Presenting the Carbon Cycle in a Biological Sciences Classroom

RET II – Summer 2014
By Catherine Borgard
INTRODUCING RET I

- Summer 2013: research with Dr. Uta Passow
- Simulate the growth of marine snow using conditions like the Deep Water Horizon Gulf oil spill.
- Successfully grew marine phytoplankton *Thalassiosira weissflogii* in the lab after making some modifications: the addition of higher concentrations of CO$_2$ and light as seen in the bottom slide.
IMAGES OF MARINE SNOW

- Tank: marine snow grown in the lab.
- Gulf of Mexico: marine snow after Deepwater Horizon spill.
- I was unsuccessful at reproducing the quantity of marine snow, as seen in the image on the right, after the spill.
CONNECTIONS

• Summer 2014
• Using a greater depth of knowledge from research in 2013 to teach:
  1. Photosynthesis
  2. Global Carbon Cycle
  3. Climate Change
  4. Student personal contribution to problem and solutions

• These lessons are designed for high school biology students grades 9 and 10 but can be adapted for younger students
• 2013 was a frustrating experience instructing students on the role carbon has on the planet.

• From a small scale, photosynthesis, to a global scale, the greenhouse effect there was a disconnect with the students. They showed no true engagement.

• After participating in research on “Carbon” and what an important role it has, I felt inspired and motivated to take on the challenge of changing students attitudes.

• I wanted to empower my students to participate in solutions in the real world right now.

• The following lessons hope to accomplish this goal.
BIOLOGICAL CARBON CYCLE

Next Generation Science Studies

- ESS3: Earth and Human Activity
- PS3D: Energy in Chemical Processes and Everyday Life
- ETS1: Engineering Design
Experiment: Indicators

Introducing CO\(_2\) indicators using Bromothymol Blue

- Students will test the indicator BTB with acid, carbonated soda, their exhaled breath, and smoke.
- Students will be able to determine if CO\(_2\) is present by the color change in BTB and that CO\(_2\) is acidic.
**Experiment:** Elodea and BTB

- Fill 3 test tubes with yellow BTB and 1 with blue BTB.
- Place a strand of Elodea in 2 of the yellow test tubes and the blue.
- A yellow test tube with elodea goes in the dark and all of the others in the light.
- Observe 2 - 3 days later.
- The removal of an acid, CO2, will turn the BTB from yellow back to blue. This is evidence of photosynthesis occurring.
WHAT’S UP WITH AIR?

• Students have difficulty conceptualizing that carbon dioxide in the air can be rearranged to form sugars and ultimately the mass of a tree.

• To facilitate this reality I introduced an activity where the students have to think through the evidence presented in a demonstration and determine that air has mass.
PHOTOSYNTHESIS AND RESPIRATION
ANALYSIS OF TWO EXPERIMENTS

(process tool)

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[Diagram with process tool and arrows for energy and matter input/output with scale placeholder]
ANALYSIS OF TWO EXPERIMENTS
PHOTOSYNTHESIS & RESPIRATION

• Photosynthesis: analysis of “van Helmont’s Willow” experiment
  • Half the students work in pairs on this experiment
  • Use the “Processing Tool” to help track the flow of matter and energy
  • Students join the next day, organize themselves to work as an efficient team
  • Goal is for everyone to present the findings using visual and auditory methods

• Photosynthesis: analysis of “Mice in a Box” experiment
  • Half the students work in pairs on this experiment
  • Use the “Processing Tool” to help track the flow of matter and energy
  • Students join the next day, organize themselves to work as an efficient team
  • Goal is for everyone to present the findings using visual and auditory methods
EXAMINING PHOTOSYNTHESIS & RESPIRATION IN PRACTICE

• Prepare for this lab 10 days in advance either with the students or by yourself.
• Create enough samples or stations for students to work this out in small groups – no more than 4 students in a group.
EXPERIMENTS THAT DEMONSTRATE SOME OF THE EFFECTS OF GLOBAL WARMING

• These experiments work best if multiple trials are performed.
• Data can then be compiled and analyzed for variation.
• Demonstrating the importance of multiple trials using the scientific method validates that results must be reproducible.
• This might be necessary as the experiment with temperature and various gases can be tricky for students.
• I have six periods of biology and so compiled all six class sets of data for analysis.
• **Experiment:** Ocean Stratification via Temperature

• Fill 2 jars with hot red water

• Fill 2 jars with cold blue water

• Glitter to represent marine snow (nutrients)

• Place hot water on top of cold water

• Place cold water on top of hot water
TEMPERATURE FLUCTUATIONS BETWEEN EARTH AND WATER
EFFECTS OF CLIMATE CHANGE

- Comparison of temperature between earth and water after 5 minutes of heat.
- Comparison of temperature between earth and water after 5 minutes of cooling.
SEA ICE VS. GLACIERS
EFFECTS OF CLIMATE CHANGE

• Beaker A: pour 150 mL of water and add several ice cubes to simulate sea ice (icebergs).
• Beaker B: fill will ice to 150 mL. Pour water into beaker until it reaches 150 mL to simulate a glacier flowing on top or into ocean.
• Melt ice completely using a hot plate.
• Compare water levels.
SEA ICE VS. GLACIERS
EFFECTS OF CLIMATE CHANGE

• Yes, it was Halloween when the students performed this lab.
The goal of this experiment is to demonstrate how global warming gases work.

Carbon dioxide is not the only global warming gas. Methane and water vapor will also trap heat as do other gases.

In this experiment normal air is compared to carbon dioxide and water vapor.

The water vapor is important to help understand feedback loops.
TEMPERATURE FLUCTUATIONS BETWEEN GASES
EFFECTS OF CLIMATE CHANGE

• Global warming gases
• Comparison of temperature fluctuations due to heating and cooling.
• Compared gases: air, carbon dioxide and water vapor.
ARTICLE SUMMARY
WHAT IS OCEAN ACIDIFICATION?

• One goal of NGSS is to increase student analytical processes.
• Another goal is to communicate their analysis.
• Article summaries offer an opportunity to hone these skills.
• Students view a demonstration on the effects of sea shells (substituting chalk) and acid.
• They then continue with the summary.
ANALYZING DATA
THE KEELING CURVE

Keeling Curve

• Students analyze Keeling’s data on increasing levels of atmospheric carbon dioxide.

• The students graph the data. Data provided: http://cdiac.ornl.gov/ftp/ndp001/maunaloa.co2

• Students answer discussion questions based upon their analysis of the Keeling Curve
This video with Neil deGrasse is excellent at walking through:

• What are contributing factors to climate change.

And

• What are not contributing factors to climate change.

• Hope and responsibility are included.

• Video may need to be paused to check for understanding especially if there are EL students.

• [Cosmos Space-Time Odyssey - Instantly Watch Free Episodes](https://sharetv.com/cosmos_space_time)

• Episode 12: The World Set Free
ARTICLE SUMMARY

CHINA AND KAZAKHSTAN COMPETE FOR CARBON NEUTRAL OLYMPICS

• Environmental factors are being taken into consideration for development.
• An example: whom will host the 2022 Winter Olympics.
• Students will see proposed evidence to offset carbon emissions.
• Point of discussion could be: “What are the differences between offsetting carbon emissions and reducing carbon emissions”? 
What are your personal carbon dioxide emissions every year?

In this modified activity from NOVA: the Big Energy Gamble, students calculate their own emissions of carbon dioxide.

The students then convert these emissions to equivalences of their own body mass. This makes the quantity more personal and relevant to themselves.

At the end, students strategize methods to reduce carbon dioxide emissions and implement them.
WHAT IS YOUR CARBON FOOTPRINT? YOUR ENERGY AUDIT

Have students bring in energy use statements a month before this activity. Having a variety of statements available is preferable. Energy statements include: electricity, gas (space and water heating), and transportation. If students do not know consumption of gasoline a “guessimate” handout is included. Sample statements are available on line but do not reflect their homes.
WHAT WILL YOU DO TO MAKE AN IMPACT?

• The final part of *The Big Energy Gamble* is to find solutions.

• Students need to feel empowered now and for their future.

• Students should work in pairs to discover solutions.

• These should include time lines.

• They then present their solutions for comments and feedback.
THANK YOU