



EDUCATOR'S
GUIDE

MACGILLIVRAY FREEMAN'S

CORAL REEF

ADVENTURE

MACGILLIVRAY FREEMAN FILMS

Dear Educator,

We at MacGillivray Freeman Films are pleased to bring you and your students another exciting and beautiful film highlighting the coral reefs from around the world. Through the engaging activities provided in this guide, we become partners in the education process of your students as they are taken to areas of the globe where they may not normally be able to travel.

This educator guide will be most useful when used either before or after viewing the film, but is a valuable resource on its own. You are encouraged to adapt any of the activities included to meet the specific needs of the grades you teach and to your students. It is important to note that the activities in this guide have been developed to provide connections to the National Science Standards for grade 4-8. Life Science Standards relating how organisms relate to their environments and their interdependency in an ecosystem are strongly related within the guide and film. Activities within this guide are strongly connected to Science in Personal and Social Perspectives and History and Nature of Science Standards. These activities offer students central ideas related to health, populations, resources and environments to show them that science is a human endeavor for setting the foundations to understanding their actions as citizens of the world.

"Teach your children well" —CROSBY, STILLS AND NASH

Greg

Greg MacGillivray

"Pollution, overfishing, and overuse have put many of our unique reefs at risk. Their disappearance would destroy the habitat of countless species. It would unravel the web of marine life that holds the potential for new chemicals, new medicines, unlocking new mysteries. It would have a devastating effect on the coastal communities from Cairns to Key West, Florida—communities whose livelihood depends upon the reefs."

—Bill Clinton,
PRESIDENT OF THE UNITED STATES, AUGUST 1996
INTERNATIONAL YEAR OF THE CORAL REEF 1997

The large format film, *CORAL REEF ADVENTURE*, is appropriate for all intermediate grades (4-8).

This educator's guide will be most useful when accompanying the film, but is a valuable resource on its own. Teachers are strongly encouraged to adapt the activities included in this guide to meet the specific needs of the grades they teach and their students.



MacGillivray Freeman's *CORAL REEF ADVENTURE*

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Introduction

The coral reef is an entire living system, a structure built by colonies of tiny coral animals over millions of years. Teaming with as much biodiversity as terrestrial rainforests, coral reefs, with their extraordinary beauty, bright palette of colors, and oddly patterned inhabitants, are one of Earth's most important ecosystems.

The biodiversity of the reef system supports a vast interdependent food web, from microscopic plants and animals to humans. However, this life sustaining resource is now seriously threatened by human impact. The possible warming of our climate with associated warming of ocean temperatures, increased sedimentation from development along coastal areas, pollution, and unsustainable fishing methods are only some of the threats to reefs worldwide. As humans change the environment on the surface of the Earth, the conditions underneath the surface of our oceans change accordingly.

Through scientific exploration and discovery at Scripps Institution of Oceanography and other research institutions worldwide, we are learning how the coral reef ecosystem is dependent on the complex interactions of its inhabitants. From the microscopic plants that live within the tissues of the corals to the diversity of invertebrates and fishes that find food and shelter within the colorful caves and crevices, the reef system's millions of species also provide important food resources for sharks, sea turtles and dolphins. Millions of people throughout the world depend directly on the reefs for their livelihood.

"Rainforests of the Sea"

There are more species of organisms living on coral reefs than in any other environment in the ocean. In fact, despite covering less than 0.2 percent of the total area of oceans, coral reefs are noted for some of the highest levels of total productivity on Earth and house 25% of all marine creatures. Like a rainforest, coral reefs form a habitat where an astonishing array of life thrives. It has been estimated that between 1-9 million species live on coral reefs. Reefs are home to thousands of species found nowhere else on Earth. For many it is a hunting ground, a safe place to hide, a place to breed, to raise young, and to grow old. There is a complex and delicate web of close relationships between the many organisms in the coral reef ecosystem.

More Than Just Colorful Rocks: Corals Are Animals

The corals that form the structure of a coral reef are living animals that feed, fight, reproduce and grow. Corals are invertebrates, animals without a backbone, belonging to the class Anthozoa (AN-THO-ZOA)

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CORAL REEF ADVENTURE

AN EDUCATIONAL RESOURCE FOR TEACHERS

and the phylum Cnidaria (NI-DARIA). Corals, like other anthozoans, have a simple body structure that has only one body opening, the mouth. They are closely related to other cnidarians such as jellyfish,

which float through the water, and anemones that, like corals, attach themselves to a hard surface. The individual coral animal body unit is called a "polyp." Each polyp has a mouth surrounded by a ring of tentacles leading to the stomach. Coral polyps are connected to other polyps in a colony. A colony is formed of millions of polyps which grew from one original larva that by dividing and budding, and in some cases fusing, became a group of interconnected organisms. As the coral grows, new polyps are formed. Old coral reefs may be over 100 feet thick, but the living part is only a thin veneer of corals and other organisms, perhaps only a few feet thick on the surface. Coral tentacles are armed with stinging structures called nematocysts that the coral uses to capture tiny animals in the ocean water called plankton. The plankton is deposited in the mouth, passes to a cavity where it is digested and nutrients are absorbed. Solid wastes then pass back out through the coral polyp's mouth. Food is shared with neighboring polyps in a colony through connections between individuals. Space on a reef is limited and corals will fight with their neighbors including other plants and animals to prevent overgrowth.

Coral polyps on the edges of colonies may use long "sweeper tentacles," loaded with nematocysts, to sting many of their neighbors that grow too close. They can also use long, tubular mesenterial filaments, which are extended from the polyp's stomach cavities to digest away encroaching neighbors. Other corals compete by growing rapidly and shading their neighbors.

On a few nights of each year many of the corals on the reef reproduce in an event called mass

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spawning. Tens to hundreds of species of corals release their eggs and sperm into the water on the same night. The eggs float to the ocean's surface where they can be fertilized, forming new coral larvae called planulae. The coral planulae swim in the ocean for several days to weeks until they settle on the reef bottom and grow into new corals. Corals can also reproduce asexually by budding. During budding the coral polyp will divide to make a nearly identical copy of itself that will remain attached to the parent polyp. A coral colony will form after repeated rounds of budding and can grow to contain hundreds and even thousands of polyps. As new polyps form they overgrow older polyps that die and add their calcium carbonate skeleton to the foundation of the reef.

There are two main types of coral: non-reef builders (ahermatypic) and reef builders (hermatypic). Ahermatypic corals, such as soft corals and solitary hard corals, do not contribute substantially to the formation of the reef. Solitary corals grow as individual polyps that do not form colonies. Soft corals are colonial corals that have a flexible skeleton and depend on toxic chemicals in their tissues to protect themselves from predators. Hermatypic, or reef building corals, are hard corals that form large colonies from thousands of connected polyps living together, sharing food and energy. Hard corals use zooxanthellae (ZOO-ZAN-THELLY), helper algae, to combine calcium and carbonate from the water and from respiration, to form a strong limestone underlying skeleton, similar to the process used by clams, oysters and snails to create their hard shells. The zooxanthellae are the corals' "solar panels" and provide enough energy to build their skeletons rapidly. Generation after generation of polyps add to the skeleton, forming corals of an incredible array of shapes and sizes. Coral colonies can grow bigger than a small house and can be several hundred years old. Over thousand of years, the skeletons of many coral colonies living together form reefs.

Major Types of Coral Reefs

There are three major types of reefs: fringing reefs, barrier reefs and atolls. Fringing reefs form just off the coast of a continent or an island and usually progress from a shallow sandy lagoon to the reef crest where the most wave resistant corals grow, to the reef face where the majority of the coral species are found. Barrier reefs form farther offshore, usually 10-100 kilometers from the coast, and often form massive walls of coral separated from the coast by a large channel or lagoon. Atolls are circular reefs surrounding a lagoon that form when volcanic islands sink into the ocean over millions of years.

Coral reefs are found throughout the warm, shallow tropical oceans of the world, mostly between the tropic of Capricorn (23°27') and the tropic of Cancer (23°27'). Since ocean currents can bring warm water to cooler places, reef corals grow in surprising locations such as off Texas and near Tokyo, Japan! There are two major coral reef regions

in the world: the Indo-West Pacific and the Western Atlantic. The Indo-West Pacific region spans from the Red Sea through Australia to the Indian Ocean and to Africa. It is the largest coral reef region in the world with the greatest diversity of coral and fish species. The Western Atlantic region spans from Florida to Brazil, and includes the Caribbean, Bermuda, and the Gulf of Mexico. Reefs are also found in the tropical eastern Atlantic and Eastern Pacific, but they are less well developed and diverse.

The Intimate Partnerships of Reefs

Reef building corals are dependent on a close relationship with tiny algae (plants) that live within their tissue, the zooxanthellae. The zooxanthellae provide the corals with up to 98% of the food that they produce, allowing the corals to make their skeletons grow faster and form reefs. Corals in turn provide the zooxanthellae with a safe place to live where they receive plenty of sunlight and nitrogen-rich waste products. Corals cannot obtain enough energy from feeding alone to build large colonies and form reefs. Coral reefs are found in the tropics where the warm, clear, shallow water allows enough sunlight to reach the algae living within their tissues.

The relationship between a coral and its zooxanthellae is delicately balanced, however, and small changes in environmental conditions, especially seawater temperature, can disrupt it. With increasing temperature the algae may die or leave the coral tissue, causing the corals to turn white and "bleach." The bleached corals can only survive for a few weeks without the energy supplied from their algae, and if seawater temperatures don't return to normal the corals cannot obtain new zooxanthellae and will die. The Earth's average temperature has been rising at an unprecedented rate, and this global warming may have dire effects on coral reefs. During the last 20 years, bleaching events have increased in severity and massive bleaching events have caused entire reef communities to die. In 1998, coral bleaching was so extensive that thousands of kilometers of reefs were damaged.



Global Warming and The Greenhouse Effect

The surface temperature for each of the planets in our solar system is determined by its heat budget. The heat budget is balanced, like other types of budgets, if the amount of energy coming in equals the amount going out. Global warming occurs when the incoming energy from the sun (solar radiation) is greater than the energy released back into space as light or heat. Recently the Earth has become abnormally warm. Ocean temperatures have increased by over 1°C over the past century and continue to increase at an even faster rate. In 1995 alone, the average temperature increased by half a degree. The increase in global warming is likely caused by the "greenhouse effect."

The greenhouse effect is the accumulation of gases in the atmosphere that prevent the heat emitted from the Earth to return to space, disrupting the Earth's heat budget. There are several types of greenhouse gases including nitrogen oxides, ozone, carbon dioxide, methane, and chlorofluorocarbons (CFCs). Carbon dioxide is the most significant of the greenhouse gases, accounting for about 64% of the total absorption of infrared energy. Human activities, such as the burning of fossil fuels and deforestation, have caused a steady increase in the concentration of greenhouse gases to levels unprecedented in Earth's recent history. The resulting global warming is increasing the severity and intensity of coral bleaching. Unless we take an active role in reducing greenhouse gases, and slow down global warming, the fate of coral reefs will remain precarious.

Coral Reefs in Peril

Coral reefs are being lost worldwide at an alarming rate. The Global Coral Reef Monitoring Network estimates that over 16% of the reefs, globally, have already been effectively lost and that up to 40% may be lost by the year 2010. Three billion of the world's 5.3 billion people live in coastal areas. This

number is expected to double in the next 50 years with the greatest population increases expected in tropical developing countries.

Coral Reef Stewardship

Coral reefs depend on our stewardship just as we depend on them. The Fijians have a taboo system run by the Chiefs, which determines when and where certain fishes can be caught. This traditional reef management system has worked well for thousands of years and has allowed the Fijians to survive without over-harvesting their reefs. The reefs provide food, protection from storms and rough seas, income from

tourists, and help Fijians become a part of their culture through ceremonies that thank the reefs and waters. The Fijians are just one

of hundreds of cultures worldwide that rely directly on the tropical marine system for survival. The loss in fisheries income is increasing and is estimated to be billions of dollars a year if reefs are lost. Coral reefs also act as an important buffer to the tropical coastline protecting the land from waves, storms, and erosion. They serve as a source of novel biomedical resources, and we may be losing potential cures to disease as the biodiversity on reefs disappear. Pharmaceuticals from coral reef organisms are now being developed as potential cures for cancer, HIV, arthritis and other diseases.

The biggest way to reverse the adverse changes to coral reefs is through education. Through films like *CORAL REEF ADVENTURE* and activities in this guide we can learn how our actions affect coral reefs so we can better protect them for the future.

Natural threats to coral reefs: Hurricanes, typhoons, El Niño, coral eating organisms and disease.
Human threats to coral reefs: overfishing, destructive fishing practices, sedimentation, coastal development, sewage and other pollution, and rising global temperatures.

Reef Partners Wanted



ACTIVITY 1

Objective: Students will identify several reef partnerships and describe how the organisms help each other.

In The Film: The coral reef is a delicately balanced and linked habitat in which creatures large and small cooperate to build a community—neighbor helping neighbor. As the Crosby, Stills, and Nash song

KEY WORDS

Symbiosis—an association between two or more organisms. Examples—**mutualism**: both organisms benefit, **commensalism**: symbiont benefits, host does not benefit nor is it harmed, **parasitism**: symbiont benefits, host is harmed.

Zooxanthellae—One celled algae that live inside the soft body parts of coral polyps.

Photosynthesis—The process by which plant-like organisms with chlorophyll use sunlight, water, nutrients, and carbon dioxide to produce organic energy or carbohydrates.

“Our House” plays in the background, the Goby and the shrimp benefit from sharing a home in the reef. The goby gets to live in a great burrow, while the near-sighted shrimp gets a live-in body-guard. Later in the film, a 300-pound potato cod visits a “cleaning station” at

which it allows the tiny wrasse to swim right into its mouth to clean its mouth and gills. The relationship the wrasse has with the potato cod requires mutual trust.

Materials: per group

- Copies of *The Coral Gazette* Want Ads Copy Page
- Players and Partnerships Cards set

Teacher Prep Notes: Copy *The Coral Gazette Want Ads* for each group of students. Copy **Players and Partnerships Copy Page** in advance and cut them into cards. Each group of students should have a complete set of Players and Partnerships cards. All symbiotic relationships identified in this activity are examples of mutualism. This activity is adapted from *Naturescope*, “Diving into Oceans.”

Note: Answer key on the inside back cover.

Background: Survival strategies on coral reefs extend beyond the usual adaptations of camouflage, spines, stingers and other physical features. Relationships between animals as well as between animals and plants have evolved on the reef to include a variety of social and biological interactions in which one or all of the organisms involved receive some benefit from the relationship. The amount of benefit (and cost) may change over time as the relationships change in response to environmental changes or other inputs. Scientists call these interactions “symbiotic” relationships.

The numbers of symbiotic relationships on a coral reef are extensive—“perhaps the greatest concentration of symbioses within one single habitat on the planet,” according to the film. The corals themselves act as hosts to a variety of symbionts, including the zooxanthellae. These “helper algae” live in the tissues of the coral polyp and use the sun’s energy to produce sugars that are necessary for the survival of the coral. When water temperatures rise, occasionally the zooxanthellae will abandon the coral tissues, leaving the coral colorless. This phenomenon is called “bleaching” and could result in death to the coral by starvation due to the loss of the sugars contributed by the zooxanthellae. The relationship between the coral and the zooxanthellae is an example of mutualism.

A mutualistic relationship involves the sea anemone and the clownfish (also called the anemonefish). The anemone’s tentacles contain cells with small stinging structures (organelles) that harm most small creatures, including fish. However, the clownfish builds a defense by acquiring a mucus coat that protects against the stinging structures (nematocysts) and makes a home within the anemone’s tentacles providing a safe place for it and its companion. In turn, the clownfish brings its meals back to the anemone where, while it eats, bits of the prey may fall into the anemone’s tentacles, providing an easy snack for the anemone. The anemone plays a part in another mutualistic relationship—this one with a specific type of hermit crab. The hermit crab first finds a snail shell to use as a mobile shelter, then adds the anemone to the shell. The anemone serves two purposes—camouflage and stinging protection. In turn, the anemone has found a place to live and gather scraps of food (space can be limited on the reef).

To Do: Discuss with students the partnerships found living in, on and around a coral reef. Ask them to explain the different types of living relationships the inhabitants of the coral have. Ask students to explain symbiosis, mutualism, commensalism, and parasitism. Ask students to think about how humans might disrupt these relationships. Write their descriptions on the board.

1 Divide class into groups and give each group one copy of *The Coral Reef Gazette* Want Ads Copy Page. Give each group a set of the Players and Partnership cards, one set per group. While working in groups ask students to take turns reading a want ad and discussing which Player could have placed the ad and which Players might answer the want ad. Students should try to match up as many partners and players as possible, based on the advertisements in *The Coral Reef Gazette*.

2 After students find matching pairs of Players and Partnerships cards, students should discuss whether each relationship is an example of mutualism, commensalism, or parasitism.

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The Coral Gazette

March 2000

Want Ads

Will Work for Food

Diverse group of maids available to clean. If interested, stop by Wrasse Alley during daylight hours. Only trustworthy fish allowed.

Grocery Delivery Offered

Attractive fish couple looking for nice, safe home with security. Willing to do grocery shopping in exchange for rent.

House for Rent

Spacious and clean 100-tentacle home available. Built-in security system. Rent charges may be waived in exchange for other services.

Fiji or Bust

Daily transportation around reef needed. I am deceptively beautiful and can offer bodyguard services in exchange for transportation.

Rental Property Available

Mobile Home on 1/1000th of an acre. Subject to high turnover in ownership. Future relocation assistance available through original owner.

The End is Near!

Photosynthetic partners needed immediately! Global warming threatens health of reef. Volunteers needed to aid in fight for survival. If available, report to any reef-building coral immediately.

Got Algae?

Have you recently lost your “helper” algae? Free-floating algae available and interested in “settling down” in the tropics. If you or a loved one are in need of assistance, call toll free 1-800-HELP.

Dental Hygienist Needed

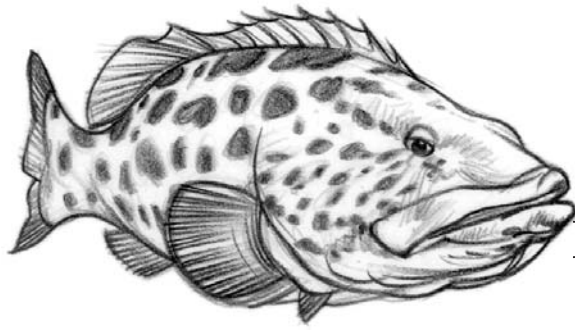
Desperate for a good teeth and gill cleaning. I may look tough, but you can trust me not to eat you!

Bodyguard Available

Off-duty security officer seeks room for rent. Willing to offer security services in exchange for rent. Would prefer a bottom dwelling.

Roommate Wanted

Visually impaired reef resident, looking for roommate to share luxury apartment on Benthic Avenue. Room and board FREE in exchange for security services.



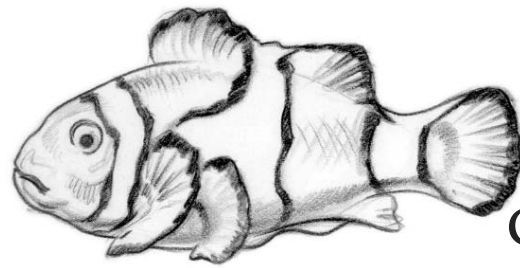
Potato Cod



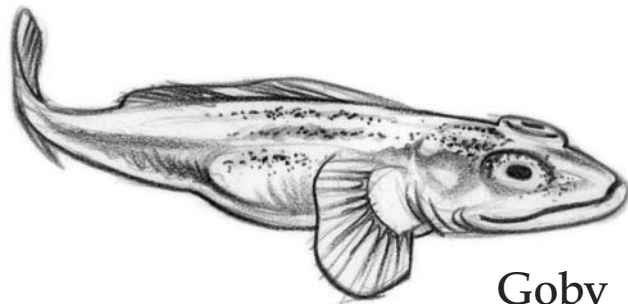
Sea Anemone



Zooxanthellae



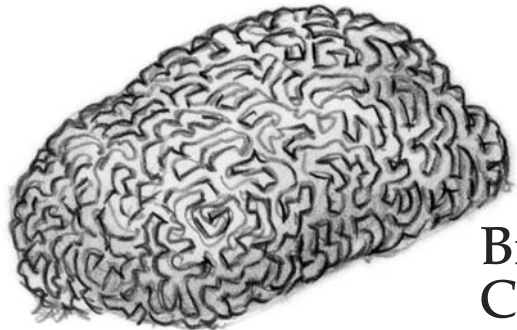
Clown Fish



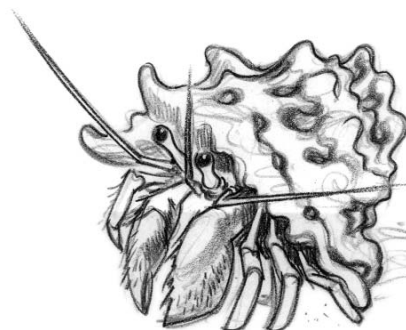
Goby



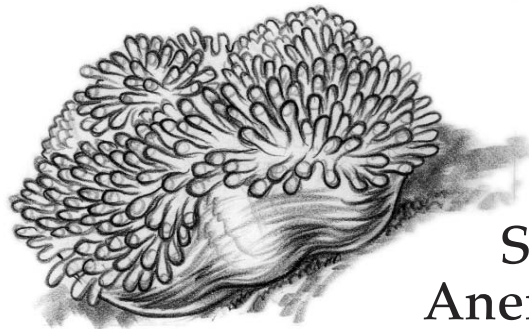
Wrasse



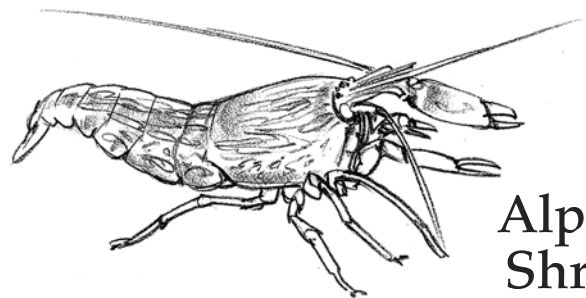
Brain Coral



Hermit Crab



Sea Anemone



Alpheid Shrimp

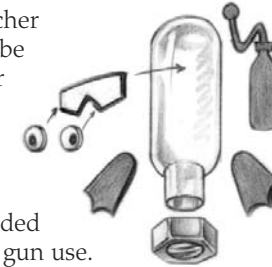
Objective: Students will construct a device to experiment with pressure, density, floating and sinking, and will make observations of these phenomena.

In The Film: Howard Hall and his companions use SCUBA to explore deep coral reefs between Australia and Tahiti in the South Pacific. At deep depths, the pressure is much greater than it is at the surface and can be very dangerous for humans. At 350 feet, divers must withstand pressure that is over 10 times greater than at sea level. Because of this pressure, normal SCUBA equipment would not suffice. A piece of specialized equipment is used during these deep dives that supplies a mixture of gases including oxygen, nitrogen, and helium to the diver. Divers must carefully control this mixture of gases as they descend and ascend during the dive. In the film, Howard scared the viewers when he forgot to adjust the mixture of gases on his first deep dive. He had to be rushed to a decompression chamber to avoid "the bends"—a very serious situation that could result in death.

Materials:

- 1 hex nut
- 1 plastic pipette
- Cup of water
- Hot glue & glue gun
- One 2-liter bottle with lid

Teacher Prep Notes: This activity can be assembled in advance and can be used by students without teacher supervision. It can also be used as a learning center activity. If students will be making their own diver bottles, extra supplies will be needed. Adult supervision is needed for cutting and hot glue gun use. Turn the bulb into a scuba diver by hot-gluing "googly eyes" onto front of the pipette. Cut fun foam to make a tank and fins for the scuba diver.



Background: At sea level the atmosphere exerts a pressure of 1 bar (14.7psi). At 33 feet (10m) below the surface of the water, this pressure is doubled to 2 bar (29.4psi), and for each further 33 feet (10m) in depth, the pressure is increased by 1 bar. Decompression sickness is sometimes called "the bends" or *caisson disease*. Its primary cause is the formation and growth of bubbles within tissues or blood. This takes place when dissolved nitrogen is being released within the body, instead of being expelled from it through the lungs. Once the diver begins to ascend toward the surface, the water pressure may fall below the total pressure of the gases dissolved in the body's tissues during the time the diver spends in deep water. The tissue is now supersaturated with gas, and bubbles may form in a manner that is similar to the appearance of bubbles when opening a bottle of soda water.

Can't Stand the Pressure

To Do: Make sure your 2-liter bottle is clean and dry. Next cut the bottom section of pipette off, leaving ¼ inch (1.5 cm) at the end of the bulb. Using a hot glue gun, carefully glue the hex nut to the remaining ¼ inch (1.5 cm) under the bulb. NOTE: Do not glue the opening to the pipette closed. See Diagram.



1 Gently squeeze the scuba diver bulb as you place it into a cup of water, then release the bulb partially filling it with water. Without bringing the bulb out of the water, place diver into cup to see if it floats near the surface of cup. To adjust the buoyancy of the diver, add or remove water in bulb.

2 Next fill the 2-liter plastic bottle with water leaving some space near top. While holding the water inside the diver, put it quickly inside the bottle. Be careful to not let the water out of the diver. Twist the lid onto the bottle and squeeze the sides of the bottle to control the direction the diver travels in the bottle.

What's Going On & Why? This activity demonstrates the property of buoyancy. An object is buoyant in water due to the amount of water it displaces or pushes aside. Therefore if the weight of water that is displaced by the object is greater than the weight of the object, it will float. In the experiment, as you apply pressure to the bottle, you apply pressure to the air bubble in the dropper therefore reducing its size. As the bubble's size reduces, the diver becomes less buoyant and begins to sink. Releasing the pressure on the bottle reduces the pressure on the bubble and the diver begins its journey upward.

KEY WORDS

Pressure-The amount of force per unit area exerted upon by a surface area.

Decompression-The accumulations of dissolved nitrogen in the body that if not eliminated slowly can cause symptoms of decompression sickness.

SCUBA-Self Contained Underwater Breathing Apparatus.

Buoyancy-Having the tendency or ability to float.



Coral Reef Café



ACTIVITY 3

Objective: Students will simulate the variety of methods with which different fishes on a reef feed. Learn how the size and shape of a fish's mouth and teeth provide hints about what type of food it eats.

In the Film: Throughout the film we see some of the many different fishes living in, on, and around coral reefs. One question that comes to mind is how can the reef support so much life? We can see that

KEY WORDS

Habitat-A place where an organism lives.

Partnership-Activities or instances where one organism joins with another, or others, to do something.

coral reefs provide a variety of food types and many feeding situations to which reef inhabitants have adapted for survival. Think of

the cleaner wrasse and its unique feeding strategy of picking parasites off the potato cod and moray eel. This illustrates survival of the fittest!

Materials:

- Pictures of a parrotfish, porcupinefish, butterflyfish
- Several large Duplo® blocks
- Sunflower seeds: approx. one cup (240 ml)
- Small bowl (for pistachios)
- Approximately 1 cup (236.58 ml) pistachios
- One piece of hard coral or rock
- One pair of tweezers
- One pair of pliers
- One clothespin or chip bag closer

Teacher Prep Notes: Pictures of the parrotfish, porcupinefish and butterflyfish can be found in library books or on the Birch Aquarium at Scripps website: www.aquarium.ucsd.edu. This activity would work well as a science station in a corner of the classroom. Students can experience this activity by using their skill and dexterity. Remind students that a simulation is a way of acting like something, in this case a fish. The tools they will use in this activity represent the mouths of some of the fishes who live on the reef.

Background: Coral reefs support a huge diversity of fishes and invertebrates; in fact, coral reefs are one of the most diverse places on the entire planet. Each animal is adapted to take advantage of a certain niche in the coral reef habitat. Survival strategies, breeding strategies, even feeding strategies all have evolved to allow each animal to

take full advantage of the habitat.

Fishes on the reef pick, scrape, crunch, or even tear to get their food. Their mouths are shaped to match their feeding style. In this exercise, students will look at several fishes and compare tools to the shape and function of the fishes' mouths.

To Do: Set up space for this activity to include a flat working surface. In one area of the working surface, set the Duplo® blocks on the table, with the bottom (side with holes) facing up. Pour some sunflower seeds into the nooks and crannies of the blocks.

1 Arrange an area for the bowl of pistachio nuts and another for the piece of coral or large rock. All three sections can be side by side on one table. Then place the tweezers, pliers and clothespin on the table.

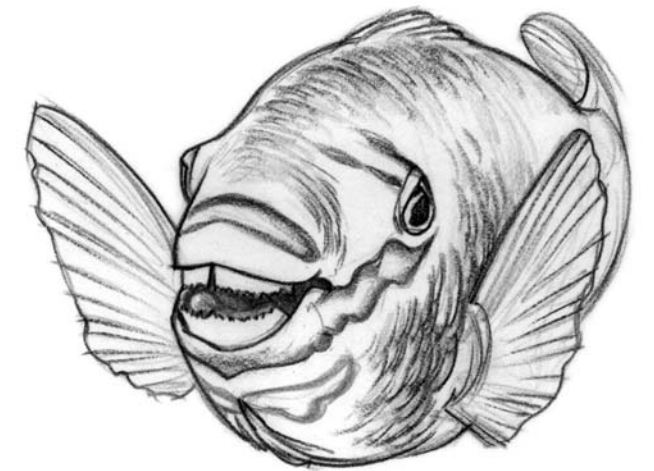
2 Ask students to investigate which tools are most effective at picking up each different type of seed or nuts. Remind students that the tools used represent the types of mouths certain fishes have depending on what type of food they eat. Have students compare the tools they have used to the three different fish pictures. Have them figure out what mouth form and function matches each of the tools.

3 Ask students to answer the following questions and discuss their answers.

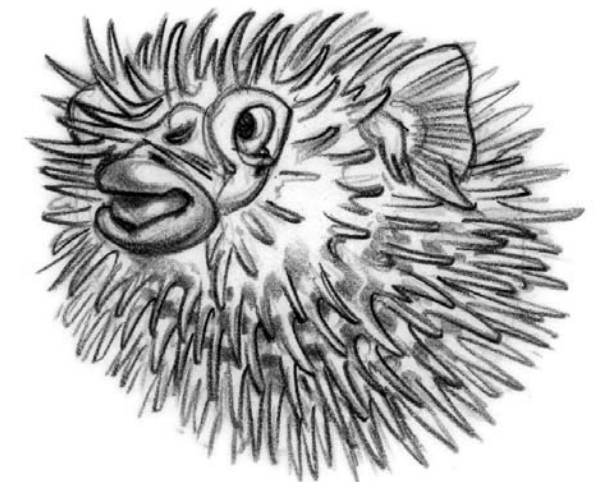
- There are bits of food in the reef's cracks and crevices for those that can reach them. **Which tool would be best for picking food from the cracks?**
- Hard-shelled reef inhabitants like snails and crabs are tasty treats for those that can crush them. **Which tool would be best for cracking hard shells?**
- Coral tissue and the algae within them are nutritious meals for those that can scrape it from the coral's hard skeleton. **Which tool would be best for scraping?**

Taking It Further: Have the students do research to figure out what the butterflyfish, parrotfish, and porcupinefish eat and whether it matches their theory of mouth function.

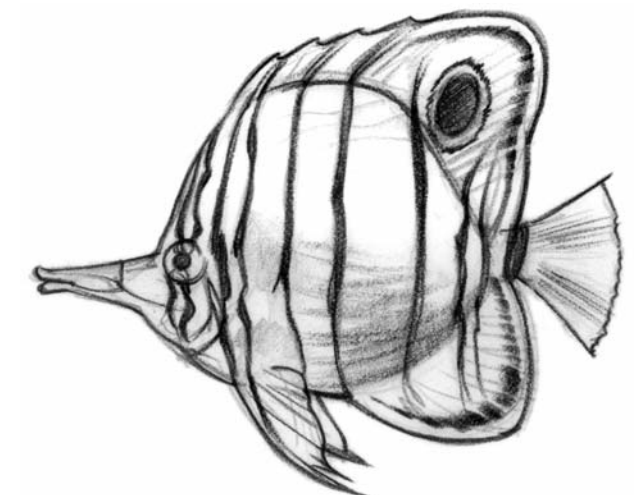
Visit a local pet store or a local aquarium to determine if you can tell what fishes eat. Ask the staff of the store or the aquarium to confirm your thoughts.



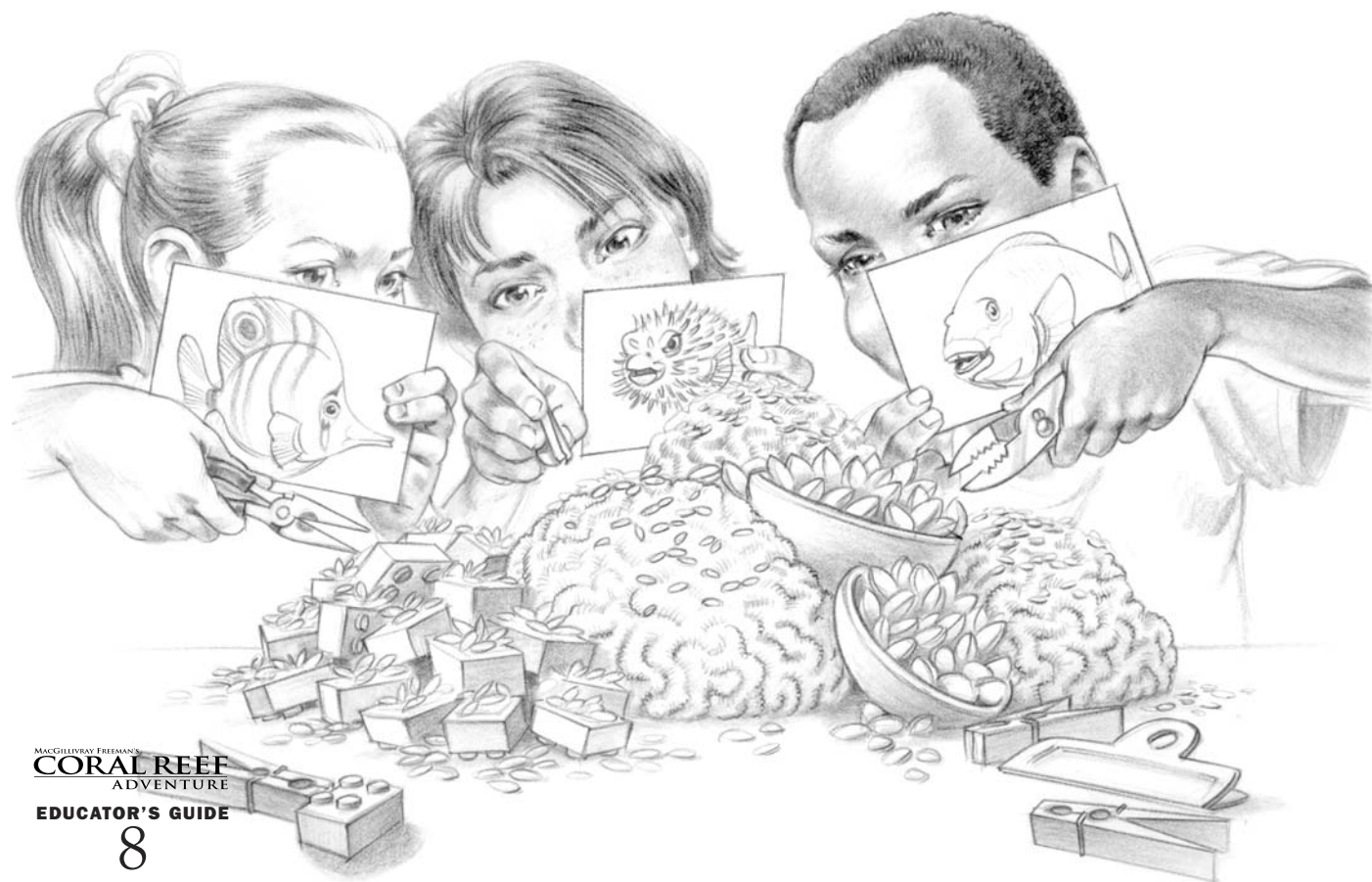
Parrotfish



Porcupinefish



Butterflyfish



Protecting the Reef is More Than Just a Game!



ACTIVITY 4

Objective: Students will understand that there are many actions, both positive and negative, that can affect the health of a coral reef.

In the Film: Throughout the film students witness many of the positive and negative impacts humans can have on the reef. Spearfishing of protected

KEY WORDS

Human Impact-The effect of human presence on an area or environment.

Conservation-The official care and protection of natural resources.

Scientific research-Careful, systematic study and investigation into an area of science.

potato cod, building of resorts along a coast, siltation of the reef from logging activities, and even fish collection for the aquarium trade are illustrated as some of the negative impacts. Positive impacts include protection of the reef by

creation of a marine sanctuary, education programs, and research projects.



Materials:

- One Jenga™ or Uno Stacko™ game per 8 students
- One copy of the game cards, cut out, for every 4 students

Teacher Prep Notes: This game will utilize the rules of Jenga™ or Uno Stacko™. Each team needs a complete set of the **Protecting the Reef Game Cards Copy Page**, cut into strips (cards).

Background: The coral reef ecosystem is extremely interconnected; even a small action can impact the entire reef. In this activity, students will play a game to illustrate this point. Each activity indicated on the game cards can have either a positive or negative effect on the health of the reef system. Each action builds on the others—the positive actions make the reef more stable, while the negative actions can cause the reef to collapse.

To Do: Divide the students into teams of four and provide each team with a set of Protecting the Reef Cards and a Jenga or Uno Stacko game. Ask students to follow the instructions provided with the game to stack the blocks but instead of using all of the blocks, have each team stack 24 blocks—three blocks per level and stacked eight levels high.

1 One student at a time will draw a strip (card) from the pile. When a student receives a negative card that asks them to remove blocks, they must remove the indicated number of blocks from any complete row and place them on the top, completing a row or beginning a new row. This will make the game stack less stable.

2 When a student receives a positive card, the students can remove the indicated number of blocks from the top row and keep them to the side. The fewer rows, the more stable the game stack. The game continues until the game stack falls down.

3 At the end of the game, have students reflect on the positive and negative things that occurred during the game and during the film. What are some actions that they could take part in to save coral reefs?

Taking It Further: Encourage students to become involved by writing letters to elected officials. Letters can include information about what was learned through the class debates and can ask elected officials to support research and conservation efforts for the coral reefs.

These are some addresses to consider sending your letter to:

President of the United States

The White House
1600 Pennsylvania Ave. NW
Washington, DC 20500

Vice-President of the United States

United States Senate
Washington, DC 20510

Your Senators' Name

United States Senate
Washington, DC 20510

Your Representatives' Name

U.S. House of Representatives
Washington, DC 20515

THE PROTECTING THE REEF GAME CARDS COPY PAGE

Your reef becomes a marine preserve, increasing the health and stability of the reef.

Take 4 blocks off the top.

An IMAX® film on coral reefs debuts, increasing stewardship of coral reefs on a global scale.

Take 1 block off the top.

A new treatment for a human disease is discovered on a coral reef, prompting protection of the reef.

Take 2 blocks off the top.

Education group provides snorkels and masks to Fijian children, allowing them to appreciate the reef habitat.

Take 1 block off the top.

A new species of fish is discovered on a reef.

Take 1 block off the top.

Classroom students in the U.S. learn about coral reefs from their teacher.

Take 1 block off the top.

An environmentally friendly resort is built on a tropical coastline, which decreases the environmental impact.

Take 1 block off the top.

Your local fish store stops buying fish from reefs whose numbers are depleted.

Take 1 block off the top.

Your local aquarium begins breeding tropical fish, decreasing collecting pressures on the reef.

Take 1 block off the top.

A hurricane occurs near your reef, destroying coral. Fortunately, the reef begins to quickly recover.

Do not remove any blocks.

A reef monitoring program is begun, allowing researchers to regularly monitor the reef health.

Take 1 block off the top.

Reefs photographed ten years ago are photographed again. There is no evidence of reef decline.

Take 2 blocks off the top.

Global warming has increased the water temperature around the reef, killing coral polyps.

Remove 3 blocks.

Collectors of aquarium fish use dynamite on the reef.

Remove 1 block.

Harvesting for food from the reefs has increased this year due to poor offshore fishing.

Remove 1 block.

A new resort with a golf course has been built along the shores of the reef.

Remove 1 block.

Deforestation of a local rainforest occurred to build a new resort.

Remove 2 blocks.

Rain has washed silt and sand into the ocean, covering the reef.

Remove 2 blocks.

Trash has covered the reef, causing death to corals and other animals.

Remove 2 blocks.

Fertilizers used on land wash into the ocean causing large blooms of marine algae, blocking sunlight from the reef.

Remove 1 block.

Pesticides from local crops have reached the reef, causing various animals to die.

Remove 1 block.

A student in the U.S. buys a new tropical fish caught using cyanide.

Remove 1 block.

Tourists accidentally step on the corals while diving and snorkeling, causing them to die.

Remove 1 block.

A boat has dropped its anchor on the coral reef, causing the coral to die.

Remove 1 block.

The Silt and Sediment of It All



ACTIVITY 5

Objective: Students will build an underwater habitat to observe the effects that sediment and other environmental changes have on plant life growing in the habitat.

In The Film: On the screen we see scientists researching and documenting where corals are currently thriving and growing on coral reefs around the world. This research will be used as baseline information for future research in the areas. Getting

KEY WORDS

Sediment-Particles of both inorganic or organic substances that are deposited on the ocean floor.

Deforestation-The process of clearing many trees from a large area.

Chlorophyll-The green pigment in plant cells that aid in the process of photosynthesis.

a baseline for research is important because very small changes in the living conditions can have huge impacts on coral reefs.

The reefs of Fiji illustrate the effects of environmental changes where a river was brown and murky because it was carrying silt down-

stream. The film demonstrates that deforestation of the rainforest can have a very serious impact many miles away in the ocean. The silt washing into the ocean has wiped out entire reefs, smothering the coral and blocking out essential sunlight.

Materials:

- rulers
- straws
- scissors
- wooden spoons
- measuring cup
- water and sink access
- student journals and pencils
- aquarium gravel from pet store
- power drill with small drill bit
- 2 small plastic cups per aquarium
- flour or fine dirt to represent silt and sediment
- alfalfa seeds and soil (enough to fill Dixie cups)
- 2 glass jars with lids (jam or jelly jars work well)
- two 2-liter soda bottles with tops cut off with a utility knife (these become aquariums)
- 2 extra jar lids (these can be larger than jelly jars and will act as ballast)
- 1 aquarium air pump with air tubing and a "T" fitting from pet store
- 4-3 inch long (8-10 cm) bolts from hardware store (use bolts that are as thin as possible)
- 6 nuts that fit on bolts from hardware store

Teacher Prep Notes: This activity is designed as a demonstration and will take several class periods to observe significant results. If the activity is to be done by groups of students, then arrangements for more materials will need to be made. If students are using the utility knife or the power drill, please make sure that they are adequately supervised. The completed units will need to be placed on a sunny windowsill for observation for one week. In this activity, students will see how changing one variable, such as the clarity of the water, can create long term negative effects on the health of growing plants and animals.

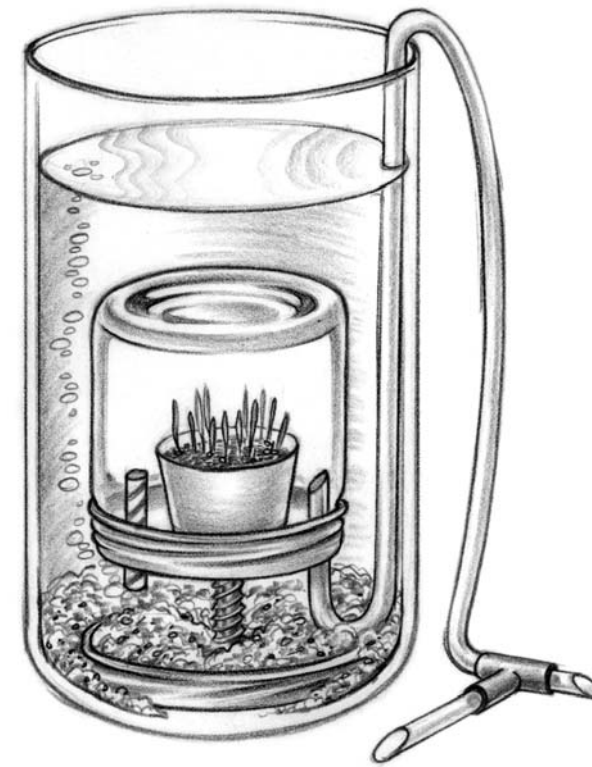
Background: The ocean consists of many diverse habitats. Each habitat is unique and supports a specific group of organisms. A few of the diverse habitats found within the ocean are: coral reefs, kelp forests, rocky intertidal zone, sandy intertidal zone, eel grass, deep sea vent, and the abyss. The living organisms that exist within any one of these habitats have survived by adapting to the conditions within their environment.

All organisms, no matter the habitat, need specific conditions for survival. Reef-building coral animals are no different. Corals thrive in their particular habitat by utilizing warm, clear water that is in motion; absorbing plenty of sunlight; and finding an ample supply of food. Corals obtain food either by stinging prey with their tentacles or by utilizing the symbiotic "helper algae" that are within their tissues. These "helper algae", zooxanthellae, are similar to land plants and photosynthesize using a variety of pigments such as chlorophyll.

Small changes in conditions, such as water temperature and sedimentation, can have a huge impact on the corals. In fact sedimentation from deforestation has become a serious threat to coral reefs all over the world. Many countries are clear-cutting their rainforests, leaving little to retain the soil. Then, when the rains come, the water strips the land of soil and silt, eventually carrying the sediment to rivers and to the sea. This sediment blankets the coral, clogging and choking the polyps making it difficult for them to feed. Sedimentation also shades the polyps from the sun, inhibiting "helper algae" from producing food through photosynthesis. When this occurs the tiny algae will vacate the coral, leaving it a bleached white color. If the algae are forced to leave, the coral will not be able to rely on the nutrition produced by the algae.

To Do: Arrange all materials needed for activity on a large work space. Make sure the 2-liter bottles are clean and dry and the tops are removed.

- 1** First fill the plastic cups half way with moist soil and plant several alfalfa seeds in the soil. These plants, when they sprout, will represent the underwater plant habitat.
- 2** Using the power drill, carefully drill three holes



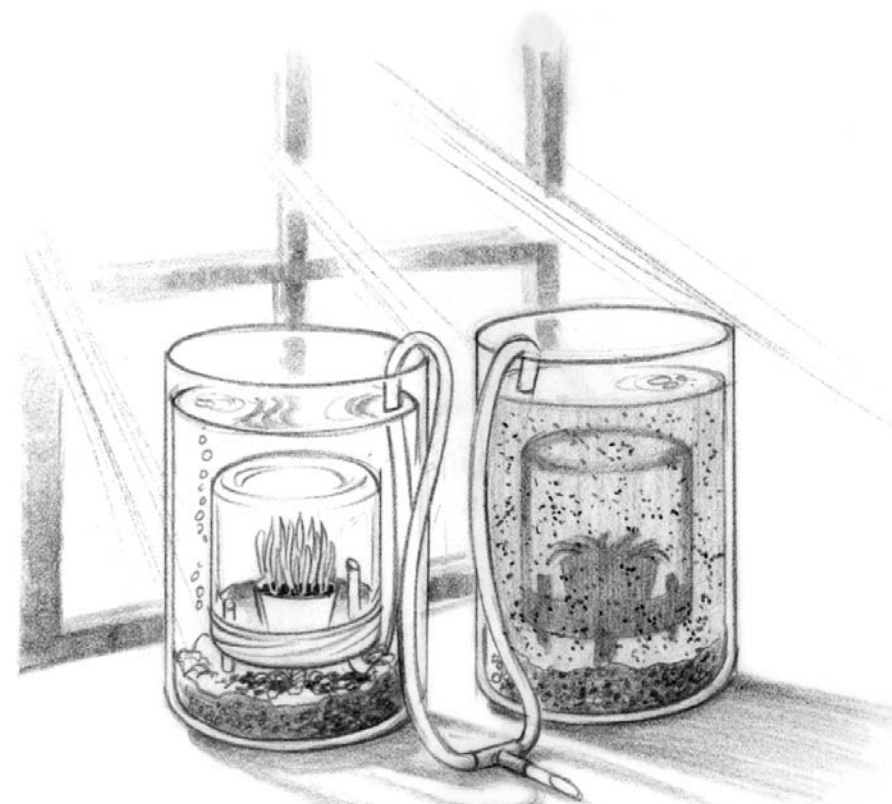
in both of the lids of the jelly jars, one in the center and two in outer sections of each lid. See Diagram. Drill a hole in the center of each large lid. These lids will be bases for the underwater plant habitats and will need to have ballast weights to ensure they do not float to the surface of the water that will eventually be added to the 2-liter bottle aquariums. To create the ballast put one bolt through the center holes in each lid (one small and one large). Secure nuts onto bolt to make sure the lids are secure. See Diagram. Push the aquarium filter air tube through one of the other holes in each lid and put a straw in the remaining hole in each lid. See Diagram.

- 3** Now place about 3 cups (709.75 ml) of gravel in the bottom of the 2-liter bottle aquariums.
- 4** To create the underwater habitat, set the plastic cup with the seeds planted, CAREFULLY onto the inside of the lid. CAREFULLY screw the jar onto the lid, making sure the straw and the air hose from the pump remain in the holes. Place this unit into the 2-liter bottle, again making sure that the straw and the air tube are in place. NOTE: You may need to trim the straw in order for it to fit in the bottle. Put the habitat jar into the bottle and CAREFULLY to get as much of the gravel from the bottle-bottom onto the large lid. This will ensure that the habitat will not float to the surface of the bottle once the air pump is turned on.
- 5** Fill one 2-liter bottle with water and turn on the air pump. You should see air coming out of the straw at the bottom of the aquarium and

the jar should not be full of water. Follow the same steps to complete the control aquarium. Use the "T" fitting at the air pump to make sure each aquarium receives adequate air. Mark one aquarium "CONTROL."

- 6** Add one cup of water, with some flour or fine dirt mixed into it. Mix the water and flour/dirt so the water in the aquarium is opaque. This will simulate silt and sediment covering the reef. You may need to mix the silt and sediment each day to keep the water opaque.
- 7** Place both aquariums on a sunny windowsill. Ask students to make observations in their journals each day for a week. Ask them to observe both aquariums and to make predictions about the outcome of the activity.
- 8** After one week, or until sprouts are growing in the plastic cups, drain both aquariums carefully. Do not get water on the sprouts. Remove the sprouts from the cup. Measure and record the plants found in each aquarium in student journals. Ask students to compare the plant growth between the silt plants and the clear water plants. Discuss how the silt has affected plant growth. Discuss the predictions students made at the start of the activity. Ask students to reflect on the relationships between this activity and that of a reef habitat. Ask students to discuss ways that we can prevent silt and sediment from covering and killing the reefs.

This project was adapted from a project by Kevin Hardy at Scripps Institution of Oceanography.



Can You Eat a Reef?



ACTIVITY 6

KEY WORDS

Coral-The hard skeleton secreted by certain marine polyps.

Polyp-A cylindrical, mostly sessile (attached to substrate), body form exhibited by corals and many other Cnidarians.

Substrate-The structure upon which an organism lives. (example: rocks).

Reef-A ridge of rock, coral, or sand at or near the surface of the water.

Invertebrate-Any member of the animal kingdom that does not have a backbone or spinal column.

Objective: Students will build an edible coral reef to reinforce their understanding of the unique structure and function of coral animals.

In The Film: Many of the colorful corals we see may look like flowers, plants, or even rocks. In

fact, corals are animals that can be observed in diverse colors, shapes, and sizes. In one of the film shots, we fly over a coral reef as the narrator discusses how the living coral reef is just a fragile layer of animal life growing one skeleton at a time, slowly enlarging the reef.

Materials:

- Water
- Pyrex® measuring cup
- Paper plates
- Toothpicks (1 per student)
- Candy sprinkles
- Napkins for clean up
- Large marshmallows (1 per student)
- Thin licorice whips (several per student)
- Heat source (microwave to melt the candy coating)
- Candy melts or baking chocolate broken into small pieces: ½ ounce (14.79 ml), melted for each student



Teacher Prep Notes: This activity can be done as a demonstration if students cannot eat the finished product. If students are allowed to eat their creations, be sure they wash their hands before beginning the project and that clean utensils are used during the activity. Also remind the students that no one is allowed to handle anyone else's candy since they may be eating it. Candy melts are sold at cooking and craft stores that sell candy-making equipment. Candy melts are ideal for this activity because they melt quickly and uniformly. Other types of chocolate can be used for this activity, but make sure the chocolate used melts uniformly. Use the Pyrex measuring cup to melt the chocolate. It will be helpful to stir the chocolate as it melts. Use caution when assisting students as they roll their marshmallows in the warm chocolate.

Background: Are corals animals, vegetables, or minerals? Some corals are hard and resemble rocks, others are soft. However, both hard and soft corals photosynthesize, which led early scientists to classify corals as plants. Even today, many students are surprised to find that corals belong to the Phylum Cnidaria, a unique group of invertebrate animals. This phylum of stinging animals can be further divided into three classes: Hydrozoa, the hydroids; Scyphozoa, the jellies; and Anthozoa, the corals and sea anemones.

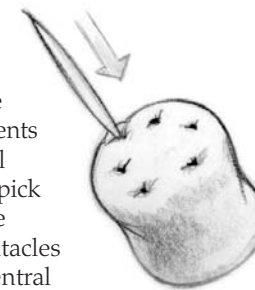
While Cnidarians are very diverse, they share some common defining characteristics. All Cnidarians have the ability to sting (Cnidaria is Greek for nettle). Cnidarians have a ring of specialized tentacles surrounding a central opening (both mouth and anus) for stinging and capturing prey, as well as for fending off predators. The Cnidarian body form is simple and can exist in either a polyp or medusa shape. The polyp body shape, like a sea anemone, is a cylindrical hollow tube. The medusa body shape, as seen in jellies, are free-floating, umbrella-like forms with the oral side and tentacles dangling down. Regardless of the body shape, Cnidarians are radially symmetrical. This means that all of their parts are arranged around a central axis similar to the spokes of a wheel.

The majority of reef-building corals are colonies of individual polyps that exist together and share a common skeleton. The polyps of these hard corals extract calcium and carbonate from the ocean water depositing it as a hard calcium carbonate skeleton. All hard coral polyps produce a stony cup (calyx) that can be used for support and protection. Polyps within a colony fuse their stony cups together to form a massive skeleton. When one coral polyp dies, the skeleton remains, allowing new corals to grow on top of the old.

To Do: Arrange students in teams of two or three. Give each team a paper plate. Ask students to write their names on the outer top edge of the plate. This plate will represent the groups hard substrate, the place where coral grows. Give each student

another paper plate as a working surface as they create the edible coral. Students need to wash their hands before working with the following items, and eating of items is allowed only *after* the activity is completed!

1 Give each student one marshmallow and a toothpick. The marshmallow represents the body of the coral polyp and the toothpick will be used to make openings for the tentacles that surround the central opening at the top. Ask students to make six holes in the top of the marshmallow, indicating where the tentacles will go later in the activity.



2 Now pour ½ ounce of melted chocolate onto each student's plate. Have students carefully roll their marshmallows in the candy coating, covering the outside of the polyp body. Students need to be careful not to fill the holes where the tentacles will be attached. The chocolate coating represents the hard calcium carbonate that creates the skeleton of the coral reef.



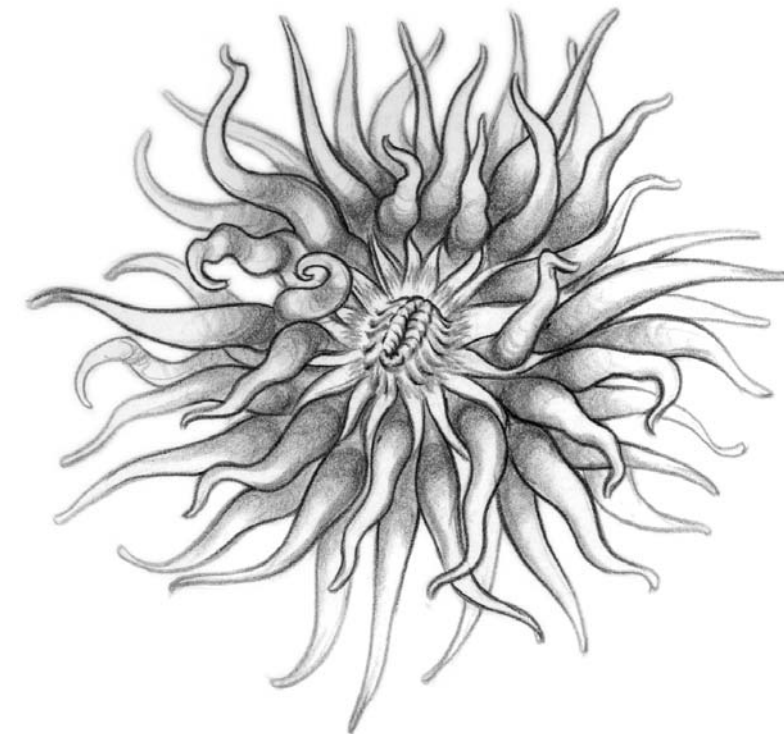
3 Next have students dampen the sides of their marshmallow with water and dust candy sprinkles on the sides of the marshmallow. The sprinkles represent the living zooxanthellae (helper algae) in the coral's tissues.



4 Give each student six licorice whips and ask them to carefully insert them into the pre-poked holes in the top of the marshmallow, using the toothpick. The licorice whips need to be inserted firmly so they do not fall out. The licorice whips represent the tentacles of the coral belonging to the Phylum Cnidaria.



5 Students then need to place their marshmallows on the team's paper plate, close enough that they could fuse together. This represents what happens as the calcium carbonate skeleton is



formed. Ask the students to discuss their coral reef with their teammates. What do each of the parts of the coral do to protect it? How can the other corals located around it help them all to survive?

6 Finally, ask the students to pretend they are predators (such as a parrotfish) on a coral reef and ask them to eat the corals they created!



Get Your Quadrats in Gear!



ACTIVITY 7

KEY WORDS

Quadrat-A frame of any shape used to sample a section of a plant or animal community.

Community-A group of animals and/or plants living together and bound by various factors.

Objective: Students will construct and use a quadrat (a simple piece of scientific gear) to gather data about their environment.

In The Film: In the film we see Michelle Hall as she trains a few volunteers to measure and observe the corals in an underwater area by using a quadrat (a rigid frame that outlines a study area). The team plans to photograph and measure the corals in the designated areas over the next few years to determine the health of the reef compared to data collected today.

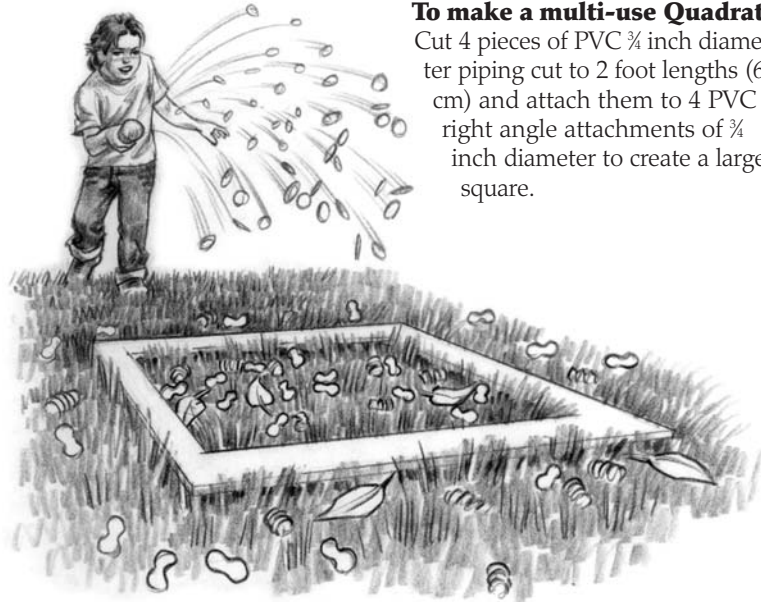
Materials: To build one quadrat

- paper
- 2 cup container
- pencils
- rulers/tape measure
- stapler
- 20 pennies
- clip boards
- 20 pieces of bow tie pasta
- 20 peanuts with the shell on
- 4 strips of foam board or mat board cut to 2 inches wide x 2 feet long (5 cm x 60 cm)

Access to outdoor area, preferably one with grass

Teacher Prep Notes: This activity is designed to take one class period to complete. Use the directions above to make the quadrat for this activity. If you will be doing more with the quadrat, it is recommended that you make a more permanent device.

To make a multi-use Quadrat: Cut 4 pieces of PVC ¾ inch diameter piping cut to 2 foot lengths (60 cm) and attach them to 4 PVC right angle attachments of ¾ inch diameter to create a large square.



Background: Research goals for some scientists are to observe and study certain plant or animal communities in a given area to monitor their change over time or over distance from a given point (such as a pollution source). Research of this nature requires that data collection be done in an objective fashion. Scientists need to record all characteristics involved with the study zone, including a list of species present (alive or dead as with the corals in the movie); species size; and species abundance (numbers of animals or plants). Since the research area may be vast, and the numbers of characteristics can be too many to record for the entire area, scientists have developed a device to help them conduct research. Scientists use a sampling technique with quadrats, which allow them to direct their observations to smaller, confined areas within the search community. The information scientists get from the areas marked with quadrats can give them an idea of the overall populations and other information relating to the entire community. Scientists often take several quadrat site readings from several different regions within the designated community.

Quadrats generally are big enough to include a representative sample of the study objective. The number of quadrats depends on how much detail you want to obtain. Usually 10% or less of the total area is ultimately included by all the quadrats. Once you have chosen a quadrat size and shape, it should remain constant throughout the study.

To Do: Explain to students that the research they will do with the quadrats will be to determine if pennies, pasta and peanuts will all land in the same area when thrown, simultaneously, underhanded. Put the quadrat out onto the play yard, as flat as possible. Place the pennies, peanuts and pasta into the small container. Select one student to throw the pennies, peanuts and pasta from the container onto the play yard in the direction of the quadrat. The idea is not to toss things all over but to see how many of the tossed items land in the measuring area of the quadrat. Once the items have been tossed, ask students to record the following:

- 1 Distance of the quadrat from the person tossing the items.
- 2 Different types of items found within the perimeter of the quadrat.
- 3 Number of each different item.

Next, move the quadrat to another area within the Toss Zone. Move the quadrat parallel to either side of the first placement. Conduct the same research as before. Record the results. Move the quadrat again and again until you have counted all of the tossed items. Can students determine why some items landed where they did based on their research?

Resources

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Web Sites

www.coralfilm.com

www.reefbase.org

www.reef.edu.au/

www.coralreef.org/

www.coralreef.noaa.gov

www.coralreefalliance.org/

www.coris.noaa.gov

www.gcrmn.org

www.reefcheck.org/

www.ourworld.compuserve.com/homepages/mccarty_and_peters/coral/c-intro.htm

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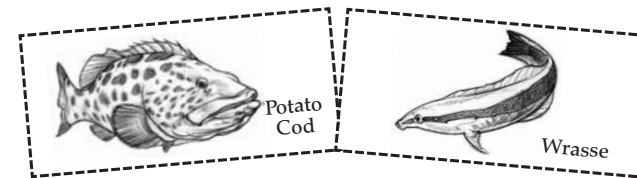
Illustration

Phil Roberts

Activity 1 Answer Key



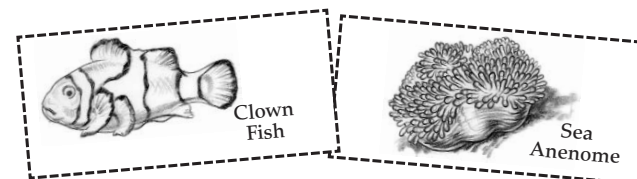
Fiji or Bust + Rental Property Available



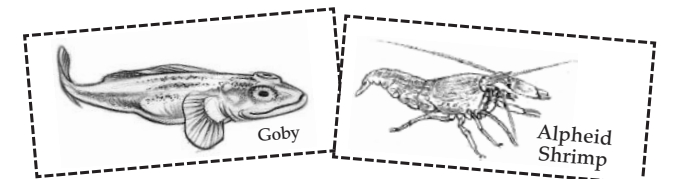
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The End is Near! + Got Algae?



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Bodyguard Available + Roommate Wanted



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