Everblue Education

Return to the Reef: Coral Bleaching

This week we're returning to the reef! In our very first lesson, we looked at the reef community as a whole. This time, we're focusing on the corals themselves. These amazing animals are the reason for the entire complex reef community; they provide other animals with food and shelter. Without corals, there simply would be no reef! Although reefs occupy barely 1% of the surface area of the ocean, almost 25% of all marine fishes rely on reefs at some point in their development, including many commercially valuable species. Unfortunately, these important habitats face many human threats, including temperature stress from global climate change. This lesson is based on a paper studying coral bleaching caused by warmer water temperatures to observe how they recover. In this lesson, students will learn about coral biology, different kinds of animal relationships, and how changing ocean temperatures affect corals and the other organisms they support.

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceanoeverblue on your prefered social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! More activities will be available to download for FREE off of our website, with a new activity added every Friday until the end of quarantine.

Research Paper:
Mass coral bleaching in 2010 in the Southern Caribbean. *Jahson Berhane Alemu I and Ysharda Clement. 2014.*

Grade Level:	Timing:
Grades 4-8	~ 1.5 hours

Materials

- Writing utensils including colored pencils, crayons, etc.
- Scissors
- Several medium sized objects such as balls, toys, books etc. (for *A Symbiotic Race*)
- Many small objects such as Legos, paper clips, etc. in two colors (for *Bleaching Simulation*)

Common Core State Standards

English Language Arts:
Vocabulary acquisition and use

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Constructing explanations Using models	Cause & effect Patterns Stability & change	Ecosystem dynamics Interdependent relationships in ecosystems

Activity Overview

Title of Activity	Learning Cycle Stage	Time
Symbiotic Races	Invitation, Exploration	20 minutes
Symbiosis Discussion	Concept Invention	10 minutes
Anatomy of a Coral	Concept Invention	10 minutes
Bleaching Simulation	Application	15 minutes
Coloring Corals	Application	10 minutes
Coral Crossword	Application	10 minutes
Reflection	Reflection	5 minutes

Appendix Contents

Appendix I Instructor Support	Appendix II Attached Lesson Materials
Ocean Vocabulary Common Questions Common Relevant Misconceptions	Coral Anatomy Key Coral Cutouts Coral Crossword Key

Activities

Symbiotic Races

To get students physically involved in modeling the different relationships found in coral reef communities, they will be racing with partners to collect “food” items. If you are able to go outside, this activity is an opportunity to get students up and running. If not, make use of a large room in your home. (If you’re feeling extra creative, you can add in an indoor obstacle course!) This race for resources will demonstrate how each organism is impacted in each type of relationship that we will be learning about in our other activities. We will be keeping score, so grab a writing utensil and something to write on.

This activity requires partners, so it’s a great opportunity to include siblings or other family members, or jump in and be your student’s partner!

1. At one end of the room (or whatever space you are in), designate a “starting line.” At the opposite end of the room, place a collection of objects. These could be balls, toys, books, whatever is available to you. These will represent resources organisms need to survive, and every object that players are able to collect and bring back to the starting line will earn them a point.
2. Have your student(s) and their partner(s) line up on the starting line. If you have a large enough group for multiple pairs, this can be turned into a race! If not, the single pair will be competing against themselves to run as fast as they can and collect as many resources as they can.
3. ROUND ONE: For the first round, your student(s) and their partner(s) will simply run down to the opposite side together, each collecting as many objects from the pile as they can, and run back to the start. If one drops an object along the way, the other may pick it up, but they must stay <u>together</u>. Record how many objects each partner brings back, being sure to count each partner’s collection separately. Then, give additional points to each player equal to half of the value of the other player’s score. (*Example: Daisy collected 14 items and Joshua collected 12 items: Daisy adds 6 to their total score and Joshua adds 7 to their total score.*) Return all objects to the pile.
4. ROUND TWO: For this round, designate one partner (in each pair if multiple) as Organism A, the other as Organism B. The pair will hold hands and run down to the opposite end, collect as many objects as they can hold while also holding hands, then return to the start. If Organism A drops any objects, Organism B may pick them up, but Organism A may NOT pick up any objects dropped by Organism B. Record how many

points each partner earned. Give additional points to Organism B equal to half the amount of points earned by Organism A this round. Organism A's points are unaffected. Return all objects to the pile. Repeat this round, switching each partner's role.

5. ROUND THREE: For the final round, designate one partner as Organism A, the other as Organism B again. Organism A will give Organism B a piggyback ride down to the opposite end of the room. Organism A will hand as many objects to Organism B as they can hold <u>while maintaining the piggyback safely</u>, then Organism A will pick up any additional objects they are able to hold while also holding Organism B safely. The pair will make their way back to the start; if any objects are dropped, Organism A must pick them up. Count how many objects each partner collected. Organism B's final score will be the total sum of the collected items, and Organism A's final score will be the number of items Organism A collected **MINUS** the number of items Organism B collected. Return all objects to the pile. Repeat this round, switching each partner's role, if it is safe to do so.

<u>Activity review:</u>

1. Which round was your favorite? Why?
2. How did it feel to be in the relationship in Round One?
3. What about the relationship in Round Two?
4. What about the relationship in Round Three? How did it compare to the other two types of relationships?

Symbiosis Discussion

In this activity, students will listen to and answer discussion prompts to learn about the symbiotic relationships they just modelled. These relationships allow coral reefs to thrive! Read to your students and follow instructions to pause, allowing them to answer questions. Words in blue are defined in the ocean vocabulary in Appendix I. Words in *italics* are notes to you, the teacher. Words in **bold** are discussion starters for the students.

1. An important part of learning how coral reefs function is understanding the relationships between organisms. The closest relationships are symbiotic. Let's break this word down to understand its meaning. "Biotic" has the root "bio" which we should be familiar with by now! *Have students come up with their own definitions of "bio" before proceeding.*

    (Check out the lesson "Sedimentation Exploration" on our website if you'd like to see the full lesson on naming scientists.)

   "Bio" means "life" so we know it has to do with living things. "Sym-" comes from a Greek root meaning "together." So by combining these two clues, we understand that we are talking about living things, living together! Symbiotic relationships or symbiosis means an interaction between two different organisms. There are three different types of symbiotic relationships, all of which can be found on a reef!

2. The first kind of symbiosis is parasitism. **What word does this sound like?** *Hopefully students hear the similarity to "parasite."* In parasitism, one organism benefits from the relationship at the expense or harm of the other organism: one wins, one loses. The organism that wins is the parasite and the one that loses is the host. **Which of the three races do you think modeled this type of relationship and why?** (*Round Three: Not only did Organism A actively lose points, they had to expend a lot of extra energy just to move. This can be the case for hosts with larger parasites, which make moving hard or other functions in addition to reducing how many resources they can get.*) In some cases, the parasite may ultimately kill its host, while in others it's important that the host stays alive. **Can you think of any examples of parasitism?** (*Mosquitos*) One very common, and surprisingly beautiful, example in reefs are Christmas tree worms which drill into corals to gain shelter and nutrients. This injury to the coral makes it more vulnerable to infection.
3. The next kind of symbiosis is commensalism, where one organism (called the commensal) benefits from the relationship while the other is neither helped nor harmed; essentially, the host is not affected by the relationship. **Which of the three races do you think modeled this type of relationship and why?** (*Round Two: Both partners were able to collect their own resources, And Organism B was able to collect whatever Organism A dropped. This commonly occurs in commensalistic relationships, where a smaller organism is able to pick up scraps of food scattered from whatever its larger host is feeding on. It is food the host would probably miss anyway, so it remains unaffected, but the commensal benefits greatly.*) Many creatures make their homes within the complex structures of coral heads to avoid being seen by predators, but in many cases, the coral receives no benefit from these animals.
4. The last kind of symbiosis is mutualism. This is when both organisms in a symbiotic relationship benefit from one another - it's a win/win! **Can you think of any examples of mutualism?** Think about the movie *Finding Nemo*; what kind of relationship do Nemo and Marlin have to their anemone? While it may appear to be commensalism, they actually have a mutualistic relationship! The clownfish gain protection for themselves and their eggs within the anemone's stinging tentacles; in return, the clownfish help protect the anemone from predators, such as butterflyfish. **Why do you think our first race modeled this type of relationship?**
5. The relationship we will be focusing on today is another example of mutualism, this time between corals and a tiny algae called zooxanthellae, which we'll learn more about in the next activity. These algae are in a special kind of mutualism with the corals because they actually live inside the soft tissues of the coral! This is called endosymbiosis ("endo"

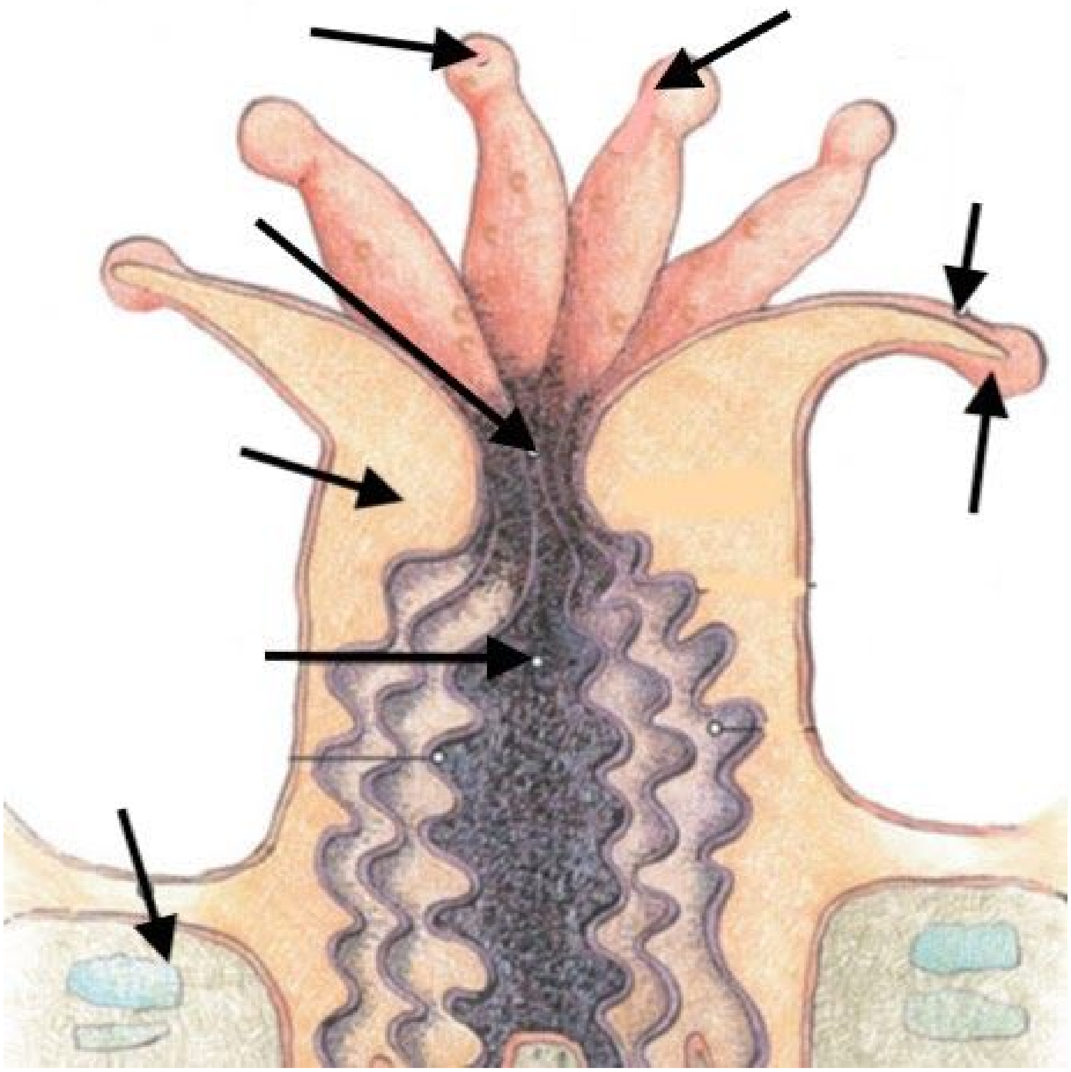
means "internal" or "within"). This relationship is critical to the survival of both the corals and the algae, as you'll see later on!

Anatomy of a Coral

In this activity, students will get up-close and personal with the coral polyp and learn all about coral anatomy and their special relationship with zooxanthellae! Read the following to your students and have them label the diagram found on the next page with the words in bold blue. Words in blue that are not bolded are defined in the ocean vocabulary list in Appendix I.
A key for the diagram is included for you in Appendix II.

1. Even though they sometimes look more like plants or rocks at first glance, corals are actually animals! Just like you, they need to eat, grow, and protect themselves. In this activity, we'll get up close and personal with a coral to learn how it does these things!
2. In front of you, there is a picture of a coral polyp. Coral colonies are made up of thousands of these, collected all over the surface of a coral like pores. Each individual polyp is considered to be a coral, and each colony is considered to be a coral as well. The coral animal is one organism made up of many individuals!
3. Corals eat by using the **tentacles** on the top of each polyp to grab tiny plankton from the surrounding water, putting it in their **mouth**. The mouth is surrounded by the tentacles.
4. The mouth leads to the **stomach**, giving the coral nutrients. However, a coral cannot obtain all of its nutrients from plankton alone, so it has to rely on another food source.
5. Along with plankton, corals also get food from **zooxanthellae**. Wow, that's a big word! Let's sound it out: **ZOH-zan-thel-ay**. These zooxanthellae are actually tiny plant-like plankton that live *inside* of the corals' soft tissues! Since the plankton are plant-like, they can photosynthesize, turning energy from the sun into food in the form of sugars, most of which they give to their coral hosts. It's a win-win situation, a mutualistic symbiotic relationship; the corals get food and the zooxanthellae get a home.
6. Corals have a layer of skin, just like you do. But, even though human skin doesn't house zooxanthellae, our skin and coral skin have the same name: the **epidermis**.
7. Corals grow by slowly creating their hard **skeleton** over time and depositing it underneath their soft **body**, which is surrounded by the epidermis. The skeleton is made up of a special material called calcium carbonate - the same kind of material that makes up shells you find on the beach!
8. As the coral grows, it needs to protect itself. So, it arms itself with special stinging cells in its epidermis called **nematocysts**. Let's sound that out: **ne-MA-toe-sists**. These cells will sting any small animals that come close, but to us, they just feel sticky. (Have you ever touched a sea anemone and felt the tentacles "stick" to your finger? That's because anemones have the same tiny nematocysts that corals do!)

9. All in all, corals eat, grow, and move just like any animal does! But, corals also have super cool, super important plant-like zooxanthellae living inside their bodies. What happens when the corals lose these zooxanthellae? Move on to the next activity to find out!



Label the diagram with the words in **bold blue** from the previous page | *Image modified from NOAA*

Bleaching Simulation

For this activity, students will experience life as a coral polyp under different heat conditions. Read the following information to your students:

The beautiful corals we've been learning about are found mostly in the warm waters of the tropics where water temperatures change very little from winter to summer. Because of this, most corals have a fairly small range of temperatures in which they can live. Unfortunately, global climate change is warming the oceans and that's bad news for corals. Temperature increases of as little as 1°C above the normal seasonal maximum can make them really stressed out, and increases of 2°C or more for a long time cause bleaching. Bleaching happens when high water temperatures damage those teeny zooxanthellae, so the coral gets rid of them; it expels its algal symbionts. These algae not only provide the coral with food, they also are what give corals their bright colors! So without algae, corals' soft tissues become clear and their bright white calcium carbonate skeleton shows through. This is why this event is called bleaching; the corals look like they have been bleached white! Our next activity will explore what life is like for a bleached coral.

1. In a large clear area, set out a bunch (At least 40 items per student participating) of small objects in two different colors. These objects could be legos, dry beans, paperclips, again just whatever you have available to you. One color will represent planktonic food, the other color will represent sugars produced by the zooxanthellae. There should be much more "sugar" available than "plankton" (roughly 5x as many pieces of "sugar" as "plankton").
2. Inform students that they are now coral polyps and they have 30 seconds to pick up as many pieces of "food" of both types as they can. At the end of the 30 seconds, have students count their pieces of food to see how well they survived.
    - More than 30 pieces = healthy coral
    - 15-30 pieces = stressed, partial bleaching
    - Less than 15 pieces = completely bleached, starving
3. HEAT WAVE!! Announce that there has been a small heat wave and water temperatures have risen by 1°C. Remove half of the objects representing sugars from zooxanthellae. They again have 30 seconds to pick up as many pieces of "food" of both types as they can. At the end of the 30 seconds, tally up how many pieces of food they were able to collect and see how well they survived this round using the same guide given above.
4. HEAT WAVE!! Announce that there has been a **major** heat wave and water temperatures have risen by an **additional 2°C**. Remove the rest of the "sugars" and repeat the mad dash for food, then conduct a final tally to measure survival.

Did anyone survive the heat waves? Notice that as it got hotter, there was less and less food available in the form of sugars from the zooxanthellae. This is what happens to corals during a heat wave; they expel their zooxanthellae and start to starve because they can't get enough food from plankton alone. If the high temperatures only last for a short time, the corals may be able to get new plankton and recover, but if the water stays hot for several weeks or even months, the corals will die and different types of algae will grow over their skeletons. Dead, algae-covered coral doesn't provide the same habitat as a healthy coral reef, so the animals that live on the reef no longer have enough food or shelter.

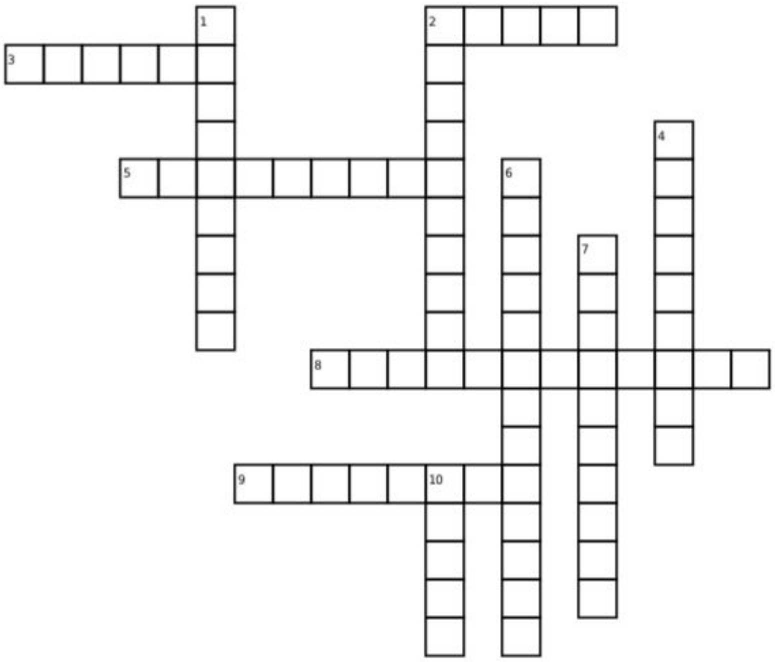
Coloring Corals

In this activity, students will use coral graphics and coloring to learn the different stages of coral life! As the students color the corals, they "add zooxanthellae." When the corals are white or brown, they do not have zooxanthellae. You will need the coral cutouts from Appendix II and some coloring implements.

1. Have the students cut out all of the corals, leaving them white. Then, read them the following:You have a healthy reef filled with corals that are growing, eating, and reproducing! These corals are happy and have their zooxanthellae to help feed them energy from sunlight. Go ahead and color three of your corals and place them in the middle of the table, which will now be the "reef."
2. Then, one day late in the summer, there is a heat wave on your reef, causing some of the corals to turn white. This is because when the water heats up, the zooxanthellae can't do their job to make healthy food for the corals, so the corals actually get rid of their zooxanthellae - they kick them out! Add three corals to the reef and leave them white.
3. It's getting later in the summer, and the water is still much warmer than normal for this time of year. This is bad news for the corals, who aren't able to get enough food without their zooxanthellae. They kicked them out when the water got too warm, but now they can't recover without their extra food. Take away the three colored corals and add three more white corals.
4. In the big heat wave of the summer, the reef "bleached," making the corals go white without their zooxanthellae color. Without this food, some of the corals starved and got overrun with algae. Color two of your corals brown to show algae cover.
5. But, the good news is, nature is incredibly resilient! It can often recover, when given the time. As the summer turned to fall on the reef, and the water temperatures got a little cooler, some of the corals were able to recover. Add the three colored corals back to the reef and color all but one of the remaining corals.
6. It's now fall on the reef, and the corals look healthy again, though you can still see signs of the most recent bleaching. At this time, the reef should have two brown corals covered in algae, one white coral that was bleached, and six healthy colored corals that were able to recover and get their zooxanthellae back.
7. This is why it's so important that we help reduce ocean warming; if heat waves keep happening year after year, more and more corals will bleach and die and it will be harder and harder for the reef to recover. But if we help to keep the ocean cool, they can have a chance to recover after mass bleaching events!

Coral Crossword

Have the students fill in this crossword with the ocean vocabulary found highlighted in blue throughout this lesson! A key is included in Appendix II.



Down:

1. a relationship between two organisms
2. a type of relationship where one organism benefits and the other is harmed
4. a type of relationship where both organisms benefit
6. a tiny plant-like plankton that can photosynthesize
7. a coral's protective stinging cell
10. an animal in the Phylum Cnidaria

Across:

2. an individual coral
3. a multitude of individuals that work together as one coral
5. a coral's skin, which houses the stinging cells and symbiotic plankton
8. a type of relationship where one organism benefits and the other is unharmed
9. a coral's specialized arm

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

- ➢ What was your favorite part of our activity today?
- ➢ What is something that you learned about corals?
- ➢ Did you notice any patterns during our activity today?
- ➢ What is something you wonder about coral bleaching?
- ➢ What is something you can do to help keep the oceans cool for corals?
- ➢ What surprised you the most during our activity today?

Appendix I - Instructor Support

Ocean vocabulary

- Commensal - the organism in a commensalistic relationship which benefits, but has no effect on its host
- Commensalism - a relationship between two organisms where one benefits and the other is unaffected.
- Coral - an animal that is characterized by stinging cells, individual polyps that make up a colony, and a special symbiotic relationship with zooxanthellae that allows them to get food from sunlight. These animals are classified in the Phylum Cnidaria.
- Endosymbiosis - a special kind of symbiotic relationship where one organism lives inside of another.
- Epidermis - the soft outer “skin” layer of a coral polyp.
- Host - an organism on or in which another organism lives in a symbiotic relationship. Depending on the type of relationship, the host may be helped, harmed, or unaffected by the other organism
- Mutualism - a relationship between two organisms where both benefit.
- Nematocyst - specialized stinging cells characteristic of the Phylum Cnidaria. Corals, sea anemones, and jellyfish, all members of Cnidaria, have nematocysts. (pronounced ne-MA-toe-sists)
- Parasitism - a relationship between two organisms where one benefits and the other is harmed.
- Polyp - an individual coral, made up of tentacles around a mouth, a body, and a stomach that grows
- Symbiosis - a relationship between two organisms in nature.
- Tentacle - a coral’s specialized arm, used for both feeding during the nighttime (when there is no sun so zooxanthellae cannot photosynthesize,) and for cleaning the surface of the coral free of bacteria and algae.
- Zooxanthellae - a special type of microscopic plankton classified as dinoflagellates. These plankton can photosynthesize during the day, using the energy of the sun to make sugars. (pronounced ZOH-zan-thel-ay)

Common Questions

Why are both a polyp and a colony called a "coral"?

A coral is an animal that is made up of many individuals. A single coral polyp is still a coral, and can survive on its own, but in order to grow it has to create more polyps and become a colony.

Why do corals expel their zooxanthellae when they get too warm?

The tiny algae become damaged by unusually high water temperatures and can no longer photosynthesize properly, or even die. The coral can tell when this happens, so it gets rid of the algae, in the hopes that it can recruit a new, more resilient batch of algae and recover after water temperatures have returned to normal.

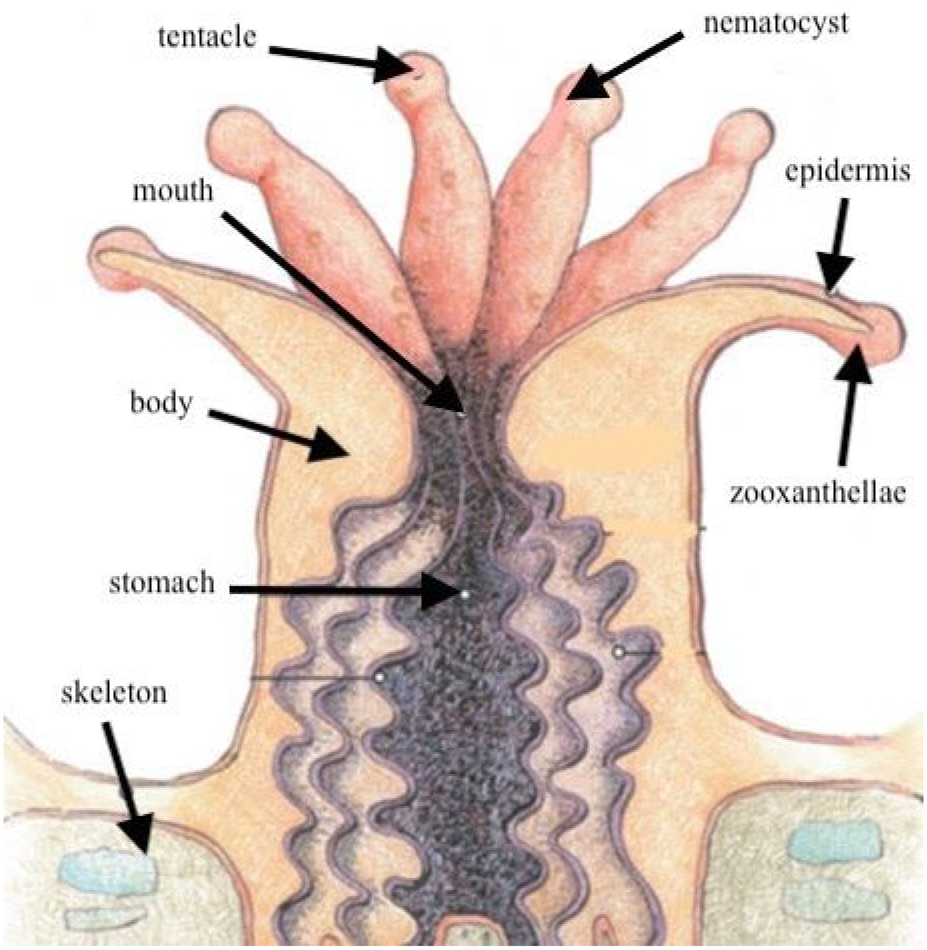
Common Relevant Misconceptions

Corals are animals, even though some look like they could be rocks, and they gain energy through the sun like a plant.

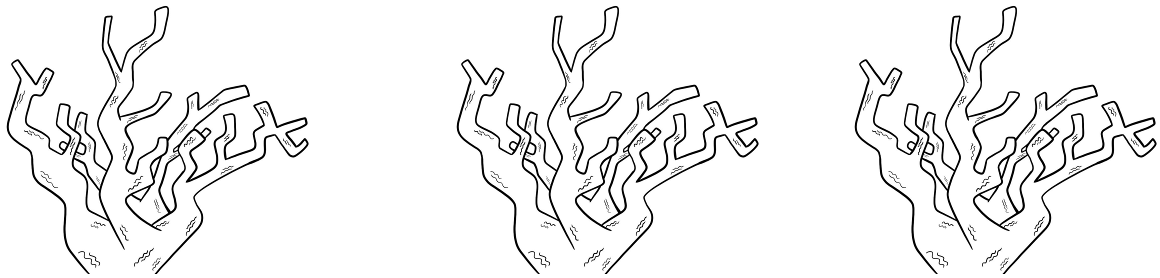
Corals are classified as animals in the phylum *Cnidaria,* but they are one of those tricky animals that toe the line between animal and plant. Corals can eat like other animals and catch floating animals with their tentacles (similar to jellyfish!). They also have a unique symbiotic relationship with the plant-like algae, zooxanthellae. The zooxanthellae live inside of the corals, allowing the corals to gain food the same way that plants do - through the sun's energy, via their plant-like algae friends. This would be like if we had plants inside of our skin that allowed us to step outside the house and photosynthesize, eating just by standing in the sun. Pretty cool, right? So, corals are animals, but they eat like plants.

Appendix II - Attached Lesson Materials

Coral Anatomy Key

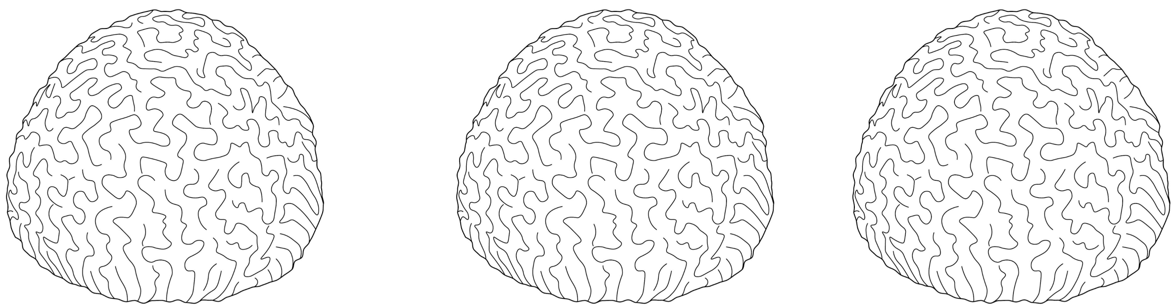


Coral Cutouts



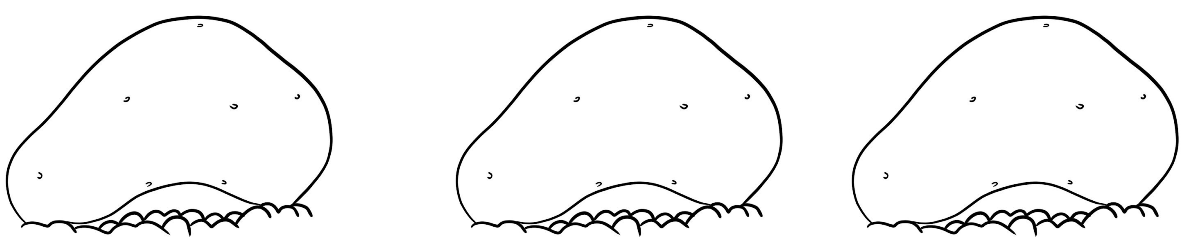
Elkhorn Coral

Acropora palmata



Brain Coral

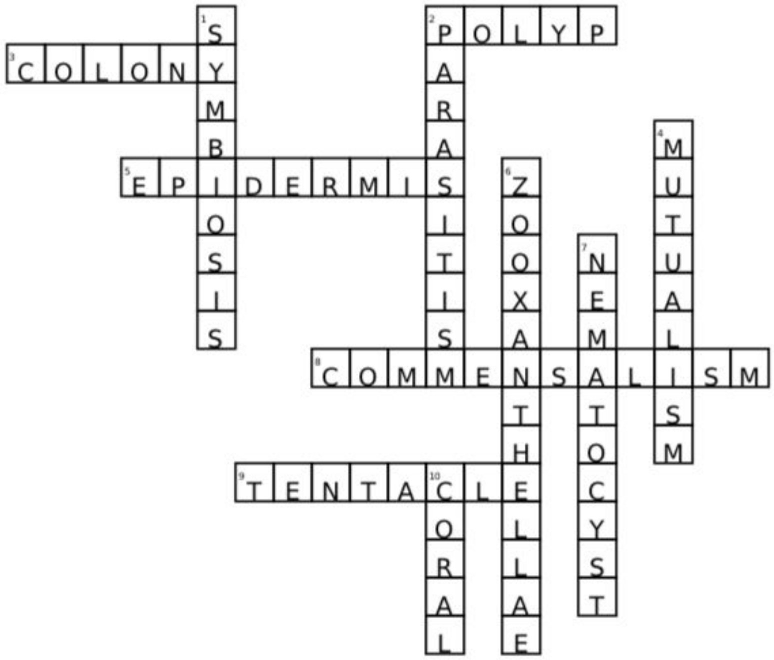
Pseudodiploria strigosa



Massive Starlet Coral

Siderastrea siderea

Coral Crossword Key



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Crossword created on Education.com