carbon dioxide levels this high for the past several _____ years.

About _____ of all human- generated carbon emissions has dissolved in the ocean.

More than _____ of Earth's added heat is now stored in the ocean.

As the planet gets warmer, the water is going to warm up and warm water can hold _____ carbon than cold water.

As the planet warms and some of the currents slow down we might not be forming as much cold _____ _____

The ocean is going to become _____ effective at removing carbon from atmosphere.

Throughout most of Earth's ocean, the warmer water, weaker circulation, and new temperature gradients that result from climate change will impact marine life and _____.

As the ocean absorbs more carbon dioxide, it becomes more _____ and this can be a threat to some of the organisms that live inside the ocean.

As Earth's climate continues to change, how will researchers monitor something as big as the ocean and something as complex as the carbon cycle?

NASA Earth-observing _____ give scientists the big picture view of our home planet.

Varied satellites help researchers detect changes in ocean climate and ecology over time, providing vital insight into the health of our home planet.

Carbon Cycle Game Name:_____ Hour: _____

Earth/Space Science

Instructions: Go to the website: http://www.windows2universe.org/earth/climate/carbon_cycle.html
Play through the Carbon Cycle Game several times, answering the following questions as you go.

1. (True or False): More carbon can dissolve in cold water than in warm water.

2. (True or False): Too much carbon in sea water makes it more difficult for sea creatures to grow shells.

3. Adding more carbon dioxide to seawater makes it more_____

4. Carbon binds to how many atoms of what other element in the atmosphere?_____

5. Carbon in the form of detritus is found in which of the six reservoirs in the cycle? _____

6. Do increased levels of carbon dioxide make the Earth warmer or colder? _____

7. How long does carbon remain in the deep ocean? _____

8. How many gigatons of carbon dissolve in the surface ocean per year? _____

9. How much has carbon dioxide increased over the last 150 years? _____

10. Name the six reservoirs of carbon? _____

_____

11. The deep ocean accounts for _____ percent of Earth's carbon.

12. What percent of the Earth's carbon is stored in soils? _____

13. What started about 150 years ago that began increasing atmospheric carbon dioxide?_____

14. What tiny marine organisms take in carbon through photosynthesis? _____

15. What types of marine life will be hurt by increasing carbon dioxide levels? _____

16. Where does the deep ocean get carbon from? _____

UNIT LESSON PLAN: DAY 3 ~ WORKING WITH A SIMPLE CLIMATE MODEL

NAME: **SUBJECT:** Science **COURSE**: Earth/Space Science

UNIT: Climate, the Cryosphere, and the Carbon Cycle

State Standards and Academic Strands: (Essentials Skills and Instructional Focus)

AZHS-S1-C1-PO1 Evaluate scientific information for relevance to a given problem.
AZHS-S1-C3-PO1 Interpret data that show a variety of possible relationships between variables, including positive, negative, or no relationships
AZHS-S3-C2-PO3 Support a position on a science or technology issue.
AZHS-S4-C5-PO2 Describe the role of organic and inorganic chemicals important to living things.
AZHS-S6-C1-PO1 Identify ways materials are cycled within the Earth system
AZHS-S6-C1-PO4 Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
AZHS-S6-C2-PO16 Explain the causes and/or effects of climate changes over long periods of time
9-10.WHST.1 Write arguments focused on discipline-specific content.

STUDENT GOALS (STUDENT LEARNING)

Student will be able to…

- Identify important features of the carbon cycle.
- Explain the role that burning of fossil fuels plays in rising carbon dioxide levels and climate change.
- Utilize scientific reasoning to support conclusions
- Use a simple climate model to project temperature outcomes at various carbon dioxide levels.
- Identify an appropriate scientific resource on the internet that details some aspect of climate change.

PERFORMANCE TASKS

A. Students will meet in the computer lab where they will access the National Geographic Carbon Bathtub[1] website; while they explore the website they will complete the Carbon Cycle Review Worksheet[2].

B. Students will access the Simple Climate Model[3] website and complete part 2 of the worksheet[2].
   1. Give students a brief overview of how to use the website.
   2. The "Start Over" button is used any time they change the settings and/or to begin again.
   3. The "Play" button is used to view projections of temperatures for selected levels of CO_2 emissions.
   4. The levels below the "Start Over" button **should not be altered** unless the students want to see the temperatures in degrees Fahrenheit.
   5. Have students run the projections at several settings for CO_2 emissions (for example 6, 8, and 10 gigatons) and complete the rest of the reflection questions on the worksheet[2].

C. Students will use the internet to look up a scientific article regarding some aspect of climate change or its effects from a reliable *scientific* source (**not Wikipedia**). The article could also involve any potential ways to slow or reduce climate change. Students must get clearance or approval from their instructor for any source prior to printing their article. Remind students that tomorrow they will be working on poster projects related to their articles to share with the class.

RESOURCES

1. http://ngm.nationalgeographic.com/img/big-idea/carbon-bath.jpg
2. Carbon Bathtub and Climate Model Reflection Questions
3. http://scied.ucar.edu/simple-climate-model

Carbon Bathtub & Climate Model Reflection Questions Name:_____ Hour: _____

Earth/Space Science

Instructions: Go to the website: http://ngm.nationalgeographic.com/img/big-idea/carbon-bath.jpg
Read both pages of the website and complete reflection questions 1 – 7 below.

1. What causes most carbon dioxide emissions?

2. What was the carbon dioxide level in the atmosphere in 2008 in parts per million (ppm)?

3. Scientists think we need to lower atmospheric levels of CO_2 to how many ppm to avoid serious climate impacts?

4. What percentage or fraction of atmospheric CO_2 is absorbed by: **a.** oceans? _____; **b.** plants and soils?_____

5. In your own words, describe how atmospheric CO_2 contributes to warming:

6. At what locations does CO_2 rich surface water sink to the deep ocean?

7. What does a bathtub level of 271 ppm CO_2 correspond to?

Instructions: Go to the website: http://scied.ucar.edu/simple-climate-model & read the official instructions. **Guidelines:**

- The **"Start Over"** button is used any time you change the settings and/or to begin again.
- The **"Play"** button is used to view projections of temperatures for selected levels of CO_2 emissions.
- The levels below the "Start Over" button **should not be altered** unless you want to see the temperatures in degrees Fahrenheit.
- Run the projections at several settings for CO_2 emissions (for example 6, 8, and 10 gigatons) and complete the rest of the reflection questions on this worksheet.

8. Briefly describe and compare what the temperature graphs look like for at least three different CO_2 levels.

9. How low do you have to set the level of CO_2 emissions to get the temperature graph and CO_2 ppm to flatten out?

10. With current CO_2 emissions of about 10.5 gigatons (the model's pre-set value), do you think it is likely that our society could reduce emissions to a level that stabilizes or reduces global temperatures? ***Explain your reasoning!!***

Use the internet to look up a scientific article regarding some aspect of climate change or its effects from a reliable *scientific* source (**not Wikipedia**). The article could also involve any potential ways to slow or reduce climate change. Once you find a suitable article, get clearance or approval from the instructor prior to printing the article.
Remember, tomorrow we will be working on poster projects related to your articles to share with the class.

UNIT LESSON PLAN: DAY 4 ~ CLIMATE POSTER PROJECT

NAME: **SUBJECT:** Science **COURSE**: Earth/Space Science

UNIT: Climate, the Cryosphere, and the Carbon Cycle

State Standards and Academic Strands: (Essentials Skills and Instructional Focus)

AZHS-S1-C1-PO1 Evaluate scientific information for relevance to a given problem.
AZHS-S1-C4-PO4 Support conclusions with logical scientific arguments.
AZHS-S6-C1-PO1 Identify ways materials are cycled within the Earth system
AZHS-S6-C1-PO4 Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
AZHS-S6-C2-PO3 Distinguish between weather and climate.
AZHS-S6-C2-PO9 Explain the effect of heat transfer on climate and weather.
9-10.RST.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

STUDENT GOALS (STUDENT LEARNING)

Student will be able to…

- Demonstrate understanding of causes and effects regarding climate change.
- Communicate scientific information creatively in poster format.

PERFORMANCE TASKS

A. Allow students to work in groups of two or three or individually to create a poster that communicates one or more aspects of climate change or human responses to climate change from the articles they researched.

RESOURCES

1. Student Research Articles
2. Butcher Paper of various colors and sizes
3. Colored pencils, markers, and crayons.

UNIT LESSON PLAN: DAY 5 ~ POSTER PRESENTATIONS & SUMMATIVE EVALUATION

NAME: **SUBJECT:** Science **COURSE**: Earth/Space Science

UNIT: Climate, the Cryosphere, and the Carbon Cycle

State Standards and Academic Strands: (Essentials Skills and Instructional Focus)

AZHS-S1-C4-PO4 Support conclusions with logical scientific arguments.
AZHS-S3-C2-PO3 Support a position on a science or technology issue.
AZHS-S4-C5-PO3 Diagram the following biogeochemical cycles in an ecosystem: Carbon.
AZHS-S6-C1-PO1 Identify ways materials are cycled within the Earth system
AZHS-S6-C1-PO4 Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
AZHS-S6-C2-PO9 Explain the effect of heat transfer on climate and weather.
AZHS-S6-C2-PO16 Explain the causes and/or effects of climate changes over long periods of time
9-10.WHST.1 Write arguments focused on discipline-specific content.

STUDENT GOALS (STUDENT LEARNING)

Student will be able to…

- Share scientific information related to climate change with classmates
- Identify specific areas of Earth that are affected by climate change
- Demonstrate understanding of the carbon cycle.
- Cite scientific research to support conclusions.

PERFORMANCE TASKS

A. As students finish their posters and post them to the classroom walls, have them circulate around the room and read each other's work
B. Handout copies of the AMNH Carbon Cycle[1] with interpretation & evaluation questions[2] (quiz) on the back.

RESOURCES

1. AMNH Carbon Cycle
2. Summative Unit Evaluation Instrument

Climate/Carbon Unit Summative Evaluation Name:_____ Hour: _____

Earth/Space Science

Instructions: Reflect on this unit's activities & use the Carbon Cycle on the back to help answer the following questions.

1. The **ocean** and **atmosphere** trade carbon annually. According to the Carbon Cycle, which one of those receives more carbon from the other and how many gigatons (Gt) does it receive in this way?

2. How do people put carbon into the atmosphere, and how many gigatons are we responsible for each year?

3. What is the most common form of carbon found in the atmosphere?

4. How many gigatons of carbon do living things, permafrost, and soils together get out of the atmosphere that is not returned each year?

5. How many gigatons of carbon are building up in the atmosphere each year?

6. Scientists have evidence for what type of climate change due to the steady increase of carbon in the atmosphere?

7. Write a paragraph explaining one aspect of climate change including at least one area of the earth that might be affected.

8. What do you think people can do to lessen the effects of climate change in your lifetime?

American Museum of Natural History

Carbon Cycle