Marine Algae and the Mystery of Dissolved Oxygen!

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Summary

Earth has finite resources, and as a result, matter recycles throughout the world by biogeochemical cycles. The Carbon/Oxygen Cycle is a biogeochemical cycle that is driven by photosynthesis and cellular respiration. As a result of organisms performing these two processes, levels of dissolved oxygen (DO) change within water columns. Inspired by the information available via the Ocean Observatories Initiative (OOI), this lesson will focus on the the impact of photosynthesis on the DO levels, specifically off the coast of New Jersey. Resources to access similar data in other locations will be available at the end of this document.

The students will propose what plants need in order to perform photosynthesis. Based upon the discussed information, the students will conduct experiments using a chemical indicator of carbon dioxide, Bromothymol blue (BTB) solution. BTB is blue in color but will change to green and then yellow based upon an increase in carbon dioxide concentration in a BTB solution. Students will set up test tubes with BTB solution and aquatic plants. At the end of setup day, students will make predictions about potential color changes to the BTB solution. From there, students will access and interpret near real time marine data of dissolved oxygen to determine if their predictions are supported by real-world evidence. After 48 hours of sitting, students will return to their BTB solution lab setup to evaluate their results and determine if their predictions were supported by the real-world data and their results.

[TAGS: Carbon/Oxygen Cycle, photosynthesis, dissolved oxygen]

Key Concepts

- Carbon/Oxygen Cycle, photosynthesis, dissolved oxygen

Objectives - NGSS 3Ds

Include clear, measurable statements of what students will be able to do, such as:

- Disciplinary Core Ideas
  - LS1.A
  - LS1.C
  - LS2.A
  - LS2.B
  - PS3.B
- Cross-cutting Concepts
  - Structure and function
  - Energy and matter

- Science and Engineering Practices
    - Ask questions and construct explanations
    - Plan and carry out investigations
    - Analyze and interpret data
    - Engage in argument from evidence
    - Obtain, evaluate, and communicate information

Materials

- Include any additional resources that educators would need to teach the lesson
    - How do Matter and Energy Flow During Photosynthesis? Student Document
    - How do Matter and Energy Flow During Photosynthesis? Answer Key
    - Day 1 Teacher Demo
        - test tube
        - straw
        - spring water (Poland Spring works best)
        - BTB
        - goggles
        - disposable gloves
    - Day 1 Investigation
        - Materials for each section/period of students
            - light bank
            - dark location (an empty draw per period works well)
            - tape (divide space under light bank for each section/period of students)
            - test tube racks under the light bank
            - test tube racks for the dark location
        - Materials for 1 group
            - Disposable gloves
            - Goggles for each student
            - China Marker
            - Test Tube Rack
            - 3 Test Tubes
            - 2 pieces of marine macroalgae of the same species (could substitute *Elodea*)
            - *Elodea canadensis* - considered invasive in some parts of the U.S., so be mindful of disposal
            - Marine macroalgae - may also be acquirable from a pet store that maintains salt water fish species or from your location tidal zone
        - Pipets
        - bottle of BTB
        - Forceps
        - 3 Test Tube Stoppers
        - Graduated cylinder
        - Spring Water (Poland Spring works best)
        - Carbonated water (can of seltzer with a cover works for multiple groups)
    - Day 3 Investigation - materials for 1 group

- Disposable gloves
- goggles
- bucket to collect photosynthetic organism (could be reused for cellular respiration setups)
- location to dump BTB solution
- eraser (helps to remove most of the China marker from the test tubes)

Procedure - based upon 40-50-minute class periods

1. Day 1
    a. complete and discuss the Catalyst question
    b. complete and discuss the Introduction
    c. run teacher Demo - be sure to **gently** bubble your breath
    d. discuss Background on setting up experiments
2. Day 2
    a. discuss Materials list and questions
    b. execute Procedure
    c. complete gaining Knowledge and discussion
3. Day 3
    a. complete and discuss the Catalyst question
    b. discuss Photosynthesis - the Equation
    c. complete and discuss Start Thinking
    d. complete Activity
    e. complete Gallery Walk
4. Day 4
    a. complete and discuss the Catalyst question
    b. complete Day 1 Follow-up Questions
    c. complete Closure CER

Assessment

- **Formative assessments**
    - Responses to questions on the student document
    - Discussion of questions in pairs, small groups, and as a class
    - I^2 Strategy response as related to selected graph
    - Gallery Walk comments to investigation group
- **Summative assessments**
    - CER: How do both matter and energy cycle through living organisms and their environment as a result of photosynthesis?
        - Generic CER Rubric

Additional Resources

- Ocean Observatories Initiative (OOI) - data from the research array network of buoys from OOI.
- National Estuarine Research Reserve System Centralized Data Management Office - data are from estuaries around the U.S. and the Great Lakes. Please note that data in marine estuary locales will reflect tidal variations in data that other data sources do not seem to reflect.
- Water Quality Monitoring in New Jersey Estuaries using Data Loggers - background information on how data are collected in NJ estuaries.
- NOAA's National Ocean Service Education: Estuaries - background on the data that are collected within water columns.
- NJDEP DWM&S Continuous Data Monitoring Program - water quality data from NJ freshwater and marine locations.
- I^2 Strategy by BCBS - an aid for identifying and interpreting components of graphs.
- NSTA CER Webinar - an aid for implementing Claim, Evidence, and Reasoning as a means of engaging in an argument from evidence.
- Screencast-o-matic - a FREE downloadable screencasting program that can be used to make videos of what is on your screen.

Extensions or adaptations

- The order of implementation of this lesson can be changed so the Day 3 graphing and data analysis comes before the Day 1-2 background and investigation setup.
- This lesson is intended to be completed digitally, but the student sheet has been formatted with enough writing space for the document to be printed. If that is the case, links will need to be provided to the students in order for them to gain access to the assorted content.
- For high school or college students, using the data from the OOI linked within the Resources section above would make collecting the data more of a challenge. Depending on your student population, using OOI may require scaffolding via a step-by-step video or directions document in order to find the data to be graphed.
- If you draw from the NJDEP data, you could have the students compare the graph to the Chlorophyll Remote Sensing data for a particular area.
- Cellular Respiration Connection
    - A similar test tube setup can be created to test for cellular respiration, but the test tubes **should not** include the carbonated water.
    - Once cellular respiration test tubes are set and predictions are made, dissolved oxygen data can be revisited, with a focus on nighttime hours.
    - When looking back at the test tubes, oxygen levels will decrease for the setup with the macroalgae in the dark location as a result of cellular respiration converting glucose and oxygen to carbon dioxide, water, and energy (chemical [ATP] and thermal). This will also cause an increase in dissolved carbon dioxide, which will cause the BTB solution to turn yellow after 48 hours.