Coral Bleaching

Do *Aiptasia* with symbiotic algae grow better than those without symbiotic algae?

Overview

Coral reefs are diverse and critically important marine ecosystems. When corals are stressed they expel the symbiotic algae living in their tissues, causing them to become completely white, or "bleached". Researchers use the sea anemone *Aiptasia* as a model organism to study coral reef bleaching. Like coral reef polyps, Aiptasia partners in symbiosis with algae to help each other make energy and survive through the cellular processes of photosynthesis and cellular respiration. In this lesson, students explore data to determine how growth rates for Aiptasia with symbiotic algae differs from Aiptasia that do not have algae. Students use the trends they see in the data to explain the cycling of matter and flow of energy in the model organism, and then apply this knowledge to their understanding of coral bleaching.

Essential Questions

- *Why are coral reefs important?*
- *What is coral reef bleaching and how does it work?*
- *Why are Aiptasia used to study coral bleaching?*
- *What is photosynthesis? What is cellular respiration?*
- *How do algae and anemones obtain energy?*
- *What is symbiosis and how does it affect organisms?*

Expanded list of EQs

Learning Goals

Students will learn the following:

- *Coral reefs are essential to healthy coasts and vibrant economies.*
- *Corals experiencing environmental stress can exhibit bleaching which adds more stress and can lead to increased mortality.*
- *To study coral bleaching, researchers use model organisms that have similar processes but are easier to work with.*
- *Photosynthesis and cellular respiration provide most of the energy for life processes.*
- *Symbiotic relationships between organisms can affect the physiology of organisms.*

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Grade Level

9-12

Time

3 weeks

Anchoring Phenomenon

Coral Bleaching

Driving Question

Do Aiptasia with symbiotic algae grow better than those without symbiotic algae?

Standards

Next Generation Science Standards

LS2.B – Cycles of Matter and Energy Transfer in Ecosystems

Common Core Math Standards

HSS.IC.A.1

Sea anemone with pedal lacerates. Photo: Jack Koch

Learning Objectives

Students will be able to:

- *describe the energy transformation in both photosynthesis and respiration.*
- *analyze data to understand how symbiosis relates to energy transfer.*
- *explain how Aiptasia are a good model for understanding the phenomenon of coral bleaching.*

Introduction

In order to get the energy they need to survive, animals need to eat plants (or other animals that ate plants). However, there are some exceptions to this rule.

Corals are animals that have "living solar panels" made of symbiotic algae. They are mutualists, organisms that live together and help each other out. The algae make food from the sun in a process called photosynthesis and ship the food to the coral so that it can eat and generate energy in a process called cellular respiration. This is the equivalent of a small chef living inside your cells and providing you with food when you get hungry. In return, the corals provide pee (used as nutrients by the algae to build the food) and a safe place to live. This partnership allows corals to live and thrive in areas of the ocean where there are relatively low amounts of food to catch and eat.

However, when corals get stressed by heat or pollution, they can lose their solar panels and, therefore, their meal ticket. Losing the algae is called coral bleaching as the loss of the algae reveals the beautiful white skeleton of the coral beneath. This can be quite damaging to the coral as they have lost a major source of energy and can't synthesize food on their own.

Aiptasia are sea anemones, small marine animals, that are closely related to corals. Because they are easier to grow and manipulate in the lab, they are used as a "model system" to study coral bleaching. They can be used as a model for how energy is shared between the two partners (coral and algae) and what happens when things break down (coral bleaching). Also, as Aiptasia move around, they leave bits of themselves behind that turn into clones (genetically identical offspring) and researchers can stimulate this process to obtain more organisms.

Teacher Guides & Keys

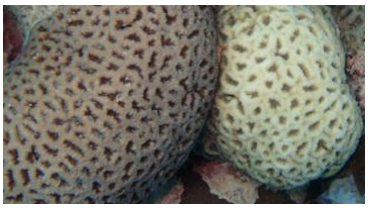
- *Guide to instruction (pdf)*
- *Quizizz (pdf)*
- *Edpuzzles (pdf)*

About Quizizz

Teachers will need to create a free account at quizizz.com to fully access and administer this linked resource. For more information, printable copies, and answer keys, see the Quizizz Teacher Guide (pdf).

About EdPuzzle

Teachers can create a free account at edpuzzle.com to fully access this resource.



Healthy (L) and bleached (R) coral.

Anemone grown with (L) and without (R) symbiotic algae. Photos: N. Kirk

Lesson Organization

*This unit is organized in a "week one, day two" or **W1D2** structure to help the instructor plan out activities over time. Additional short "**Deep Dive with Nate**" videos provide useful information outside of this daily structure. Teachers are encouraged to use these resources in whatever way makes sense for their classroom.*

Lesson Procedure

ENGAGE

During the week-long ENGAGE phase, students are led through a series of activities that will help them understand the importance of coral reefs, the phenomenon of coral reef bleaching, and why Aiptasia are a good model organism to study coral reef bleaching.

Activity Week 1 Day 1 – Why are coral reefs important?
Begin the class with a daily quiz: *Quizizz W1D1*. Then, have students work in groups through the *EdPuzzle W1D1* which includes watching the *Why are coral reefs so important?* video from the Natural History Museum. Next, students may work individually to read the NOAA article *The Importance of Coral Reefs* and complete *Worksheet W1D1*. End the class by having students address *Personal EQs W1D1*.

Activity Week 1 Day 2 – Coral reef bleaching
After the daily *Quizizz W1D2*, students work in groups through the *EdPuzzle W1D2* which features a *Coral Bleaching 101* video from the Great Barrier Reef Marine Park. Remaining class time can be used to complete individual work from the previous day, and students can address *Personal EQs W1D2*.

Video Extensions: Deep Dive with Nate
Oregon State University researcher Nate Kirk provides additional background and detail in two short videos:
- *Nutrient Cycling and Symbiosis*
- *Corals and Bleaching*

Activity Week 1 Day 3 – Coral reef bleaching, continued
After the opening *Quizizz W1D3*, students work in groups of about six students to create one slide per group in the *Group EQs W1D3* presentation. Students then present their Group EQs to the class.

Activity Week 1 Day 4 – Why Aiptasia?
Following the opening *Quizizz W1D4*, students work in groups through the *EdPuzzle W1D4* which focuses on the *Meet Aiptasia!* Video from the Red Sea Research Center. End the class by having students address *Personal EQs W1D4*.

Activity Week 1 Day 5 – Test
On this last day of the ENGAGE phase, students take the *Quizizz W1D5* as a test. They may use the rest of the class time to catch up on late work as needed.

Bleached coral in Guam during a period of elevated sea surface temperatures in August 2016. Photo: NOAA

LESSON RESOURCES

Healthy coral reef. Photo: NOAA

W1D1 Why are coral reefs important?
- *Quizizz W1D1*
- *EdPuzzle W1D1*
- Video: *Why are coral reefs so important?* [1:27]
- Reading: *The importance of coral reefs*
- Worksheet W1D1(*pdf*)(*ppt*)
- Personal EQs W1D1 (*pdf*)(*ppt*)

W1D2 Coral Reef Bleaching
- *Quizizz W1D2*
- *EdPuzzle W1D2*
- Video: *Coral Bleaching 101* [4:14]
- Personal EQs W1D2 (*pdf*)(*ppt*)

Deep Dive with Nate
- *Nutrient Cycling and Symbiosis* [5:46]
- *Corals and Bleaching* [6:58]

W1D3 Coral Reef Bleaching, cont'd
- *Quizizz W1D3*
- Group EQs W1D3 (*pdf*)(*ppt*)

W1D4 Why Aiptasia?
- *Quizizz W1D4*
- *EdPuzzle W1D4*
- Video: *Meet Aiptasia* [2:18]
- Personal EQs W1D4 (*pdf*)(*ppt*)

EXPLORE

During the EXPLORE phase, students are supported through the process of creating a *Research Project* that uses Aiptasia as a model for studying coral reef bleaching. These activities are designed so that all students will have concrete experiences which can be used when formally discussing topics later.

Activity Week 2 Day 1 - Research Project Step #1

Begin the week with the daily *Quizizz W2D1*. Then have students work in groups through the *EdPuzzle W2D1* which features a *Aiptasia Pallida as a Model System* video from the Pringle Lab at Stanford. Then, introduce the Research Project and the first assignment. The guide for the Research Project provides text that the teacher can copy and paste to set up a Google classroom assignment so that students can begin to work invidiually on the first assignment, *Student slides Step 1*.

Video Extensions: Deep Dive with Nate

In two short videos, OSU researcher Nate Kirk describes how Aiptasia can be used to study coral bleaching:

- *Aiptasia the model*
- *Aiptasia project and data*

Activity Week 2 Day 2 - Research Project Step #2

Begin by using a JamBoard or holding a class discussion to review the importance of coral reefs, the process of coral bleaching, and why Aiptasia are a good model organism for studying coral reef bleaching. Students can work in groups on *EdPuzzle W2D2* which continues to reference the Pringle Lab video. Then, the teacher introduces Step #2 of the Research Project and students continue with individual work on the second assignment using *Student slides Step 2*.

Activity Week 2 Day 3 - Research Project Step #3

Again, use a JamBoard or have a class discussion to ask: What coral reef bleaching research questions can we investigate by studying Aiptasia? The teacher introduces Step #3 and students work on the third assignment using Student slides Step 3 for either the *Article Review* project or the *Live Animal* project.

Activity Week 2 Day 4 – Examples of Projects

Begin the class with a short *Quizizz W2D4*. Then the teacher can share several project examples and lead a discussion on what needs to be in the reports. Depending on your classroom, the teacher or students may choose to do an *Article Review (see sample)* project or a *Live Animal (see sample)* project. Students can use the remainder of class time to finish individual work for Step #3 and groups can begin giving their student presentations.

Research Project: Teacher Guide

- *Research Project (pdf)*

W2D1 Aiptasia as Model Organisms

- *Quizizz W2D1*
- *EdPuzzle W2D1*
- *Video: Aiptasia Pallida as a Model System [12:03]*
- *Student slides Step 1 (ppt)*

Deep Dive with Nate

- *Aiptasia the model [6:22]*
- *Aiptasia project and data [7:16]*

W2D2 Aiptasia as Model Organisms, cont'd

- *EdPuzzle W2D2*
- *Student slides Step 2 (ppt)*

W2D3 Energy Transformation

- *EdPuzzle W2D3*
- *Student slides Step 3 for Article Review project (ppt) or Live Animal project (ppt)*

W2D4 Sample Projects

- *Quizizz W2D4*
- *Article Review sample (pdf)*
- *Live Animal sample (pdf)*

Example Research Questions

Study Aiptasia to find out:

→ *At what temperature do Aiptasia bleach?*

→ *How fast do fed Aiptasia grow compared to ones that aren't being fed?*

→ *How fast do Aiptasia that are kept in the dark grow compared to those that are kept in natural sunlight?*

→ *How fast do Aiptasia that are under an aquarium light grow compared to Aiptasia that are in natural sunlight?*

→ *Do Aiptasia that have their symbionts move toward light while bleached Aiptasia do not move toward light?*

Activity Week 2 Day 5 - Test
Use *Quizizz W2D5* as a test, and then continue with student group presentations of step #3.

EXPLAIN
In this 3-day phase, students will complete activities that will help them articulate their understanding of the new concepts they explored. During the first day, students learn about how symbiotic mutualism leads to benefits for both sides of the relationship. During day 2 and 3 of the Explain phase, students learn how photosynthesis works. These lessons contribute to the students' ability to analyze the novel situation presented in the summative performance assessment during the final evaluation phase.

Activity Week 3 Day 1 - Symbiotic Relationships in Cnidarians
Open the class with the short *Quizizz W3D1* and then have students work in groups on *EdPuzzle W23D1* which focuses on *The Coral and the Algae* video from NOAA. End the class by having students work on *Personal EQs W3D1*.

Activity Week 3 Day 2 - Energy Transfer
After the daily *Quizizz W3D2* have students work in groups on *EdPuzzle W3D2* which features an *Energy Transformation* video prepared by Nate Kirk from Oregon State University. Explore the *Researcher Bio* to learn more about Nate and his research questions. Close the class with *Personal EQs W3D2*.

Activity Week 3 Day 3 - Photosynthesis
Begin with *Quizizz W3D3* and then transition to group work on *EdPuzzle W3D3* for *Photosynthesis* video from the Amoeba Sisters. Students work individually to complete *Personal EQs W3D3*, and then in groups they begin work on *Group EQs W3D3*.

Video Extension: Deep Dive with Nate
In this video, OSU researcher Nate Kirk takes a deep dive into photosynthesis:
- *Photosynthesis*

ELABORATE
The elaborate phase begins on day 4 of week 3. In order to elaborate on what they have learned students will work in groups to create short presentations to answer the essential questions. These essential questions have all been explored during the project and previous lessons in the unit. Students will be expected to incorporate new vocabulary and concepts into their presentations. They will receive direct feedback from the

W2D5 Test
- *Quizizz W2D5*

Career Connection
- *Researcher Bio: Nate Kirk (pdf)*

Nate Kirk at at work in the field and lab.

W3D1 Symbiotic Relationships
- *Quizizz W3D1*
- *EdPuzzle W3D1*
- *Video: The Coral and the Algae[3:16]*
- *Personal EQs W3D1 (pdf)(ppt)*

W3D2 Energy Transfer
- *Quizizz W3D2*
- *EdPuzzle W3D2*
- *Video: Energy Transformation [2:20]*
- *Personal EQs W3D2 (pdf)(ppt)*

W3D3 Photosynthesis
- *Quizizz W3D3*
- *EdPuzzle W3D3*
- *Video: Photosynthesis [7:58]*
- *Personal EQs W3D3 (pdf)(ppt)*
- *Group EQs W3D3 (pdf)(ppt)*

Deep Dive with Nate
- *Photosynthesis [7:40]*

instructor and present to the class. This process will prepare them for the summative performance assessment.

Activity Week 3 Day 4
After the opening *Quizizz W3D4* , students continue working on Group EQs from the previous day. After the teacher has checked in with the groups and provided suggested edits, students present slides to the class. Finally, students may work individually to read *Who controls whom: Algae or sea anemone?* and complete *Worksheet W3D4*.

EVALUATE
For the evaluate phase, students work on a *Summative Performance Assessment* (SuPA). The SuPA is divided into two sections: In section one, students create slides to answer the essential questions. In section two, students analyze the data from a real scientific study to show mastery of the standards. This will be a formal assessment where students will receive feedback from the instructor on their mastery of the standard.

Activity Week 3 Day 4
Administer *Quizizz W3D5* as a test, and then students can work on their SuPA. Students read an *Annotated Abstract* from *Presnell et al., 2022*, analyze data presented in the article, and explain how the flow of matter and energy in Aiptasia with symbiotic algae differed from that of Aiptasia lacking symbiotic algae. Students and classes may need more than one day to complete the SuPA.

W3D4 Elaborate
- *Quizizz W3D4*
- *Reading: Who controls whom: Algae or sea anemone?*
- *Worksheet W3D4 (pdf)(ppt)*

W3D5 Evaluate
- *Quizizz W3D5*
- *Summative Performance Assessment (ppt)*
- *Annotated Abstract (pdf)*

Next Generation Science Standards

Performance Expectations:
HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Science & Engineering Practices:
Constructing Explanations and Designing Solutions

Disciplinary Core Ideas:
LS2.B – Cycles of Matter and Energy Transfer in Ecosystems

Crosscutting Concepts:
Energy and Matter

Common Core Math Standards

Math Standards:
HSS.IC.A.A – Understand statistics as a process for making inferences about population parameters based on a random sample from the population.

Presnell et al, 2022
Presnell JS, Wirsching E, Weis VM. 2022. Tentacle patterning during Exaiptasia diaphana *pedal lacerate development differs between symbiotic and aposymbiotic animals. PeerJ 10:e12770*
https://doi.org/10.7717/peerj.12770

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