POLAR TREC

TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

Chlorophyll Conundrum: Can factors affect chlorophyll levels in plankton samples?

Overview

This lesson incorporates techniques and experimental designs used by researcher during the Southern Ocean Diatoms PolarTREC expedition and during post-expedition laboratory analysis. This guided inquiry lesson provides students the opportunity to explore photosynthesis and primary productivity using techniques to measure chlorophyll levels.

Objectives

SWBAT: 1. Use models to predict chlorophyll levels in the global oceans 2. Identify variables that may influence the process photosynthesis in autotrophs 3. Develop a research question and design a controlled experiment to measure a variable's effect on chlorophyll levels in plankton samples 4. Interpret chlorophyll data as a means of drawing conclusions on photosynthesis in plankton samples 5. Analyze data sets to report findings 6. Evaluate experimental designs

Lesson Preparation

- List or write brief paragraphs describing the steps needed to complete the lesson. Also, list or include a paragraph describing the content that must be covered prior to the start of the lesson.
- Using models of chlorophyll concentrations in ocean regions, students will brainstorm possible reasons for chlorophyll levels in various locations. Teacher facilitated

Details

Lesson
Antarctic
More than a week
Download, Share, and Remix
High school and Up
NASA Earth Observatory Global Chlorophyll Map

Materials

Goggles and apron
Gloves
Water samples or macro algae samples. (Samples can be collected from local bodies of water during a field trip, purchased, or acquired through coordination with research scientists).
20% Ethanol in Acetone solution (solvent)
Pipettes (disposable plastic pipettes work great)

discussion leads to a list of possible variables to explore in individual or a classroom experiments. These incubation experiments use plankton samples or macro algae samples to test for the effect of a given variable on the chlorophyll levels. Students measure chlorophyll levels over the course of the incubation using a spectrophotometer. The chlorophyll levels will serve as a proxy for photosynthesis.
- Prior to the lesson, students should have knowledge of the difference between autotrophs and heterotrophs. Food web ecology knowledge is not required, but this lesson could be used as a conclusion to a unit on food webs and nutrient sampling, or as an activity to introduce the idea. Knowledge of designing an experiment is necessary. If this lesson is used as the first inquiry activity of the year, or early in the year, scaffolding of the experimental design is suggested. This lesson can also be presented as a confirmation or structured inquiry activity by creating specific instructions related to the experimental design and/or providing table and graph templates for the activity.

Procedure

Introduction/Engage Experience

Project chlorophyll map and ask students to record at least two observations about the map.

- Students are led in a group discussion to ask questions about chlorophyll levels and what might influence and increase or decrease in levels. A collection of questions is displayed on the board for students to review. These questions can be used to guide students in a discussion about developing their investigations.

Investigation

The guiding question is displayed in the classroom (and is also located on the student worksheet).

Centrifuge
Vortex
Spectrophotometer
Quartz or plastic cuvette for spectrophotometer)
Incubation sample bottles (size varies based on water/plant sample sizes)
Materials including but not limited to: growth lights (white or other wavelengths), air pumps, vitamins, etc. based on student experimental design.
Ocean chlorophyll level maps (available for download - URL under Resources)
Student inquiry worksheet (available for download in Documents)
Lab report rubric (available for download in Documents)
Light microscopes (for optional extension)

Standards

2016 Massachusetts Science and Technology/Engineering Curriculum Frameworks

Life Sciences

LS2. B Cycles of Matter and Energy Transfer in Ecosystems (9-10): Photosynthesis captures energy in sunlight and stores it in chemical bonds of matter. Most organisms rely on cellular

Guiding Question(s)

1. What factors influence the chlorophyll levels in phytoplankton samples?
2. Sentence prompt (if needed): How does _____ affect the chlorophyll level in phytoplankton samples?

- Students are placed in groups of four.
- Students will be given class time to develop their predictions based on their prior knowledge of photosynthesis and autotrophs in addition to research about phytoplankton.
- Time is also provided for students to develop a procedure.
- Approval of the procedure is necessary before the investigation begins.
- The variables, hypotheses, procedure and data tables should be submitted for approval.
- Students should also create a model (drawing) of their experiment.
- Students submit their proposals in their laboratory notebooks and include a data table for data collection.

As students develop their investigations, teacher can prompt students with questions to help facilitate the process:

- What variables will you consider in designing the investigation?
- How many trials will you conduct?
- Do you need a control for this investigation? Why or why not?
- What other outcomes are possible?

Chlorophyll extraction protocol

While the incubation experiments will be developed by the student groups, all groups should use the following protocol to measure chlorophyll levels to produce results.

1. Remove a sample of water from each incubation bottles (control and experimental groups)

respiration to release energy in these bonds to power life processes. About 90% of available energy is lost from one trophic level to the next, resulting in fewer organisms at higher levels. At each link in an ecosystem, elements are combined in different ways and matter and energy are conserved. Photosynthesis, cellular respiration and decomposition are key components of the global carbon cycle.

Science and Engineering Practices

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating and Communicating Information

Next Generation Science Standards (NGSS)

High School

2. Centrifuge ~1.5mL water sample for 60s at 10,000 rpm to concentrate the phytoplankton at the bottom of the tube.
3. Use pipettes to discard supernatant while not disturbing the pellet of cellular material at the bottom of the tube.
4. Steps 1-3 may be repeated as needed to create a larger sample of cellular material, especially with samples which may have low phytoplankton density. Record the total volume of water in order to estimate and compare chlorophyll concentrations across different volumes.
5. Add 2mL of acetone solvent to the cellular material.
6. Vortex the solution for to break up cellular material and mix until there is no longer a pellet of material at the bottom of the tube.
7. Store all samples in a dark location overnight.
8. Centrifuge the sample for 2min @ 10,000rpms.
9. Transfer 2ml of the supernatant liquid to the spectrophotometer cuvette. This liquid contains the extracted chlorophyll of the cell, while the pellet at the bottom contains cellular debris, etc.
10. Fill a second cuvette with 1-2ml of ethanol:acetone solvent for use as the blank.
11. Follow specific machine instructions to turn on and warm up the spectrophotometer.
12. Set absorbance to 664nm to measure chlorophyll. You can also measure from 400 – 700nm and compare against a pigment graph if there are other types of pigments present in your sample which may show different groups of phytoplankton.
13. Zero the spectrophotometer using the blank following specific machine instruction
14. Record absorbance of all samples at the 664nm absorbance

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Middle School

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

All Science and Engineering Practices

Daily Check In

Before students leave the classroom, each student must complete an Exit Ticket to summarize the day's events, ask for clarification on questions or issue related to the experiment and provide a plan for the next day. Exit tickets should be returned the following class period with comments/suggestions from the teacher.

Wrap-Up

To finish the investigations, students will submit a lab report to communicate findings and analyze results. As students begin to work on their report, the teacher can lead the group in a "speed-dating" activity. Students arrange their desks in long rows so that pairs of desks face each other. Students seated in one row will continue to move, while the students in the other row stay seated. As student

move seats and sit across from their new “date”, they take turns describing their experiment and discussing their outcomes. Students should have approximately 5 “dates” and each date should be about 8-10 minutes long. This gives both students time to explain and ask questions. As the students continue to practice communicating their results, they refine their conclusions. Peers also help by asking for clarification and pointing out areas of improvement.

Students will submit a lab report (see rubric) as a completion of this investigation.

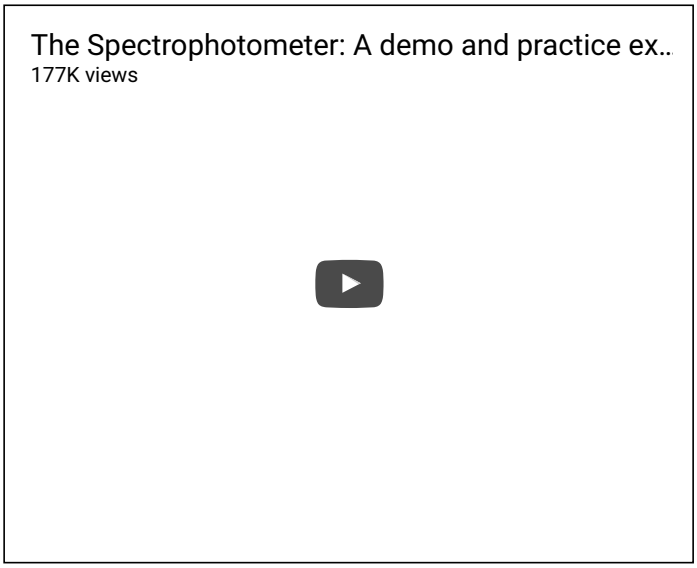
Extension

1. Students can collect water samples from the incubation bottles and use light microscopes to extend their understanding of the phytoplankton through: a. Cell counts b. Cell isolation for species identification c. Food web depending on the size of the net used to collect samples
2. Carbon cycle lessons

Resources

Southern Ocean Diatoms PolarTREC journals: https://www.polartrec.com/expeditions/southern-ocean-diatoms

A Spectrophotometer: A demo and practice experiment by BioNetwork



U.S. Global Change Research Program http://www.globalchange.gov/browse/indicators/indicator-ocean-chlorophyl...

NASA Earth Observatory Global Chlorophyll Map
http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MY1DMM_CHLORA

Assessment

- Describe how student understanding, learning, and achievement are evaluated for this lesson. List any related documents (e.g. surveys, rubrics) when submitting the lesson and send them separately.
- Engage: Group discussion on chlorophyll levels
- Embedded activity assessment: approval of proposed project, drawing of investigation technique, compliance with lab safety protocols, etc.
- Post-activity assessment: peer-editing (speed dating activity), lab report rubric

Authors/Credits

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