

THE NEED IS MUTUAL: THE IMPORTANCE OF BIOLOGICAL INTERACTIONS

Subject Area: Science - Food Webs

Grades: 6th-8th

Time: This lesson can be completed in two 45 minute sessions.

Essential Question:

- What kinds of relationships are involved in biological interactions?

Purpose and Overview:

Students use a series of real-life examples to compare biological interactions and their impact on organisms. The teacher presents various species relationships and students brainstorm which type of interaction is most appropriate to represent each relationship.

Nature Works Everywhere Themes:



Coral reefs provide habitat for many aquatic species and nurseries for ocean fish.



Barrier reefs protect coastlines and property from erosion and waves, and life-saving medicine

Introduction:

In this lesson plan, students learn about the main kinds of relationships between organisms, with examples from coral reefs. They learn to categorize relationships according to their impact on organisms and the terminology for these biological interactions. The connection with coral reefs shows how humans benefit from the food provided by reefs and the protection reefs afford to coastal beaches and property.

Students should be familiar with the concept of predator and prey, but this is only one of several kinds of biological interactions. Symbiosis is the term given to persistent biological interaction between two species. Some scientists believe that symbiosis should be applied to types of mutualism – an interaction in which both types of organisms benefit. Other scientists think that symbiotic relationships apply to parasitic relationships as well as mutualistic ones.

Students use their general knowledge to brainstorm different kinds of biological interactions with which they are already familiar. They are then introduced to the terminology scientists use to characterize biological interactions. They are challenged to apply the terms to their examples. To reinforce the lesson, the teacher presents a range of examples from coral reefs.

To extend the lesson, students have a number of options including investigating a food web of a coral reef. This activity emphasizes that the food web models only a few kinds of interactions and to consider the differences between interactions among individuals of the same species versus different species. Students can also explore how well the concept of mutualism applies to how humans benefit other species, while also benefiting from those species.

Objectives:

Knowledge

- Describe the main kinds of biological interactions.
- Outline the main benefits of coral reefs to humans.

Comprehension

- Describe the key features of primary biological interactions.
- Explain how biological interactions are the basis for complex communities, particularly in coral reefs.

Application

- Illustrate the nature of a biological interaction with examples of interacting organisms.

Analysis

- Infer the type of biological interaction from knowledge about interacting organisms.

Synthesis

- Compare three classes of biological interaction between two species and assign positive, negative or neutral values to the effect on either species.

Evaluation

- Hypothesize on the type of biological interaction in specific instances of interaction between organisms.



Standards:

Next Generation Science Standards

Disciplinary Core Ideas

- LS2.A Interdependent Relationships in Ecosystems
- LS2.B Cycle of Matter and Energy Transfer in Ecosystems
- LS2.C Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts

- Systems

Science and Engineering Practices

- Communicating information

Performance Expectations - Middle School

- MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Common Core English and Language Arts Standards for Writing Grades 6-8

- CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on *discipline-specific content*.
- CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
- CCSS.ELA-LITERACY.WHST.6-8.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.
- CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- CCSS.ELA-LITERACY.WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Vocabulary:

Competition: An interaction in which two organisms require the same resource

Coral: Animals related to jellyfish that live in colonies and secrete a calcium carbonate skeleton that forms the basis of coral reefs.

Mutualism: An interaction in which both types of organisms benefit

Symbiosis: An on-going interaction between two different types of organisms

Predation: An interaction in which one organism is consumed by another

Materials:

- Copies of [Table 1](#) and [Table 2](#) to project to class (at the end of this lesson plan)
- One copy of [Table 2](#) for each student (optional)
- Computer with Internet connection
- Document camera/projector or whiteboard

Nature Works Everywhere videos supporting this lesson plan:

- Overview video *Coral Reefs – Feeding and Protecting Us* <https://vimeo.com/77811130>
- *Meet the Scientist: Stephanie Wear* <https://vimeo.com/77237898>
- Scientist Interview Questions
 - *Mutualism #1: Differences* - “How does mutualism differ from other interactions between species?” <https://vimeo.com/79497280>
 - *Mutualism #2: Examples* - “What are examples of mutualism among coral reef organisms?” <https://vimeo.com/79497277>
 - *Mutualism #3: Humans* - “How are humans mutualists with coral reef organisms?” <https://vimeo.com/79497281>

- *Mutualism #4: Healthy Reefs* - “What can science do to help maintain healthy coral reefs?” <https://vimeo.com/79497282>

Websites used in the lesson plan:

- Food web image
http://epa.gov/acidrain/education/site_students/images/3rdlevel/foodweb.gif
http://en.wikipedia.org/wiki/Chesapeake_Bay#/media/File:Chesapeake_Waterbird_Food_Web.jpg
- Coral reef food web JPEGs
JPEG
http://coralreef.noaa.gov/education/educators/resourcecd/posters/images/iyor_foodweb.jpg
PDF:
http://coralreef.noaa.gov/education/educators/resourcecd/posters/resources/iyor_foodweb_p.pdf
- Coral reef global distribution map
http://www.grida.no/graphicslib/detail/distribution-of-coldwater-and-tropical-coral-reefs_1153

Classroom Activities:

Part 1: Engage

1. Ask students what kind of relationships they might encounter in their everyday lives. Of course, family and friends come to mind.
2. Ask students what other kinds of relationships they might have with living things. Some might have pets. Have students consider who benefits from that kind of relationship.
3. Broaden this idea to consider other types of benefits. How do we benefit from animals raised for produce? Or from crop plants? Explain that these are relationships with other species of organisms.
4. Explain that most species of plants and animals survive as a result of their relationships with other species.
5. Present the [*Coral Reefs – Feeding and Protecting Us*](#) introductory video highlighting the beauty and variety of coral reefs.
6. Ask students which animal is their favorite, and why. Have students make brief notes about the types of interactions they see in the video.
7. Ask students to recollect which kinds of coral reef animals are depicted in popular culture, such as movies and books.
8. Lead students to the conclusion that the coral reef is home to a multitude of organisms. Have students consider the key question of how so many species coexist in coral reefs.

9. In this lesson students will learn how the interdependency of organisms allows many different species to coexist.

Part 2: Explore

1. Have students brainstorm, based on the video, specific examples of interactions between pairs of organisms. To help students relate to organisms with which they might be familiar, have them use their knowledge about plants and animals to think of other organisms that interact in some way (such as hawk and mouse, or deer and plant). If necessary, prompt students by having them look at a simple food web (there are many food webs online – a few possibilities are:
 - o http://en.wikipedia.org/wiki/Chesapeake_Bay#/media/File:Chesapeake_Waterbird_Food_Web.jpg
 - o http://epa.gov/acidrain/education/site_students/images/3rdlevel/foodweb.gif).
2. For the following activity, you can use a food web that is common to your region, a student-generated web, or you can use a food web that you find online like those suggested in step 1.
3. Bear in mind that food webs just show predator-prey interactions, which is only one kind of interaction.
4. Complete the table on the next page (Table #1) with the ideas presented by the students and project it using a document camera or copy to your whiteboard as you fill it in. [A larger version to project can be found at the end of this lesson plan.](#)
5. Have students suggest two organisms that interact in a web and then fill in the table accordingly.
6. Indicate in the “details of the interaction” column whether or not one or both organisms benefits from, or is harmed by the interaction. For example, in the hawk eats mouse food web, **Organism 1** could be Hawk, **Organism 2** would be Mouse, and the **type of interaction** could be described as “hawk eats mouse.”
7. Aim to have at least 10 examples of interactions. The goal is to include at least three types of interactions where:
 - i. Both organisms are harmed
 - ii. One organism benefits, the other is harmed
 - iii. Both organisms benefit
8. Next, have students assign which organism is harmed or benefits in each of the examples. The first five columns of the table should be complete before moving on.

Table #1: Food Web Interactions

Name of organism 1	Name of organism 2	Details of interaction	Organism 1 harm/benefit	Organism 2 harm/benefit	Type of interaction

9. Introduce students to the terminology for each type of interaction (from the table below). Many instances of interactions are considered to be symbiotic. Explain that not all scientists agree on the definition of this term (just as not all scientists agree on the definition of “planet”). The table below indicates the term for each of the primary types of interaction:

Interaction details	Term for interaction	Examples
Both organisms can be harmed	Competition	Different species of coral competing for space on the reef
One organism benefits, the other is harmed	Predation, parasitism, herbivory	Shark eats a fish
Both organisms benefit	Mutualism	Zooxanthellae (+) live in coral tissue (+)

10. Show the [Meet the Scientist: Stephanie Wear](#) video followed by the scientist video [Mutualism #1: Differences](#) that answers the question, “How does mutualism differ from other interactions between species?”

11. Based on the information in the Table #1, have students assign the correct term to each pair of interacting organisms in the “type of interaction” column in Table #1.

12. Now students will transfer their knowledge to types of interactions in a marine environment.
13. A large worksheet for [Table #2 is at the end of this lesson](#). Below is the answer key. You can project the blank table or photocopy it and use it as a worksheet for students to complete. Either individually or in a large group, have students complete the table column “types of symbiosis” for the examples of reef organisms and description of interactions provided.

Table #2: Interactions and Symbiosis

Species	Description of interaction	Type of symbiosis
Zooxanthellae/Coral	Zooxanthellae live in coral tissue. Zooxanthellae are algae that provide products of photosynthesis to coral. The coral provide a home and protection (since coral have stinging cells) for the algae.	Mutualism
Clown fish/Sea anemone	Clown fish get protection from the anemone’s stinging tentacles. The clownfish eats invertebrates that the anemone attracts.	Mutualism
Cleaner shrimp/Fish	Cleaner shrimp groom a fish by removing parasites and dead tissue. The shrimp gets a meal and the fish has damaging parasites removed.	Mutualism
Sponge crab/Sponges	Some crabs attach sponges to their carapaces. The sponges camouflage the crab and in turn receive access to more food than if they were stationary.	Mutualism
Isopods/Fish	Some species of isopods (a type of invertebrate) attach to a fish and feed on its tissue.	Parasitism
Coral polyps/Sea squirt	Corals and sea squirts are both sessile (live in one place). As they grow, they come into contact with each other, competing for the available space.	Competition
Coral polyps/Flatworms	Flatworms feed on coral mucus and capture zooplankton.	Parasitism and Competition

14. Show the scientist video [Mutualism #2: Examples](#) that answers the question, “What are examples of mutualism among coral reef organisms?”
15. Have students choose several examples of **predation** and **parasitism** among reef organisms. They can use Table#2, examples from the video, online resources like the [Coral Reef food web](#) to help.
16. Have students create a simple graphic to illustrate the relationships among the different organisms. Use a line to indicate a connection between two species. This is a simple food web.
17. Explain that a food web is a map of relationships in an ecosystem. In most cases, ecosystems are too complicated for a food web to show all the relationships. Usually a food web just shows the most important relationships.
18. Explain that a food web shows only feeding relationships (predation, herbivory, parasitism). It does not show competition or mutualism.
19. Have students choose a specific scenario to consider what happens when one species is removed from their food web. For example, controlling a fish parasite might increase populations of desirable food fish, but it might also reduce competition and the ability of other fish to compete effectively.
20. Introduce students to the concept of symbiosis between humans and other species. Provide examples in which humans act as predators or competitors. We also have parasites, although we are very rarely preyed upon.
21. Introduce examples of mutualisms from human interactions with other organisms, such as where humans have protected species that serve a specific purpose. Have students discuss what kinds of interactions are represented in the kinds of human activities depicted in the video.
22. Show the scientist video [Mutualism #3: Humans](#) that answers the question, “How are humans mutualists with coral reef organisms?”

Part 3: Explain

1. Have students articulate how understanding relationships between organisms is the basis of building a more detailed picture of a community such as a reef or forest. Students should be able to explain that this information can be used to build food webs, which illustrate the interdependencies of organisms.
2. Have students explain the effects of disturbance on a food web, such as when a predator or parasite is removed. As a brief writing assignment, have students describe how removal of a species might disrupt a food web.
3. Students should be able to explain that symbioses occur only between two different species of organisms.

4. Students should be able to cite examples of mutualism from other ecosystems. Have students brainstorm different examples and enter their examples in a table that you project or share with the students on the board. Possible examples:
 - Plants reward pollinator animals with nectar thereby ensuring pollination and reproduction.
 - An oxpecker eats ticks from the coat of a cow.
 - Humans are mutualistic with their domesticated animals. Animals get protection and food. Humans get companionship (pets) or, food and other products (wool, leather, etc.).
 - Some fungi provide nutrients to plant roots and get sugars from the plant.
 - Some plants harbor ants, which protect the plants from herbivores. In turn the ants get a place to live and sugar meals.
5. Ensure that students can explain that an organism often participates in more than one symbiotic relationship. For example, a fish that has parasites (parasitism) may be groomed by a cleaner shrimp (mutualism).

Part 4: Extend

1. View the video [Coral Reefs – Feeding and Protecting Us](#) and have students observe interactions to discover other kinds of symbiosis such as *commensalism* (one species benefits, the other is unaffected) and *amensalism* (one species is harmed, the other is unaffected).
2. Use the Coral Reef Food Web illustration (http://coralreef.noaa.gov/education/educators/resourcecd/posters/resources/iyor_foo_dweb_p.pdf) to characterize the complexity of feeding relationships among coral reef organisms. Emphasize that this simply shows harm/benefit interactions. A map showing all the interactions (including mutualism, competition, commensalism, etc.) would be much more complicated.
3. In some cases, a mutualism between species becomes so interdependent that it is termed “obligate,” such that neither species can survive without the other. For example, coral cannot survive without zooxanthellae and vice versa.
4. Instances where the species are not interdependent are termed *facultative* mutualism. For example, sponge crabs can survive without attached sponges and vice versa.
5. Interactions among individuals of the same species are not symbiotic. For example, competition between individuals of different species is symbiotic—*interspecific* competition. On the other hand, competition between members of the same species is not symbiotic—it is *intraspecific* competition.
6. Show students the distribution of coral reefs globally (http://www.grida.no/graphicslib/detail/distribution-of-coldwater-and-tropical-coral-reefs_1153).
7. Have students consider why reefs occur only in some areas and not others.

8. Show the scientist video [Mutualism #4: Healthy Reefs](#) that answers the question, “What can science do to help maintain healthy coral reefs?”

Part 5: Evaluate

Students will be evaluated on how well they grasp the concepts introduced in the lesson. Can they distinguish between predation and competition, or between the different types of symbioses?

Specific questions:

1. Two individuals of the hawk fish fight over a crevice in which to spend the night safe from predators. Is this a symbiotic relationship? Support your answer with evidence.
2. Surgeonfish patrol the reef in schools, grazing on algae. Characterize the relationship between surgeonfish and algae using the appropriate term. Support your answer with evidence.
3. Although the clownfish and sea anemone are mutualistic, neither is entirely dependent on the other to survive. Is this an example of obligate or facultative mutualism? Explain the reasons for your answer. Could it become the other option? What would need to happen for that to occur?
4. Hermit crabs live in the shells of dead snail. What is the correct term for the relationship between hermit crabs and snails? Explain.
5. Can a food web show all the relationships between organisms in an ecosystem? Support your answer with evidence.

Scoring key for evaluation

1. No, this is not a symbiosis since the fish belong to the same species. It is an example of intraspecific competition.
2. Grazing is a form of “herbivory.” Surgeonfish benefit while algae are negatively affected.
3. Facultative mutualism. In obligate mutualism both species are entirely dependent on one another for survival.
4. Commensalism. Since the hermit crabs do not kill the snails, it is not predation. The hermit crabs do not oust the snails from the shells, so it is not competition. The snails do not benefit, nor are they harmed by the hermit crab, but the hermit crabs do benefit.
5. For most ecosystems, a food web showing all the relationships between organisms in an ecosystem would be too complicated to depict. Only a very simple ecosystem with a few species could be shown entirely in a food web.

Additional Resources and Further Reading

- http://www.education.noaa.gov/Marine_Life/Coral_Ecosystems.html
Resource collection for education on the topic of coral ecosystems
- <http://coralreef.noaa.gov/>
NOAA's Coral Reef Conservation Program Website
- <http://life.bio.sunysb.edu/marinebio/coralreef.html>
Coral reef information
- <http://www.pbs.org/wgbh/evolution/survival/coral/partners.html>
Coral reef relationships for PBS Evolution Series
- <http://marinebio.org/oceans/symbionts-parasites.asp>
Description of Symbionts, Parasites, and Hosts for marine species
- <http://icb.oxfordjournals.org/content/41/4/825.full>
Journal article on the costs of mutualism

Jackson, J. and L. Buss (1975) Allelopathy and spatial competition among coral reef invertebrates. *Proc. Nat. Acad. Sci.* 72: 5160-5163

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