Symbiotic Strategies
Lesson Overview

GRADE LEVEL: Grades 9-12

TIME ALLOTMENT: Five 45-minute class periods

OVERVIEW: This lesson focuses on symbiosis and ecological relationships. Students will investigate the many ways that species that live in close proximity to each other might interact in an ecosystem, whether via competition or predation or through an ongoing symbiotic relationship such as mutualism, commensalism, or parasitism. Segments drawn from the NATURE episode *The Secret Lives of Sharks and Rays* and an online interactive featuring the malaria parasite will be used to provide specific examples of these interactions. The students will discover that all ongoing ecological relationships, even parasitic or predatory ones, have evolved over long periods of time and are integral to the maintenance of the balance and stability of an ecosystem.

The lesson then moves to a discussion of the ways that ecosystems can be thrown out of balance, often as a result of human action. A video segment showing the barbaric practices of the shark fin harvesting industry is used as a case in point of a human behavior that places a species in peril. Students will brainstorm ideas for restoring the relationship between sharks and humans to a healthy balance and will view an optimistic video segment featuring the ecotourism industry. As a culminating activity, students will select a case study for which to formulate an "Ecosystem Action Plan." They will research an ecosystem thrown out of balance by human action and will prepare a presentation for the class describing the problem and suggesting three possible actions that could be taken to rectify the imbalance.

SUBJECT MATTER: Biology/ Living Environment

LEARNING OBJECTIVES:

- Define and describe the possible ecological relationships between species that coexist in an ecosystem
- Classify specific interspecies relationships as mutualistic, commensal, or parasitic
- Understand that ecological relationships evolved over time and are integral to maintaining the balance and stability of ecosystems
- Name factors that can throw ecosystems out of balance
- Describe human actions that have contributed to ecosystem imbalance and species decline
- Suggest remedial actions to ameliorate human-caused imbalances in ecological relationships

STANDARDS AND CURRICULUM ALIGNMENT:

National Science Education Standards

http://www.nsta.org/publications/nses.aspx

CONTENT STANDARDS C: *Life Science*

All students should develop understanding of:

The interdependence of organisms

- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

New York State Regents Core Curriculum Alignments

Living Environment Core Curriculum

http://www.emsc.nysed.gov/ciai/mst/pub/livingen.pdf

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seeks answers, and develop solutions.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

> **Performance Indicator 1.1:** Elaborate on basic scientific and personal explanations of natural phenomena, and develop extended visual models and mathematical formulations to represent one's thinking.
>
> > **1.1a** scientific explanations are built by combining evidence that can be observed with what people already know about the world.
>
> **Performance Indicator 1.2:** Hone ideas through reasoning, library research, and discussion with others, including experts.
>
> > **1.2a** Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources.

1.2b Inquiry involves making judgments about the reliability of the source and relevance of information.

Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

Performance Indicator 1.1: Explain how diversity of populations within ecosystems relates to the stability of ecosystems.

1.1c In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem.

1.1d The interdependence of organisms in an established ecosystem often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species.

1.1f Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of species and environmental changes can upset ecosystem stability.

Key Idea 6: Plants and animals depend on each other and their physical environment.

Performance Indicator 6.1: Explain factors that limit growth of individuals and populations.

6.1g Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship or one organism may cause disease in, scavenge, or decompose another.

Performance Indicator 6.3: Explain how the living and nonliving environments change over time and respond to disturbances.

6.3c A stable ecosystem can be altered, either rapidly or slowly, through the activities of organisms (including humans), or through climatic changes or natural disasters. The altered ecosystem can usually recover through gradual changes back to a point of long-term stability.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

Performance Indicator 7.1 Describe the range of interrelationships of humans with the living and nonliving environment.

> **7.1a** The Earth has finite resources; increasing human consumption of resources places stress on the natural processes that renew some resources and deplete those resources that cannot be renewed.
>
> **7.1c** Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

Performance Indicator 7.3 Explain how individual choices and societal actions can contribute to improving the environment.

MEDIA COMPONENTS

Video

NATURE: *The Secret World of Sharks and Rays,* selected segments

Clip 1: "Shark and Turtle"

A battle between a loggerhead turtle and a shark.

Clip 2: "Unlikely travel companions"

A variety of symbiotic relationships exist between sharks and other marine species.

Clip 3: "Sharks and fishermen"

Sharks and fishermen compete for the same catch.

Clip 4: "Collapse of sharks"

This clip shows the destructiveness of the shark fin and shark cartilage industries.

Clip 5: "Sharks in our future"

If sharks can be shown to have value while alive, their future may be bright.

Access the streaming and downloadable video segments for this lesson at the Video Segments Page (http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/).

WEB SITES

Malaria games from nobelprize.org

http://nobelprize.org/educational_games/medicine/malaria/

This site provides two games - the mosquito game and the parasite game - to help students understand the transmission of malaria.

Life Cycle of a Malaria Parasite Interactive Tour

http://malaria.wellcome.ac.uk/node40036.html

This flash-based interactive tour provides a detailed explanation of each stage of the malaria parasite's life cycle.

MATERIALS

For each student:

- Ecological Relationships Student Organizer

For each group (3-4 students):

- Malaria Student Organizer
- Computer with Internet access
- Ecosystem Action Plan Student Organizer

For the teacher:

- One computer with Internet access for class demonstration
- Teacher Answer Key
- Ecosystem Action Plan Assessment Rubric

PREP FOR TEACHERS

Prior to teaching this lesson, you will need to:

Preview all of the video clips and Web sites used in the lesson.

Download the video clips used in the lesson to your classroom computer, or prepare to watch them using your classroom's Internet connection.

Bookmark the Web sites used in the lesson on each computer in your classroom. Using a social bookmarking tool such as del.icio.us or diigo.com (or an online bookmarking utility such as portaportal.com) will allow you to organize all the links in a central location.

Gather the necessary materials as outlined above in "Materials" in advance of teaching the lesson.

INTRODUCTORY ACTIVITY

1) Clear some room on the classroom whiteboard or on a sheet of posterboard. Review students' knowledge of different ecological relationships by asking them to generate a list of types of interactions that might exist between different species living close to each other. Write these on the board (for example, Species A might eat Species B, Species A might use Species B's discarded shell for shelter, etc.) NOTE - the list should focus on interactions between different species, not between members of the same species.

2) Ask the students if they can recall a definition for "symbiosis" *(symbiosis is a long-term interaction between different species that interact in close proximity)*. Write the following on the board in three rows: +,+; +,0; and +,-. These symbols represent the three main types of symbiosis. Ask the students if they remember the term for a symbiotic relationship that benefits both species? *(mutualism, +,+)*. What about one that benefits one species while the other species is not affected? *(commensalism, +,0)*. Finally, what about a symbiotic relationship that benefits one species and harms the other? *(parasitism, +,-)*.

3) As a class, see if you can classify the interactions that the students brainstormed in Step 1 as mutualistic, commensal, parasitic, or none of the above. Once you have identified the symbiotic relationships that the students thought of, point out that additional ecological relationships NOT generally considered to be symbiotic include predation *(not a long-term relationship as one species is eaten)* and competition *(not considered to be a direct interaction between species as the focus is a fight over an external resource)*.

LEARNING ACTIVITY 1

1) Distribute the "Ecological Relationships Student Organizer" to each student. Tell your students that they will be watching several video clips that capture ecological relationships between ocean species. They will be making predictions about the relationships between the species and will check their predictions with the information given in the videos.

2) Frame the first clip by telling the students that they will see a tiger shark and a loggerhead turtle interacting in the waters near the Bahamas. Ask your students to silently make a prediction about the relationship between these two animals and to mark it in the appropriate box of the "Ecological Relationships" organizer.

3) Provide your students with a FOCUS FOR MEDIA INTERACTION by asking them to check their prediction as they watch the clip. Play Clip 1, "Shark and Turtle," for the students (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/).

4) Follow up with the students by asking them to name the ecological relationship between the shark and the turtle *(predation)*. Have the students fill in this information on their organizer. Ask the students if anything surprised them about this clip *(accept all answers)*.

5) Frame Clips 2 and 3 for your students by explaining that the next clips will show many pairs of oceangoing species interacting. The list of interacting species pairs can be found on the "Ecological Relationships" organizer. Ask the students to silently predict the relationship they expect to see between each interacting pair of species and to note it on the organizer.

6) Provide your students with a FOCUS FOR MEDIA INTERACTION by asking them to check their predictions as they watch the clip. Play Clip 2 for the students (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/). Give the students a few minutes to fill in the "actual relationship" column in the organizer after viewing the clip, noting the name of the relationship and the description of the behavior observed. You may need to play the clip twice for students to record all the information.

7) Play Clip 3 for the students, asking them to fill in the last row on their organizer (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/). Follow up the clips by reviewing the relationships using the "Teacher Answer Key" provided. Ask the students to explain if the actual relationships were different than the ones the students predicted.

LEARNING ACTIVITY 2

1) Ask the students to name the types of ecological relationships that were seen between different species in the video clips *(predation, competition, mutualism, commensalism)*. Ask: What type of symbiotic relationship was NOT seen in these clips? *(parasitism)*. Remind the students that parasitism is a symbiotic relationship between two species living together that provides a net gain for one species and a net loss for the other species. It is different from predation in that the relationship is prolonged and ideally does not end in the death of the host - the parasite requires its host to remain alive in order for the parasitic relationship to continue — but it may make the host very sick.

2) Ask the students if they can name any examples of parasitic relationships between species *(answers will vary, but some examples include intestinal worms and mammals - for example the tapeworm and the cow; cuckoo birds and other bird species; and fleas and dogs/cats)*.

3) Explain that one example of a human parasite is the protozoan that causes the disease malaria. These protozoans, of the genus *Plasmodium*, are especially interesting in that they have TWO species that act as their hosts, not just one. Ask if the students know how malaria is transmitted to humans? *(The disease is transmitted by mosquitoes)*. Point out that it is not the mosquito itself that is the parasite - it is the protozoan that is transmitted from one animal or person to another via the mosquito's saliva. The mosquito is a vector - an organism that transmits disease but does not cause it.

4) Have the students form groups of 3-4, each with a computer. Tell the groups to visit the Malaria web site from nobelprize.org (http://nobelprize.org/educational_games/medicine/malaria/). Distribute a "Malaria Student Organizer" to each group. Give the students approximately 15 minutes to play both the "Mosquito" and the "Parasite" games on the site. Provide the students with a FOCUS FOR MEDIA INTERACTION by asking them to try to successfully complete each of the two challenges and to answer the questions on the Malaria Student Organizer when they are finished.

5) When the groups have finished playing the games, review the "Malaria Student Organizer" as a class *(Teacher Answer Key is provided)*.

6) To reinforce the learning gained in the online game, project the Life Cycle of a Malaria Parasite interactive tour (http://malaria.wellcome.ac.uk/node40036.html), and walk through each stage to help the students understand the parasitic relationship between the *Plasmodium* protozoan, the mosquito, and the human.

LEARNING ACTIVITY 3

1) Review the types of ecological relationships studied thus far *(predation, competition, mutualism, commensalism, parasitism)*. Explain that these relationships have evolved over a long period of time between species that coexist. Even the relationships that are detrimental to one species (i.e. predation, parasitism) are integral to the maintenance of ecological balance. But threats to this stability can occur when dramatic events or shifts in behavior throw an ecosystem out of whack. Ask the students to name some examples of events and behaviors that may be dramatic enough to threaten the stability of a particular ecological niche *(answers will vary but may include human actions, climate change, pollution, and the like).*

2) Frame Clip 4, "Collapse of Sharks," for the students by explaining that the clip they are about to see will show an ecological relationship that has been thrown out of balance. Provide the students with a FOCUS FOR MEDIA INTERACTION by asking them to explain how the relationship between human and sharks has changed over time. PLAY Clip 4 for the students (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/).

3) Review the focus - How has the relationship between humans and sharks changed? *(When humans fished for sharks for subsistence and on a small-scale basis, there was no threat to the continued survival of sharks. With the recent dramatic increase in shark fishing that has resulted from the demand for shark fins and shark cartilage, shark populations worldwide are in danger of collapse).*

4) Lead a brainstorming session about possible ways that the collapse of shark populations can be averted. As a class, come up with a list of different strategies that might help rectify the situation seen in the clip, restoring ecological balance and preventing the collapse of shark populations.

5) Frame Clip 5, "Sharks in Our Future," by telling the students that the clip will demonstrate one strategy that is being undertaken to restore the balance in the human-shark relationship. Provide students with a FOCUS FOR MEDIA INTERACTION by asking them to explain how this strategy is helping to solve the problem. Play Clip 5 for the students (access the video segments for this lesson at the Video Segments Page, http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/video-segments/1496/).

6) Review the focus - How is ecotourism helping to restore shark populations? *(Ecotourism, an industry that provides opportunities for tourists to pay for the privilege of diving with sharks to observe them in their natural environment, demonstrates that living sharks are just as valuable as dead sharks. Sharks do not need to be killed, and their fins sold, for communities to benefit financially from them. Encouraging this practice helps maintain a healthy population of living sharks.)*

CULMINATING ACTIVITY

1) Form groups or pairs of students. Explain that each group will be investigating a case study of an ecosystem thrown out of balance by human action. Their task is to research the case and formulate an action plan outlining three possible actions that humans could take to restore the ecosystem to balance, and one possible action that the class could make during this school year.

2) Distribute the "Ecosystem Action Plan Student Organizer" to each group or pair and go over the instructions as a class.

3) Provide the class with a list of case studies they may select. A few examples are below, but feel free to add your own cases to the list (you may also entertain student ideas for case studies):

- What's happening to frogs? (What is causing amphibian populations to decline worldwide?)
- Where have all the wild fish gone? (How is the fishing industry affecting populations of wild fish?)
- What's wrong with a fish farm? (What are the effects of factory fish farming on ocean ecosystem health?)
- Uh oh, I lost my way! (How is increased development harming migratory birds and butterflies?)
- Romeo, Romeo, I can't hear you. (What effect are changing undersea sound levels having on ocean species?)

4) Assign a date for class presentations. Provide the students with in-class and homework time to complete their research and plan their presentations.

5) On the assigned date, have each group present its case. Allow for class feedback and discussion. What do the students think of the action plans? Use the "Ecosystem Action Plan Assessment Rubric" to aid in assessing the presentations.

6) After all the groups have presented, ask the class to make a commitment to follow through during the current school term with at least ONE of the concrete actions outlined by the groups (for example, students might collect signatures on a petition, hold a fundraiser to support a conservation organization, create a video for the school and/or the PTA raising awareness of the issue, or devote one or more days to volunteering for a conservation effort in your region). Once an action has been decided upon, help students uphold their commitment and enact their plan.

CROSS-CURRICULAR EXTENSIONS

English Language Arts

Rachel Carson's *Silent Spring* highlights the potential effects of human behaviors on the environment and on ecosystems. In another vein, Henry Thoreau's *Walden* provides a

riveting account of Thoreau's experience in the Massachusetts wilderness. Discuss the scenarios presented in this book in light of the relationship between humans and nature. What are the consequences (or potential consequences) of human behavior on the environment if it is not valued or protected? What can be done to protect the planet from these consequences?

Biology/Medicine
Recent studies have suggested that parasitic worms may provide unexpected benefits to the humans they colonize, helping allergy sufferers by calming the allergic response. Have students research this unexpected upside to the worm-human symbiotic relationship.

COMMUNITY CONNECTIONS

Invite a local park ranger or invasive species specialist to visit your class to describe threats to fragile ecosystems in your area and measures being undertaken to protect them.

Investigate what ecological restoration efforts are being undertaken in your area. Organize your class to participate in a river cleanup, invasive plant removal day, or native seed planting effort in your region.

Engage your students in a community fundraising effort to provide mosquito nets to people in underdeveloped, malaria-prone areas of the world. The Nothing But Nets (http://www.nothingbutnets.net/) campaign is one organization spearheading this effort.

NATURE®

NAME: _____

DATE: _____

Ecological Relationships

Interacting Species Pair	**Ecological Relationship Prediction** (predation, competition, commensalism, mutualism, parasitism)	**Actual Ecological Relationship** (name and describe)
Clip 1: **Tiger Shark/ Loggerhead Turtle**		
Clip 2: **Shark/Jack**		
Clip 2: **Shark/Mackerel**		
Clip 2: **Shark/Shark Suckerfish**		
Clip 2: **Hammerhead Shark/Barberfish**		
Clip 3: **Shark/Fishermen**		

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Malaria Student Organizer

Mosquito Game:

1. How does the malaria parasite get into a mosquito?

2. How does the malaria parasite get into a human?

3. Which sex of mosquito drinks a blood meal?

Parasite Game:

4. What two places in the human body must the malaria parasite go in order to reproduce?

5. Draw what the malaria parasite looks like before it enters the liver:

6. Draw what the malaria parasite looks like after it leaves the liver:

7. What is the scientific name of the malaria parasite?

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ECOSYSTEM ACTION PLAN STUDENT ORGANIZER

Your assignment:

- Select a case study in which human behavior provides a direct threat to an ecosystem, throwing ecological relationships out of balance and putting one or more species at risk.
- Research the case using classroom and web-based resources.
- Based on your research, prepare a presentation for the class in which you describe the case study and suggest THREE possible actions that could be taken to restore the balance of the ecosystem.

*The presentation should address **all** of the following points:*

1) *What is the threat to the ecosystem? Which species are at risk?*
2) *What human action(s) are causing this threat?*
3) *What are the possible consequences to at-risk species if nothing is done to address this problem?*
4) *Suggest THREE possible actions that humans could take to restore the balance of the ecosystem.*
5) *Suggest one concrete action that your class could take during this school year that would make an impact on this issue.*

SELECTED CASE STUDY:

Notes:

PRESENTATION DUE ON:

_____

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Teacher Answer Key

Ecological Relationships ANSWER KEY

Interacting Species Pair	**Actual Ecological Relationship** (name and describe)
Clip 1: **Tiger Shark/ Loggerhead Turtle**	Predation (Shark eats turtle, or tries to)
Clip 2: **Shark/Jack**	Commensalism (Jacks use the shark as a "blind" - to keep out of the view of prey. Shark is neither helped nor harmed)
Clip 2: **Shark/Mackerel**	Commensalism (Mackerel bump up against the shark's skin to rid themselves of loose scales and parasites. Shark is neither helped nor harmed)
Clip 2: **Shark/Shark Suckerfish**	Commensalism (suckerfish attaches to shark and gets a free ride. Shark is neither helped nor harmed)
Clip 2: **Hammerhead Shark/Barberfish**	Mutualism (Barberfish benefit the hammerhead by ridding it of parasites and at the same time benefit themselves with a meal)
Clip 3: **Shark/Fishermen**	Competition (sharks are after the same fish as the humans and will often steal the humans' catch)

Malaria Student Organizer ANSWER KEY

Mosquito Game:

1. How does the malaria parasite get into a mosquito? *(The mosquito draws up the parasite along with a blood meal from an infected person or animal)*
2. How does the malaria parasite get into a human? *(A mosquito transfers the malaria parasites in its saliva when it bites a human)*
3. Which sex of mosquito drinks a blood meal? *(Female)*

Parasite Game:

4. What two places in the human body must the malaria parasite go in order to reproduce? *(Liver and red blood cell)*
5. Draw what the malaria parasite looks like before it enters the liver: *(Drawing should appear narrow and snaky)*
6. Draw what the malaria parasite looks like after it leaves the liver: *(Drawing should appear egg-shaped)*
7. What is the scientific name of the malaria parasite? *(Plasmodium, or Plasmodium falpicarum)*

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Ecosystem Action Plan Assessment Rubric

	Criterion	**Score, from 1-5:** 1= element is missing 2= minimally satisfies 3=partially satisfies 4=mostly satisfies 5= fully satisfies
1.	Is the **threat to the ecosystem** clearly explained?	
2.	Are the **at-risk species** named and their risk clearly described?	
3.	Are the **human causes** of the ecosystem's endangerment clearly explained and described?	
4.	Are the **consequences** that might result if no protective action is taken described at the species level and at the ecosystem level?	
5.	Are at least **three possible actions** named that could help prevent these consequences?	
6.	Is the **first action logical, reasonable, and feasible** (relying on resources currently available, such as current and/or emergent technology)?	
7.	Is the **second action logical, reasonable, and feasible**?	
8.	Is the **third action logical, reasonable, and feasible**?	
9.	Does the group outline at least **one concrete action** that the class might take immediately to make an impact on this issue? Is this action reasonable and feasible during the current school	
10.	Overall, does the presentation seem **high quality**? (Is it well organized? Do students speak clearly and project their main points? Do they use visual aids effectively, and respond to	

Total (maximum: 50)

_____

Grade (Total score x 2, maximum: 100)

_____