Modified Educational Transfer Plan (mETP)

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Coral Bleaching: Multiple Perspectives in Ecology Curriculum
Biology: 9th Grade
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Coral Bleaching:
Multiple Perspectives in Ecology Curriculum

0. Abstract

Coral bleaching research is at the heart of my fellowship in the Pringle Lab at Stanford, where they study the symbiosis between reef-building corals and dinoflagellate algae. This symbiosis is crucial to the survival of coral reefs. When this symbiosis breaks down, coral bleaching occurs and the diverse ecosystems coral support die. The lessons following here take coral bleaching as a meaningful and relevant scientific phenomenon to revisit throughout the year as a central part of my biology curriculum. To help my students build an understanding of coral bleaching (including what it is, why it matters, and what we can do about it), students complete three investigations in each of our three ecology units. Each of those investigations touches on different aspects of ecology and human impact and uses a distinct science practice to explore the coral bleaching phenomenon. In this way, coral bleaching acts as an anchor and context for learning multiple biological concepts, ways of thinking scientifically, as well as scientific perspectives through which marine environments (and all environments) may be viewed.

Units: 1) Ecology: Dynamics and Relationships, 2) Ecology: Cycles of Energy and Matter, 3) Human Impact, Climate Change, & Biodiversity

Driving Question:

Why is coral bleaching a problem and what can we do about it?

Anchoring Phenomenon:

Coral bleaching

Phenomena driven questions	*Practices used to make sense of phenomena*	*What students do and figure out*
Investigative Phenomenon #1: Introduction: Is coral an animal, plant or mineral? Driving Question: How do corals sustain themselves? Eat, develop, reproduce?	Science & Engineering Practice Focus: Constructing Explanations	Analyze scientific description about the various features of the coral organism to identify to identify and classify coral as animal, plant or mineral.
Investigative Phenomenon #2: Coral Reef Development Driving Question: How do coral reefs develop? Compare and combine two theories Darwin's *Subsidence* and Daly's *Glacial Control* theories?	Science & Engineering Practice Focus: Obtaining, Evaluating, and Communicating Information	Compare, integrate and evaluate sources of information presented in different media in order to develop a better model to fit the evidence.
Investigative Phenomenon #3: Corals and Biodiversity Driving Question: How do corals maintain a biodiverse ecosystem?	Science & Engineering Practice Focus: Analyzing and Interpreting Data	Analyze scientific data to identify the effects of coral loss on the local diversity of coral reef fishes.
Investigative Phenomenon #4: Symbiosis Between Corals and Algae Driving Question: How do corals and algae depend on compounds from each other through photosynthesis and respiration?	Science & Engineering Practice Focus: Developing and Using Models	Develop a model explaining the processes of photosynthesis and respiration in endosymbiotic algae and coral.
Investigative Phenomenon #5: Coral Bleaching: Human Impact and Solutions Driving Question: How do human activities influence the ocean environment and what solutions can we design to prevent/reverse coral bleaching?	Science & Engineering Practice Focus: Defining Problems and Designing Solutions	Describe ways in which human activity has adverse impacts on coral reefs (habitat destruction, pollution, climate change, etc) and propose solutions for mitigating coral bleaching.

I. Standards Connection to NGSS or Common Core

1. Focal Standard:

Science and Engineering Practices:
Developing and using models Analyzing and interpreting data Defining problems and designing solutions Obtaining, evaluating and communicating information

Performance Expectations:
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. 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. HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Disciplinary Core Ideas:
LS1.C: Organization for Matter and Energy Flow in Organisms The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1- 7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.(HS-LS1-7)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6) Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS4.D: Biodiversity and Humans
Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7) Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7), (HS-LS4-6)

Crosscutting Concepts:
Systems and System Models Energy and Matter Stability and Change

2. Active STEM Learning (and *optional* 21st Century Skill):

Active STEM Learning is a central piece of the investigations described in this mETP (see organizer in the Abstract). Throughout the year, students will construct their own understanding of coral bleaching as a real-world, relevant scientific phenomenon. To build this understanding, students will engage in science and engineering practices including analyzing and interpreting data, constructing models, and designing solutions. This allows students to learn ecology content (including biodiversity, photosynthesis and respiration, and human impact) in a purposeful way that builds towards a focal understanding, as well as practice scientific thinking by doing what scientists do.

II. Fellowship Connections

1. Fellowship Description

The Pringle Lab at Stanford studies the symbiosis between reef-building corals and dinoflagellate algae, which is crucial to the survival of coral reefs. This is an important area of study because when this symbiosis breaks down ("coral bleaching"), corals and the diverse ecosystems they support die. Since corals are very difficult to work with in a laboratory setting, the lab uses a closely related small sea anemone, *Aiptasia*, that is symbiotic with algae similar to those in corals as a model organism. To help elucidate the cellular and molecular mechanisms of symbiosis, my project is focused on understanding the patterns in relationships between certain host species of *Aiptasia* and certain strains of algae. To this end, I am conducting experiments in which I infect different Aiptasia strains with multiple different algae strains and quantify the rates of infection using flow cytometry, qPCR, and fluorescence microscopy. I am interacting with people in many different scientific careers including research scientists, lab managers, and data analysts.

2. Fellowship Connection to School/Classroom

Because I am using the research being conducted in my fellowship lab as a focal context for much of my biology curriculum, I will share my experience with my students at multiple points during the year. As I introduce the phenomenon of coral bleaching, I will describe the research questions being investigated in the Pringle Lab and explain the use of the anemone *Aiptasia* as a model organism. This will include pictures of the lab and, ideally, I'd like to bring in some live *Aiptasia* for students to observe. When students model the symbiosis between coral and algae through photosynthesis and respiration, I will share some of the data from my infection experiments, including images of anemones with fluorescent algae inside their cells. I will also share my mETP with the other biology teachers at my school with the hope of finding a collaboration partner to further develop the lesson plans to best meet the needs of San Mateo High School.

III. Instruction

1. Instructional Plan

Coral Bleaching Phenomena Organizer (Overview of Learning Sequence)

Anchoring Phenomenon: Coral Bleaching

Investigation #1: Is coral an animal, plant, or mineral? "Introduction to Coral"

- **Investigation #1** Classifying Coral: Animal, Plant or Mineral? (Slide Presentation)

Investigation #2: Structure of Corals and Coral Reef Development

- Development of Coral Reefs (Slide Presentation)

Investigation #3: Corals and Biodiversity

- **Background Lesson:** Coral Reef Ecosystems

Investigation #4: Modeling Symbiosis Between Corals and Algae

Investigation #5: Coral Bleaching: Human Impact and Solutions

- Infographic Rubric (summative assessment)
- **Background Lesson:** Coral Reef Goods and Services

2. Additional Instructional Context

Each of the three investigations in this mETP will take place in three different units of study throughout the year: 1) Ecology: Dynamics and Relationships, 2) Ecology: Cycles of Energy and Matter, and 3) Human Impact, Climate Change, & Biodiversity. The context for each investigation (including understandings that students should have prior to each) are described on the first page of each lesson.

3. Supply List

Anchoring Phenomenon: Coral Bleaching

- Copies of student handout
- Color copies of pictures and maps
- Live symbiotic and aposymbiotic Aiptasia in ASW (artificial sea water) in small dishes
- Magnifying glasses

Investigation #1: Corals and Biodiversity

- Copies of student handout
- Copies of figures

Investigation #2: Modeling Symbiosis Between Corals and Algae

- Copies of student handout
- 1 piece of poster paper per group
- Markers
- Post-its (3 different colors)

Investigation #3: Coral Bleaching: Human Impact and Solutions

- Copies of student handout
- Computers
- Post-its

4. Bibliography:

Anchoring Phenomenon: Coral Bleaching

- **Coral Pictures:**
  "Coral bleaching." *Wikipedia*. Wikimedia Foundation, 21 June 2017. Web. 29 June 2017.

  Ferraro, Kathleen. "Global coral 'bleaching' threatens reef survival." *Medill Reports Chicago*. N.p., 09 Mar. 2016. Web. 29 June 2017.
- **Maps:**
  Inc., Pelmorex Weather Networks. "Fourth mass bleaching event strikes Great Barrier Reef." *The Weather Network*. N.p., n.d. Web. 29 June 2017.

  "Major Coral Reef Regions of the World." *Major Coral Reef Regions of the World | World Resources Institute*. N.p., n.d. Web. 29 June 2017.

  "Warm Oceans Pose Risk Global Coral Bleaching Event in 2015." *NOAA Climate.gov*. N.p., 03 Mar. 2015. Web. 29 June 2017.'

- ***Aiptasia* Pictures:**
  "Disease, immunity and Coral bleaching." *Coral Biome*. N.p., n.d. Web. 17 July 2017.

  Fransolet, David, Stéphane Roberty, and Jean-Christophe Plumier. "Establishment of endosymbiosis: The case of cnidarians and Symbiodinium." *Journal of Experimental Marine Biology and Ecology* 420-421 (2012): 1-7. Web.

Investigation #1: Corals and Biodiversity

- **Analyzing and Interpreting Data Example:**
  "Instructional Materials - Identify and Interpret." *BSCS*. N.p., n.d. Web. 29 June 2017.

- **Figures:**
  Pratchett, M.S.; Hoey, A.S.; Wilson, S.K.; Messmer, V.; Graham, N.A. "Changes in Biodiversity and Functioning of Reef Fish Assemblages following Coral Bleaching and Coral Loss." *Diversity* 2011, *3*, 424-452.

Background Lesson: Coral Reef Ecosystems

- **Online Simulation:**
  Society, National Geographic. "Coral Reef Food Web." *National Geographic Society*. N.p., 09 Nov. 2012. Web. 17 July 2017.

- **Podcast:**
  "How Coral Reefs Work." *Stuff You Should Know*. N.p., 09 Feb. 2012. Web. 18 July 2017.

- **Food Web Organism Cards:**
  "Lesson G5U1L2: Everybody has a role in a coral reef." *NOAA Office for Coastal Management*. N.p., n.d. Web. 18 July 2017.

Background Lesson: Structure of Corals and Coral Reefs

- **Coral Structure:**
  Structure of a coral polyp - Cnidaria - Photo (JPG) - IAN Image and Video Library - Free High Resolution and Vector Environmental Science Images. N.p., n.d. Web. 31 July 2017

- **Types of Coral Reefs and Coral Reef Pictures:**
  "Aerial Photography." *Steve Parish Nature Connect*. N.p., n.d. Web. 31 July 2017.

  "Navigation." *Corals of the World - Types of Coral Reefs*. N.p., n.d. Web. 31 July 2017.

  "Scuba Diving Belize." *Scuba Diving Belize - Reefs Of Belize*. N.p., n.d. Web. 31 July 2017.

  "Type of Coral Reefs." *Coral Reef Types Page*. Montgomery College, n.d. Web. 31 July 2017.

Investigation #2: Modeling Symbiosis Between Corals and Algae

- **Reading and Video Model:**
  "Corals." *NOAA National Ocean Service Education: Corals*. N.p., n.d. Web. 29 June 2017.

Investigation #3: Coral Bleaching: Human Impact and Solutions

- **Readings:**
  Edmunds, Peter et al. "A Lesson Plan in Coral Reef Ecology." *California State University, Northridge.* 19 June 2007

  "High water temps at Great Barrier Reef may have caused irreversible damage." *Agence France-Presse via Newsela*. N.p., 20 Mar. 2017. Web.

  "Persian Gulf's coral reefs may hold clues to surviving climate change." *Scientific American via Newsela*. N.p., 9 Mar. 2015. Web.

  Slezak, Michael. "Great Barrier Reef supporters trying to stop the coal mines that are harming it." *The Guardian via Newsela*. N.p., 30 Nov. 2016. Web.

  Vince, Gaia. "Future - How can we save our dying coral reefs?" *BBC*. BBC, 06 Sept. 2012. Web. 11 July 2017.

- **Videos:**
  Destructive and Overfishing: Coral Reef Threat. YouTube, 12 Dec. 2016. Web. 11 July 2017.

  University of California. *How Pollution Affects the Health of Coral Reefs*. YouTube, 15 Jan. 2009. Web. 11 July 2017.

- **Infographic Resource:**
  Staff, Creative Bloq. "10 free tools for creating infographics." *Creative Bloq*. Creative Bloq ART AND DESIGN INSPIRATION, 01 Sept. 2016. Web. 17 July 2017.

Background Lesson: Coral Reef Goods and Services

Moberg, Fredrik, and Carl Folke. "Ecological goods and services of coral reef ecosystems." *Ecological Economics* 29.2 (1999): 215-33. Web.

5. Keywords

Coral bleaching, human impact, biodiversity, symbiosis, photosynthesis, respiration, analyze data, construct models, design solutions

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IV. Attachments

Coral Bleaching Phenomena Organizer (Overview of Learning Sequence)

Anchoring Phenomenon: Coral Bleaching

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