Diatom Diversity in Acid Mine Drainage: Microscopic and Molecular Approaches

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Title and Description of Primary Image: Hughes Borehole Acid Mine Drainage Site with a pH of 3.4

Article Context: To make the submission process easier, you may want to examine the following form, which you will be asked to fill in during the submission process. Choose all applicable options that effectively **describe the conditions IN WHICH THE LESSON WAS TAUGHT**. Modifications to expand the usability of the Lesson will be addressed in the discussion.

****Not all categories will pertain to your article, in those cases, please select 'NA' when submitting on the website.**

Course

- Biochemistry
- Cell Biology
- Developmental Biology
- Genetics
- Microbiology
- Molecular Biology
- Introductory Biology
- Bioinformatics
- Evolution
- Ecology
- Anatomy-Physiology
- Neurobiology
- Plant Biology
- Science Process Skills

Course Level

- Introductory
- Upper Level
- Graduate
- High School
- Other

Class Type

- Lecture
- Lab
- Seminar
- Discussion Section
- On-line
- Other

Audience

- Life Sciences Major
- Non-Life Science Major
- Non-Traditional Student
- 2-year College
- 4-year College
- University
- Other

Class Size

- 1 – 50
- 51 – 100
- 101+

Assessment Type

- Assessment of individual student performance
- Assessment of student groups/teams
- Assignment
- Exam/quiz, in class
- Exam/quiz, take home
- Homework
- Answer clicker-type question(s)
- Answer essay question(s)
- Answer fill in the blank question(s)
- Answer multiple choice question(s)
- Answer short answer questions(s)
- Answer true/false question(s)
- Create a concept map
- Create a diagram, drawing, figure, etc.
- Create a website
- Create graph, table etc. to present data
- Design an experiment or research study
- Design/present a poster
- Give an oral presentation
- Informal in-class report
- Interpret data
- Order items (e.g. strip sequence)
- Participate in discussion
- Peer evaluation
- Post-test
- Pre-test
- Produce a video or video response
- Respond to metacognition/reflection prompt
- Self evaluation
- Solve problem(s)
- Written assignment: One minute paper
- Written assignment: Brochure
- Written assignment: Essay
- Written assignment: Figure and or figure legend
- Written assignment: Lab report
- Written assignment: Literature review
- Other - Written manuscript

Lesson Length

- Portion of one class period
- One class period
- Multiple class periods
- One term (semester or quarter)
- One year
- Other – 8 week summer research

Key Scientific Process Skills

- Reading research papers
- Reviewing prior research
- Asking a question
- Formulating hypotheses
- Designing/conducting experiments
- Predicting outcomes
- Gathering data/making observations
- Analyzing data
- Interpreting results/data
- Displaying/modeling results/data
- Communicating results

Pedagogical Approaches

- Think-Pair-Share
- Brainstorming
- Case Study
- Clicker Question
- Collaborative Work
- One Minute Paper
- Reflective Writing
- Concept Maps
- Strip Sequence
- Computer Model
- Physical Model
- Interactive Lecture
- Pre/Post Questions
- Other

Bloom's Cognitive Level (based on learning objectives & assessments)

- Foundational: factual knowledge & comprehension
- Application & Analysis
- Synthesis/Evaluation/Creation
- Principles of how people learn
- Motivates student to learn material
- Focuses student on the material to be learned
- Develops supportive community of learners
- Leverages differences among learners
- Reveals prior knowledge
- Requires student to do the bulk of the work

Vision and Change Core Concepts

- Evolution
- Structure and Function
- Information flow, exchange and storage
- Pathways and transformations of energy and matter
- Systems

Vision and Change Core Competencies

- Ability to apply the process of science
- Ability to use quantitative reasoning
- Ability to use modeling and simulation
- Ability to tap into the interdisciplinary nature of science
- Ability to communicate and collaborate with other disciplines
- Ability to understand the relationship between science and society

Key Words: List 3 to 10 key words that are relevant for the Lesson (e.g. mitosis; meiosis; reproduction; egg; etc.)

1. Diatoms
2. Metagenomics
3. Acid Mine Drainage
4. Environmental Microbiology
5. Bioinformatics

Scientific Teaching Context

Learning Goal(s)

Students will be able to identify diatoms by using a number of different of techniques.

Students will understand how to troubleshoot experiment procedure.

Students will be able to conduct laboratory experiments without direct oversight.

Learning Objective(s)

Students will be able to prepare diatoms and mount on microscope slides.

Students will be able to identify diatoms by microscopic examination of frustules.

Students will be able to isolate genomic DNA from environmental isolates.

Students will be able to conduct metagenomic approaches to determine what diatoms are present in diverse environmental conditions.

Students will compare and contrast the two methods of identification.

Introduction

Scientific Introduction

We are interested in using the unicellular photosynthetic diatoms as an indicator of water quality. Diatoms can be identified to the genus level (and sometimes to the species level) by their unique shaped silica cell wall called a frustule. Identification can also be determined by metagenomic analysis. This project focuses on acid mine drainage (AMD). Water escaping from abandoned and active mines in the Appalachia area of the United States of America contains high levels of iron and sulfur leached from the high levels of pyrite present. When the dissolved pyrite is exposed to oxygen iron and sulfuric acid is released. With the limited buffering capacity of the water, the pH decreases substantially, reaching levels as low as 2.5.

Student Involvement

The study of AMD covers multiple disciplines which allows multiple student involvement. Chemistry students analyze dissolved mineral content, environmental students observe and measure organisms present, and molecular biology students isolate DNA and use metagenomic techniques to identify organisms present. Emphasis is placed on students becoming independent in their approach to scientific design and experimentation as well as learn to work cooperatively and collaboratively.

Student Description

Over half of the students at Mount Aloysius College are the first in their families to attend higher education. Often as a result they do not have the support of their families. All too often, students working towards a biology degree are asked what they plan to do with their degree and they don't have an answer. Our aim is to provide a paid summer research experience for students so that not only can they learn what it is to conduct research but also communicate to our students to that there are further opportunities within the field of biology.

Intended Audience

The summer research opportunity is intended for upper level biology major undergraduates in a four-year institution.

Required Learning Time

The summer research lasts eight full time weeks.

Pre-requisite student knowledge

Students should have some knowledge of scientific process including hypothesis writing, experimental design, and basic laboratory skills. Students must have passed at least Biology I, II, and III.

Scientific Teaching Themes

Active Learning

Students will collect specimens from AMD sites, then actively carry out wet-bench experiments to mount diatom frustules, identify diatoms microscopically, and isolate genomic DNA. Additionally, students will participate in a metagenomics bioinformatic pipeline, and/or analyze statistical bioinformatic output.

Assessment

Students will be administered an online pre and post SALG (Student Assessment of their Learning Gains) evaluation. In addition, students will present their results in a campus wide student research symposium, and write a manuscript for publication.

Inclusive Teaching

Students will participate in all the learning objectives with one on one instruction from the instructors. Students may spend more time on the areas that interest them, but they will be involved in all aspects of the research. Two instructors are involved in the research with different backgrounds. One of the instructors is a plant pathologist and the other is a molecular and cellular biologist.

Lesson Plan

Initially students will learn diatom identification using slides prepared by students form previous summer research.

Students will then learn how to properly gather samples form the environment.

Back in the lab students will learn how to mount and prepare microscopic slides of the diatom frustules.

Throughout the following weeks students will be identifying and counting diatoms from their samples.

Next students will learn to isolate genomic DNA from new samples followed by PCR analysis.

Once the sequence data is available the students will begin the metagenomic pipeline analysis.

Finally students will compare and contrast the two data sets.

With the two data sets the students will make environmental observations and present their data.

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References

Arena, CM, JL Galeach, TM Mandichak, JM Engle, MG Anderson. 2015. Identification of diatoms in a healthy Pennsylvania stream compared to three downstream sites impacted by abandoned mine drainage. Fine Focus 1:xx