coral reefs

Activity Guide for Grades 3-5

BY SHEDD AQUARIUM

Shedd Aquarium Activity Guide Series

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Coral Reefs Activity Guide
for Grades 3-5

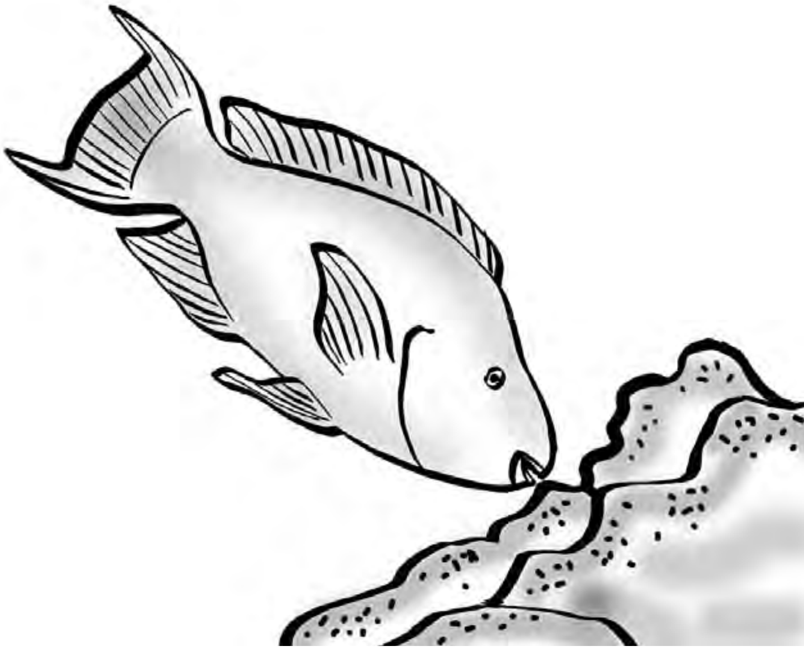
OBJECTIVES

This Activity Guide provides teachers with a resource for incorporating the study of aquatic science, specifically coral reefs, into their existing curricula. Each activity will help meet specific learning objectives. If all of the activities in this Guide are completed, the following learning objectives will be met:

- Illinois Learning Standards:
  English Language Arts: Goals 1, 3, 4 and 5
  Mathematics: Goals 6 and 9
  Science: Goals 11, 12 and 13
  Social Science: Goal 17
- National Science Education Standard:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A through G
  5-8 Content Standards A through G

GOALS

- Provide teachers with an interactive teaching tool and curriculum on coral reefs for grades 3-5
- Build students' critical thinking skills and scientific literacy
- Approach the study of coral reefs in an interdisciplinary way
- Offer students a fun, hands-on learning experience



Using this Book:
Guidelines for Teachers

GETTING STARTED

Whether you are looking for a few activities on coral reefs to enhance your lesson or a more in-depth course of study, this book will provide an invaluable resource. Because the activities build on each other, it is most advantageous to complete all or most of them. We recommend you peruse the entire book before you begin and plan accordingly. Hang the poster at the beginning of the study and leave it up for the duration of your study as a reference.

The activities provided are not meant to be a strict formula to follow. There are many side roads upon which you can venture and we encourage you to investigate new interests as they evolve. For example, you may find your study leads to curiosity about other ecosystems such as rainforests.

DIRECT EXPERIENCE

The more time students have observing and studying live fishes and other reef animals, the better. For example, a trip to an aquarium at the beginning of your study will give students a jump-start. After learning about reef animals, a repeat visit will be even more meaningful.

FOR CONTINUITY

Begin each activity with a review of previous topics and questions that will move students towards the next topic of inquiry. Throughout the experience, revisit major ideas to reinforce learning and document the process through photographs, videotapes, and transcriptions of student dialogues. Documentation done by students in the form of writing, (see right) drawing, painting, or 3-D models is also invaluable.

REEF REFLECTIONS: KEEPING A CORAL REEF JOURNAL

Enrich your study of coral reefs by having students keep a journal. This will allow them the opportunity to write down what they are learning. But perhaps more important it provides students a "safe" creative outlet for expressing their ideas, and puts the emphasis on drawing connections between coral reefs and their own lives.

Through questions provided with each activity, students should be encouraged to think about some of the ways we are all interconnected. The questions are provided only as a springboard and we suggest you have a brief discussion after each activity so that students can ask additional questions and share other things they are curious about.

Introduction to Coral Reefs— A City Beneath the Sea

Coral, is it a rock? Is it a plant? Believe it or not, coral is an animal that consists of little more than a mouth and stomach. Yet, this simple animal is an aggressive predator that hunts with poison-tipped harpoons. Building upon the skeletal remains of its ancestors, these unassuming creatures form the "skyline" of a bustling underwater city.

At a glance, a coral reef can appear chaotic and otherworldly. Curtains of silvery schooling fish move in unison in rhythmic waves. Impossibly thin disc-shaped fishes of brilliant colors hover in zigzag patterns. Armored crabs scurry along the sea floor looking for food. Throngs of tiny translucent fish move in a haze and then quickly disappear.

Imagine a place more colorful, more crowded, more diverse, and even more dangerous than the largest cities on Earth. These underwater reef metropolises host an incredible variety of plant and animal life. Every nook and cranny is home to one creature or another. In fact, there is so much competition for a place to hide, that many spaces are shared, occupied by one animal by day and another by night.

Sadly, through over-fishing, tourism, pollution and other factors, we are destroying coral reefs at a frightening pace. Yet, most people are unaware of the problem. Very few of us witness coral reefs firsthand, but for the same reasons that all of nature requires protection and preservation, coral reefs need and deserve our attention. To lose them would be a devastating blow to the natural world, the world we share with all living things.

Learning about coral reefs is the first step in becoming an advocate to ensure their future, so enjoy your encounter with this fascinating city beneath the sea.

Please note: There are two types of corals—soft and hard. Hard corals (i.e. brain, elkhorn or plate) actually build reefs, but soft corals (i.e. sea fans and sea whips) do not have a hard skeleton and therefore do not build reefs. This activity guide deals mainly with reef-building hard corals.

Colony of Coral Polyps

Coral Cities

Strange as it may seem, coral reefs have a lot in common with a city. There is one big difference—the "buildings" are made of the skeletons of millions of tiny animals!

Activity 1

OBJECTIVES

Students will:

- Be introduced to coral reefs by making comparisons to their own cities
- Understand that coral reefs are made up of tiny animals called ***coral polyps***
- Begin writing a journal to keep their thoughts about coral reefs

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goal 3
  Science: Goal 12
  Social Science: Goal 17

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

VOCABULARY

coral polyp: a tiny cylindrical-bodied animal consisting of a simple stomach and a mouth surrounded by tentacles

coral colony: many coral polyps of the same species interconnected through a common skeleton

coral reef: a structure composed of the skeletons of hundreds of coral colonies usually forming a line or ridge on or near the surface of ocean water

ecosystem: all living organisms, including plants and animals of a given community along with the non-living physical environment

invertebrate: an animal without a backbone

TIME

30-45 minutes

MATERIALS

For each student:

- materials for journaling (See Reef Reflections: Keeping a Coral Reef Journal on page 3.)
- optional: photocopy of Reefs of the World map on page 9

For the class:

- overhead projector
- transparency of the Reefs of the World map on page 9

BACKGROUND

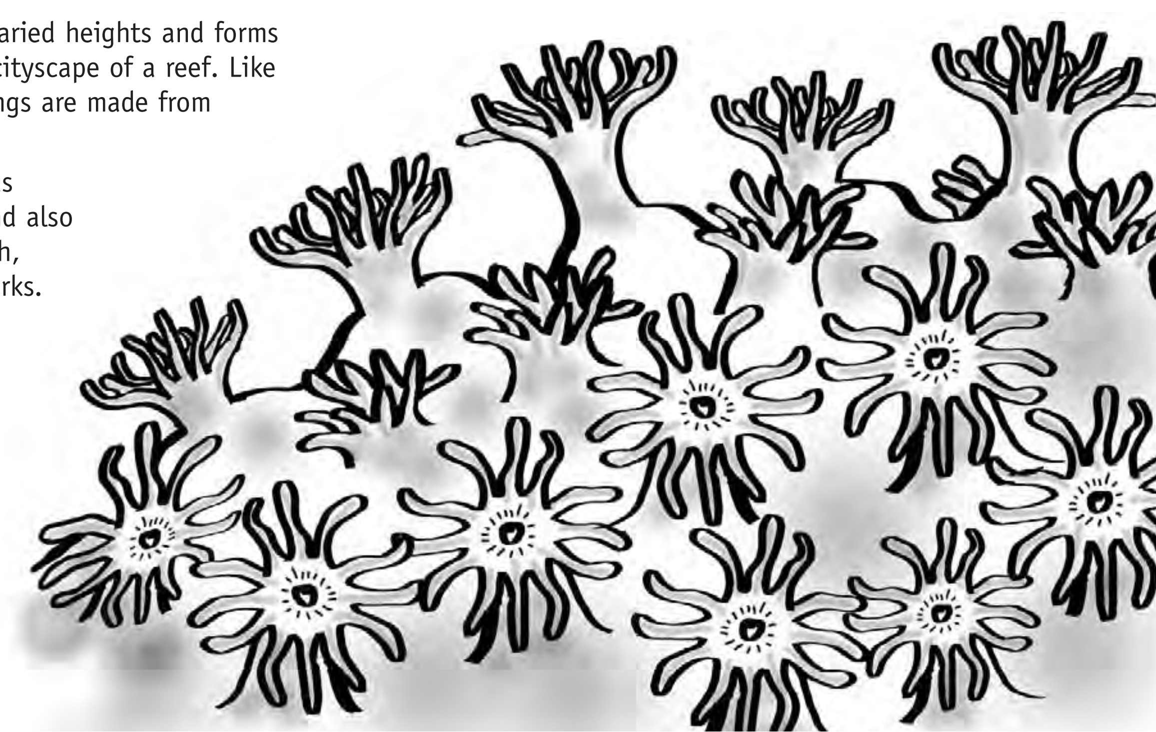
In many ways, a coral reef is like a city, complete with places to live, eat, and socialize for its countless residents. This underwater city can be even more crowded, more competitive, and more dangerous than a city on land. So many creatures live together on the reef that it is considered one of the most diverse ***ecosystems*** on Earth.

Without brick and mortar or steel beams, how did these coral cities come to be? Amazingly, the chief architect of the reef is a tiny animal called a ***coral polyp.*** (See illustration page 11.) Each polyp secretes calcium carbonate (limestone) throughout its life, continuously extending the length of the stony cup underneath it. Over the centuries, millions of individual polyps grow upon one another in colonies to create the wild profusion of shapes and sizes of coral that make up a reef. Each coral colony represents a specific species. These "buildings" provide the basis for food and shelter for thousands of fishes and ***invertebrate*** species. The entire "metropolis" of hundreds of coral colonies is a coral reef.

Animals living around coral reefs vie for limited food and safe places to live and hide. Leaving one's residence is a risky proposition on the reef and many animals rarely do. Every creature is viewed as a meal by another, and life is about finding food and not becoming someone else's supper.

The city analogy provides a way for students to draw connections to a reef and envision some of the qualities of life on a reef, while at the same time learn about ways it is different. Here are some ways to think about this analogy, but be sure to include other ideas your students may have:

- The coral itself in its varied heights and forms creates the skyline or cityscape of a reef. Like coral, some city buildings are made from limestone.
- The reef, like a city, has permanent residents and also visitors passing through, such as turtles and sharks.
- Just as people have different jobs in a city, coral reef animals also play different roles. For example, some tiny fishes and shrimp set up cleaning stations. Larger fishes line up to wait for the cleaner animals to rid them of tiny parasites they can't get off themselves. (See Activity 7 on page 29.)
- Coral reefs, like all large cities, are busy 24 hours a day with some animals active and feeding during daylight hours and some at night. In fact, the reef has a "rush hour" occurring just before and just after sunrise and sunset. These are the busiest times of the day, as day feeders and night feeders are trading places.
- The coral reef counterpart to city streets and highways are the crevices and canyons formed by corals and other plants and animals of the reef.
- Like city apartment dwellers, reef residents live at many different levels. New housing is difficult to find, and animals rarely move out unless evicted by a bigger tenant.
- Just as cities are filled with vibrant colors, some of the most intensely vivid animals on Earth can be found on the coral reef.
- Cities tend to be places of diversity where all types of people live together. The reef, however, is home to an almost incomprehensible variety of life forms ranging from millions of microscopic free-floating plants to large sharks passing through in search of a meal.



Colony of Coral Polyps

Despite commonalities between terrestrial cities and coral reefs, there are many differences. Perhaps the most notable is that a reef itself is made up of animals living on top of their skeletal ancestors. Another difference is their location. Cities are found in just about every corner of the Earth. Coral reefs, however, require certain conditions in order to grow. (See map on page 9.) Coral reefs can only thrive in warm salt waters with average temperatures ranging between 20° C (68° F) and 30° C (86° F). They are generally found near the equator since this part of the world receives the most sunlight and therefore has the warmest waters.

PROCEDURE

1. To help your students get a sense of a coral reef as a busy, colorful place, first ask them to think about their idea of "a city." Make a "city concept map" on a large sheet of paper and write their answers to such questions as: ***What is a city? What happens in a city? Who lives in a city? Where do the inhabitants live? Who might visit a city? What is necessary to make a city?*** Keep the concept map hanging throughout your study as a point of reference and add to it as new ideas evolve.

2. Use the Background information in this activity to draw parallels between students' answers and coral reefs. For example, if students speak about colors found in a city, you might talk about the amazing array of colors found on a reef and share photographs from resource books. Point out some of the ways that a city and a reef are quite different. For example, the "buildings" of the reef are actually alive! Emphasize the incredible diversity of plant and animal life found on the reef.

3. Project a transparency of the Reefs of the World map on page 9. (Optional: Provide each child with a copy of the map.) Ask students to make any observations they can about the location of coral reefs. Ask: ***Where are most coral reefs located? Why? Which reef is the closest to your town? Why are there no reefs in the Arctic or Antarctic? Has anyone in the class ever been to a reef?*** Use the Background to help students understand that coral reefs are only found in warm salt waters that are generally near the equator. Make note of reefs that are threatened, which will be discussed further in Activity 8.

REEF REFLECTIONS

Introduce the Reef Reflections journal. Before you begin journaling with your students, refer to Reef Reflections: Keeping a Coral Reef Journal on page 3 and choose a format. Begin with a discussion of the purpose of the journal emphasizing that it will not be graded but rather is a place for them to record any thoughts and ideas. Discuss the concept of "reflection" and how their journal serves this purpose.

Ask students to consider questions and ideas they would like to address. Following are some additional questions to get you started:

- What would life be like if every brick in your city were a living animal?
- What would life be like if you lived in a tiny apartment with hundreds of neighbors all around you?
- Write a short story describing "rush hour" traffic on a reef. Which animals would represent taxi cabs? Which animals would be buses or pedestrians?

City Concept Map

EXTENSIONS

Ask a scuba diver to visit your class to share experiences and photos or slides of coral reefs.

Compare a coral reef to a tropical rainforest. How are the corals in a coral reef similar to the trees in a tropical rainforest?

ADDITIONAL RESOURCES

Cerullo, Mary M. *Coral Reef: A City That Never Sleeps.* New York: Cobblehill Books, 1996.

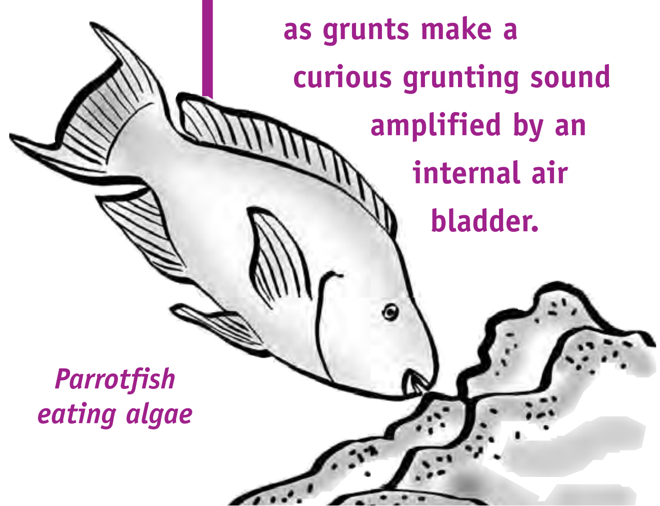
Holing, Dwight. *Coral Reefs.* Parsippany, NJ: Silver Burdett Press, 1995.

Roessler, Carl. *Coral Kingdoms.* New York: Harry N. Abrams, Inc., 1986.

Wu, Norbert. *A City Under the Sea: Life in a Coral Reef.* New York: Atheneum Books for Young Readers, 1996.

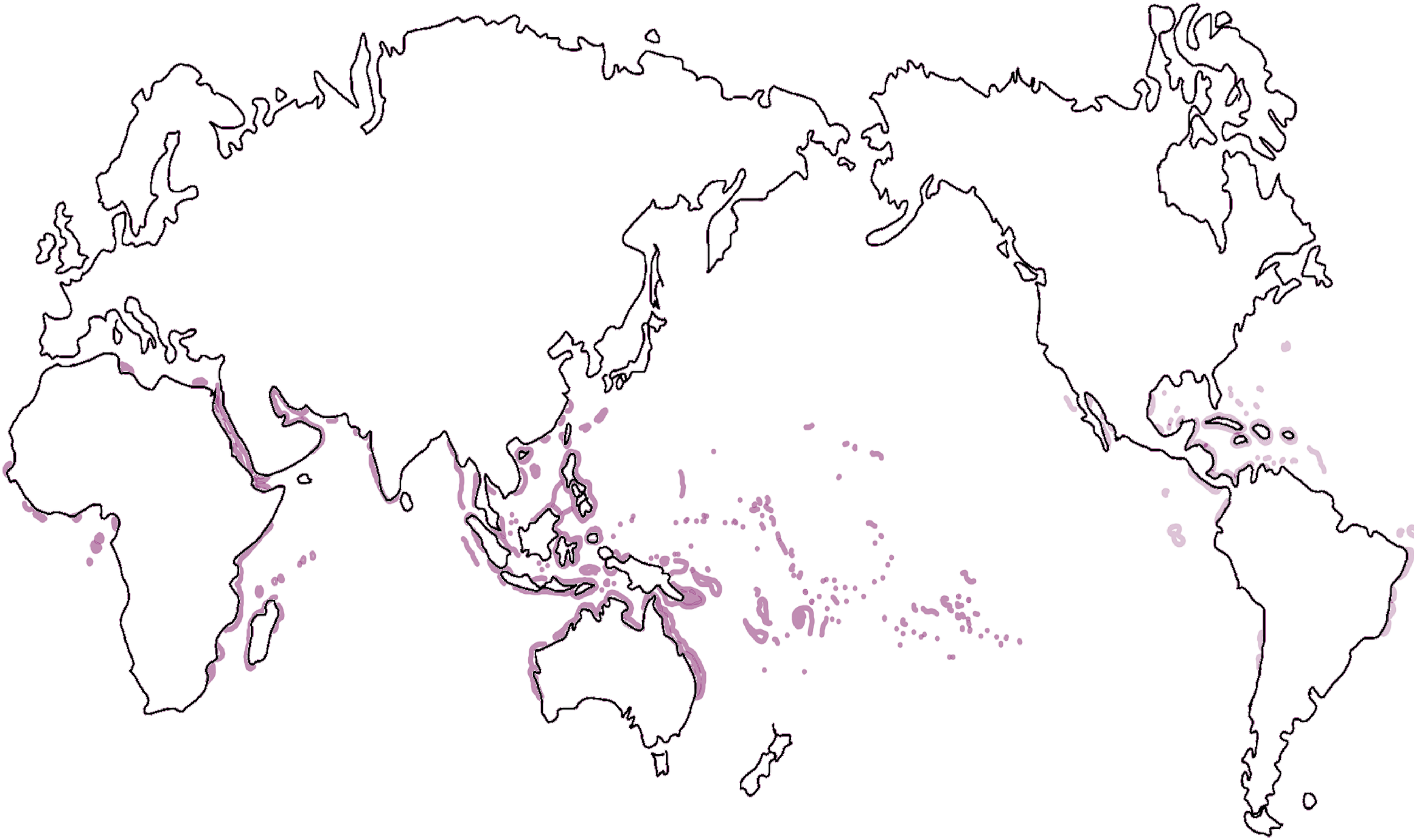
Coral Choral? Sounds of the Reef

Typically, we encounter fishes in aquariums, but because we are not in the water with them we aren't able to hear the sounds they make. Some fishes, in fact, are very noisy, and because sound carries better in water than in air, a cacophony of sound can be heard on the reef. If you were underwater, you could hear the loud, crunching sound of a parrotfish grazing on algae growing on coral. Triggerfishes also drill noisily with powerful teeth through mollusk shells. The cause or purpose of other sounds is not always clear. For example, adult emperor angelfish can make a thumping noise loud enough to startle a diver. When grinding their teeth, fish known as grunts make a curious grunting sound amplified by an internal air bladder.



Parrotfish eating algae

Reefs of the World



Coral Up Close

Meet the coral polyp—it acts like a plant during the day, and hunts with a harpoon by night

Activity 2

OBJECTIVES

Students will:

- role play a coral polyp to understand its function on the reef
- be introduced to the biology of coral polyps
- explore the role that ***photosynthesis*** plays in a coral polyp's relationship with ***zooxanthellae***

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goal 3
  Mathematics: Goal 9
  Science: Goal 12
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A, C, and D
  5-8 Content Standards A, C, and D

VOCABULARY

calcium carbonate: the material that forms coral skeletons found dissolved in seawater, it is a white chemical compound which also occurs in nature as limestone (Calcium carbonate also forms the shells of snails, clams, and crabs.)

nematocyst: thread-like stinging cells that contain toxic substances used to capture prey

photosynthesis: the process by which plants use sunlight and chlorophyll to convert carbon dioxide and water into simple carbohydrates and oxygen

zooplankton: free-floating, often microscopic, aquatic animals

zooxanthellae: single-celled photosynthetic plant organisms (algae) that live symbiotically within coral polyp tissues

TIME

45-60 minutes

MATERIALS

For each student:

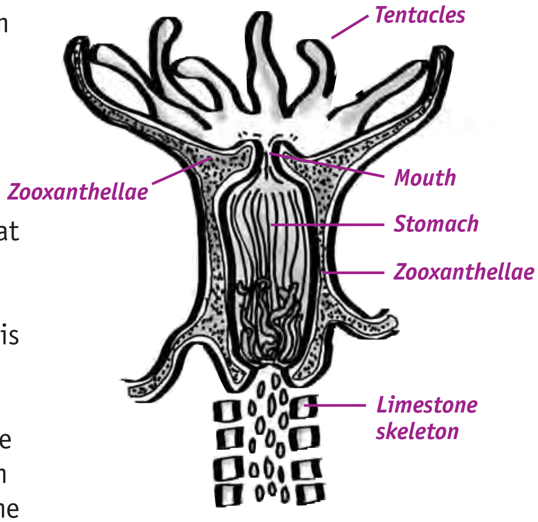
- surgical glove
- paper lunch bag
- green marker

For the class:

- thread
- gummy worms
- dowel rod or broomstick

BACKGROUND

As larvae, coral polyps are free swimming. However, most of their lives are spent stationary in a circular stone structure (see diagram). Polyps make their home by taking ***calcium carbonate*** from seawater and depositing it as a hard limestone cup under their bodies, thus cementing themselves to the reef. Generation upon generation of polyps connect and lengthen their cups to make a base composed of ancestral skeletons and a thin layer of live polyps on the surface. These polyps cluster into colonies, which together form the largest living structures on Earth. The longest reef, the Great Barrier Reef off the coast of Australia, is over 1200 miles in length, or the distance from Chicago to the Florida Keys. (See Reefs of the World map, page 9.)



Coral Polyp Cross Section

By themselves, coral polyps could not create reefs. The key to the their growth is tiny algae called ***zooxanthellae,*** which live inside the polyps. This plant, just like familiar green plants, carries out ***photosynthesis,*** using sunlight to convert carbon dioxide and water into oxygen and carbohydrates, thereby creating food and oxygen absorbed by the polyp. In this way, each species benefits from the other. The coral has a live-in food source, and the algae inhabit a sunny home and get nutrients from the polyp.

By day, the coral polyp curls up inside its limestone shelter, letting the zooxanthellae do their job. At night, polyps become predators. They come alive by stretching tentacles up out of the polyp with harpoon-like ***nematocysts*** that act as poisonous stinging harpoons. In this way, they make a quick meal of tiny ***zooplankton*** drifting by.

PROCEDURE

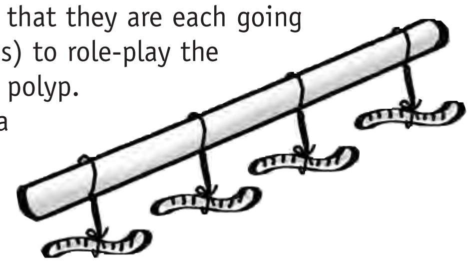
1. Copy the diagram of a coral polyp cross section onto your chalkboard. Point out that a coral polyp consists mostly of a mouth and stomach, though it lacks most body parts of other animals, rendering it unable to move from place to place, see, or hear. Use the Background in this activity to guide a discussion of how coral use two methods to feed. (If your students are not familiar with photosynthesis, you may want to simplify the explanation.)

2. Tell the class they are going to role-play the life of a coral polyp using models they make. For this activity, the following items represent these coral parts and prey:
   gloved hand = coral polyp
   gloved fingers = tentacles
   double-sided tape = stinging nematocysts that line the tentacles
   green dots on gloves = algae that lives inside coral called zooxanthellae
   paper bag = the limestone skeleton of a coral polyp
   gummy worms = zooplankton, food for the polyp

   Provide each child with the materials listed above and begin by having them cut off the bottom of the bag so that the remaining shape is that of a cylinder. Instruct them to roll the bag into a donut shape that fits over their hand like a bracelet. This will represent the limestone skeleton (see Background). Have students use green markers to add small dots to the glove signifying the zooxanthellae, making it clear that coral polyps do not eat the plant. Have students place pieces of double-sided tape on the fingers of the glove to represent the stinging nematocysts.

3. To simulate how zooplankton drifts through the water, attach gummy worms to a pole with thread as shown to make a "plankton pole." (If time is limited, you could prepare this portion in advance.)

4. Divide the class into groups of eight to ten students. Tell them that they are each going to use their model(s) to role-play the daily life of a coral polyp. Remind them that a coral polyp cannot



move (except their tentacles at night) or see. The action of a polyp retracting is similar to an open hand closing its fingers into a fist. Polyps do not move up and down within their skeleton. Have all but one from each group put on their "polyps" and sit close together with their elbows "glued" to the tabletop. Students should stretch their fingers as high as possible to try and catch the zooplankton (gummy bears) floating by.

5. Review the way coral polyps feed during the day referring to the zooxanthellae they drew on their gloves. Remind them of the importance of the sun in the process of photosynthesis. At this point, their hands should be closed in a fist since coral polyps do not extend their tentacles during the day. Next, darken the room to simulate feeding at night. Since coral polyps are blind, have students close their eyes or use blindfolds. Remind them that coral polyps are unable to move since they are attached to the reef. Have one child pass the "plankton pole" just barely within reach of their hands to see if they can use their "tentacles" to catch their dinner.

6. Discuss the results and close by reiterating some major points:
    - coral polyps are simple animals that are one of the chief architects of the reef
    - coral polyps utilize two unique methods for getting food and nutrients
    - without coral polyps (and their zooxanthellae) there would be no reefs

REEF REFLECTIONS

- How would your life be different if you had a plant that lived inside you?
- Describe how it felt to have to catch food without being able to see or move.

EXTENSIONS

Compare how coral polyps eat to how other aquatic and land animals eat. Are there any other animals that have very limited movement and eat like coral polyps?

Make a more lasting model (of nighttime feeding) by stuffing the gloves and taping the polyps together into a "colony."

ADDITIONAL RESOURCES

The cousteau Society. *Corals: The Sea's Great Builders.* New York: Simon and Schuster Books for Young Readers, 1992.

Massa, Renato. *The Deep Blue Plant: The Coral Reef.* Austin, TX: Steck-Vaughn Co., 1998.

Sayre, April Pulley. *Coral Reef.* New York: Twenty-First Century Books, a division of Henry Holt and Company, 1996.

Mending Bone with Stone

Many people with fractures, cancer, or other medical conditions need to replace bone tissue. In the past, doctors had limited options, each with disadvantages: to use a patient's bone from another part of the body, to use cadaver bone, or to use synthetic substitutes. Recently it was discovered that coral was a promising substitute for bone. Like human bone, coral has calcium as a primary component and is porous, providing a good surface for attaching it to the existing bone.

Coral Constructors

Activity 3

The myriad shapes and sizes of coral colonies form an incredible "skyline" to rival any large city's. Find out how they withstand environmental pressures.

OBJECTIVES

Students will:

- build a coral city to consider the many possibilities for shapes and sizes of coral colonies
- test their designs to see how well they hold up to wave action
- understand some of the challenges coral colonies face for survival

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goal 3
  Mathematics: Goals 6 and 9
  Science: Goals 11 and 12
  Social Science: Goal 17
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A, C, D, and E
  5-8 Content Standards A, C, D, and E

TIME

45-60 minutes

MATERIALS

For each student:

- ample Lego® bricks or other building material that provides a variety of shapes and sizes (sugar cubes glued together also work well for this activity)
- individual base for Lego bricks or larger one to share with small group

For each small group:

- towel or scarf

For the class:

- large base for Lego bricks or combination of smaller bases upon which to build a class reef

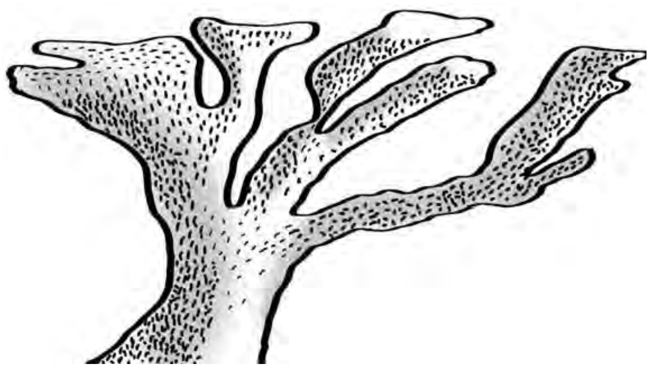
BACKGROUND

In the cities beneath the sea, coral skylines are made up of shapes reminiscent of towering skyscrapers, sturdy squat structures, and everything in between. Why have corals evolved into so many forms? Evolution occurs over time as corals make adaptations to compete for the limited resources of the reef.

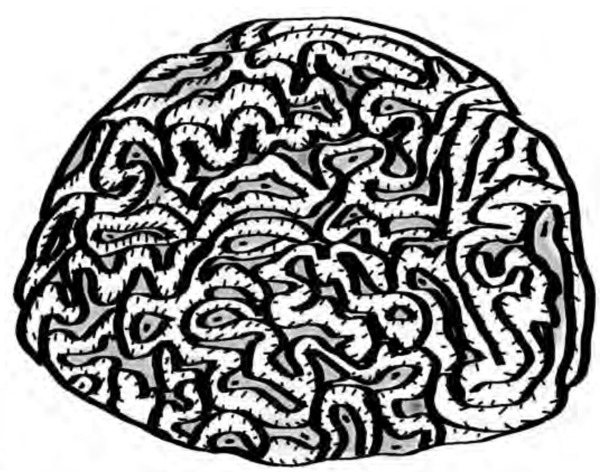
Most reef-building coral polyps have the same basic biology (see Activity 2) but each species takes on a different shape as it grows into a colony. As their names such as elkhorn, plate, and brain imply, some coral grow in branch-like fashion while others spread into mounds or form a variety of other shapes (see illustrations).

Since coral can grow as much as fourteen times faster in sunlight than in darkness, the quest for light is constant and very much affects the shape of coral and how it grows. Branching corals, such as elkhorn and staghorn, grow close to the surface to capture sunlight from every angle possible. Plate corals often live in deeper water and fan out to capture any rays of light that may penetrate the depths.

Another factor determining the shape of coral colonies is the challenge of withstanding ocean waves and storms. Corals growing near the surface are more susceptible to wave action than those found in deeper water. Corals found in shallow waters tend to break more easily but are also able to recover from damage quickly because they are relatively fast growing. If a piece of coral breaks off, it can often regenerate from the severed piece, depending on where the piece lands. In some ways, breakage can work to their advantage as it helps them to spread and form new colonies. Sturdy boulder-shaped corals withstand rough seas better but also grow more slowly. Brain coral, for example, takes a long time to build and, as a result, is very sturdy.



Elkhorn

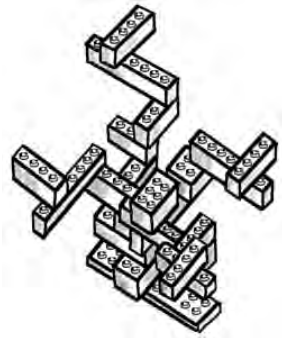


Brain

Plate

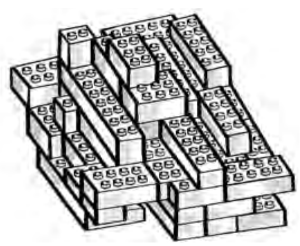
PROCEDURE

1. Begin by reviewing information students learned in Activity 2 emphasizing that coral colonies are made up of tiny animals, living and dead, called coral polyps. Using the analogy of a city, discuss how individual polyps, like bricks in a city, are the building blocks of the reef. Tell them they will use Lego bricks representing coral to make a colony. Ask: ***Have you ever built a big structure out of Lego bricks? How many pieces did you need to use? How long did it take?*** Like bricks and real coral, it takes many individual parts to create a large structure and generally the bigger the structure the longer it takes to build.



Elkhorn

Plate



Brain

2. Arrange the class into groups of four to six students. Provide each group with photographs of as many species of coral as possible. Use the Background information in this activity to introduce basic information about the different types of coral colonies. Ask students to create a coral colony with Lego bricks using the photos or poster included as a guide. Encourage each child in a group to choose a different type of coral to build.

3. After they have built their coral colonies, ask them to consider challenges coral might face for survival. Can they guess what some of them are? Students should remember from Activity 2 that coral polyps eat zooplankton and need sunlight for the algae living within them to photosynthesize. Use the Background to discuss these and other issues that distinguish between natural circumstances and threats caused by humans. (The impact of human activity will be addressed further in Activity 8.)

4. To simulate how well their coral design might hold up to wave action, have two students pass a scarf or towel across their structure. Each child should hold on to one side of the towel and pass it over their coral structure to simulate a wave. Designs that include any branching pieces will probably break apart, at least at one point. Questions to ask as students are testing: ***What happens? If yours falls over, is it dead? What would happen if your coral were in a storm? How does your coral compare to others in your group?*** Ask students to look at the photos of real corals. Which do you think might survive a storm? Which would probably break?

5. To continue the city analogy, ask students: Which are the strongest buildings in a city? How long do they take to build? Point out that generally, more substantial buildings that would hold up well in a tornado are often also those that took the longest to build. Some coral colonies grow only $\frac{1}{5}$ of an inch a year. Small buildings, such as wooden houses that might be damaged in a storm, take less time to build and would take less time to rebuild after a storm. Similarly, massive, slow-growing coral will generally withstand the waves caused by a storm much better than less substantial fast-growing coral. At the same time, fast-growing coral will recover much more quickly from any damage, and some will even bend a little in the waves. Point out that there is no ideal design for coral, that each has developed strategies for growth and survival, and each plays an important role on the reef.

6. Culminate the activity by working together as a class to build a Coral City out of the Lego bricks. Provide a tabletop or other space as well as a large base for the Lego bricks for students to build upon. Plasticine or clay can also be used as a base to hold the Lego bricks in place. Like a real reef, your Lego reef should include many different types of corals mixed together in a seemingly random fashion. The finished Coral City will serve as a setting for the animals you will study in Activity 4.

REEF REFLECTIONS

- Design a building that, like coral, is solar-powered and able to withstand storms.
- What if you lived in an underwater city that was like a giant coral reef? How would you get to school or go out to play? What kinds of things would you do for fun living in an underwater city made of coral?

EXTENSIONS

Compare limestone to bricks and other types of building materials. Why aren't all buildings made out of these materials?

What kinds of materials do other animals use to build shelter?

Math Problems: How large would your students be if they were coral? For example, if a student is 10 years old and grew 2 cm every year, how tall would they be? How tall would they be at 33 years of age? If a student is 110 cm tall and grows at a rate of 1.5 cm per year, how old would they be?

ADDITIONAL RESOURCES

The Cousteau Society. *Corals: The Sea's Great Builders*. New York: Simon & Schuster Books for Young Readers, 1992.

Humann, Paul. *Reef Coral Identification*. Jacksonville, FL: New World Publications, Inc., 1993.

Sammon, Rick. *Rhythm of the Reef: A Day in the Life of the Coral Reef*. Stillwater, MN: Voyageur, Inc., 1995.

Quarrel Reefs—Corals Battle for Space and Sunlight

Space on the coral reef is at a premium and corals need not only space upon which to grow but also access to sunlight. Although corals look passive, they can be very aggressive when it comes to competing for space with colonies of other species. Fast-growing species tend to grow upward and then branch out, shadowing their neighbors to cause their zooxanthellae to die. Other corals take a more direct approach and actually attack their neighboring colonies with their stinging tentacles or with special long filaments that digest enemy polyps. Large, slow-growing corals tend to be more aggressive but both strategies have their advantages allowing many kinds of corals to thrive on the reef.

Life in the Big City

Coral reefs are teeming with life of every imaginable kind. Take a close look at your city beneath the sea to see how it all works.

Activity 4

OBJECTIVES

Students will:

- research information about a particular reef animal and present it to the class
- create a 3-D model of the creature to become part of your classroom's Coral City
- become aware of the ecosystem of a coral reef and some of its vast diversity of life

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goals 1, 3, and 4
  Mathematics: Goal 9
  Science: Goal 12
  Social Science: Goal 17

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

90-120 minutes
(can be divided into several shorter time segments)

MATERIALS

For each student:

- crayons, markers, or colored pencils
- copy of Resident of the Reef sheet on page 20
- various materials to make 3-D models

For the class:

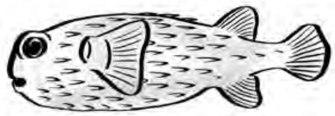
- as many resource materials as possible

BACKGROUND

It is difficult to contemplate the elaborate variety of animal life that finds food and shelter among the coral branches, boulders, and pillars of the reef. Thousands of fish and invertebrate species live together in tight quarters amidst a rich and complex ecosystem that we are just beginning to understand.

Following are some suggested animals to study, for which information should be readily available:

- octopus
- lionfish
- damselfish
- angelfish
- triggerfish
- brittle star
- moray eel
- seahorse
- frogfish
- hermit crab
- barracuda
- blenny
- porcupinefish
- squirrelfish
- spanish dancer
- urchin
- sea cucumber
- white-tipped shark
- parrotfish
- stingray
- sponge
- giant clam
- shrimp



Porcupinefish

Octopus

Triggerfish

PROCEDURE

Angelfish

1. Choose from the reef animals listed above (or add any of your own) which you would like your students to study and include in your classroom's Coral City model (see Activity 3). Place each animal name on a small piece of paper, fold it, and put it in a hat or bowl. Decide whether you would like students to work individually or with a partner. Have each child or pair pick a name to determine which animal they are to study. To provide an example for students, you might also draw a name and participate in the activity.

2. Ask each child or pair of students to learn about their creature by using the books, videos, posters, and other resources you provide. If possible, take a field trip to an aquarium and/or arrange to visit the school or local library. Instruct them to complete the Resident of the Reef sheet provided (see page 20), or simplify or embellish to create your own format for the information they gather. They should include a full-color, detailed drawing of their animal from which to create a 3-D model.

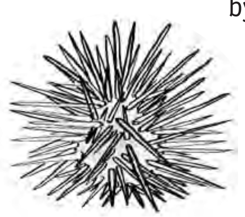
Giant Clam

Seahorse

3. After the research and drawings are completed, tell students to make a 3-D model of their animal to be placed in the Lego Coral City they made in Activity 3. Provide materials of your choice for students such as paper, clay, recyclable items, etc., or better yet, allow each child to choose the material they feel is most suitable for their creature. You may want to approve each drawing before they begin work on the model and discuss the size of the animal. It would be difficult to make animals exactly to scale since the coral is not measured precisely, but you could encourage them to be somewhat accurate. For example, fishes that are only a few centimeters in size such as a blenny should look much smaller than a barracuda that can grow to almost two meters.

Moray Eel

4. Tell students they will complete the Coral City by adding the inhabitants they made, but that first they will need to consider on which part of the reef their animal lives. Does it live mostly on the sea floor, in hiding places in the coral, or in the open water? Have students present what they learned to the class as they place their animal model in the Lego reef scenario. Depending on the animal, you may need to assist students. For example, if the creature lives in the open water, it will need to be suspended by either hanging it from above or supporting it from below. (This could be done by attaching the model to a popsicle stick placed in clay.)



Urchin

(Optional: Have students fill out an index card with pertinent information to identify their animal. Display the cards near the reef placing a number on the animal and on the corresponding card.)

5. The result of this activity is a model of a miniature Coral City that will reflect some of the diversity and richness of the animals on a reef. Point out to students that every creature is important to the balance of life on a reef. The reef ecosystem fits together like a puzzle so that even one missing piece affects the whole picture. This idea will be explored further in Activity 8.

REEF REFLECTIONS

- If you lived on a coral reef, which animal would you like to be? Why?
- Use what you learned in this activity to write a story using your animal as the main character.

EXTENSIONS

Learn more about your animal and find out if it is diurnal (active during the day), nocturnal (active at night) or crepuscular (most active at sunrise and sunset).

To further explore the diversity of life on the reef, research additional species to add to the model reef. What plants might you add?

ADDITIONAL RESOURCES

Human, Paul. *Reef Creature Identification*. Jacksonville, FL: New World Publications, Inc., 1992.

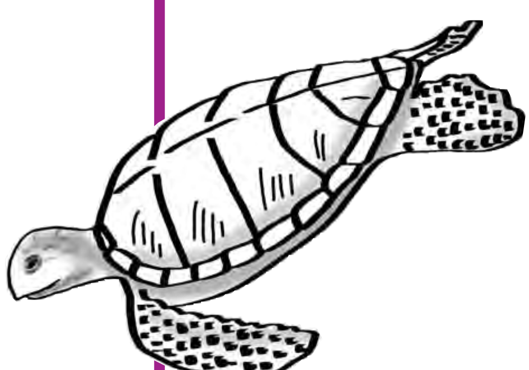
Humann, Paul. *Reef Fish Identification*. Jacksonville, FL: New World Publications, Inc., 1989.

Levine, Joseph S. *The Coral Reef at Night.* New York: Harry N. Abrams, Inc., 1993.

Roessler, Carl. *Coral Kingdoms.* New York: Harry N. Abrams, Inc., 1986.

Turtles as Tourists

Turtles do not usually live on coral reefs but they often visit because reefs are filled with lots of possibilities for a quick meal. Swimming almost continuously, sea turtles are well adapted to life in the water. Their legs are modified into paddles ideal for swimming, and some travel for thousands of miles in the open ocean. As reptiles, they need to breathe air, but they can stay submerged for almost two hours. In fact, they only come on land to lay eggs, somehow finding their way back to the beach where they were born.



RESIDENT OF THE REEF

Drawing of animal (make the features and coloring as accurate as possible):

Name of animal:

Average Size:

Special Adaptations/Interesting Facts:

Where it lives on the reef:

What it eats:

Who is its predator:

Importance to the ecosystem of the reef:

Dining Out in a Coral City

If you live on a coral reef, you have no use for knives and forks. Take a look at some of the unique eating "tools" reef animals have developed.

Activity 5

OBJECTIVES

Students will:

- learn some of the ways reef animals have developed different ***adaptations*** for feeding
- experiment with some reef animal eating "tools"
- make comparisons between how humans eat and how reef animals eat

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goals 3 and 4
  Science: Goal 12

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

VOCABULARY

adaptation: an inherited trait that increases an organism's chances of survival and reproduction

exoskeleton: an external skeleton that forms the outer surface of an animal (i.e., lobsters, crabs)

TIME

45-60 minutes

MATERIALS

For each student:

- hard chocolate chip cookie
- napkin
- Dots® candy or mini marshmallow
- toothpicks
- 2-3 gummy worms
- glass of water
- drinking straw
- bottle of cake decorations (like Jimmies or tiny star shapes—small enough to fit through a straw)
- 2-3 walnuts or other kinds of nuts in shells

For the class:

- turkey baster
- dishtub of water
- cardboard egg carton
- regular pliers
- needlenose pliers
- nutcracker

BACKGROUND

Looking at coral reefs teeming with life may lead one to believe there is an endless supply of food in the ocean. Compared to colder waters, there are very few nutrients floating in tropical seas. This explains why tropical waters are so clear. A coral reef is like an oasis in a desert, supplying the only source of food and shelter for many miles around.

So how does a coral reef support so much life and so much diversity? The reef ecosystem is very efficient and complex. Every living thing is food for some other living thing, and every nook and cranny of the reef is used as a home. To avoid a high level of competition for food and space, reef animals have developed incredible strategies for survival.

One way reef dwellers have been able to share the limited resources of the reef is that they have built-in "tools" for feeding that allow them to obtain food that other animals can't access. For example, parrotfishes have developed special teeth that are fused together. Acting as a chisel, their teeth allow them to scrape away at the algae found on and around the stony skeleton of coral.

PROCEDURE

1. For this activity, familiarize yourself with the five feeding adaptations of the animals on page 25. In advance, set up the following five activity centers in your classroom, each to explore one of the "tools" that reef animals use to feed:

   Activity Center 1: Triggerfish
   Supplies—a Dot (or mini marshmallow) and six toothpicks for each student, turkey baster and dishtub of water

   Activity Center 2: Parrotfish
   Supplies—hard chocolate chip cookie, napkins

   Activity Center 3: Butterflyfish
   Supplies—cardboard egg carton with dime-sized holes cut along sides, regular pliers, needlenose pliers, small gummy worms

   Activity Center 4: Seahorse
   Supplies—star-shaped or other cake decorations (small enough to fit through a straw), straw and cup of water for each student

   Activity Center 5: Stone Crab
   Supplies—walnut or other nut in a shell for each student, nutcracker

   Photocopy page 25. Cut the page into sections and place the appropriate paragraph at each station.

2. Begin the activity by sharing the information included in the Background and telling your students they will be experimenting with the eating "tools" of some reef animals. Divide the class into five groups and start one group at each activity center. Ask one student in each group to read the paragraph to the rest of the group and then follow the directions on the card. Encourage them to discuss the results. After they have all tried the activity, have the class rotate through the centers until they have visited all of them.

3. After they have rotated through all the activity centers, encourage the students to exchange ideas about what they found. Show them photographs of each animal, if possible, or refer them to the poster included in this activity guide. Ask: ***Did you find it difficult to eat like these animals? Why? What advantage or disadvantage does each type of eating tool have?*** For example, the parrotfish has the disadvantage of having to contend with the coral skeleton to get at their food but at the same time a parrotfish has a reliable food source since coral, and the algae growing on and around coral, is very plentiful on a reef.

REEF REFLECTIONS

- What kinds of adaptations do humans have that help them eat? How do your own teeth work to help you eat both plants and meats?
- If you could only eat one kind of food, what would you pick and how would you eat it?
- Can you imagine going out to eat in an underwater oasis?

EXTENSIONS

Explore other reef animal feeding adaptations (i.e., sharks, sea stars, pufferfishes). Design your own coral reef creature and a way for it to obtain food.

ADDITIONAL RESOURCES

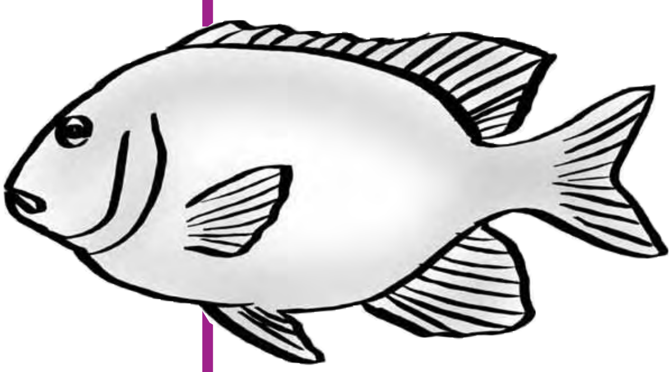
Coulombe, Deborah A. *The Seaside Naturalist: A Guide to Study at the Seashore.* New York: A Fireside Book published by Simon & Schuster, 1992.

Sibbald, Jean H. *Strange Eating Habits of Sea Creatures.* Minneapolis: Dillon Press, Inc., 1986.

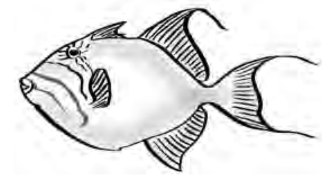
Wilson, Roberta, and James Q. Pisces. *Guide to Watching Fishes: Understanding Coral Reef Fish Behavior.* Houston, TX: Pisces Books, 1992.

Fish as Farmers?

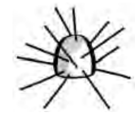
You may have thought that farming can only happen on land. But several types of damselfish have taken up farming as a way to insure a steady food supply. They cultivate algae within tiny plots on the coral reef, spending their days tending and protecting their crop. Despite their small size, damselfish fearlessly defend their "fields" against just about any intruder. Even divers have gotten nipped when they've come too close.

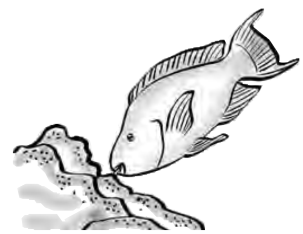


Dining Out in a Coral City Activity Centers



1. One of the triggerfish's favorite meals is a sea urchin, but how does it avoid the urchin's pointy spines? It blows a powerful stream of water, like a firehose, to overturn the urchin and expose its soft tasty underside. Make a sea urchin by first breaking 6 toothpicks in half. Poke the toothpicks randomly (see illustration) into the sides and top of a Dot candy. Place it in water. Use a turkey baster to see if you can overturn your urchin and expose the part that's not equipped with pointy weapons. (For sanitary reasons, don't eat the Dot that was in the water.)





2. Parrotfish are one of many fishes that graze on the reef for algae in much the same way that a cow grazes in a pasture. Their teeth (unlike ours) have fused together into a beak-like shape to form a powerful scraping device that allows them to scrape at algae found on coral. Imagine that you are a parrotfish and the chocolate chip cookie is coral. The chocolate chips represent the algae and you have to scrape them out with your teeth. To extract the algae from the rock, parrotfish have a second set of teeth in their throat that grinds the coral into sediment. The coral comes out the other end as sand!

3. Longsnout butterflyfish feed on tiny invertebrates that live in crevices on the coral reef. But how can the fish get to the worms in tiny holes? Its name might give you a clue. To try for yourselves, take turns hiding a gummy worm under the egg carton. Now try to extract the gummy bear through the small holes with regular pliers and then needlenose pliers. Which one works better? Longsnout butterflyfish use their long, tapered snouts to reach into spaces inaccessible to fishes with blunter snouts and extract the tiny worms within.

4. With jaws shaped like a long, hollow straw, seahorses feed by sucking shrimp and plankton out of the water. Seahorses have no teeth and swallow their food whole. Incredibly, because they have no stomach in which to store food, seahorses eat as many as 3,500 tiny shrimp a day. That means they need to feed almost continuously. Can you imagine how much work that would be? To try eating like a seahorse, place 10 pieces of cake decorations (pretend they are shrimp) in a glass of water (each student should begin with the same amount of water) and stir them up. Suck up as many as you can while drinking as little water as you can. Who in your group ate all ten, drinking the least amount of water?

5. Just think how hard you could pinch if your bones were on the outside of your fingers. Like most crabs, the stone crab is covered with a hard exoskeleton and is fitted with powerful claws that act like a knife and fork. They can easily crush the shell of a snail, one of their favorite foods. To see how difficult this could be, try to crack open a nut shell with your fingers. Why can't you do it? Try again using a nutcracker. This is similar to the way a crab cracks open a snail's shell to get at the animal inside.

Going to School in a Coral City

When fishes "go to school" they swim in remarkable unison. Find out how being in a school helps some fishes find food and avoid enemies on a coral reef.

Activity 6

OBJECTIVES

Students will:

- learn how schooling behavior is important for the survival of many species of fish
- participate in games to explore the difficulty a predator might have in pursuing an individual fish in a school

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goals 3 and 4
  Mathematics: Goal 9
  Science: Goals 11 and 12

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

30-45 minutes

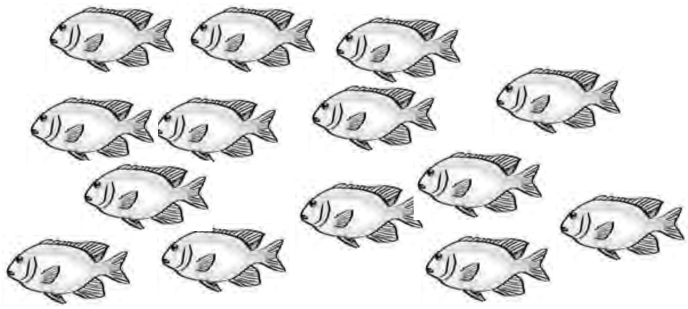
MATERIALS

For the class:

- flashlight
- colander
- two fans
- 100 or more feathers of one color plus two of a second color
- 20 white ping pong balls plus two of a second color
- two bowls to hold the balls
- stopwatch (optional)

BACKGROUND

Some fishes live alone, some live in pairs, but many fishes live in large groups. These groups, called schools, range in size from a handful of individuals to millions of fish—usually all of the same species. Fishes in a school move with such precision, and are so evenly spaced, that they appear to move almost as a single animal. Schooling is so important to fishes that most species do it for at least part of their lives. For example, some fishes live in schools as juveniles or around spawning time to find a mate.



Why do fishes school?

To avoid predators

Protection from predators is the main reason most fishes school. This probably explains why the fishes that school all the time tend to be the smallest and most defenseless species. At a glance, it might seem that schooling would make fishes more vulnerable to predators because a large group is so much more conspicuous than a single fish. But, for a predator, sighting the school is only the beginning. The far more difficult task is choosing and pursuing a specific target amongst thousands of darting fishes. A surprise attack is nearly impossible with so many eyes on the watch. When a predator does charge, the entire school breaks apart simultaneously and moves in different directions.

To increase chances of finding food

Their large numbers make schools easier to spot but it also enables them to locate food more easily. By spreading out and moving as one, schooling fishes are more likely to come across a source of food that can then be shared by the whole group.

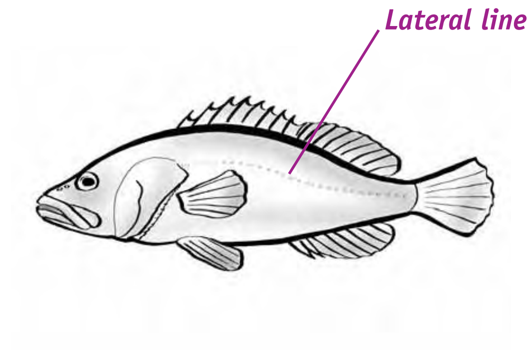
To increase reproductive success

Living in a group with so many fishes of the same species makes it easier to find a mate and allows fishes to synchronize their reproductive cycles. In fact, some species of fish, such as herring, school only during spawning time.

To increase swimming efficiency

By swimming in a group, fishes can take advantage of reduced water resistance created by the movement of the fish they are following. This is similar to the way bicycle riders find reduced wind resistance if they stay just behind and to the side of the bicycle in front of them.

How do fishes move in a school with such precision? Part of their ability is due to a sense fishes have that is different from any of our senses. It is called the lateral line and it is just that—a line that is usually visible on the outside of fishes running along their side from the head to the tail. The lateral line helps fishes keep their position in a group because they can detect even the slightest movement in the water with this sensitive feature. Experiments have shown that even blind fish have been able to keep other fishes schooling at a constant angle and distance because of their lateral line.



PROCEDURE

1. In advance, set up four stations (placing them as far from each other as possible), two of each of the following:

   Fan & Feathers

   Place a fan on its side so that the air will shoot up vertically when turned on. (Some fans have stands that allow turning this way. Others, such as a box fan, will need to be elevated off the floor and supported by blocks or books.) Supply as many feathers as possible (preferably 50 or more) of one color and a single feather of a different color.

   Bowl of Balls

   Provide a bowl with ten white ping pong balls and one of a different color. (You can use a permanent marker to color them.)

2. To begin the activity, ask: ***What is a school of fish? Why do fish school? What advantages might it have?*** Use the Background to lead a discussion about the many reasons fish might school focusing on survival as the central issue. Tell the students that they will be trying several games to find out how difficult it is to catch an individual fish in a school.

3. Darken the room and point the flashlight on a wall where the students can see it. Tell them that they are predators and the spot is their prey. Their challenge is to point at their prey with their finger and follow it around the room as it moves. Move the flashlight, causing the beam to move to various places around the room. Discuss whether or not they think they would have been able to catch their prey. Most likely, as long as they could swim as fast or faster, they would have had an easy meal.

4. Now, tell them that their prey is part of a school. Shine the flashlight through the holes of a colander and ask the students to pick one of the resulting spots of light as their prey. Tell them to follow their prey as it moves just as before. Move the flashlight and colander together causing the group of lights to move about the room. Ask: ***Were you able to follow the one spot of light? Why was it more difficult?***

5. Divide the classroom into four groups and have each group move to a station. If you like, have the students time each other with a stopwatch:

Fan & Feathers

With the fan off, place the feathers (all of the same color but one) on top of the screen. Tell the students that the feathers represent a school of fishes and that the moment they spot a predator, they disperse. They will be simulating this moment by turning on the fan. Ask one student to be the predator and see how long it takes him or her to catch the one fish of a different color. Remind the students that the predator needs to focus on one fish in order to attack.

Bowl of Balls

Have the students place the balls in a bowl and take turns being the predator and the one who tosses (or rolls) the balls. The predator's job is to catch (or grab) the one ball of a different color as all the balls are thrown (or rolled) toward him or her.

6. If time allows, have each group do a demonstration and/or present their findings to the class. Use the Background to explain the lateral line and discuss some of the ways schooling can be advantageous in the struggle for survival. Ask the students what possible disadvantages there might be. For example, fishes in schools are easier for fishermen to find and catch.

REEF REFLECTIONS

Compare a school of fishes to your own school.

- What would it be like to have a "sixth sense" like a lateral line?
- What other kinds of animals have a "sixth sense" (i.e., a cat has whiskers)?
- If you were a fish, would you like to live in a school, in a pair, or alone? Explain why.

EXTENSIONS

Research some of the fish species that school. Explore those that school throughout their lives as well as those that school only at certain times, such as when they are juveniles or during spawning season.

Explore the other reasons why fishes school (i.e., finding food or swimming efficiency).

ADDITIONAL RESOURCES

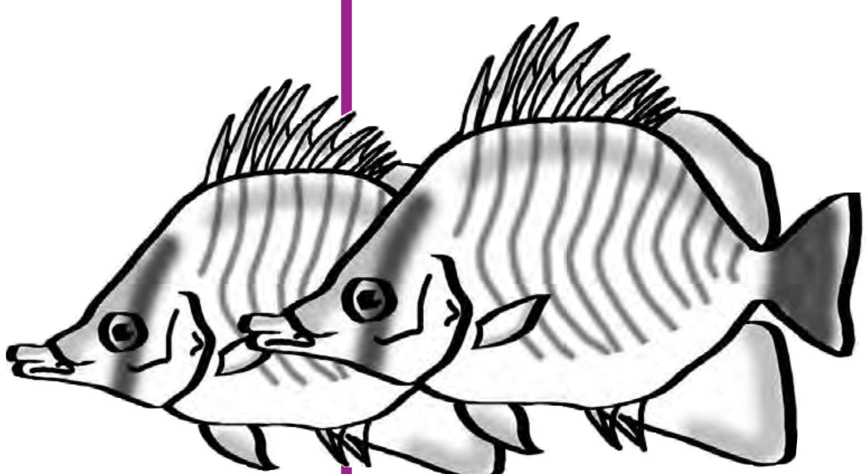
Holing, Dwight. *Coral Reefs*. Parsippany, NJ: Silver Burdett Press, 1995.

Moyle, Peter B. *Fish: An Enthusiast's Guide.* Berkeley: University of California Press, 1993.

Wilson, Roberta, and James Q. Pisces. *Guide to Watching Fishes: Understanding Coral Reef Fish Behavior*. Houston, TX: Pisces Books, 1992.

Happily ever after . . .

Some kinds of fishes never "go to school" but instead live in pairs. One of the more common sights on a coral reef is a pair of butterflyfishes flitting about together. Butterflyfishes are so devoted to each other that if one is lost, the other will stop feeding and go in search of its partner. When reunited, they celebrate by swimming in circles around each other for several minutes.



Friend or Anemone?

Despite rampant predation on the coral reef, there are surprising examples of cooperative living. Find out how dissimilar species use each other to increase their chances for survival.

Activity 7

OBJECTIVES

Students will:

- explore symbiotic relationships on the coral reef
- participate in a game to find their symbiotic partner
- represent what they've learned by presenting it to the class

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goals 1, 4, and 5
  Science: Goal 12
  Social Science: Goal 17

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

VOCABULARY

symbiosis: a relationship between two organisms of different species in which at least one of the two animals benefit

TIME

45-90 minutes
(can be divided into several shorter time segments)

MATERIALS

For each student:

- scissors
- safety pin
- copy of Symbiotic Shuffle game card on page 32

For each small group

- copy of Symbiotic Shuffle Partners on page 33

BACKGROUND

Even though danger and predation are prevalent on the coral reef, there are many examples of cooperation among different species of animals. ***Symbiosis***, literally "to live together," refers to situations in which two species live in close contact with each other and interact in unexpected ways. You've already explored a key symbiotic relationship between coral and zooxanthellae (see Activity 2), without which reefs would not exist.

These mutually beneficial partnerships have developed on reefs over thousands and thousands of years. By learning patterns of cooperation with another organism, many marine plants and animals have improved their chances of survival. The reasons for symbiosis often involve food, protection, cleaning or transportation.

This activity focuses on four such relationships presented as Symbiotic Shuffle Partners on page 33. To prepare for this activity, familiarize yourself with these animals.

PROCEDURE

1. In advance, photocopy page 32 so that there is one Game Card for each student. (There are eight animals in total, so there will be several of each animal.) Also make one copy of the Symbiotic Shuffle Partners on page 33. Cut both so that each animal picture and partner description is on a different slip of paper. Begin the activity with a brief discussion of symbiosis using the relationship between coral and zooxanthellae as an example. For a more familiar example you might talk about the symbiotic relationship between people and houseplants. People provide plants with a steady temperature and water supply in return for beauty and cleaner air. Now tell the students that they will be playing the Symbiotic Shuffle.

2. Give each student a game card instructing them to cut out the picture of their animal, pin it to their clothes, and carefully read the description of the animal. Their task is to find their symbiotic partner by going around the room and asking each other questions until they find their "match." (Note: There will be several possibilities for matches since there is more than one of each animal. Also, there are two types of anemones, but the description should make the difference clear.) For instance: Are you a fish? Do you live in a cave? Each student should determine his or her own questions based on the description of their animal.

3. After they have found their symbiotic partner, have them group together with the other animals in the same partnership. For example, all of the cleaner wrasses and groupers should be in a group. Provide each group with their partnership description so they can learn their names and more about their animals. Have them write the name of their animal on its picture.

4. Their next task, as a group, is to decide together how to "teach" the class about their symbiotic partnership. This can be done in any number of ways such as by acting it out, through creative writing, or by drawing an illustration.

5. After each group has presented their symbiotic partnership to the class, discuss each partnership. Even though both animals benefit in these relationships, usually it is more beneficial for one animal than the other. For example, the clownfish might not survive long without the anemone, but the anemone would not suffer without the presence of the clownfish.

REEF REFLECTIONS

- Can you think of any symbiotic relationships in your community? How about in your school or family?

EXTENSIONS

Research symbiotic relationships in more familiar species.

Learn about different types of symbiotic relationships such as ***mutualism,*** in which both organisms benefit from living together, ***commensalism,*** in which one organism benefits and one is unaffected, and ***parasitism,*** in which one organism benefits and the other is harmed.

ADDITIONAL RESOURCES

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Moyle, Peter B. *Fish: An Enthusiast's Guide.* Berkeley: University of California Press, 1993.

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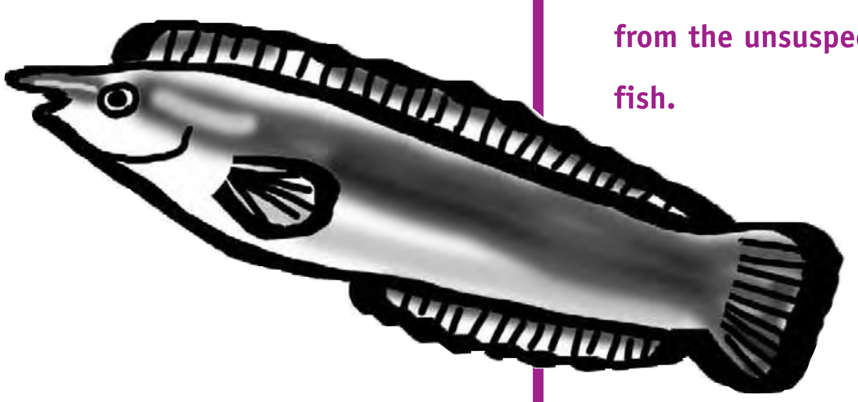
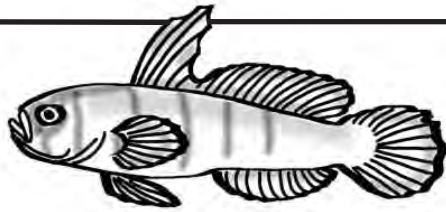
Tigers Aren't the Only Ones with Saber-Like Teeth

Not everyone on the reef participates peacefully in these cooperative relationships. The sabertooth blenny for one takes advantage of a "cleaning station truce." This small fish mimics the cleaner wrasse's appearance and swimming habits so well that it is quite difficult to tell them apart. It waits near a cleaning station and lures large fish in by pretending to be a cleaner fish. But instead of cleaning off parasites, it takes a bite of flesh, even eyeballs, from the unsuspecting fish.

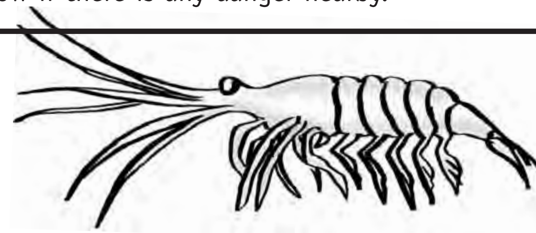


Symbiotic Shuffle Game Cards

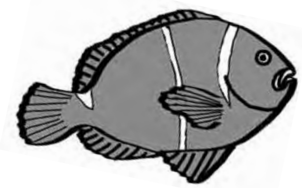
I share a burrow built by another animal and in exchange I act like a "seeing-eye fish." My friend is almost blind, so I leave the "house" first and check out the neighborhood to see if there are any threats to our safety.



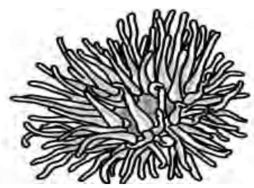
I am a small invertebrate and I can barely see, so I need to get help from a friend for protection. That's why I invite a small fish friend to live with me. This fish helps me by going out first and letting me know if there is any danger nearby.



I am a fish that needs protection because I am quite small. I find safety by living among the stinging tentacles of another animal even though other fish would die from the poison. I will also chase away some animals and even divers who may try to harm my symbiotic partner.

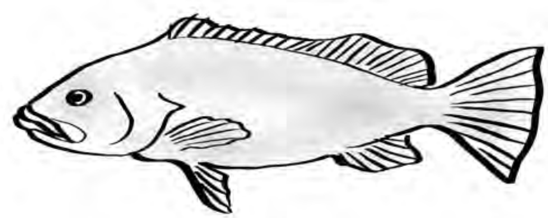


I am an animal that looks like a plant. Even though I make a meal of small fish by stinging them with my tentacles, there is one fish that I don't mind living with. In fact, this fish helps me because it lures in other fish for me to eat and sometimes scares away harmful predators.

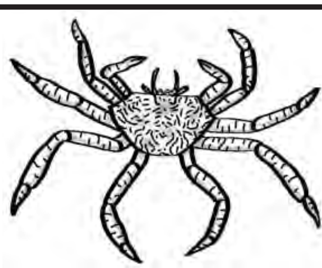


I am a small fish whose favorite food is the tiny parasites that drive the big fish crazy. Normally, big fish would like to eat me for a snack but when I work at the station they leave me alone.

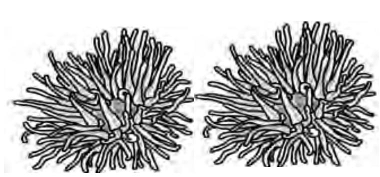
I am a large fish and a fierce predator, but there is one little fish that I will never eat. This little friend does me the favor of picking parasites off of me and cleaning between my teeth.



I have claws, but they are not powerful enough to protect me from some large fish. So I have a trick. I grab small animals with stinging tentacles and place them on my front claws.



I am a small plant-like animal with stinging tentacles. I am sometimes carried around on the front claws of another animal for protection. I don't mind because I can't move on my own and I get a free ride to different neighborhoods where I might find new foods.

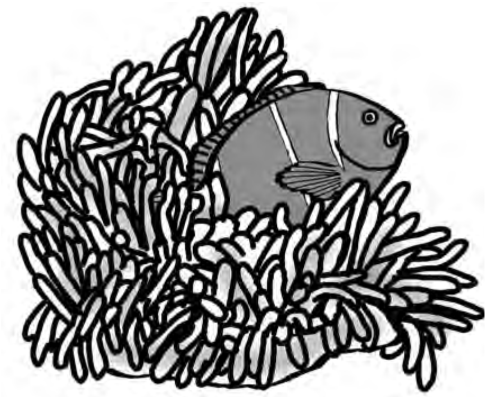


Symbiotic Shuffle Partners

Goby and blind shrimp

Because of its poor eyesight, the blind shrimp happily shares its burrow with the goby, which acts as its built-in alarm system. Both animals spend much of their time foraging for food near the burrow entrance. The goby leaves the burrow first. It it spots a threat, it sounds the alarm by hitting the shrimp's antenna with the flick of its tail. Both then retreat to the safety of the burrow. In exchange for providing an early warning system, the shrimp shares it hiding place and provides cleaning service to the goby.

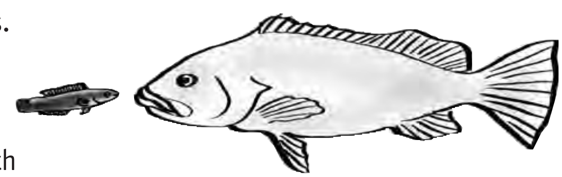
Clownfish and anemone



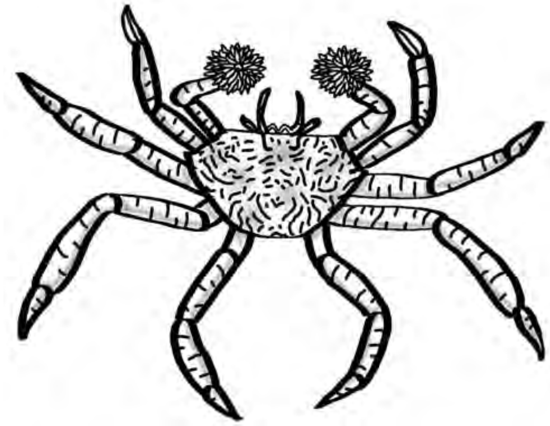
Despite their bright coloring, clownfish are quite shy and spend most of their lives hovering above and darting into anemones at the slightest sign of danger. Anemones have stinging tentacles that normally would sting and capture fishes the size of clownfish. Yet clownfish have a special coating of mucus that protects them from the anemone's sting. The clownfish benefit because they can hide in the protection of stinging tentacles where predators won't pursue them. But the anemone also benefits because the clownfish lures in fish for a meal, sharing its catch with the anemone.

Cleaner wrasse and grouper

Cleaning stations on the reef can look like a Saturday morning at the local carwash. Groupers and other big fishes wait patiently in line while tiny cleaner wrasses groom them one by one. These brightly colored wrasse advertise their occupation by twisting their body and waving their fins. Even though they are usually fierce predators, groupers never attack the cleaners. They let the tiny fish pick parasites off their body and even let them safely into their mouths to clean their teeth. If there is a threat while a grouper is being cleaned, it closes its mouth and swims away but leaves a small opening to allow the cleaner to escape. Without cleaners, groupers could get sick or even die from the parasites and debris lodged in their bodies. Without groupers and other large fish, the cleaners would lose a steady food supply.



Boxing crab and anemone



Even though the boxing crab is relatively large, its claws aren't as powerful as those of some of its cousins. So how can it defend itself against a large attacking fish? The crab looks for two small anemones, one to place on each of its two front claws. Fish will back away from the anemones because of their stinging tentacles. This allows the crab to protect itself by holding the anemones out in front the way a boxer protects his face by holding up boxing gloves. When an enemy approaches, the crab jabs at it with one of the anemones, scaring off the predator. In this partnership, the boxing crab gets protection and the anemone gets transported to new food sources and also feeds on leftover morsels from the crab's meals.

Reefs at Risk

Each plant and animal is integral to the balance of life on the coral reef. Find out what could happen if any of these organisms should disappear.

Activity 8

OBJECTIVES

Students will:

- make a mobile using hangers to represent the food pyramid of the coral reef
- consider the impact of human activities on individual species and on the reef as a whole

GOALS AND STANDARDS

This activity meets:

- Illinois Learning Standards:
  English Language Arts: Goals 3 and 4
  Mathematics: Goal 9
  Science: Goals 12 and 13
  Social Science: Goal 17

- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A, C, E and F
  5-8 Content Standards A, C, E and F

VOCABULARY

phytoplankton: free-floating, often microscopic, aquatic plants

TIME

45 minutes

MATERIALS

For the class:

- 31 wire clothing hangers (preferably dry cleaner hangers with white paper attached)
- overhead projector
- transparency of Reefs of the World map on page 9

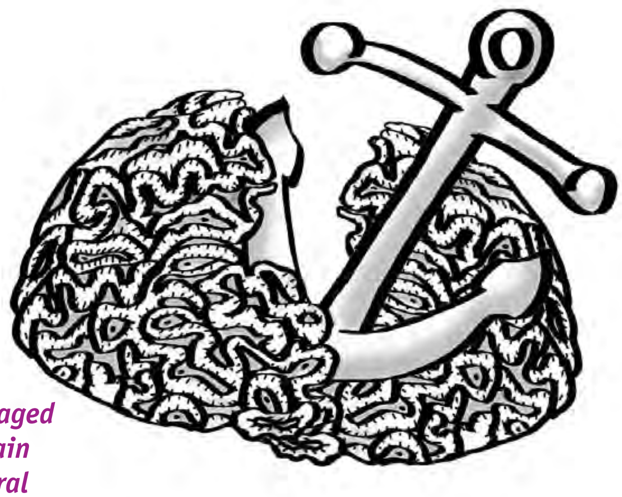
BACKGROUND

On a coral reef, each plant and animal is part of an incredibly complex system that has evolved over millions of years. Even though there may seem to be an abundant and diverse number of animals, each living organism is significant and invaluable to the survival of a coral reef. For example, without zooxanthellae there would be no coral. Without grazing fish, algae could grow out of control and deprive the coral of light and oxygen.

All of these animals are part of the coral reef food web, which can also be viewed in a pyramid configuration (see illustration, page 37). In this activity, the five levels of the pyramid show a sample "slice" of the much more complex food web of a coral reef. In general, bigger animals eat smaller animals, and the smallest animals, such as coral and small fishes, eat algae and other plants. The food pyramid illustrates how those organisms in the lowest level are the most plentiful. In other words, the prey population must outnumber the predator population above it to keep the system in balance.

But how do humans fit into the pyramid? For centuries, humans lived harmoniously with coral reefs while using them for food, tools and building materials. Only recently have we begun to over exploit coral reefs, jeopardizing the health and survival of this ecosystem. Following are some of the ways we imperil the reefs:

Careless boating and diving practices—Visitors to reefs damage them by dragging anchors over coral or running boats aground in shallow water.



Damaged Brain Coral

Divers stand on or accidentally kick the coral with their flippers. Delicate coral branches are easily broken and can take years to grow back.

Harmful fishing techniques—As human demand for fishing increases, more and more fish are caught through wasteful or harmful means. In one of the most destructive practices, hunters explode dynamite in the water, and the dazed fish float to the surface where they are scooped up with ease. Since fish not considered valuable are left to die the loss of fish is immense. The coral reefs themselves are also extensively damaged. This is common practice in the Philippines where up to 75% of the reefs have already been destroyed.

Commercial collection—Many fish for the home aquarium market are captured by releasing cyanide onto a reef to drive fishes from their hiding places. Some fishes die immediately, and it is estimated that only one in ten will survive beyond a few weeks. Coral and seashells are also harvested in great number for souvenir and jewelry markets around the world.

New construction—The excavation required for new homes, resorts, and roads causes millions of tons of sand and silt to flow out to reefs, smothering the live coral. Often because it is hard and weather-resistant, coral itself is mined and made into roads and sidewalks. Clearing trees for construction also fills the waters with silt.

Pollution—Pollution comes in many forms and all types can be damaging to coral reefs. Sewage, for example, is filled with natural fertilizers that cause algae to grow too rapidly, robbing the water of oxygen and light. Agricultural chemicals run off into rivers and streams and can be a serious problem for reefs even when the source is many miles away. Factory waste and oil spills are other major sources of pollution.

Since all species are interrelated, the cumulative effects of these abuses are far-reaching and felt throughout the food web. Coral reef animals, unlike land animals, have no possibility of escape. They have no choice but to live or die among the coral. It is our responsibility to make sure they get a fair chance. Even if we don't damage reefs directly, we may still jeopardize them by the chemicals we use, the fish we eat, or even the habits we take along on vacation.

PROCEDURE

1. Decide where to hang your mobile. You will need a high point from which to hang it as well as a fair amount of floor space. You may want to put it together in advance to see how it hangs and fits in your space (see illustration for mobile configuration). Also, before you start, write the names of the animals (see procedure #2) to be included in the food pyramid on the board, so the students will have an idea of all the animals at a glance.

2. Tell the students that they are to make a mobile that will serve as a model of the coral reef food pyramid. Each student will write the name of a reef animal (and/or draw a picture, if you like) on both sides of the white paper part of the hanger.

Provide each student with a hanger and assign them one of the following animals:

shark
barracuda
parrotfish
grouper
triggerfish
butterflyfish
damselfish

You will need two hangers with each of the following names on them:

coral/algae
urchin
marine worm

You will need four hangers with the following animal name on them:

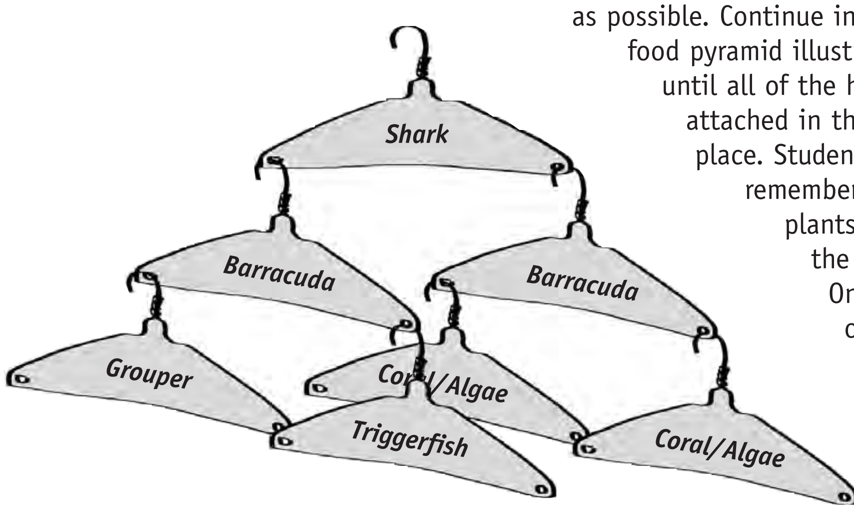
zooplankton

You will need six hangers with the following plant name on them:

algae

You will need eight hangers with the following plant name on them:

phytoplankton



3. To begin assembling your mobile ask the students which animal they believe would be at the top of the food pyramid of the coral reef. By reading the animals on the board, they will probably know that the shark is the largest predator. Ask the student who has the shark to come hang it in the designated spot. Now ask: ***What would the shark eat?*** A shark might eat any number of things but it would target a bigger fish to get as much out of a meal as possible. Continue in this way using the food pyramid illustration to guide you until all of the hangers are attached in the appropriate place. Students should remember most of the other plants and animals from the previous activities. One unfamiliar organism is ***phytoplankton***, important as one of the bases of the food pyramid.

4. Tell the students that your mobile represents a picture of a coral reef food pyramid when everything is healthy and in balance. It is important to emphasize that there is not just one right answer to this "puzzle." Many animals, like sharks, are not picky eaters and will consume almost anything that comes their way. Use the Background to further explain the pyramid model. Encourage students to think about the interdependence of species. For example, ask: ***Is algae important to the survival of sharks? Do sharks eat algae?*** No, but it is important to sharks because without algae, urchins would have nothing to eat, which would mean triggerfish would lose a food source. In the end there would be fewer animals for sharks to eat.

Coral Reef Food Pyramid

<table>
<tr><td colspan="16">Shark</td></tr>
<tr><td colspan="8">Barracuda</td><td colspan="8">Parrotfish</td></tr>
<tr><td colspan="4">Grouper</td><td colspan="4">Triggerfish</td><td colspan="4">Coral/Algae</td><td colspan="4">Coral/Algae</td></tr>
<tr><td colspan="2">Butterflyfish</td><td colspan="2">Damselfish</td><td colspan="2">Urchin</td><td colspan="2">Urchin</td><td colspan="2">Zooplankton</td><td colspan="2">Zooplankton</td><td colspan="2">Zooplankton</td><td colspan="2">Zooplankton</td></tr>
<tr><td>Marine Worm</td><td>Marine Worm</td><td>Algae</td><td>Algae</td><td>Algae</td><td>Algae</td><td>Algae</td><td>Algae</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td><td>Phyto-plankton</td></tr>
</table>

5. What happens when something disrupts the food pyramid? What would happen if predators outnumber their prey? With this exercise, challenge your students to consider the importance of each species as they see how too few or too many of any creates an imbalance in the system. For each scenario below, have a student remove the appropriate hanger(s). Determine how the removal of the animal affects those above and below it and rearrange the remaining hangers accordingly to show how the event might affect the balance of the pyramid. For example, if an animal is removed from the middle of the pyramid, those above it will have less to eat and will need to look for a new food source. Those below will increase and could disrupt the balance by becoming too numerous. Present the students with the following scenarios based on real situations happening in reefs around the world:

   - A resort and several roads are built on a tropical shore. Trees and plants are removed so that when heavy rains come, mud and sand are washed into the water covering the coral and blocking the sun from the zooxanthellae. How would the loss of coral impact the food pyramid? (Remind students that coral supplies not only food, but homes for many animals.)
   - Many fishes are captured for the aquarium trade with the use of cyanide poisoning. What would happen if fishes destined for the aquarium trade, such as parrotfish, triggerfish, butterflyfish and damselfish, were removed from the pyramid?
   - Overfishing is a common problem on coral reefs and groupers are fished heavily in many areas of the world. What if there were no groupers left on a reef? (Groupers are one of the largest fishes on the reef, growing up to two meters long, and therefore consume large amounts of food.)
   - Shark fin soup has become a popular delicacy in many Asian countries. What happens if sharks are removed from a reef?

6. To conclude, ask the students how humans fit into the food pyramid. How do we threaten the reef? Use the **Background** and project the Reefs of the World map on the overhead projector to discuss the extent of the damage humans have caused. Ask students to think of ways they can help stop the devastation. For example, they could make sure that any tropical fish they buy are obtained in a responsible way. For more ideas about getting your students involved, here are some organizations to contact for information:

   Center for Marine Conservation
   1725 DeSales Street, NW
   Washington, D.C. 20036
   (202) 429-5609

   Reef Relief
   P.O. Box 430
   Key West, FL 33041
   (305) 294-3100

   Greenpeace USA
   1436 U Street, NW
   Washington, D.C. 20009
   (202) 462-1177

   John G. Shedd Aquarium
   1200 S. Lake Shore Drive
   Chicago, IL 60605
   (312) 692-3224

REEF REFLECTIONS

As your study of coral reefs draws to a close, decide how you would like to proceed with the journals. For example, students could trade journals to share ideas, or they could be presented to parents at conferences or events.

- What are the natural events and human activities that impact the environmental health of your city or neighborhood?
- How can you participate in the conservation of your area?

EXTENSIONS

Do research to find out which species of reef animals are in particular danger and try to get them boycotted in your area. (For The Audubon Guide to Seafood, call 800.274.4201.)

Write articles to educate consumers about the problem.

Research the kinds of conservation issues cities are concerned about (i.e., recycling, waste management, clean water).

ADDITIONAL RESOURCES

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Sammon, Rick. *Rhythm of the Reef: A Day in the Life of the Coral Reef.* Stillwater, MN: Voyageur, Inc., 1995.

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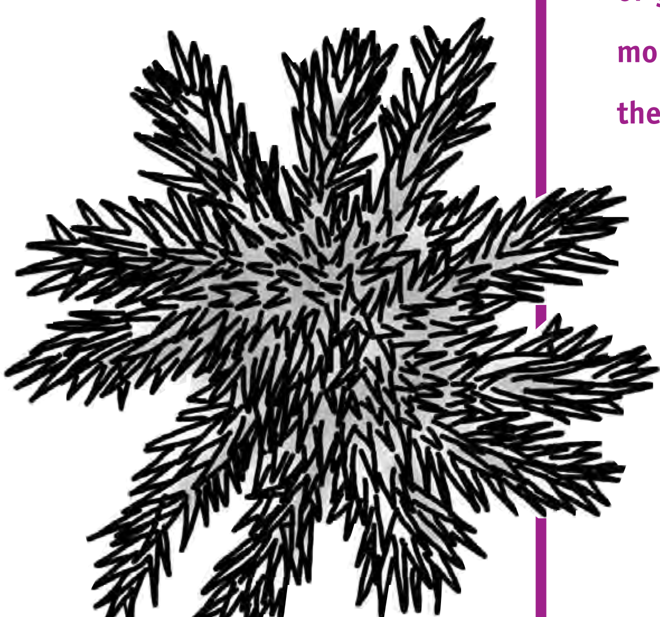
A Thorny Problem

The many-armed crown of thorns sea star has a voracious appetite for coral. It eats by pushing its stomach out of its mouth and pouring its digestive juices onto the coral. In parts of the Philippines and the Great Barrier Reef, a population explosion of the crown of thorns has killed large sections of reef. Some scientists blame this overpopulation on shell collectors who decimate the population of giant triton, a mollusk that preys on the crown of thorns.

Others believe population increase is part of a natural process serving to open space on the reef for new coral.



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WEB SITES

www.audubon.org
Audubon Society is a non-profit organization dedicated to conservation.

www.blacktop.com/coralforest
Coral Forest is a non-profit organization dedicated to the preservation of coral reefs through education and action.

www.nationalgeographic.com
National Geographic Society

www.reefrelief..org
Reef Relief is a private non-profit membership organization dedicated to preserving and protecting North America's only living coral barrier reef.

www.shedd.org
John G. Shedd Aquarium

For more information about Shedd Aquarium and its education programs, please write, call, fax, or visit our home page:

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