**Lesson Plan: Coral Conference**

**Learning Overview:** Coral reefs are one of the most biodiverse ecosystems on the planet. Along with providing food and shelter for a variety of marine organisms, coral reefs reduce erosion and protect coastal cities from storms. However, coral reefs are threatened by the effects of climate change. In this activity, students will model the complex interactions that occur within corals, their ecosystem and the Earth’s spheres to learn about how climate change harms coral reefs. After modeling how these interactions change with increasing ocean temperatures, students will brainstorm potential ways to solve or mitigate coral bleaching.

**NGSS-DCI:** HS-LS2; HS-ESS2; MS-LS2; MS-ESS2.

**Paired Articles:**

*Science News:*“[Record-breaking Coral Sea temperatures threaten the Great Barrier Reef](https://www.sciencenews.org/article/coral-sea-temperature-great-barrier-reef)”

Readability Score:9.9

**Approximate Class Time:** 2 class periods

**Directions**: In this activity, students will learn about coral reefs and climate change by reading the *Science News* article “[Record-breaking Coral Sea temperatures threaten the Great Barrier Reef](https://www.sciencenews.org/article/coral-sea-temperature-great-barrier-reef)” before splitting into groups to learn more about coral bleaching. In these groups, students will diagram three different stages of coral bleaching and coral reef health, creating diagrams that show a healthy reef, a reef in the process of bleaching, and a fully bleached reef. Each group will create diagrams that display perspectives on coral bleaching from different scientific disciplines. Students will then brainstorm solutions that may stop or mitigate coral bleaching with their group. At the end of the class, each group will combine their diagrams into a larger diagram that shows the biological, ecological and chemical processes and their interactions and relationships that occur within a coral reef and will identify the solution that may best address coral bleaching.

This activity can be taught in conjunction with the Science News Learning lesson plans “Saving the world’s coral reefs” and “Corals across the disciplines.” If using these lessons, they should be taught prior to the “Coral Conference” activity.

**Supplies:**

* Computer
* Student Worksheets
* Pencils
* Paper
* Crayons/Pastels/Color Pencils/Markers
* Whiteboard/Chalkboard/Easel
* Dry erase markers/Chalk

**Coral Bleaching**To start this activity, ask students to read the *Science News* article “[Record-breaking Coral Sea temperatures threaten the Great Barrier Reef](https://www.sciencenews.org/article/coral-sea-temperature-great-barrier-reef)” as homework and ask students to answer the questions on their student worksheet. While question two is in reference to the article, all questions ask students to draw on their prior knowledge. Because of this, students may use outside resources if needed but should be encouraged to answer each question to the best of their abilities on their own.

1. Using your prior knowledge, why might greenhouse gas emissions have seen a significant increase starting around the year 1900?

*Student answers may vary. Greenhouse gas emissions began to increase around the industrial revolution and have continued to rise with increasing fossil fuel use.*

2. How were scientists able to measure sea surface temperatures over time? Imagine coral growth rings, like those of trees, that vary in thickness, color and density. Thick rings can represent years of good growth and thin rings can represent years of poor growth.

*To study how sea surface temperatures have changed over time, scientists drilled into coral skeletons to measure the growth rings of the coral. Using the thickness, color and density of each ring, scientists can gauge whether water temperatures were good or bad for coral growth.*

3. How have greenhouse gas emissions impacted ocean temperatures and how might this change in temperature impact coral growth?

*Greenhouse gas emissions have increased global temperatures, including ocean temperatures. If ocean temperatures become too hot for the corals, coral health may decline and growth may slow or stop.*

4. What scientific careers might focus on coral reefs? What aspect of coral reefs would each type of these scientists study? Be specific. Name and describe at least 3 different scientific careers.

*Student answers may vary. Biogeochemists might study water quality and how the carbon dioxide produced by the burning of fossil fuels impacts coral reefs. Coral biologists might study the mutualistic relationship between coral and zooxanthellae. Ecologists may study how corals provide food and shelter to other organisms within the coral reef ecosystem.*

**Representing Relationships**

Ask students to form three equally sized groups. Tell students that each group will be creating three diagrams that show the processes, interactions and relationships that occur within a coral reef at different stages of coral bleaching.

Tell students that each group will create diagrams that focus on different aspects of the coral reef and assign each group one of the following careers: biogeochemist, coral biologist, and ecologist. Tell students that they will be acting in their assigned career to create their diagrams. To help students create their diagrams, each group will be given a separate set of guiding questions on a worksheet. Give each group their associated worksheet and ask students to answer the questions and follow the instructions on their worksheet to create their diagrams. Give students at least 45 minutes for this portion of the activity.

Place paper and drawing tools in a central location. Students will need access to these materials to illustrate their diagrams. Students will also need access to computers for this portion of the activity. While students can use any online resource, resources like NOAA’s [coral tutorial](https://oceanservice.noaa.gov/education/tutorial_corals/welcome.html) and the [Smithsonian Ocean Portal](https://ocean.si.edu/ocean-life/invertebrates/corals-and-coral-reefs) can be used as good starting places for student research.

**Representing Relationships as a Biogeochemist**

1. What is a biogeochemist and what do they study?

*A biogeochemist is a type of chemist that studies how elements and chemicals move throughout living and non-living things.*

2. What are Earth’s spheres? What does each sphere include?

*The Earth’s spheres include the lithosphere, hydrosphere, atmosphere and biosphere. The lithosphere is composed of the solid Earth, the hydrosphere is composed of all water on Earth, the atmosphere is composed of all gases surrounding Earth, and the biosphere is composed of all living things on Earth.*

3. How does the burning of fossil fuels impact ocean temperatures? Be specific and identify each sphere where applicable.

*Fossil fuels come from the lithosphere. When burned for energy, fossil fuels release carbon into the atmosphere, where it can then trap heat energy from the sun. This trapped heat energy causes global warming and increases the temperature of the atmosphere. Heat trapped in the atmosphere is transferred into the hydrosphere, increasing ocean temperatures. These increased ocean temperatures impact the biosphere’s aquatic organisms, including corals.*

For each of the following diagrams, label the spheres and include carbon, carbon dioxide (CO2), the sun, light/heat energy, and industry (where applicable).

4. Take a full piece of paper and write “Cool” at the top of the page. On this page, draw a coral reef. Diagram the movement of chemicals and light/heat energy and show how they interact with a healthy reef that has no signs of coral bleaching.

*Student diagrams may vary. The diagram is divided into three sections, stacked one on top of the other. From the bottom up, each section is labeled lithosphere, hydrosphere, and atmosphere. The lithosphere extends up into the atmosphere on one side of the diagram. This area represents an island or continent. In the diagram, carbon is primarily located in the lithosphere and carbon dioxide is primarily located in the atmosphere. The sun provides a set amount of light/heat energy. This light/heat energy is able to enter and exit the atmosphere. The corals are brightly colored.*

5. Take a full piece of paper and write “Warming” at the top of the page. On this page, draw a coral reef. Diagram the movement of chemicals and light/heat energy in a warming climate and show how they interact with a coral reef that is beginning to bleach.

*Student diagrams may vary. The diagram has the same structure as the “Cool” diagram. In the diagram, an industry has been added to the island or continent. In this diagram, the industry is releasing carbon dioxide. There is less carbon found in the lithosphere and more carbon dioxide in the atmosphere. The sun provides a set amount of light/heat energy. This light/heat energy is able to enter the atmosphere, but less light/heat energy is able to exit the atmosphere. The corals begin to lose their color.*

6. Take a full piece of paper and write “Bleaching Event” at the top of the page. On this page, draw a coral reef. Diagram the movement of chemicals and light/heat energy in a hot climate and show how they interact with a coral reef that has been completely bleached.

*Student diagrams may vary. The diagram has the same structure as the “Cool” and “Warming” diagrams. In this diagram, the industry is releasing large amounts of carbon dioxide. Significantly less carbon is found in the lithosphere and significantly more carbon dioxide in the atmosphere. The sun provides a set amount of light/heat energy. This light/heat energy is able to enter the atmosphere, but even less light/heat energy is able to exit the atmosphere. The corals have fully lost their color.*

7. Brainstorm three solutions to climate bleaching based on your assigned career and diagrams. These solutions can either work to solve coral bleaching or mitigate the issue.

*Student answers may vary. To mitigate coral bleaching, we focused our solutions on the use of coal and oil and brainstormed three alternatives for energy production. These alternatives include renewable energy sources, like solar and wind energy, nuclear energy and natural gas. While natural gas is still a fossil fuel, its use produces significantly lower carbon emissions than coal and oil.*

**Representing Relationships as a Coral Biologist**

1. What is a coral biologist and what do they study?

 *Coral biologists study corals. This includes studying their biology, their interactions with other organisms, and their interactions with their environment.*

2. What are the different types of symbiotic relationships? What type of symbiotic relationship is the relationship between coral and zooxanthellae? Why?

 *There are three main types of symbiotic relationships: mutualism, commensalism, and parasitism. Corals and zooxanthellae have a mutualistic relationship, as the corals provide shelter for the zooxanthellae and the zooxanthellae produce and provide food for the coral.*

3. Why does coral expel zooxanthellae when temperatures become too warm? Be specific.

 *When ocean temperatures rise, that can begin to stress the zooxanthellae. This makes it hard for the zooxanthellae to complete photosynthesis. As a result, the zooxanthellae need to make food through other chemical processes, which produce reactive oxygen species. Reactive oxygen species are toxic, so corals expel the zooxanthellae to avoid being hurt by the compounds.*

For each of the following diagrams, label the coral polyp and the zooxanthellae and include photosynthesis and reactive oxygen species (where applicable).

4. Take a full piece of paper and write “Cool” at the top of the page. On this page, draw a coral polyp and diagram its relationship with zooxanthellae in cool water temperatures.

*Student diagrams may vary. The diagram shows a coral polyp that contains colorful zooxanthellae. The zooxanthellae are photosynthesizing — taking in light energy and CO2 and releasing O2 and energy.*

5. Take a full piece of paper and write “Warming” at the top of the page. On this page, draw a coral polyp and diagram its relationship with zooxanthellae in warming water conditions that are beginning to stress the zooxanthellae.

*Student diagrams may vary. The diagram shows a coral polyp that contains fewer zooxanthellae. The zooxanthellae are struggling to photosynthesize — taking in less light energy and CO2 and releasing less O2. The zooxanthellae are beginning to produce reactive oxygen species and are producing slightly less energy than they were in the “Cool” diagram. The corals begin to lose their color.*

6. Take a full piece of paper and write “Bleaching Event” at the top of the page. On this page, draw a coral polyp and diagram its relationship with zooxanthellae in a hot climate that has resulted in complete coral bleaching.

*Student diagrams may vary. All the zooxanthellae have either died or left the coral, leaving the coral colorless. In a hot climate, the zooxanthellae are unable to photosynthesize, taking in no light energy and CO2 and releasing no O2. The corals have fully lost their color.*

7. Brainstorm three solutions to climate bleaching based on your assigned career and diagrams. These solutions can either work to solve coral bleaching or mitigate the issue.

*Student diagrams may vary. We focused our solutions on helping corals adapt to warmer water temperatures. To do this, we can help corals spawn. We would release large quantities of coral larvae, hoping that some of these larvae have a higher resistance to warmer water temperatures. We could genetically modify the zooxanthellae so that they are not stressed by warmer temperatures, or we could modify corals to be more resilient to reactive oxygen species so that they retain their zooxanthellae for a longer time during bleaching events.*

**Representing Relationships as an Ecologist**

1. What is an ecologist and what do they study?

*Ecologists study the relationships and interactions between organisms and their environment. This includes the relationships and interactions between different species.*

2. What are trophic levels? What do the different trophic levels represent?

 *Trophic levels indicate different levels in the food web within an ecosystem. The food web show how energy, in the form of food, flows from prey to predators. Producers do not prey upon any other organisms and instead generate energy through chemical processes. Consumers prey upon other organisms to gain energy. Primary consumers prey upon producers, secondary consumers prey upon producers and primary consumers, etc.*

3. What relationship do other marine organisms have with corals in the coral reef? Be specific.

 *Corals are a food source for consumers including some fish and sea stars, but corals are also a consumer themselves. While the corals get most of their food from the algae living inside of them, they also feed on small organisms that float by. Additionally, corals reefs provide shelter to other organisms, such as fish, crabs, sponges and sea turtles.*

For each of the following diagrams, label a variety of aquatic organisms that have a relationship with corals and identify the type of relationship these organisms have with each other and with corals. These relationships may include sources of food and shelter.

4. Take a full piece of paper and write “Cool” at the top of the page. On this page, draw a coral reef and diagram the relationship between organisms in a healthy reef with no signs of coral bleaching.

 *Student diagrams may vary. The diagram shows a food web within the coral reef and shows organisms sheltering under or near corals. The corals are not covered by algae. The corals are brightly colored.*

5. Take a full piece of paper and write “Warming” at the top of the page. On this page, draw a coral reef and diagram the relationship between organisms in a coral reef that is beginning to bleach.

 *Student diagrams may vary. The diagram shows a food web within the coral reef and shows fewer organisms sheltering under or near corals. The corals are starting to be covered by algae. The corals begin to lose their color.*

6. Take a full piece of paper and write “Bleaching Event” at the top of the page. On this page, draw a coral reef and diagram the relationship between organisms in a coral reef that has been completely bleached.

 *Student diagrams may vary. The diagram shows a food web within the coral reef and shows few to no organisms sheltering under or near corals. The corals are completely covered by algae. The corals have completely lost their color.*

7. Brainstorm three solutions to coral bleaching based on your assigned career and diagrams. These solutions can either work to solve coral bleaching or mitigate the issue.

 *Student answers may vary. Our solutions focused on coral aquaculture and the use of artificial reefs. We could outplant corals to declining reefs, create artificial reefs that promote coral growth, or create artificial reefs that provide shelter to reef-dwelling organisms in the event that the coral reef dies.*

**Coral Conference: Part One**

During the next class period, ask each group to come up one at a time and explain their assigned career and the focus of their studies. Once all groups have shared their careers, ask each group to explain the movements, interactions and relationships they included in their diagram of the “Cool” coral reef. As students share each component of their diagram, draw the component on a whiteboard/chalkboard/easel. This will create one large and more comprehensive diagram. After all groups have shared their “Cool” diagrams, ask students if they are able to identify any additional interactions between the components on the whiteboard/chalkboard/easel. These interactions should include the movement of carbon dioxide from the biogeochemist group to photosynthesis from the coral biologist group. Once students have identified any remaining interactions and they have been added to the complete “Cool” diagram, repeat the process for the “Warming” and “Bleaching Event” diagrams.

After all three diagrams are complete, students should answer the following questions.

1. What did you learn about coral bleaching from another group that surprised you?

*Student answers may vary. I was surprised to learn from the coral biologist group that individual corals are called polyps and are colonial animals.*

2. Why is it important that scientists work with other scientists outside their field?

*By working with other scientists outside their field, a scientist can gain a deeper understanding of their topic of study and see connections they may have missed.*

3. Reflect on your solutions from the “Representing Relationships” part of the activity. Now that you know more about coral reefs, which one of your solutions best addresses the issue of coral bleaching? Why?

*Student answers may vary. Our solution of switching to renewable energy sources, like solar and wind energy, is the best solution. While this solution does not directly address the issue of coral bleaching, it can significantly decrease the production of CO2. This would slow global warming and give scientists more time to develop solutions that directly aid corals. If we do not decrease our CO2 production, we may lose coral reefs before we can save them.*

**Coral Conference: Part Two**

Ask each group to share the solution they believe best addresses the issue of coral bleaching with the rest of the class. After every group shares their solutions, ask students to do a blind vote for the solution they believe is the most realistic and would have the greatest impact on reducing coral bleaching. To conduct the blind vote, ask students to close their eyes or place their head on their desk and raise their hand to vote for a solution. Once all votes are tallied, tell students which solution won the vote.

**Optional: Solution Implementation**At the end of this activity, students may be given an optional homework assignment. In this homework assignment, students would have to develop an implementation plan for the solution that got the most votes in “Coral Conference: Part Two.” This implementation plan should include cost of implementation (considering both long-term and short-term costs), a timeline for implementation, a risk-assessment that identifies potential issues with the implementation of the solution, and a benefit-assessment that identifies how and to what extent the solution mitigates coral bleaching.