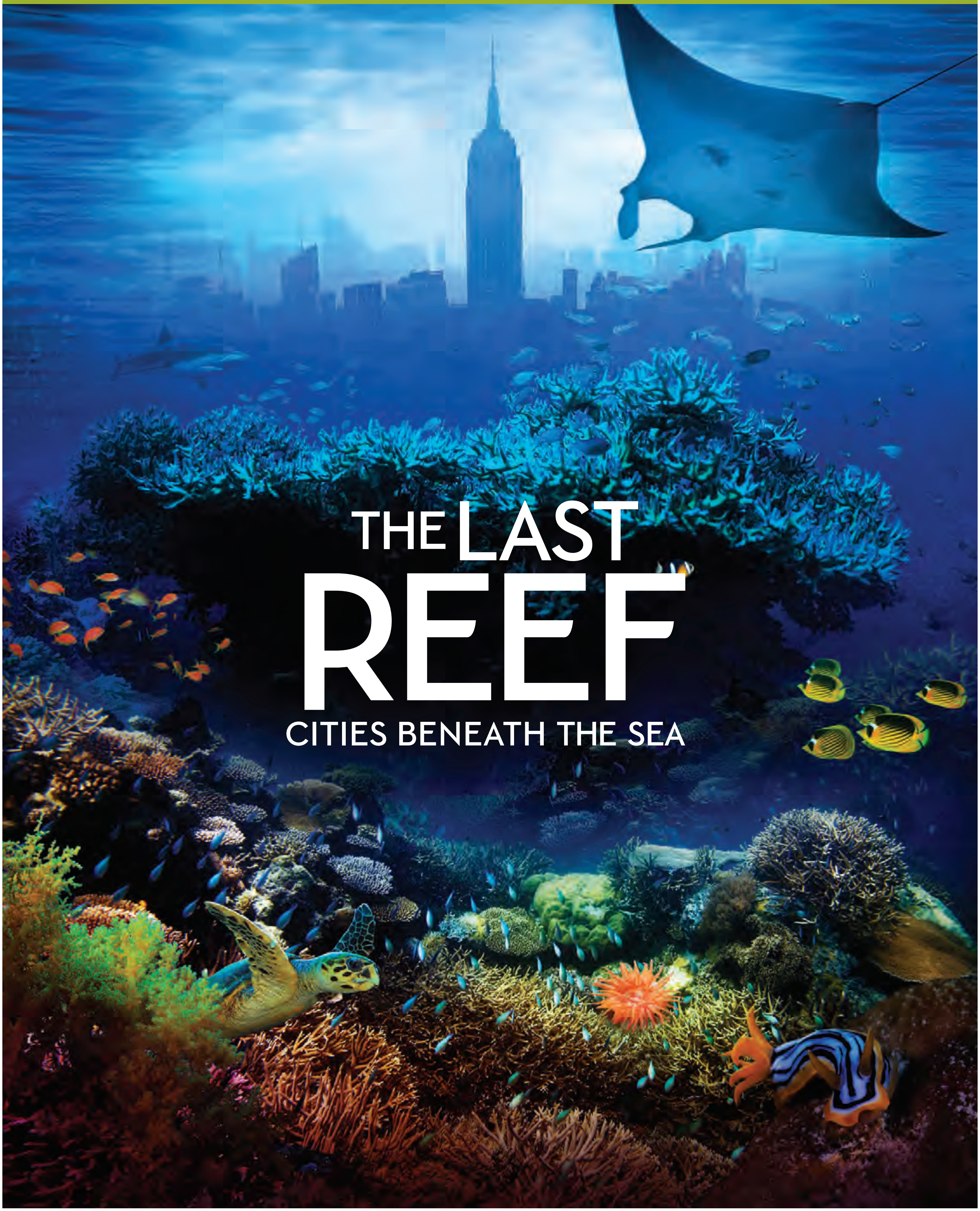
TEACHER ACTIVITY GUIDE



The activities in *The Last Reef* Teacher Activity Guide can be explored following the showing of the film *The Last Reef*. Students will be able to expand their knowledge of coral reefs and discover the science behind important conservation issues facing our world ocean.

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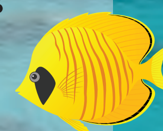


Grade K-2 Activity

Turtle Eggs

OBJECTIVE

To demonstrate that sea turtles hatch from eggs laid on sandy beaches.

Time Requirement

- 20 minutes

Materials

- photos of sea turtles
- Hatching Turtles Worksheets
- scissors (one for each student)
- brads (one for each student)

Preparation

- On the Internet or in books and magazines, find photos of sea turtles to show students.
- Make enough copies of worksheets so that each student can have one turtle and one egg.
- Cut out the turtles and the eggs and punch holes where indicated.
- Assemble one hatchling to use as a model (see Practice).

Vocabulary

- hatch
- hatchling
- jellies
- lungs
- reptiles
- scales
- sea turtles

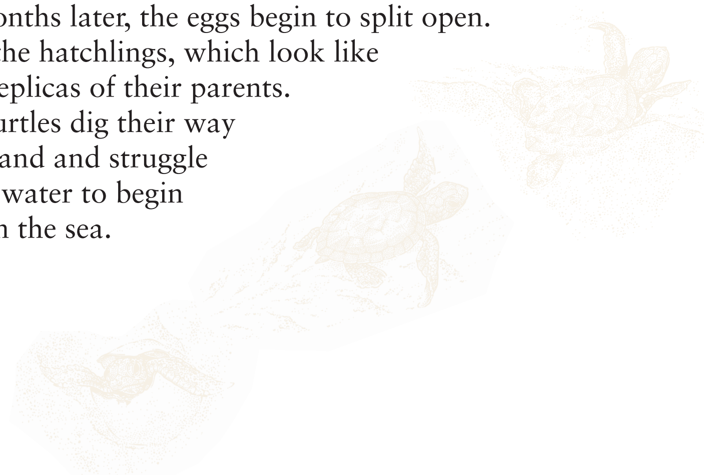
BACKGROUND

Sea turtles are members of a class of animals known as reptiles. All species of sea turtles share certain reptilian characteristics: a skin covering of scales or horny plates and a pair of lungs. Of course, the most identifiable feature of a sea turtle is the shell on its back, which is primarily used as a defensive shield. Sea turtles also have powerful flippers, resembling broad paddles, which easily propel them through the water.

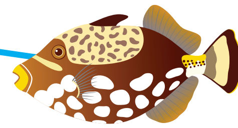
Sea turtles can be found in shallow coastal waters and in the open ocean. They often visit coral reefs looking for jellies and other favorite foods.

During certain times of the year, female sea turtles come ashore on sandy beaches to lay their eggs. The female sea turtle uses her back flippers to dig a deep hole in the sand, where she then lays from 80 to 120 eggs before returning to the sea.

About 2 months later, the eggs begin to split open. Out crawl the hatchlings, which look like miniature replicas of their parents. The baby turtles dig their way out of the sand and struggle toward the water to begin their lives in the sea.



Turtle Eggs



ENGAGE

1. Ask students where turtles live. Explain that some kinds of turtles live on land, other kinds live in rivers, and other kinds live in the ocean.

2. Show students photos of sea turtles.

MODEL

1. Tell students that turtles are a type of animal called "reptiles." Ask if they can name other reptiles *(snakes, lizards, alligators, crocodiles, extinct dinosaurs)*.

2. Explain that all reptiles have lungs, that all have skin covered by scales, and that most lay eggs with a leathery covering.

3. Explain to students how sea turtles lay their eggs on a sandy beach and how the hatchlings dig out of the sand and crawl to the sea.

4. Show students an assembled "turtle egg" cutout from the worksheet and open the egg to reveal the hatchling. Explain that they will be making their own turtle eggs and helping the baby turtles hatch.

PRACTICE

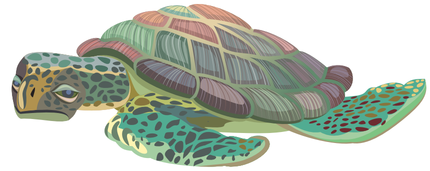
1. Hand out a turtle and an egg to each student.

2. Have students assemble their turtle eggs and hatchlings, helping students who need assistance.
   a. Cut the egg in half along the jagged line.
   b. Line up the holes of the egg halves with the hole in the turtle fin.
   c. Insert a brad through the holes to attach the eggs halves and the turtle.

3. Allow students to color their turtles and eggs.

CHECK FOR UNDERSTANDING

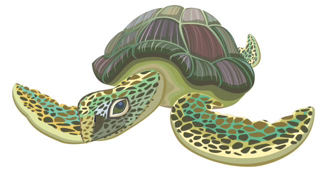
1. Ask students to explain, and maybe act out, how baby turtles are born.



EXTEND ACTIVITY

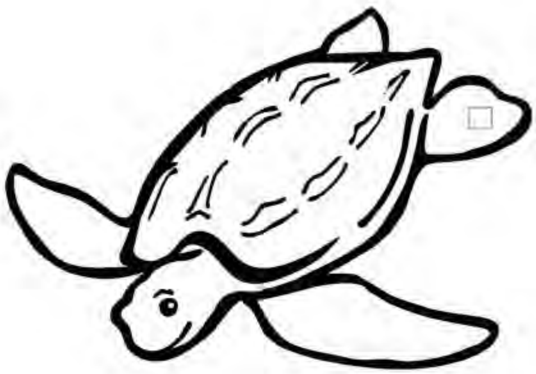
1. Create a mural or a diorama of a sandy beach with sea turtles, turtle eggs, and hatchlings.

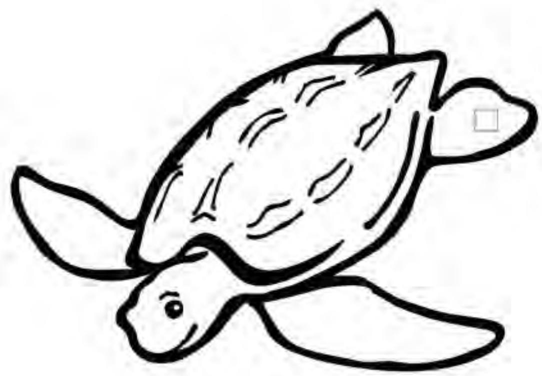
Hatching Turtles
Worksheet

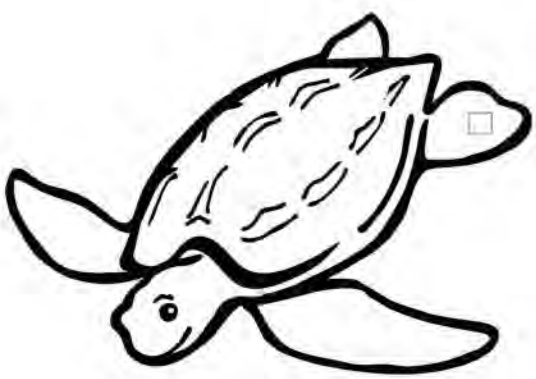


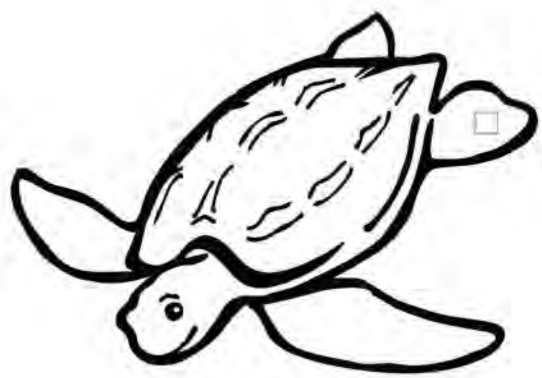
TURTLE HATCHLINGS

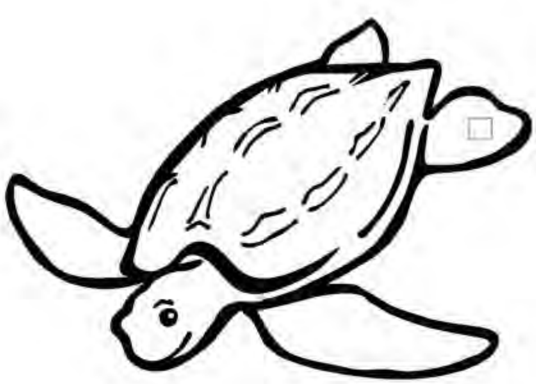
Cut out a hatchling for each student.
Punch a small hole on the fin where indicated by the square.

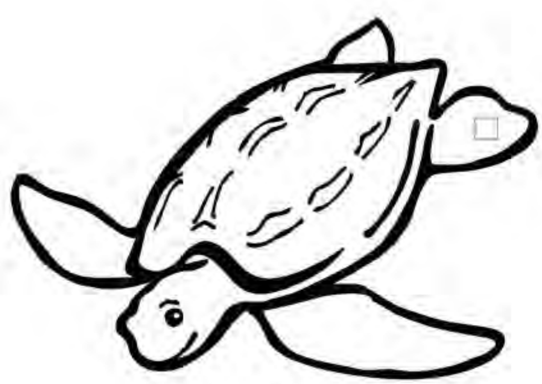








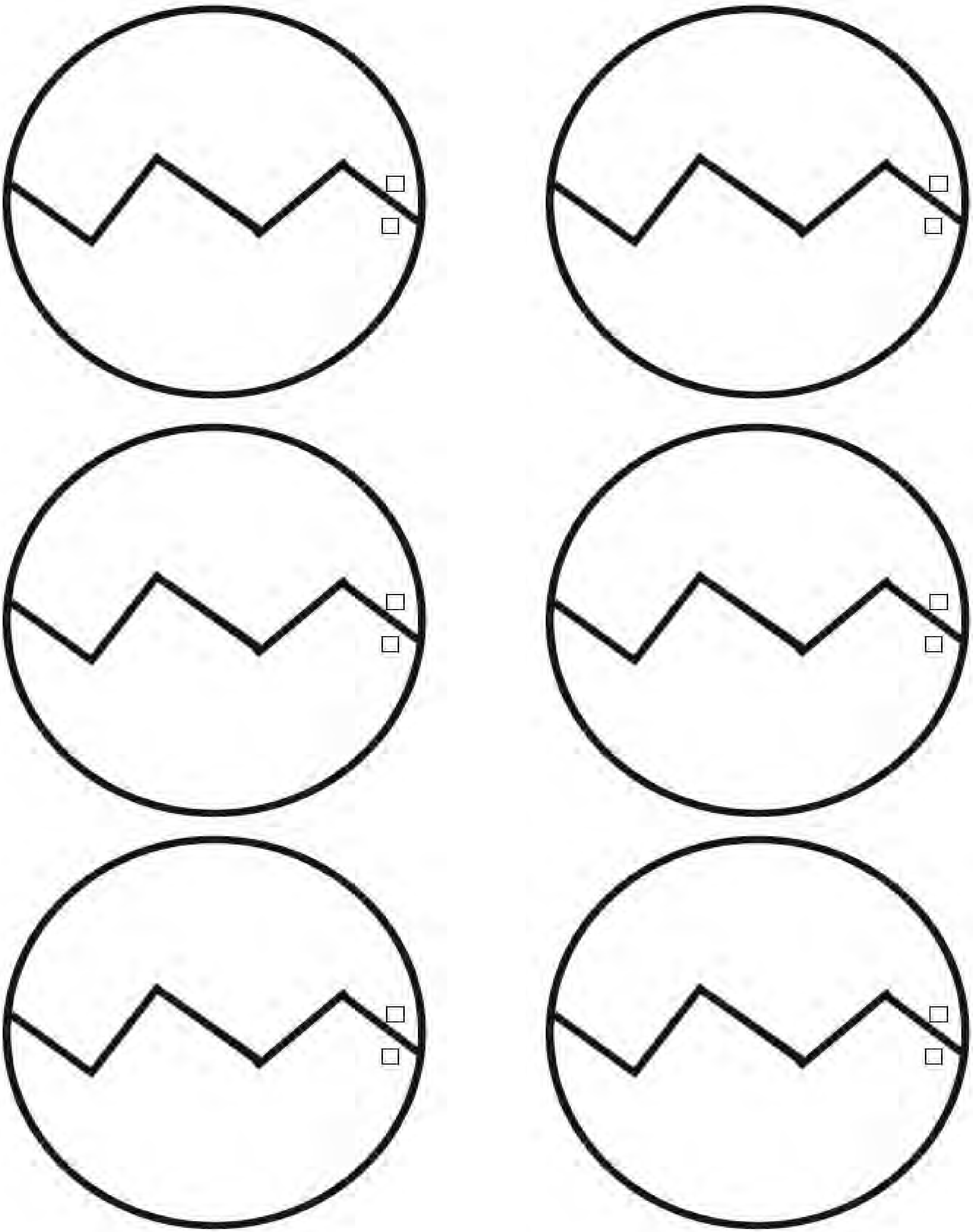




Hatching Turtles Worksheet

TURTLE EGGS

Cut out an egg for each student. Punch a small hole where indicated by the square. Cut along the jagged line. Use a brad to attach turtle to egg halves.



Grade K-2 Activity

Spud Sharks

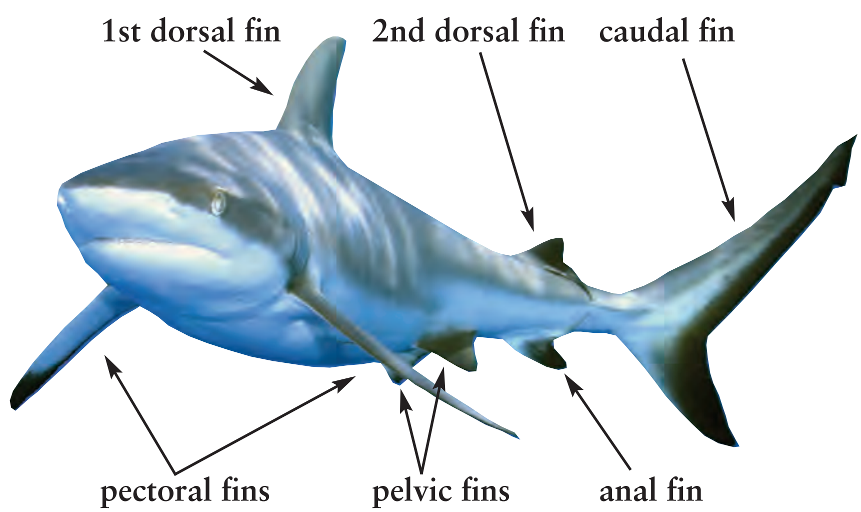
OBJECTIVE

To learn the form and function of a shark's body shape and fins.

BACKGROUND

Young sharks in the mangrove forests of coral lagoons are hunters from the day they are born. As they mature, they venture out into the open ocean, but many often return to the reefs to hunt for food.

Sharks are built to hunt—with keen eyesight, an acute sense of smell, and streamlined bodies that allow them to move easily through the water. One of the most recognizable adaptations of these predators is their fins. Sharks have five different types of fins, each with a different function that helps them in their pursuit of prey.



The *caudal fin*, or tail fin, propels the shark through the water.

The *dorsal fin* on the shark's back—either one or two—provides stability, to keep the shark from spinning.

The two *pectoral fins*—one on each lower front side—provide lift and allow the shark to steer.

The two *pelvic fins*—on the underside behind the pectoral fins—provide stability.

The *anal fin*—if the shark has one—is positioned behind the pelvic fins near the tail to help provide stability.

Without a top predator like sharks, the food chain in the ocean could be disrupted. Thus, sharks are important for maintaining the health of the marine environment, including reefs.

Time Requirement

- 30 minutes

Materials

- photos of reef sharks *(e.g., black-tip reef shark, white-tip reef shark, tiger shark, whale shark, hammerhead shark)*

For each student or small group:

- potato or sweet potato
- toothpicks
- construction paper
- white glue or glue sticks
- scissors
- plastic knife
- googlie eyes
- Shark Fins Pattern Worksheet

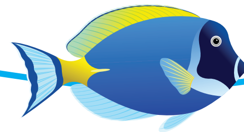
Preparation

- On the Internet or in books and magazines, find photos of sharks to show students.
- Make a copy of the Shark Fins Pattern Worksheet for each student or group.

Vocabulary

- fins
- predator
- prey
- stability

Spud Sharks



ENGAGE

1. Ask students what they think of when they hear the word shark.

2. Show students pictures of various reef sharks.

MODEL

1. Explain that the shark's fins and body shape help to make it a great hunter.

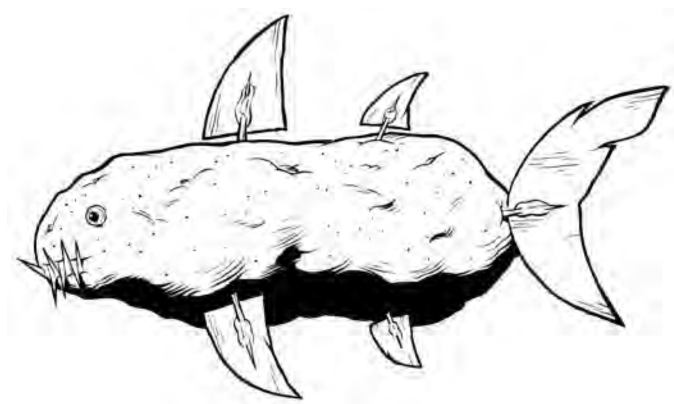
2. Display the photo from the Background Section and explain the function of each shark fin.

3. Tell students that they are going to be making their own sharks.

PRACTICE

1. Distribute the spud shark materials and the Shark Fin Pattern Worksheet to students.

2. Have students—or aides for younger students—build their sharks.
   a. Cut a mouth out of one end of the potato using a plastic knife.
   b. Fold construction paper in half and draw the number of fins indicated on the pattern (8 sets of fins).
   c. Cut out all the fins.
   d. Spread glue onto one fin of each set and lay a toothpick down the middle. Press the other fin of the set on top so that some of the toothpick is exposed.
   e. Poke the fins into the potato in the correct shark fin positions.
   f. Glue on googlie eyes.



CHECK FOR UNDERSTANDING

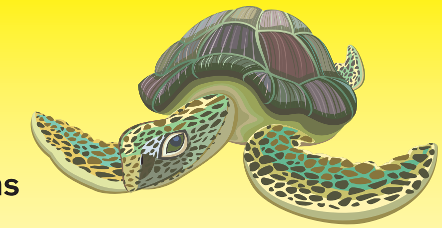
1. Have students display their spud sharks. Ask each group to describe one of the fins on their shark.

EXTEND ACTIVITY

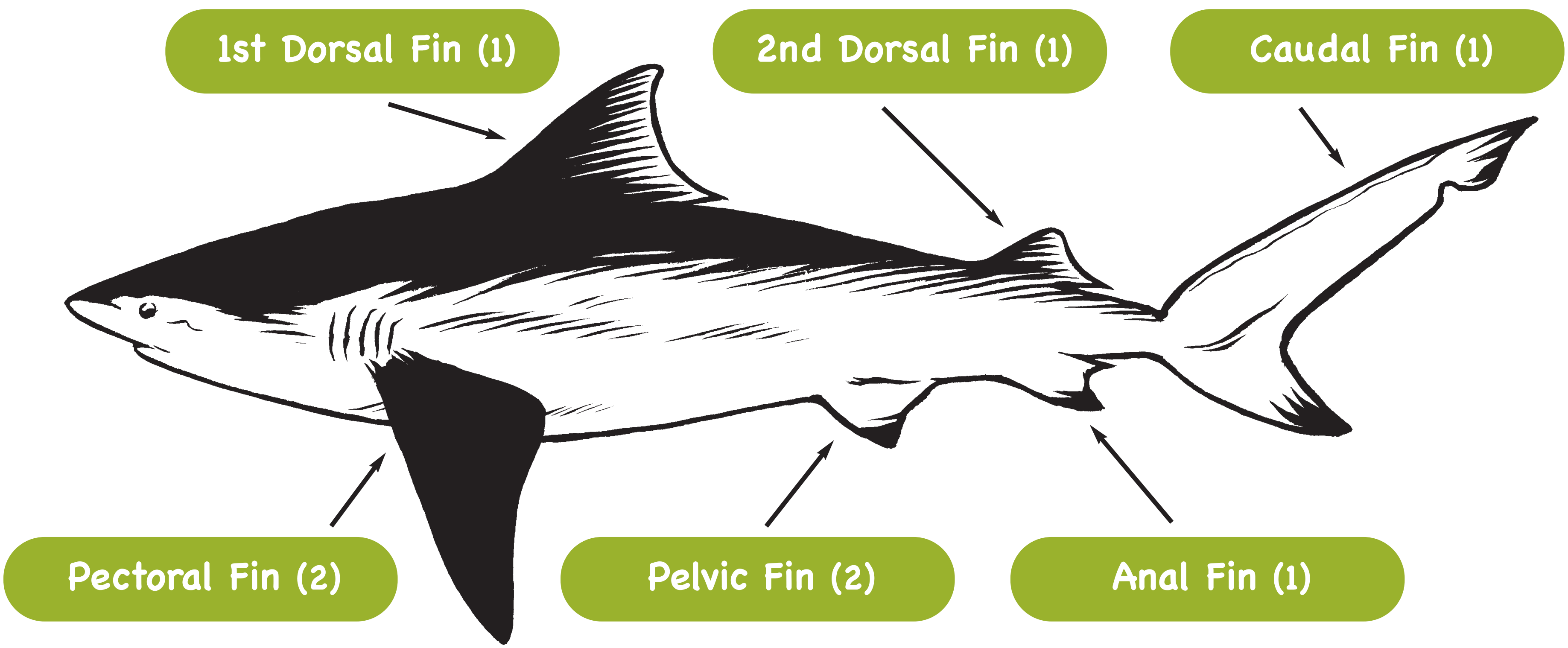
1. Help students learn more about sharks—the different species, their sizes, their shapes, their physical characteristics, their behaviors.

2. Find out what sharks eat in a coral reef and what the sharks' prey eat and then what those organisms eat—creating a food chain.

Shark Fins Pattern
Worksheet



Use the illustration below as a pattern to draw the shark's fins and to place them on your spud shark.



Grade K-2 Activity

Working Together

OBJECTIVE

To demonstrate symbiosis by having students discover that sometimes they need to work together to accomplish a goal.

BACKGROUND

In nature, organisms—animals and plants—sometimes work together to accomplish a common goal, or sometimes they live together in an arrangement that is mutually beneficial. This is called *symbiosis*.

An excellent example of a symbiotic relationship is the clownfish and the giant anemone as seen in the movie *The Last Reef*. The tentacles of the anemone have stinging cells, but the clownfish has developed an immunity to the sting. So the clownfish hangs out among the tentacles of the anemone for protection from larger fish. In return, the clownfish drops morsels of food into the anemone. Each animal relies on the other, one for food and the other for protection.

Another example of a symbiotic relationship in a coral reef can be found at the “cleaning stations.” Here, small “cleaner fish,” such as wrasse and remora, swim into the manta ray’s gills and over its skin, feeding on dead tissue and parasites. Both animals benefit from the interaction as the manta ray has parasites removed and the smaller fish gains a source of nutrition.

Time Requirement

- 30 minutes

Materials

- 1.5 to 2 feet PVC pipe for each student
- plastic spoon for each student
- duct tape
- rubbing alcohol
- 10 to 15 feet of butcher paper
- large package of M&M’s or other candy

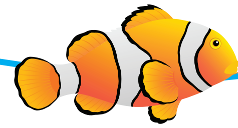
Preparation

- Tape a spoon to one end of each PVC pipe.
- Clean each spoon with the rubbing alcohol.
- Spread enough butcher paper on the floor so that half the class can stand facing across it on one side with the other half of the class on the other side.

Vocabulary

- parasites
- symbiosis

Working Together



ENGAGE

1. Ask students:
   - Have you ever had a job to do that you couldn't do by yourself *(for example, lifting something heavy)*? What did you do?
   - Do you have friends or brothers or sisters that you help and that in turn help you? How do you help each other?

MODEL

1. Explain symbiosis by telling students about the relationships between:
   - clownfish and sea anemones
   - cleaner fish and manta rays

2. Tell students that they are going to participate in an activity to demonstrate the importance of symbiosis.

PRACTICE

1. Spread out the M&M's (or other candy) on the butcher paper.

2. Ask students to line up along each long side of the butcher paper with half the class on one side facing the other half on the other side. Tell students to be careful not to touch the paper or the candy.

3. Hand out a pipe-spoon to each student, telling students to hold it only at the very end opposite the spoon.

4. Explain that they are to use the spoons to try to pick up and eat the candy but that they are not to bend their elbows or their wrists. Demonstrate the correct way to hold and maneuver their spoons.

5. Give students about one minute to try to pick up and eat some M&M's. Then tell students to try working with another student to try to accomplish this task. If students are still struggling, suggest that they do not have to feed themselves.

CHECK FOR UNDERSTANDING

1. Ask students to explain how their symbiotic relationship is working. Emphasize that they were unable to get the M&M's into their mouths on their own but that with the help of a fellow student, the task became doable. Ask students to explain how their relationship is like others in nature.

2. Ask students if they would continue to help feed M&M's to their partner if their partner never helped them get some candy.

EXTEND ACTIVITY

1. Help students look into other symbiotic relationships. For example:
   - honeybees and flowers
   - zebras and oxpeckers (birds)
   - coral and algae

Grade 3-5 Activity

Time Requirement
- 30 minutes

Materials
- Coral Reef Ecosystem Worksheet

Preparation
- Make a copy of the Coral Reef Ecosystem Worksheet for each student or group.

Vocabulary
- abiotic
- biotic
- carnivore
- herbivore
- omnivore
- photosynthesis
- primary consumer
- primary producer
- secondary consumer
- tertiary consumer

Ecosystem Interactions

OBJECTIVE

To learn about the ecology of coral reefs, including the biotic and abiotic factors that impact the environment, and the interconnectedness of organisms in a food web.

BACKGROUND

An ecosystem refers to all the biotic (living) and abiotic (nonliving) components in an environment and their interactions. Within every ecosystem, living organisms are categorized according to their position within a food chain or pyramid.

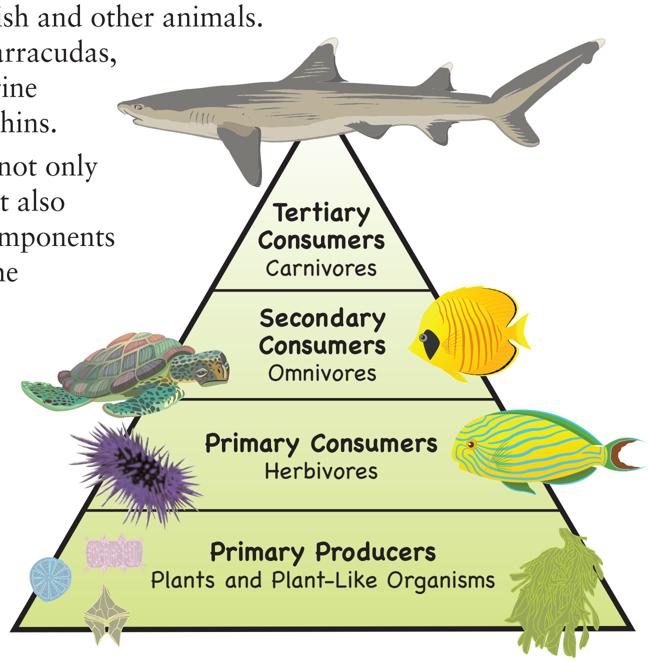
Primary producers, autotrophs, are organisms that are capable of making their own food through photosynthesis. Some common primary producers in a coral reef ecosystem are phytoplankton, algae, and seaweed. An important primary producer in a coral reef is zooxanthellae, a type of microscopic algae that lives inside the coral, providing the coral with its well-known colors.

Primary consumers are herbivores that feed on the primary producers. In a coral reef, they include zooplankton, corals, sea urchins, green sea turtles, some crabs, and some fish, such as many species of parrotfish and surgeonfish.

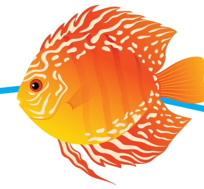
Secondary consumers are omnivores, meaning that they eat both plants and animals (primary consumers and other secondary consumers). The secondary consumers in a coral reef can be very small—such as tiny nudibranchs, barnacles, and coral polyps—and very big like a whale shark. Others include butterflyfish, damselfish, triggerfish, loggerhead sea turtles, octopus, jellies, crabs, shrimps, snails, worms, and sea stars, including the destructive crown-of-thorns sea star.

Tertiary consumers in a coral reef are large fish at the top of the food chain that eat smaller fish and other animals. They include sharks, barracudas, and eels, as well as marine mammals, such as dolphins.

An ecosystem includes not only the living organisms but also the many non-living components that greatly influence the environment. Such abiotic factors include water temperature, sunlight, water clarity, wave action, wind, and weather, as well as elements sometimes introduced by humans, such as trash or sunken boats.



Ecosystem Interactions



ENGAGE

1. Ask students: What is your "environment"?
2. Emphasize that their environment is not just the natural environment (trees, water, air) but all of the things that surround them that they encounter on a daily basis.
3. Ask students how they are affected by elements in their environment. Encourage them to think about elements both living (people, animals, plants) and nonliving (buildings, cars, weather, trash).

MODEL

1. Tell students that, as they saw in the film *The Last Reef*, a city—the environment in which they live—is an ecosystem on land, much like a coral reef is an ecosystem in the ocean. Point out that just as they are affected by both living and nonliving elements in their ecosystem, organisms in a coral reef are impacted both by other living organisms around them—called "biotic" factors—and by nonliving elements—"abiotic" factors.
2. Write the following words on the chalkboard: *fish, seal, sea urchin, seaweed.* Ask students to put them in order as to what might eat what.
   seaweed eaten by **sea urchin** eaten by **fish** eaten by **seal**
3. Explain that this is a food chain. Explain the levels in a food chain or pyramid, from the primary producers to the tertiary consumers.
4. Point out that food chains often intertwine; for example, the fish may eat both the sea urchin and the seaweed, and the seal may eat both the fish and the sea urchin, and they all eat other food. Tell students that this intertwining of food chains is called a food web.
5. Tell students that they are going to determine both the biotic and the abiotic factors in a coral reef ecosystem and create a food web within that ecosystem.

PRACTICE

1. Hand out a Coral Reef Ecosystem Worksheet to each student or group. Ask students to study the picture and to list all the biotic (living) elements and the abiotic (nonliving) elements they see.
2. When students have completed listing the elements, have them identify both the living and nonliving factors in the ecosystem and discuss how they might impact the environment.
3. Next, have students draw arrows from each organism pointing to what it might eat.
4. Discuss the food web that has been created. Emphasize that the connection between species in a food web can greatly impact the health of an ecosystem.

Biotic Elements

anemone	parrotfish
angelfish	plankton
butterflyfish	scorpionfish
clownfish	sea star
corals	sea urchin
eels	shark
grouper	snorkler
jellies	tube sponge
octopus	turtle

Abiotic Elements

anchor
rocks
sun
trash (*plastic bag, cup, bottle, 6-pack ring)*
water clarity
water temperature
waves

Ecosystem Interactions *continued*

CHECK FOR UNDERSTANDING

1. Ask students:
   - What are some abiotic factors in a coral reef?
   - What are some primary producers in a coral reef?
   - What are some primary, secondary, and tertiary consumers in a coral reef?
2. Discuss what would happen in coral reefs if the ecosystem were disturbed, for example by:
   - the algae being polluted and dying
   - the top predators disappearing from the site

EXTEND ACTIVITY

1. Have students investigate other food chains/webs in other marine ecosystems (e.g., kelp forests, rocky tidepools, wetlands).
2. Have students research some of the organisms in a coral reef, perhaps:

   - the parrotfish that crunches on the coral reef in search of algae
   - the crown-of-thorns sea star that extrudes its guts to devour coral polyps
   - the lionfish that can deliver a venomous sting with the needles on its dorsal fins.

Coral Reef Ecosystem
Worksheet

List the biotic and abiotic elements in this coral reef system.
Then draw arrows from each organism pointing to what it might eat, creating a food web.

Biotic Elements		Abiotic Elements

Where's That Fish?

OBJECTIVE

To demonstrate that fish living on a coral reef can "disappear" into their surroundings or use various coloration techniques for protection from potential predators.

Time Requirement
- 50 minutes

Materials
- coral reef photos
- overhead projector

For each small group (at least 4 groups):
- variety of cellophane colors
- 2 clear transparencies
- transparency markers in several colors
- scissors
- clear tape

Vocabulary
- advertising
- camouflage
- coloration
- cryptic
- directive
- disruptive
- predator

BACKGROUND

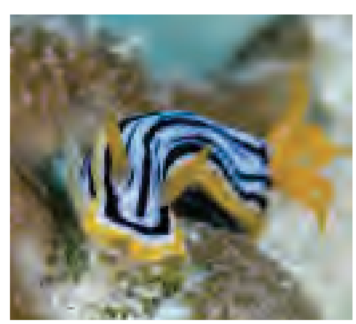
The coral reef habitat is diverse, and the types of camouflage and colorations animals use to survive there are just as diverse.

Cryptic coloration, as seen on the crocodile fish and scorpion fish in *The Last Reef*, helps an animal blend in with its surroundings.

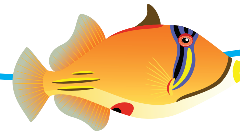
Advertising coloration, such as that displayed by the brightly colored yellow tang, warns predators to stay away.

Directive coloration uses markings, like the false eyespots on butterflyfish, to confuse predators.

Disruptive coloration, like the uneven stripes and spots seen on the tiny nudibranchs in *The Last Reef*, makes it hard to determine the outline of animals.



Where's That Fish?



ENGAGE

1. Ask students:
   - Have you ever heard a bird in a tree or an animal on the ground but when you looked up or down to find it, you couldn't see it? Why?
   - What animals sometimes blend in with their surroundings, perhaps in a forest or in a desert or in the snow? Why do the animals try to blend in?
   - If animals don't blend in, what others methods do they use to keep predators away? Think about a porcupine or a skunk or a cat.

MODEL

1. Explain to students that animals that live in a coral reef have many types of coloration to help protect them from predators.

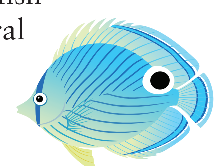
2. Explain the types of fish coloration to students, displaying example photos.

PRACTICE

1. Arrange students into small groups, a minimum of four groups, and assign each group one of the types of coloration: cryptic, advertising, directive, or disruptive.

2. Provide each group with several colors of cellophane, a clear transparency, scissors, tape, and markers. Tell each group to cut out pieces of the cellophane to create a colorful underwater coral reef scene on the transparency. Provide photos—from books, magazines, the Internet—for students to refer to.

3. Once each reef scene is complete, lay another transparency on top of the cellophane. Tell students to draw on this top transparency one or two fish that display the coloration they were assigned—perhaps one actual coral reef fish and one imagined.



CHECK FOR UNDERSTANDING

1. When all groups are finished, have each group display their creation, preferably on an overhead projector, and explain to the class how their fish uses coloration to keep predators away.

2. Ask students why it is important that the coral reef maintain a diversity of species.

EXTEND ACTIVITY

1. Have students investigate the color of fish from different areas in the ocean.
   - Compare fish from the Tropical Pacific to fish from the Northern Pacific. What extreme changes do they see? Why?
   - Compare the fish that live near the surface, down to 30 feet (9m), to the fish that live toward the bottom, below 100 feet (30 m). How does their color differ? Why?

Grade 3-5 Activity

Spawning Polyps

OBJECTIVE

To demonstrate how coral polyps spawn, create new coral polyps, and build the coral reef.

Time Requirement
- 20 minutes

Materials
- photos of corals and coral reefs
- bucket of tennis balls

Preparation
- On the Internet or in books and magazines, find photos of corals and coral reefs to show students.

Vocabulary
- budding
- coral
- planula
- polyps
- reef
- reproduce
- spawning

BACKGROUND

Coral is often mistaken for a plant, but it is actually a simple animal. A coral's body is a polyp—a tube-like form with a single opening at one end surrounded by tentacles. Coral polyps, each much smaller than a fingernail, congregate in colonies. When a polyp dies, its skeleton remains and becomes part of the reef on which other corals grow.

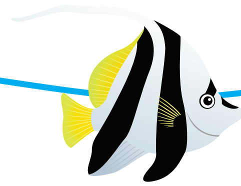
Corals reproduce in two different ways.

Budding is a form of asexual reproduction. A coral polyp may split in half to form two new polyps, or a new polyp may form at the base of the parent polyp's tissue.

Spawning is a form of sexual reproduction. The animals release eggs and sperm into the water. When an egg and a sperm meet, they form a larval coral or *planula*. After a few weeks, the surviving planula must find a place on the coral reef, or on another solid surface, to grow into a new coral.

If water conditions are right, any hard surface—even sunken ships and underwater statues—can become coral reefs.

Spawning Polyps



ENGAGE

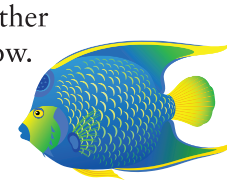
1. Ask students:
   - Where do baby chickens come from? *(They hatch out of eggs.)*
   - How are kittens or puppies born? *(Kittens and puppies are born live from their mothers.)*
   - How do fish and other creatures in the ocean reproduce? *(Some hatch from eggs; some are born live; and others reproduce by dividing.)*

MODEL

1. Show students photos of corals and coral reefs and ask if they think coral is a plant or an animal.
2. Explain to students that a coral is a tiny animal with a tube-like body called a polyp and that the coral polyps live together in colonies, forming reefs.
3. Explain the two ways that corals reproduce.
4. Tell students that they are going to play a game to show how corals spawn.

PRACTICE

1. Take students outdoors to an area large enough for all students to eventually stand in a square or an oval and toss balls to one another.
2. Choose two students and give each one a tennis ball. Have the students stand several feet across from one another (close enough so that they can toss the balls to one another but not so close that it is always guaranteed that they will catch the ball).
3. Explain that the students are individual coral polyps on a reef and the tennis balls represent the particles (egg or sperm) that the polyps release into the water during spawning.
4. Explain the game:
   a. The object of the game is to add more coral polyps so that the reef can grow.
   b. When you call out "corals spawn," the students are to toss their tennis balls to one another. Because they are polyps attached to a reef, students may **not** move their feet at any time; they must remain "planted" to the ground.
   c. Catching a ball represents successful reproduction (a surviving planula that now needs to attach to the reef). So for each ball that is caught, another student with a tennis ball is added to the "reef," helping the reef grow.



CHECK FOR UNDERSTANDING

1. Ask students to explain how their game represents corals spawning.
2. Ask students what challenges might exist in the ocean for successful reproduction of corals.

EXTEND ACTIVITY

1. Have students research corals to learn more about:
   - different types of corals
   - how reefs are formed
   - what problems corals face

Trash Timeline

OBJECTIVE

To understand how long it takes various trash items to decompose, how trash in the ocean is harmful to marine life, and how important it is to reduce the amount of trash we produce.

Time Requirement

- 30 minutes

Materials

- various trash items
- Trash Timeline Worksheet

Preparation

- Gather various items that regularly go into the trash.
- Make a copy of the Trash Timeline Worksheet for each student or group.

Vocabulary

- decompose

BACKGROUND

On average, about 10 billion tons of trash—from households, businesses, and industry—are generated each year in the United States alone. Each of us throws away about 3 to 4 pounds (1.3 to 1.8 kg) of trash per day.

A significant portion of our trash finds its way to the ocean—sometimes left behind by beachgoers or tossed from boats or washed into waterways from city streets. In the ocean, this trash harms marine life and the environment. Many trash items, such as 6-pack rings or yogurt cups, entangle and trap ocean animals causing them to suffocate or starve. Some items, such as plastic bags, are mistaken for food and eaten, making the animal sick. Other items absorb plankton, decreasing the food supply for many animals, including corals.

Some of our trash decomposes—breaks down—quickly, but much of it takes a very long time. The time it takes an item to decompose depends on its ability to biologically break down into the raw materials of nature and be reabsorbed into the environment. Natural products decompose fairly quickly; a banana peel or a piece of paper takes roughly two months. However, manufactured products—such as a plastic bag or a glass bottle or a Styrofoam cup—may take hundreds or even thousands of years to fully decompose.

We can help protect the ocean environment by reducing the amount of trash we produce, by reusing and fixing items instead of throwing them away, by recycling, and by always depositing trash in appropriate containers, not on the ground or in the ocean. “The last reef is in our hands.”

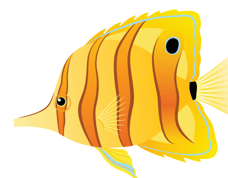
Trash Timeline

ENGAGE

1. Ask students:
   - Have you ever seen trash littered on the ground? Have you ever been at the ocean or at a lake or by a river and seen trash in the water? What did you see?
   - What happens to trash in the water?

MODEL

1. Tell students that all the products we use come from natural resources. Show students various trash items and ask them to identify the main natural resource from which each item is made. For example:
   - paper towel comes from a tree
   - corn cob comes from a plant
   - leather shoe comes from a cow
   - plastic bottle comes from petroleum



2. Explain decomposition to students, emphasizing that some items break down quickly while others take quite a long time.
3. Tell students that they are going to try to determine approximately how long it takes for various trash items to decompose.

PRACTICE

1. Arrange students into groups and hand out copies of the Trash Timeline Worksheet.
2. Tell students to write each trash item on the timeline indicating how long they think it will take that item to decompose. Encourage students to discuss their guesses within their groups.
3. When students have finished, tally their responses before sharing the correct answers.
4. Discuss how trash in the ocean can harm marine life.

Paper towel	3 weeks
Banana peel	2 months
Notebook paper	3 months
Cotton rag	5 months
Wool sock	1 year
Waxed milk carton	5 years
Plastic grocery bag	20 years
Leather shoe	50 years
Steel can	100 years
Aluminum can	200 years
Plastic 6-pack ring	400 years
Plastic bottle	450 years
Disposable diaper	500 years
Glass jar	1,000,000+ years
Polystyrene (Styrofoam) cup	Undetermined

CHECK FOR UNDERSTANDING

1. Ask students why some trash items decompose quickly and others last for hundreds, even thousands, of years.
2. Have students brainstorm how we can all help keep trash out of the ocean.

EXTEND ACTIVITY

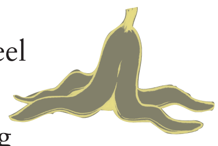
1. Have students experiment with decomposition. For example, in a large glass jar or small aquarium, create a "landfill" with layers of dirt and pieces of various kinds of trash, having some of the trash items visible through the glass. Keep the landfill moist and observe and record the decomposition of the trash items. At the end of the experiment, dig up the trash and record the results.
2. Have students research other pollution problems that can harm marine life, especially in coral reefs.

Trash Timeline
Worksheet

List each of the trash items on the timeline to show approximately how long you think it will take for that item to decompose.

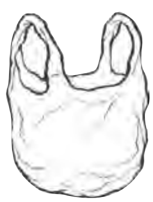
Trash Items

- Aluminum can
- Banana peel

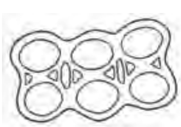


- Cotton rag
- Disposable diaper
- Glass jar

- Leather shoe
- Notebook paper
- Paper towel



- Plastic bottle
- Plastic grocery bag



- Plastic 6-pack ring
- Polystyrene (Styrofoam) cup
- Steel can
- Waxed milk carton
- Wool sock

3 weeks ______________________

______________________ 2 months

3 months ______________________

______________________ 5 months

1 year ______________________

______________________ 5 years

20 years ______________________

______________________ 50 years

100 years ______________________

______________________ 200 years

400 years ______________________

______________________ 450 years

500 years ______________________

______________________ 1,000,000+ years

Undetermined ______________________

Weather and Oceans

OBJECTIVE

To discover how different surfaces on Earth absorb and retain heat and why the heat capacity of substances affects weather.

Time Requirement

- 45 minutes

Materials

For each group of students:

- 1 glass or cup of water
- 1 glass or cup of soil
- 2 thermometers
- heat source *(e.g., desk lamp)*
- Heat Capacity Worksheet

Preparation

- For each group, fill one cup or glass with water and one with soil.
- Make a copy of the Heat Capacity Worksheet for each group.

Vocabulary

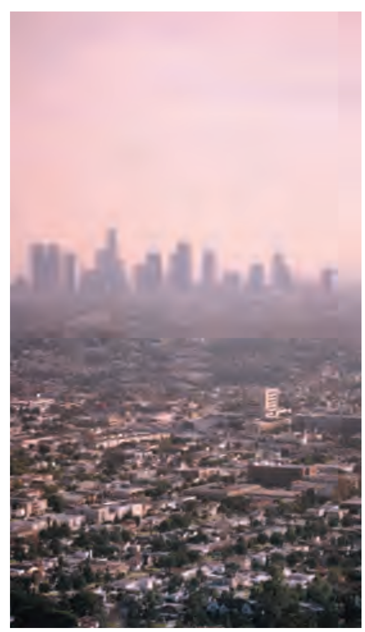
- heat capacity
- heat retention
- radiant heat

BACKGROUND

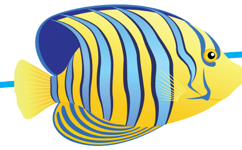
Heat capacity refers to the ability of matter to absorb and retain heat. Materials such as metal, sand, and skin have a low heat capacity, meaning that the temperature of the substance increases and decreases very quickly. Water, on the other hand, has a high heat capacity, meaning that its temperature increases and decreases very slowly.

This high heat capacity of water allows Earth to be inhabitable by humans. Since 70% of the Earth is covered by water, primarily oceans, we have a hospitable climate that stays relatively constant from day to night and from season to season. If Earth's surface consisted mostly of land, we would reach high temperatures very quickly during the day and freezing temperatures as the sun went down at night—just like other planets in our solar system.

With high heat capacity, large bodies of water require a great deal of heat energy to change the water's temperature very much. Earth's temperature has remained fairly even, but most climate scientists agree that the heat energy on Earth is increasing. Carbon dioxide (CO_2) and other "greenhouse gases"—which are released from cars, power plants, and industries—are trapping more and more heat on Earth rather than allowing the heat to radiate back into space. This increased heat energy can increase the ocean's temperature. As seen in *The Last Reef,* even a very small rise in ocean temperature can put stress on a coral reef.



Weather and Oceans



ENGAGE

1. Ask students:
   - Have you ever walked barefoot across sand on a hot day? What did the sand feel like?
   - Have you gone into the ocean or a lake on a hot day? What did the water feel like?
   - When you get into a car on a hot day, what does the metal buckle on the seatbelt feel like? What does the belt feel like?
   - Why do materials that are exposed to the same amount of heat feel different in temperature?

MODEL

1. Turn on a lamp that has an incandescent light bulb. Have a student position his/her hand a few inches from the bulb. (Be sure that the student does **not** touch the light bulb.) Ask the student what he/she feels.
2. Explain that heat is *radiating* from the bulb, much like heat radiates from the sun. Tell students that:
   - radiant heat energy comes from a central heat source in waves that travel through the air;
   - when the waves hit the surface of another object, the material absorbs the energy, forcing its molecules to move faster, thus creating heat and warming that object.
3. Briefly expose a piece of clothing or a cloth chair to the heat radiating from the light bulb, and then ask a student to feel the temperature of the cloth. Explain that different materials have different heat capacities—the ability to absorb and retain heat. Tell students that skin has a low heat capacity—absorbing and releasing heat quickly—whereas cloth has a higher heat capacity.
4. Ask students what substances make up most of the Earth's surface. Explain that they are going to be testing the heat capacity of water and soil—the two substances that cover most of the Earth.

PRACTICE

1. Arrange students into small groups and distribute the Heat Capacity Worksheet and the materials for the experiment.
2. Explain the procedures for their experiment:
   a. Put one thermometer in the water and one in the soil.
   b. Allow time for the thermometers to register the starting temperatures and then read and record the temperatures of each substance.
   c. Place both cups under the heat source *(e.g., a desk lamp).*
   d. Wait several minutes for the substances to absorb the radiant heat energy; then read and record the temperatures of substances.
   e. Remove the cups from under the heat source.
   f. Wait several minutes and then read and record the temperatures for the third time.

CHECK FOR UNDERSTANDING

1. Ask students:
   - Which substance's temperature increased the most when exposed to the heat source—the difference between the first two readings?
     (The soil should have absorbed heat faster than the water.)
   - Which substance's temperature decreased the most when the heat source was taken away—the difference between the second two readings?
     (The soil should have cooled down the most as soil does not retain heat as long as water.)
   - What percentage of the Earth is covered in water?
     (70%)
   - What do you think the temperature on Earth would be like if it was mostly land and only a small percentage of water?

EXTEND ACTIVITY

1. Have students design other experiments to test the heat capacity of other substances, perhaps even using other heat sources.
2. Have students investigate climate change and the effects on oceans, including coral reefs.

Heat Capacity
Worksheet

Experiment to test the heat capacity of water and soil.

1. Put one thermometer in the water and one in the soil.
2. Allow time for the thermometers to register the starting temperatures; then read and record the 1st Reading of the temperatures of each substance.
3. Place both cups under a heat source.
4. Wait several minutes for the substances to absorb the radiant heat energy; then read and record the 2nd Reading of the temperatures of substances.
5. Remove the substances from under the heat source.
6. Wait several minutes and then read and record the 3rd Reading of the temperatures.

1st Reading

starting temperature		F°	C°
Time:	WATER		
	SOIL		

2nd Reading

after exposure to heat source		F°	C°
Time:	WATER		
	SOIL		

3rd Reading

after removal from heat source		F°	C°
Time:	WATER		
	SOIL		

Grade 6-8 Activity

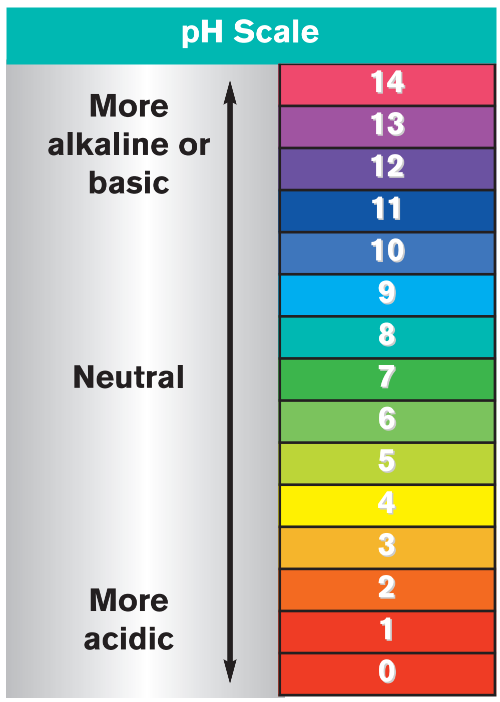
Determining pH

OBJECTIVE

To determine the pH of various substances and understand the effects of a change in pH in the ocean.

BACKGROUND

All soluble substances can be classified as being acidic or basic (alkaline). Solutions are classified according to their number on the pH scale, which ranges from 0 to 14 with "neutral" being 7. Solutions with a pH of less than 7 are considered acidic, and those with a pH greater than 7 are considered basic or alkaline. Solutions at either end of the scale are harmful. For example, battery acid, with a pH of about 1, would burn your skin. And lye (sodium hydroxide), which has a pH of 14, is caustic.



The pH numbers are based on a logarithm, so each pH number varies from the next by a factor of 10. For example, a solution with a pH of 5 is ten times more acidic than one with a pH of 6, and a solution with a pH of 4 is 100 times more acidic than one with a pH of 6.

The pH of seawater has decreased, from a range of 8.1-8.2 to 8.0, making the ocean more acidic. The carbon dioxide (CO_2) that we release into the air dissolves in the ocean to create carbonic acid. Ocean acidification reduces the carbonate ions in seawater, a component needed by coral to build their skeletons.

Time Requirement

- 45 minutes

Materials

- pH scale
- drops of vinegar or coffee or cola

For each pair of students:

- Acid or Base Worksheet
- 8 small containers
- 8 pieces of pH indictor paper
- 7 small dropper bottles with:
  - A. hydrochloric acid
  - B. sodium hydroxide
  - C. clear soda
  - D. water
  - E. ammonia
  - F. milk
  - G. milk of magnesia

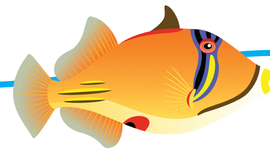
Preparation

- Make a copy of the Acid or Base Worksheet for each pair of students.
- Fill the dropper bottles with the solutions and label the bottles A through G, as listed above.
- Label one container "Control" and label the others 1 through 7 (or have students label them).

Vocabulary

- acid / acidic
- alkaline / alkalinity
- base / basic
- neutral
- pH

Weather and Oceans



ENGAGE

1. Ask students:
   - Would you, or most people, eat a whole lemon? an orange? an egg?
   - Why would you eat an orange and an egg but not a lemon?
2. Emphasize that the lemon is sour because it is acidic. An orange is not as acidic as a lemon, and an egg isn't acidic at all.

MODEL

1. Explain that all soluble substances are classified as acidic, basic, or neutral.
2. Show students the pH scale and explain the logarithm. Point out that a lemon is about a 3 on the scale, an orange a 5, and an egg about an 8.
3. Explain that one way to test the pH of a solution is to use indicator paper. Model the experiment by putting a strip of indicator paper in a small container and using a dropper to add one drop of vinegar or coffee or cola. Have students note the resulting color of the paper and compare it to the pH scale to determine the pH of the substance.
4. Tell students that they are going to be testing several solutions to test their pH.

PRACTICE

1. Arrange students into pairs and distribute the Acid or Base Worksheet and the materials for the experiment.
2. Guide students through testing the hydrochloric acid and sodium hydroxide:
   a. Put strips of indicator paper in the containers labeled ***Control***, **#1**, and **#2**. Note the color of the paper in the Control Container and record it on the worksheet.
   b. Add one drop from Bottle A—hydrochloric acid—to the paper in Container #1.
   c. Add one drop from Bottle B—sodium hydroxide—to the paper in Container #2.
   d. Compare the resulting colors of the paper to the pH scale to determine the pH of each solution. Record the colors and numbers on the worksheet. Then indicate whether the solution is an acid or a base.
3. Tell students that they are going to test five more solutions—without knowing what they are—to determine their pH. Have students follow the guidelines on the worksheet, dropping solution from the bottle indicated onto the indicator paper in each well—3 through 7. Tell them to record on their worksheets the resulting paper color and the pH, indicate whether the solution is an acid or base, and then guess what the solution is.

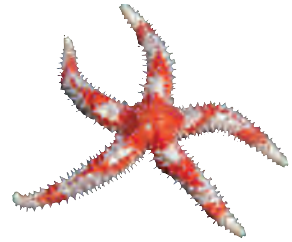
CHECK FOR UNDERSTANDING

1. Discuss the results of their tests, determining if each solution is an acid or a base.
2. Tally students' guesses for each solution and discuss the reasoning for their choices. Discuss the characteristics of substances that are acidic, basic, and neutral.
3. Ask students how a change in pH in the ocean might affect the organisms living there? Explain that many marine organisms can thrive only within a specific pH range.

EXTEND ACTIVITY

1. Test other solutions, asking students to hypothesize the solution's pH before the test.
2. Have students design experiments to test the affects of solutions with different pH.
3. Investigate ocean acidification.

Acid or Base
Worksheet



	Color	pH	Acid or Base	Solution
CONTROL Container				
Container 1 *use Bottle A*				Hydrochloric Acid
Container 2 *use Bottle B*				Sodium Hydroxide
Container 3 *use Bottle C*				
Container 4 *use Bottle D*				
Container 5 *use Bottle E*				
Container 6 *use Bottle F*				
Container 7 *use Bottle G*				

Energy Sources

OBJECTIVE

To demonstrate how various resources produce energy and to identify the advantages and disadvantages of both renewable and nonrenewable energy sources.

Time Requirement

- 1 to 2 class sessions

Materials

For each small group of students:

- pinwheel
- materials to create pinwheel power sources *(e.g., water, hotplate, teakettle, candles, batteries, magnets, pre-wired DC motor, pre-wired solar cells, tape, glue, nails)*
- Energy Source Comparison Worksheet

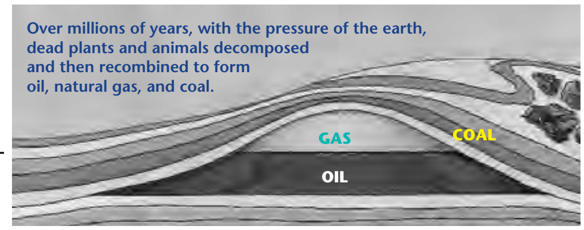
Preparation

- Obtain or make pinwheels.
- Gather materials to create pinwheel power sources.
- Make a copy of the Energy Source Comparison Worksheet for each student or group.

Vocabulary

- biomass
- energy
- fossil fuels
- geothermal
- hydropower
- nonrenewable
- nuclear power
- petroleum
- photovoltaic
- renewable
- solar

BACKGROUND



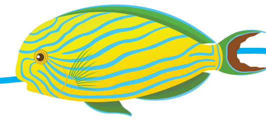
Worldwide, most of our energy—about 95%—comes from fossil fuels—petroleum (oil), natural gas, and coal. Millions of years ago, dead plants and animals were covered with water, mud, and rock. Over millions of years, subjected to pressure and heat from the Earth's crust, the remains decomposed and then recombined to form oil, natural gas, and coal.

Fossil fuels contain hydrocarbons, stored up energy, and when we burn them, that energy is released as heat. But whether they are burned in power plants or in vehicles, fossil fuels also release harmful pollutants, including large amounts of carbon dioxide (CO_2). As seen in *The Last Reef*, this increased amount of CO_2 entering our atmosphere is contributing to ocean acidification and to global warming, including a rise in the ocean's temperature.

Fossil fuels are limited—a nonrenewable energy source—and they are becoming more and more difficult and expensive to find and recover. The remaining 5% of our energy does come from renewable energy sources—such as solar, wind, nuclear, and hydropower. These sources are "cleaner" than fossil fuels, but they are not without challenges.

Using more renewable energy sources will help us counter the diminishing supply of fossil fuels and reduce the CO_2 released into the atmosphere, but we also need to conserve energy—use less, use it wisely, and not waste it.

Energy Sources



ENGAGE

1. Ask students:
   - What did you do today that used energy from another source (e.g., electricity)?
   - How has our use of energy changed throughout history?
   - Where does the energy that you use come from?
   - Can you imagine a day without the use of energy?

MODEL

1. Show students a pinwheel and ask what would make the pinwheel spin.
2. Ask a student to blow against the blades of the pinwheel to demonstrate that wind energy can, indeed, power the pinwheel.
3. Tell students that they are going to experiment to discover other ways to make the pinwheel spin.

PRACTICE

1. Arrange students into small groups and give each group a pinwheel.
2. Give students access to materials that they can use to try to spin the blades of their pinwheel. Tell them how long they have to create a power source for their wheel.

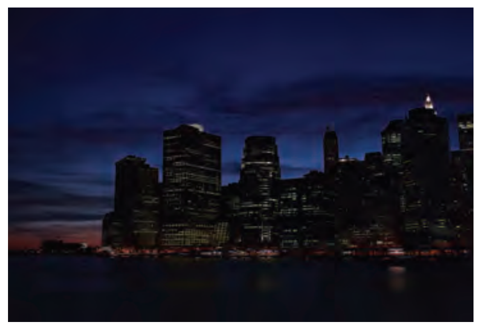
CHECK FOR UNDERSTANDING

1. Have each group present their method to spin their pinwheel. As each method is presented, discuss how it is like a current energy source and encourage students to think about the advantages and the disadvantages of using their energy source to power the pinwheel.
   - blowing – similar to **wind power**
   - direct heat – similar to **wind power**
   - falling water – similar to **hydropower**
   - solar cells – similar to **photovoltaic cells**
   - steam from heat source – similar to electricity generation plants powered by **fossil fuels, nuclear power, biomass, solar thermal heat, geothermal heat**

Energy Sources *continued*

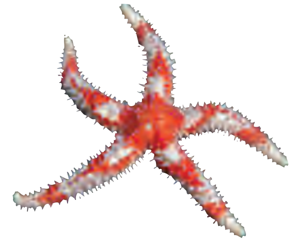
2. Distribute an Energy Comparison Worksheet to each student or small group. Ask students to fill in the advantages and disadvantages of each of our energy sources, considering:
   - supply, especially whether the source is renewable or nonrenewable
   - environmental effects
   - cost
3. Before the advantages and disadvantages of each source are discussed, ask students to explain how that source is used to provide us with energy. Emphasize that currently worldwide, 95% of energy comes from burning fossil fuels.
4. Ask students what can be done to reduce the environmental problems caused by our use of energy.

EXTEND ACTIVITY

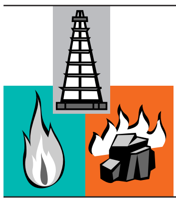


1. Investigate energy resources, having students look into:
   - how they are used
   - where they are used
   - what percentage of our energy they provide
   - why some are used so much more than others
2. Have students research the specific environmental effects that energy sources can cause to the ocean environment.

Energy Source Comparison
Worksheet



What are some advantages and disadvantages
of each of the following energy sources?
Consider supply, cost, and environmental effects.

Energy Source	Advantages	Disadvantages
 Fossil Fuels		
 Hydropower		
 Nuclear Power		
 Solar		
 Wind		
 Geothermal		
Biomass		

Grade 9-12 Activity

Ocean Acidification

OBJECTIVE

To learn how carbon dioxide enters the ocean, how CO_2 changes the chemistry of seawater, and how ocean acidification is affecting the shell- and exoskeleton-building marine organisms.

Time Requirement

- 1 class session to 1 week (for crystals to grow)

Materials

For each group:

- one inch diameter pieces of charcoal briquettes or sponge or brick or porous rock
- distilled water
- 5 tablespoons uniodized salt
- 5 tablespoons ammonia
- 8 tablespoons liquid bluing
- food coloring
- glass pie plate or plastic bowl
- measuring spoon
- jar or glass
- Ocean Acidification Worksheet

For option 1 demonstration:

- 125 ml flask
- tap water
- bromothymol blue solution OR red cabbage juice
- straw
- pH indicator paper or pH meter
- pH scale

For option 2 demonstration:

- 500 ml Pyrex container
- water (fresh or salt)
- pH indicator paper or pH meter
- pH scale
- 100 ml bromothymol blue solution OR red cabbage juice
- dry ice and ice chest to store dry ice
- hammer and screwdriver
- safety equipment (gloves, goggles, tongs or potholders)

Preparation

- Obtain the bromothymol blue solution *(aquarium store or school chemical supply)* OR make red cabbage juice by chopping up a head of red cabbage, covering it with water in a pan, boiling it for about 10 minutes *(until cabbage loses its color)*, letting it cool, and straining it into a glass jar.
- For option 2 demonstration, purchase dry ice as close as possible to the time of the demonstration and keep it wrapped tightly in the ice chest.
- Make copies of the Ocean Acidification Worksheet for each student or group.

Vocabulary

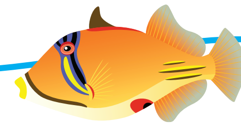
- acid / acidic
- acidification
- bicarbonate (HCO_3^-)
- calcium carbonate ($CaCO_3$)
- carbonate ion (CO_3^{2-})
- carbon dioxide (CO_2)
- carbonic acid (H_2CO_3)
- hydrogen ion (H^+)
- pH
- sublimation

BACKGROUND

Over the past several decades, burning fossil fuels for the majority of our energy has sharply increased the amount of carbon dioxide (CO_2) in the atmosphere. Though most of the CO_2 remains in the air, contributing to global warming, about one-third of it sinks into the oceans, where it dissolves to create carbonic acid, which dissociates into bicarbonate and hydrogen ions. This process changes the chemistry of seawater; the excess hydrogen ions have decreased the pH, from a range of 8.1-8.2 to 8.0, making the ocean more acidic.

Ocean acidification has an impact on marine organisms. The increase in the acidity of seawater reduces the availability of carbonate ions, a component used in shell-building. With fewer carbonate ions available, the rate and amount of calcification decreases among many marine organisms that build external skeletons and shells, ranging from plankton to oysters to sea urchins to reef-building corals. Some organisms are able to adapt more rapidly than others to this change. But for corals, the reduction in carbonate ions will likely lead to weaker, more brittle coral skeletons and slower coral growth rates. In the future, this may cause coral reefs to erode faster than they can calcify.

Ocean Acidification



ENGAGE

1. Ask students:
   - What mineral do you need to build and maintain your skeleton?
   - Where do people get the calcium they need to build their bones?
   - What are the effects if a body does not get enough calcium?

MODEL

1. Explain to students that just as their bodies need calcium to build and repair their skeletons, corals and other marine organisms need calcium ions, which are found in seawater, to build and maintain their shells or exoskeletons.
2. Tell students that they are going to build crystals to simulate how corals build their external skeletons.

PRACTICE

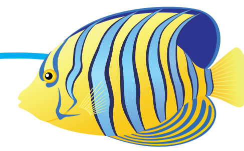
1. Arrange students into groups and distribute the materials for the experiment.
2. Provide students with the procedures for growing their crystals:
   a. Put pieces of charcoal, sponge, brick, or porous rock in an even layer in the pie plate or bowl.
   b. Sprinkle water onto the base pieces until they have been thoroughly dampened. Pour off any excess water.
   c. In the jar or glass, mix until dissolved:
      - 3 tablespoons salt
      - 3 tablespoons ammonia
      - 6 tablespoons bluing

   d. Pour the mixture over the base.
   e. Add random drops of food coloring across the surface.
   f. Sprinkle about 2 tablespoons more salt across the surface.
   g. Set the plate where it can receive free air circulation and not be disturbed.
   h. On the third day, mix and pour into the bottom of the plate, not directly on the base material:
      - 2 tablespoons ammonia
      - 2 tablespoons water
      - 2 tablespoons bluing

   i. If the crystals are not growing, repeat the above mixture the next day.

CHECK FOR UNDERSTANDING

1. Ask students:
   - How are the crystals forming?
     (Crystals form on the porous material pieces as the water evaporates. They grow by drawing the solution up using capillary action. Water evaporates on the surface, depositing solids and forming crystals, which pull more solution up from the base of the plate.)
   - How are the forming crystals similar to the exoskeletons produced by corals?
     (Just as the water, bluing, and dissolved salt combined to form crystals, coral polyps use calcium and carbonate to create external skeletons that protect their soft bodies and create reefs.)
   - What do you think would happen to your crystals if one of the ingredients were missing?



DEMONSTRATE OCEAN ACIDIFICATION

1. Ask students:
   - How does carbon dioxide (CO_2) enter the atmosphere?
     (CO_2 enters the atmosphere naturally every time we exhale; however, the majority of carbon dioxide comes from burning fossil fuels, and more and more CO_2 is released into our air every year.)
   - What is the problem with so much CO_2 in the atmosphere?
     (CO_2 contributes to global warming.)
2. Tell students that the good news is that the ocean is absorbing a good deal of this CO_2, slowing global warming, but the bad news is the CO_2 that dissolves in the ocean is making the seawater more acidic, therefore threatening marine life.
3. Explain to students that you are going to show that when CO_2 is dissolved in water, the acidity increases. Choose either option 1 or 2 for the demonstration.

Option 1

a. Fill a 125 ml flask about 1/3 full of water.

b. Add about 7 drops of bromothymol blue solution and stir until the solution turns blue.
OR
Add a small amount of cabbage juice, enough to turn the water purplish.

c. Use indicator paper or a pH meter to test the pH of the water and record it.

d. Explain that the bromothymol blue or the cabbage juice acts as a pH indicator, so it will change color when the water becomes more acidic or more alkaline (basic).

e. Put a straw all the way into the container and blow repeatedly until the solution changes color.

f. Use the indicator paper or meter to test the pH and compare it to the previous reading.

g. Explain that the CO_2 in your breath dissolved in the water to form carbonic acid, a weak acid used in making soda. Point out that it's the carbon dioxide gas under pressure that causes soda to be effervescent.

Option 2

a. Fill a 500 ml Pyrex container about 1/2 full of water.

b. Stir in enough bromothymol blue solution to turn the water blue.
OR
Add enough cabbage juice to turn the water purplish.

c. Use indicator paper or a pH meter to test the pH of the water and record it.

d. Explain that the bromothymol blue or the cabbage juice acts as a pH indicator, so it will change color when the water becomes more acidic or more alkaline (basic).

e. Using all the safety equipment, add a piece of dry ice, enough so that as it sublimates—changes straight from a solid to a gas—the top of the container fills with gas. Point out that "dry ice" is the solid form of carbon dioxide, containing no water.

f. As the top of the container fills with water vapor and carbon dioxide gas, ask students:

- What is happening to the dry ice in the water?
  (It is changing from a solid to a gas, which is called sublimation.)
- Why does the carbon dioxide gas stay in the container rather than floating upward?
  (Carbon dioxide is heavier than air.)

g. Gently blow or wave your hand to waft some of the carbon dioxide out of the container, pointing out that the gas falls downward.

h. Note the color of the water in the container. Point out that as more dry ice sublimates, the color should be continuing to change. Use the indicator paper or pH meter to test the water and compare it to the previous recording.

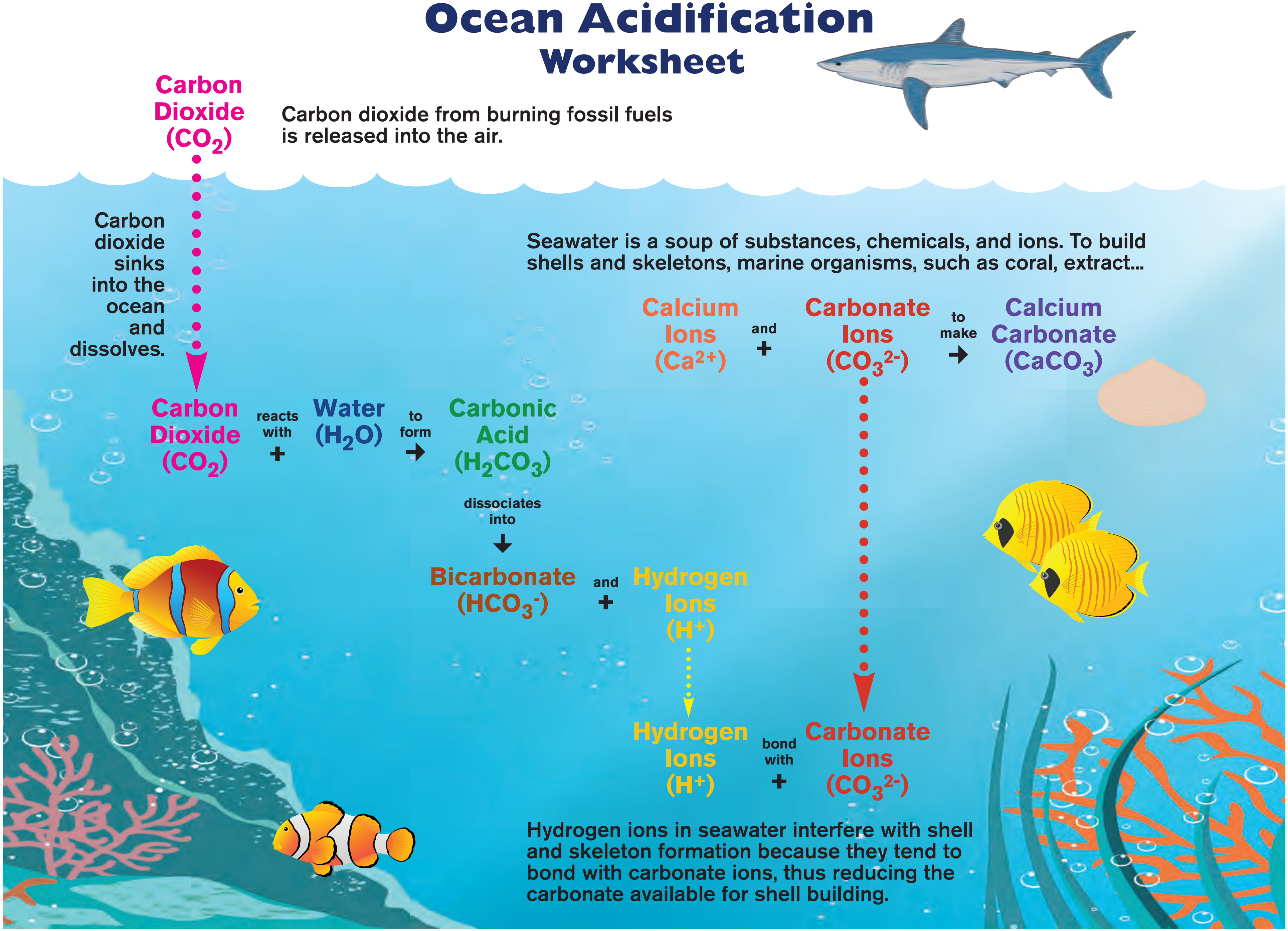
CHECK FOR UNDERSTANDING

1. Ask students:
   - How does the demonstration relate to ocean acidification?
     (*About one-third of the carbon dioxide released into our atmosphere sinks into the ocean, changing the chemical makeup of seawater, making it more acidic.)*
   - What problems might be caused by seawater becoming more acidic?
2. Distribute to each student or group (and perhaps project overhead) the Ocean Acidification Worksheet. Refer to it to help explain the causes and the effects of changing ocean chemistry.

EXTEND ACTIVITY

1. Devise and conduct experiments to test the effects of acidic and alkaline water on substances.
2. Research the environmental and economic impacts of losing marine organisms or ecosystems due to ocean acidification.

Ocean Acidification
Worksheet



Grade 9-12 Activity

Carbon Footprint

OBJECTIVE

To discover the source of greenhouse gases and learn what each individual can do to reduce the amount of greenhouse gases being released into the atmosphere.

Time Requirement

- 1 to 2 class sessions

Materials

For each student:

- computer with Internet access
- family utility bills and average car mileage for one year (optional)
- Carbon Footprint Worksheet

Preparation

- Make a copy of the Carbon Footprint Worksheet for each student.

Vocabulary

- carbon dioxide
- greenhouse gases

BACKGROUND

Whenever we turn on a light or television, recharge our laptops and cell phones, heat or cool our buildings, we use electricity. And most of our electricity comes from power plants that burn fossil fuels, which release emissions into the air. Driving our cars releases more emissions. And even more emissions come from manufacturing, packaging, and transporting products that we use every day.

Many of these emissions are considered "greenhouse gases"—for example, carbon dioxide, methane, nitrous oxide. Greenhouse gases form a natural, invisible layer over the Earth that traps some of the sun's heat that radiates from our planet back into space. These gases help keep the Earth warm and livable. However, more and more of these gases are being released into the atmosphere, trapping more heat and more gases.

This "greenhouse effect" impacts weather patterns, agriculture, plants, animals, and entire ecosystems. One effect, as noted in the film *The Last Reef,* is ocean acidification, which can decrease coral's ability to calcify.

We can each help reduce the amount of greenhouse gas emissions by our daily actions. Using less energy—at home, at school, in business, on the road—recycling, and creating less waste can reduce the "carbon footprint" we leave on the Earth.

Carbon Footprint

ENGAGE

1. Remind students that at the end of the film *The Last Reef*, the narrator says, "The last reef is in our hands." Ask what that means.
2. Show students a brief introductory video about climate change at www.epa.gov/climatechange/kids.

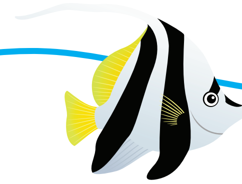
MODEL

1. Tell students that it is possible to estimate the amount of greenhouse gas emissions from an individual or a household. Direct students' attention to one of the following carbon calculators on the Internet:
   - www.epa.gov/climatechange/ghgemissions/ind-calculator.html
     Students will need their families' utility bills for a year and an average of the number of miles driven.

   - www.epa.gov/climatechange/kids/calc/calculator.html
     This calculator is good for younger students and for students that do not have access to their utility bills.
2. Tell students that the calculator will help them see what they do every day to contribute to greenhouse gas emissions and how they can reduce the emissions.
3. Explain that there are several kinds of greenhouse gases but that the emissions on the calculators are shown in "pounds of carbon dioxide" equivalents because carbon dioxide is the most common greenhouse gas. *(For example, a pound of methane is expressed as 25 pounds of carbon dioxide equivalents.)*
4. Emphasize that the calculator is intended to provide only a rough estimate of their carbon footprint as the calculator uses general assumptions about the amount of energy the average person uses for different activities. Tell students that explanations of the assumptions and the formulas used are available on the website.

PRACTICE

1. Distribute a Carbon Footprint Worksheet to each student.
2. Tell students that as they are working their way through the calculator, they should record on the worksheet actions that they are already doing to reduce CO_2 emissions and actions that they will take.
3. Encourage students to go beyond just the activities listed in the calculators. Point out that:
   - If they are using the "kids calculator," each section has a "Find Out More" button that will provide additional information as well as more activities that save CO_2 emissions.
   - If they are using the "ghgemissions calculator," they should visit the "What You Can Do" section of the website to learn about more actions they can take.

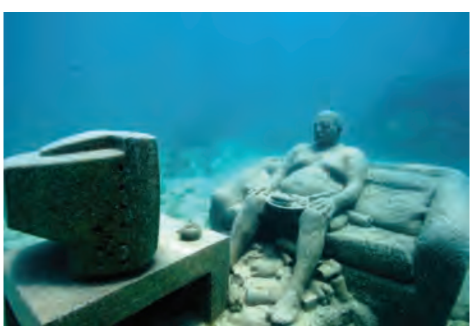


CHECK FOR UNDERSTANDING

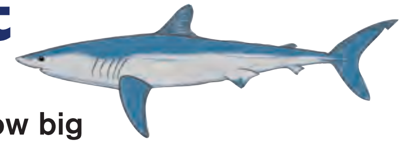
1. Discuss the results of students' carbon calculations. For example:
   - What activities seem to save the most emissions?
   - What activities are most people already doing?
   - What actions are they committing to take? reluctant to take?
   - How do their emissions compare with the "average"?
   - What are their CO_2 savings equivalent to in terms of miles driven or electricity used?
2. Ask students why energy consumption is central to the production of greenhouse gas emissions.

EXTEND ACTIVITY

1. Further explore the EPA Climate Change website (both the "ghg emissions" section and the "kids" section) to discover:
   - greenhouse gas emission data and charts
   - the science of climate change
   - impacts by region and by sector
2. Debate climate change, looking at:
   - the evidence for human-caused climate change in the context of historical climate data
   - the relevant scientific uncertainties and possible evidence to the contrary
3. Track your school's climate impact using "EPA's Climate Change Emission Calculator Kit." (www.epa.gov/climatechange/wycd/school.html)
4. Discuss the technological options that exist for reducing emissions.



Carbon Footprint Worksheet



Use an online "carbon calculator" to estimate how big your carbon footprint is and what you can do to reduce greenhouse gas emissions.

Actions You Already Take	Estimated CO_2 Savings

Actions You Will Take	Estimated CO_2 Savings

Total Estimated Savings

National Science Education Standards

TURTLE EGGS (K-2)

Life Science

Characteristics of organisms (K-4 C1)
- Needs of organisms (1.1)
- Behavior and senses (1.3)

Life cycles (K-4 C2)
- Resembling parents (2.2)

Organisms and environments (K-4 C3)
- Organisms relations to the environment (3.2)

SPUD SHARKS (K-2)

Science as Inquiry

Understandings about scientific inquiry (K-4 A2)
- Develop explanations using observations (2.4)

Life Science

Characteristics of organisms (K-4 C1)
- Structure and function (1.2)
- Behavior and senses (1.3)

Organisms and environments (K-4 C3)
- Food chains (3.1)

WORKING TOGETHER (K-2)

Science as Inquiry

Abilities necessary to do scientific inquiry (K-4 A1)
- Employ simple equipment and tools to gather data (1.3)
- Communicate investigations and explanations (1.5)

Understandings about scientific inquiry (K-4 A2)
- Develop explanations using observations (2.4)
- Review and ask questions about results (2.6)

Life Science

Characteristics of organisms (K-4 C1)
- Behavior and senses (1.3)

Organisms and environments (K-4 C3)
- Organisms relations to the environment (3.2)

National Science Education Standards

ECOSYSTEM INTERACTIONS (3-5)

Life Science

Characteristics of organisms (K-4 C1)
- Needs of organisms (1.1)

Organisms and environments (K-4 C3)
- Food chains (3.1)
- Organisms relations to the environment (3.2)
- Organisms effects on the environment (3.3)
- Humans and the environment (3.4)

Regulation and behavior (5-8 C3)
- Environmental survival needs (3.1)

Population and ecosystems (5-8 C4)
- Components—species and physical factors (4.1)
- Energy transfer, food webs (4.3)
- Relationship of ecosystem features to number of organisms (4.4)

Science in Personal and Social Perspective

Changes in environments (K-4 F4)
- Environmental factors affect the ability to survive and the quality of life (4.1)
- Changes in environments can be natural or influenced by humans (4.2)

WHERE'S THAT FISH? (3-5)

Life Science

Characteristics of organisms (K-4 C1)
- Structure and function (1.2)
- Behavior and senses (1.3)

Organisms and environments (K-4 C3)
- Organisms relations to the environment (3.2)

Regulation and behavior (5-8 C3)
- Environmental survival needs (3.1)
- Adaptation (3.4)

Diversity and adaptations of organisms (5-8 C5)
- Biological evolution and adaptation (5.2)

SPAWNING POLYPS (3-5)

Life Science

Characteristics of organisms (K-4 C1)
- Needs of organisms (1.1)
- Behavior and senses (1.3)

Life cycles (K-4 C2)
- Life cycles of different organisms (2.1

Reproduction and heredity (5-8 C2)
- Types—sexual, asexual (2.1)
- Sexual reproduction (2.2)

Regulation and behavior (5-8 C3)
- Environmental survival needs (3.1)

Population and ecosystems (5-8 C4)
- Population functions (4.2)
- Relationship of ecosystem features to number of organisms (4.4)

TRASH TIMELINE (3-5)

Science as Inquiry

Abilities necessary to do scientific inquiry (K-4 A1)
- Plan and conduct a simple investigation (1.2)

Abilities necessary to do scientific inquiry (5-8 A1)
- Design and conduct a scientific investigation (1.2)
- Develop descriptions, explanations, predictions, and models using evidence (1.4)

Understandings about scientific inquiry (K-4 A2)
- Develop explanations using observations (evidence) (2.4)
- Review and ask questions about results (2.6)

Physical Science

Properties of objects and materials (K-4 B1)
- Observable properties (1.1)
- Materials and their properties (1.2)
- States of matter (1.3)

Properties and changes of properties in matter (5-8 B1)
- Characteristic properties (1.1)

Life Science

Organisms and environments (K-4 C3)
- Organisms relations to the environment (3.2)
- Humans and the environment (3.4)

Science in Personal and Social Perspective

Types of resources (K-4 F3)
- We get resources from the living and nonliving environment (3.1)
- Some resources are basic materials, some are produced from basic resources, some are nonmaterial. (3.2)

Changes in environments (K-4 F4)
- Environmental factors affect the ability to survive and the quality of life (4.1)

Natural hazards (5-8 F3)
- Human activities can induce hazards through various means (3.2)

National Science Education Standards

WEATHER AND OCEANS (6-8)

Science as Inquiry

Abilities necessary to do scientific inquiry (5-8 A1)

- Identify questions that can be answered through scientific investigations (1.1)
- Design and conduct a scientific investigation (1.2)
- Use appropriate tools and techniques to gather, analyze, and interpret data (1.3)
- Think critically and logically to make the relationships between evidence and explanations (1.5)

Physical Science

Transfer of Energy (5-8 B3)

- Energy properties, associations, and transfer (3.1)
- Heat flow (3.2)
- Sun energy (3.6)

Earth and Space Science

Structure of Earth system (5-8 D1)

- Atmospheric properties (1.8)

Science in Personal and Social Perspective

Natural hazards (5-8 F3)

- Human activities can induce hazards through various means (3.2)

DETERMINING pH (6-8)

Science as Inquiry

Abilities necessary to do scientific inquiry (5-8 A1)

- Identify questions that can be answered through scientific investigations (1.1)
- Design and conduct a scientific investigation (1.2)
- Use appropriate tools and techniques to gather, analyze, and interpret data (1.3)
- Think critically and logically to make the relationships between evidence and explanations (1.5)

Physical Science

Properties and changes of properties in matter (5-8 B1)

- Characteristic properties (1.1)
- Characteristic chemical reactions (1.2)

Life Science

Regulation and behavior (5-8 C3)

- Environmental survival needs (3.1)

ENERGY SOURCES (6-8)

Physical Science

Transfer of energy (5-8 B3)

- Energy properties, associations, and transfer (3.1)
- Chemical and nuclear reactions (3.5)
- Sun energy (3.6)

Earth and Space Science

Earth's history (5-8 D2)

- Fossils (2.2)

Science and Technology

Abilities of technological design (5-8 E1)

- Design a solution or product (1.2)
- Implement a proposed design (1.3)
- Evaluate technological designs or products (1.4)
- Communicate the process of technological design (1.5)

Science in Personal and Social Perspective

Science and technology in society (5-8 F5)

- Science/technology cannot answer all questions or solve all problems (5.6)

National Science Education Standards

OCEAN ACIDIFICATION (9-12)

Science as Inquiry

Abilities necessary to do scientific inquiry (9-12 A1)

- Identify questions and concepts (1.1)
- Design and conduct investigations (1.2)

Physical Science

Structure and properties of matter (9-12 B2)

- Elements/Periodic table (2.2)
- Bonding (2.3)
- Compounds (2.4)
- Solids, liquids, and gases (2.5)
- Carbon atoms (2.6)

Chemical reactions (9-12 B3)

- Mechanisms of chemical reactions (3.3)

Life Science

Interdependence of organisms (9-12 C4)

- Human effects on ecosystems (4.5)

Science in Personal and Social Perspective

Environmental quality (9-12 F4)

- Materials from humans disturb cycles of Earth (4.2)

Science and technology in local, national, and global challenges (9-12 F6)

- Humans have a major effect on other species (6.5)

CARBON FOOTPRINT (9-12)

Science as Inquiry

Abilities necessary to do scientific inquiry (9-12 A1)

- Identify questions and concepts (1.1)
- Analyze alternative explanations (1.5)

Physical Science

Structure and properties of matter (9-12 B2)

- Carbon atoms (2.6)

Conservation of energy and increase in disorder (9-12 B5)

- Heat and temperature (5.3)
- Increase in disorder over time (5.4)

Life Science

Interdependence of organisms (9-12 C4)

- Human effects on ecosystems (4.5)

Earth and Space Science

Energy in the Earth system (9-12 D1)

- Energy sources (1.1
- Global climate (1.4)

Science in Personal and Social Perspective

Natural resources (9-12 F3)

- Humans use environmental resources to maintain and improve their existence (3.1)

Environmental quality (9-12 F4)

- Materials from humans disturb cycles of Earth (4.2)

Science and technology in local, national, and global challenges (9-12 F6)

- Humans have a major effect on other species (6.5)

History and Nature of Science

Nature of scientific knowledge (9-12 G2)

- Science distinguishes itself through the use of empirical standards, logical arguments, and skepticism (2.1)