# Whale Adaptations

The three short activities in this collection explore adaptations that help whales survive in the ocean. The activities include demonstrations and experiments.

**GRADE LEVELS**
4-8

**TIME**
1 1/2 hours total (can be broken into separate activities)

**OBJECTIVES**
Students will be able to
- identify whale adaptations.
- explain how adaptations assist with ocean survival.
- compare whale adaptations and human activities.

**MATERIALS**
- Listed by individual activity
- Further Background teacher sheet

## BACKGROUND

All organisms have adaptations that help them survive. Some adaptations are structural, that is, physical, like the insulating blubber on a whale. Other adaptations are behavioral, that is, things organisms do. The different whale feeding patterns are behavioral adaptations.

Adaptations are the result of evolution. Adaptations usually occur because a gene mutates, or changes by accident. Some mutations can help an animal or a plant survive better than those of its species that don't have the mutation. For example, a whale born with a more streamlined shape than that of other whales can swim faster and catch more food. Because the whale can catch more food, it is healthier than other whales, lives longer and breeds more. Eventually, over thousands of years, the beneficial mutation—a more streamlined body—is found throughout the species. Thus, today's whales look much different than their ancient, land-dwelling ancestors.

The four activities in this collection demonstrate different adaptations that help whales survive. Each activity stands alone, but taken together, the collection offers a comprehensive look at features that enable whales—the largest mammals on Earth—to survive the challenges of their ocean environment.

## WARM-UP

Use the online activity "Adaptations That Help Gray Whales Survive" from Journey North where students take a close look at gray whales, from head to toe, and explore the *why* behind *what* they see. They'll play a matching game comparing whale adaptations to human inventions. The activity can be found at http://www.learner.org/jnorth/tm/gwhale/Adaptations.html

**OVERVIEW**
Students use a tuning fork to explore how sound travels through air, solids and water. They explore why sound is important to whales' undersea communication and navigation.

**SUBJECTS**
Science

**GRADE LEVELS**
Grades 4–8

**TIME**
30 minutes

**OBJECTIVES**
Students will be able to
- observe, feel and hear vibrations in air, solids and water and communicate their observations.
- formulate a hypothesis and draw conclusions based on data they gather.
- infer and discuss why sound is an effective means of communication and navigation for whales.

**MATERIALS**
Per student group:
- Tuning fork
- Shallow pan of water
- Paper and pencil

## PROCEDURE

### Activity 1: Good Vibrations

1. **Introduce limited underwater vision**
Point to a spot at the far end of the room and ask students to raise their hands if they can see it. Ask what would happen if the room was filled with water. Would they still be able to see the spot? Explain that it's also hard for whales and other marine mammals to see well underwater.

2. **Divide into groups**
Divide students into learning groups. Give each group a tuning fork and a shallow pan of water. Ask students to submerge the tines of the tuning fork in the water and to describe what they see.

3. **Demonstrate tuning fork**
Holding the handle of the tuning fork, strike it on a hard solid surface. Gently move the fork toward the shallow pan of water and submerge the two tines underwater. Again, ask students to describe what they see. *(The vibrating tuning fork tines produce ripples in the water.)* Allow each student to try it.

4. **Explain sound waves**
Explain that the ripples they see are evidence of sound waves that are moving outward from the source (the tuning fork). Describe how sound is the vibration of molecules. As sound waves travel through a substance, each molecule of the substance hits another, then returns to its original position.

5. **Discuss rates of sound travel**
On the board, write the rate at which sound travels through air and through water (see Further Background sheet).
Ask your students the following questions:
   - In which medium does sound travel faster, air or sea water?
     sea water
   - About how much faster does sound travel through sea water than it does through air?
     4.7 times faster in sea water
   - Which is a better conductor of sound: sea water or air?
     sea water
   - What are some possible explanations?
     Water molecules are closer together than the molecules in air.

**STANDARDS**

**National Science Education Standards Grades 5–8**
http://www.nap.edu.catalog/4962.html

**Unifying Concepts and Processes:**
Evidence, models and explanation
Form and function

**Science As Inquiry – Content Standard A:**
Abilities necessary to do scientific inquiry

**Life Science – Content Standard C:**
Structure and function in living systems

**Ocean Literacy: Essential Principles and Fundamental Concepts**
http://coexploration.org/oceanliteracy/

**Essential Principle #5:**
The ocean supports a great diversity of life and ecosystems.
d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

6. **Introduce experiment**
   Tell students that they will have the opportunity to hear the sound made by a tuning fork. They will hear the sound conducted through air, then they will hear the sound conducted through bone and soft tissue *(their chin)*. Which do they think will be a better conductor of sound?

7. **Predict results**
   Ask students to formulate a hypothesis about whether there will be a difference in the way they perceive the vibrations. Have each student group write down its hypothesis on a sheet of paper.

8. **Test sound waves through air**
   Ask one student in each group to strike the tuning fork on a hard solid surface and hold it a few inches from his or her ear. Ask that student to describe what he or she hears. *(Students may hear a faint hum.)* Have students record their observations.

9. **Test sound waves through bone**
   Have one student strike the tuning fork again and hold the tip of the handle to his or her lower jaw. Ask the students to describe what they hear or feel. *(The vibration is more audible.)* Repeat for each student in the group. Ask students to record their observations of how bone and soft tissue conduct vibrations to the middle ear. *(The sound is more audible because the vibration is traveling though the bone and tissues of the lower jaw. Because the molecules comprising these structures are more densely packed than the molecules in air, sounds travel faster and farther.)*

   Students may be surprised to discover that the bone and soft tissue of their lower jaws conduct sound waves to their middle ears.

**10. Record conclusions**

When all students have experienced the vibration through water, air and their chin, help them to communicate what they observed and experienced. Have each student write three sentences that describe his or her observations of the vibrations (1) through air, (2) through water and (3) through their chin.

**11. Review the students' predictions**

Did anyone predict that they would be able to hear the sound best through their chin?

**12. Define echolocation**

Write the word "echolocate" on the board and draw a circle around "echo" and a circle around "locate." Ask students if they know what each word means. Define the word "echolocate" and describe how whales echolocate. (See Further Background sheet.) Explain how some toothed whales (and other animals) find food and each other by listening for echoes.

**13. Discuss whale communication and navigation**

Discuss with students why sound is an effective way for whales to communicate and navigate. Ask the following questions to spur discussion:

- What does it look like when you open your eyes underwater?
- Is ocean water clear or murky? Bright or dark?
- How do we see when it gets dark at night? (by turning on a light; by moonlight; by firelight)
- Are there lights in the sea?
- How would you find your way around if you couldn't see where you were going?
- How do you think toothed whales find their way around a dark ocean?
- How might human-made sounds in the ocean impact whales?

## EXTENSIONS

- Play a game that helps students better understand how whales navigate by sound. (This game is similar to the swimming pool game Marco Polo.)

- Students hold hands and form a circle.

- Blindfold a volunteer "dolphin" and steer him or her to the center of the circle.

- Choose five students to be "fish." The fish stand inside the circle.

- When the dolphin calls out "Dolphin!" the fish respond by calling out "Fish!" (The students are representing a dolphin making sounds and the echoes returning to the dolphin.) The dolphin moves around the circle trying to find and tag the fish by following the sounds of their voices. When the dolphin tags a fish, that fish sits outside the circle.

- After a few minutes, call a time-out. In the ocean, dolphins sometimes hunt together in pods. Add a few more blindfolded dolphins to the center of the circle and see if the hunting gets easier.

## CREDITS

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http://www.seaworld.org/just-for-teachers/index.htm

OVERVIEW
This experiment illustrates the role of blubber in keeping whales and other marine mammals warm in their cold ocean habitats.

SUBJECTS
Science

GRADE LEVELS
Grades 1–8

TIME
30 minutes

OBJECTIVES
Students will be able to
- state the importance of insulation in keeping warm.
- explain how blubber keeps marine mammals warm in the ocean.

MATERIALS
- Ice
- Dishpans or coolers
- Rubber gloves that are too big for the students
- Gloves made of assorted materials (rubber, cotton, wool, neoprene diving gloves)
- Stopwatches or clocks with a second hand
- Thermometers
- Blubber bags
- Solid vegetable shortening (such as Crisco®)
- Quart- or pint-sized Ziploc® bags
- Tablespoon
- Paper towel
- Packing tape

## Activity 2: Blubber Experiment

### TEACHER PREPARATION

1. Prepare blubber bags
- Put half a can or more of vegetable shortening in a Ziploc® bag. of shortening.
- Push the second bag down gently so that the top of both bags matches up. Keep the shortening pushed a couple inches down from the zippers.
- Carefully lock the two bags together. Wipe the top of the bags and press it down tight. You now have a "blubber bag."

2. Using the set of gloves that you have available, prepare and copy a Blubber Experiment Worksheet on which students will record their observations. *(Optional: Students can develop their own worksheets.)*

### PROCEDURE

1. **Divide into groups**
Divide the class into small groups of three to four students each. Depending on the grade level, have enough materials for each group to simultaneously do the activity or do the activity as a demonstration, using student helpers.

2. **Distribute worksheets**
Distribute copies of the Blubber Experiment Worksheet or have students design their own worksheet on which to record their observations.

3. **Fill dishpans**
Fill the dishpans or coolers with ice.

4. **Predict and measure temperature**
Ask the students to predict what the temperature of the ice water might be. Then have them take the temperature of the ice. The temperature of the North Pacific Ocean varies from 48°F to 64°F. Is the ice within the temperature range of the North Pacific Ocean?

5. **Experiment with insulation**
To demonstrate the effectiveness of insulation as a protection from cold water, have students take turns putting a bare hand in the ice (control). (Students can participate all at once if you are using a clock with which they can keep their own time.) See how long they can keep their hand in the ice. Record results on the observation sheet.

STANDARDS

**National Science Education Standards Grades 5–8**
http://www.nap.edu.catalog/4962.html

**Unifying Concepts and Processes:**
Form and function

**Science As Inquiry – Content Standard A:**
Abilities necessary to do scientific inquiry

**Life Science – Content Standard C:**
Regulation and behavior

**Ocean Literacy: Essential Principles and Fundamental Concepts**
http://coexploration.org/oceanliteracy/

**Essential Principle #5:**
The ocean supports a great diversity of life and ecosystems.
d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

CREDITS

Used with permission from The Marine Mammal Center, www.marinemammalcenter.org.

6. **Compare forms of insulation**
   Next have students repeat the experiment wearing a rubber glove only, a rubber glove lined with another glove *(cotton or wool)*, a blubber bag and a scuba glove *(if available)*.important: Students should be serious about this and not be thinking of this activity as an endurance test or a competition to be the one in the group that can do it the longest. Stress that they need to think of their hand as their whole body. So as soon as it becomes chilled, they need to pull their hand out and stop timing.

7. **Compare results**
   Which hand covering provides the most warmth?

8. **Discuss insulation and body heat**
   - What do humans do to warm up when we are cold? *(shiver; blow into our cupped hands; turn up the heat; put our hands in warm spots, like under our arms or between our legs; cover up with layers)*
   - When humans stay in cold water for long periods of time, what do we need? (wet suits, dry suits, a submarine with a controlled temperature) A human being without any protection in water that is 32°F (0°C) can lose consciousness in 10 minutes.
   - Pinnipeds and polar bears have both blubber and fur to help them conserve body heat. Sea otters do not have blubber—they rely only on their thick fur. The fur traps air, which serves as the insulator that keeps the water from soaking through to the skin.

Note: Blubber bags can also serve as their own experiment. Using a hand dipped in water without a bag as the control; students can compare the insulation effectiveness of blubber bags that have been made with different amounts of shortening.

## SAMPLE BLUBBER EXPERIMENT WORKSHEET

### Temperature of the Ice

| Hand Covering | Time Until Chilled |
|---|---|
| Hand without covering (control) | 1 minute |
| Rubber glove alone | 1 minute, 10 seconds |
| Scuba glove | |
| Rubber glove with cotton glove | |
| Rubber glove with wool glove | |
| Blubber bag | |

**OVERVIEW**
Students simulate four different whale feeding methods—skimmers, gulpers, bubblers and biters—and learn the difference between baleen and toothed whales.

**SUBJECTS**
Science

**GRADE LEVELS**
Grades 1–8

**TIME**
45 minutes

**OBJECTIVES**
Students will be able to
- name the two groups of whales, based on the presence or absence of baleen.
- describe four common methods some whales use to feed.
- simulate these methods using common materials.

**MATERIALS**
- Photos of the different whales for the introduction
- Large bottle of dry parsley
- Dishpans with water
- Straws
- Plastic pocket combs (combs without handles work best)
- Plastic sandwich bags
- Tongs
- Absorbent paper towels
- Small pieces of Styrofoam
- Copy of *The Gray Whale Obstacle Course* episode of ***Jean-Michel Cousteau Ocean Adventures*** (optional)

## Activity 3: Eat Like a Whale

### TEACHER PREPARATION

1. Prepare supplies
   a. Fill one plastic tub full with water.
   b. Label four paper towels, one for each whale group (biters, skimmers, gulpers, bubblers).
   c. Put about 2 tablespoons of parsley in the water, to represent food items (krill, copepods or other zooplankton).
   d. Put out the combs, which represent the baleen.

### PROCEDURE

1. **Simulate skimmers**
   The bowhead and right whales are examples of baleen whales that feed by skimming the surface of the water with their mouths open. To simulate their feeding, have students take a comb and move the comb through the parsley as if they were a skimmer swimming. Remove the parsley from the comb by tapping it on the labeled paper towel. Set the labeled results aside.

2. **Simulate gulpers**
   The roqual whales (blue, humpback, fin, sei, minke and Bryde's) have pleats in their throat that allow their throat to expand and take in large amounts of water and prey. Place more parsley in the water. Take a plastic sandwich bag that represents the throat of a gulper. Move the bag through the water, filling it with water and parsley. Place the comb in front of the open end of the sandwich bag. Position it so that it traps the parsley inside the throat. Carefully squeeze the water out of the bag through the comb a little bit at a time. Remove the parsley from the comb by tapping it on the labeled paper towel. Do this until all the water is drained from the bag, as if the gulper were closing its pleated throat.

3. **Simulate bubblers**
   Place more parsley in the water. Pass out straws to the students. Have three or four students simulate bubble netting by gently blowing bubbles into the water. Working as a group, they should be able to move the food to the center of the tub. Have one student bring a plastic bag up from the bottom of the tub through the center of the concentrated food. As before, use a comb to strain the parsley from the water. Remove the parsley from the comb by tapping it on the labeled paper towel.

**STANDARDS**
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4. **Observe gray whales**
   Watch the segment from *The Gray Whale Obstacle Course* that illustrates gray whales feeding on the ocean floor *(beginning about 3 minutes into the episode).*

5. **Simulate biters**
   Place more parsley in the water and add pieces of Styrofoam. Have the students simulate the biters using the tongs.
   The Styrofoam represents fish, squid or seals. Have the biters take a couple of turns at catching the prey. Put the prey on the labeled paper towel.

6. **Draw conclusions**
   To compare the methods, have the students observe the amounts collected and record their visual estimates. If scales are available, the amounts can be weighed. Of the three methods for mysticetes that were simulated, which method worked best? Did one method work best for all the students? Or did different students prefer different methods? Based on their success at feeding with the different methods used by mysticetes, which baleen whale would students want to be? Which prey should they concentrate on as a biter? How much can they bite in one feeding?

## FURTHER RESOURCES

Additional educator resources for ***Jean-Michel Cousteau Ocean Adventures*** can be found at **pbs.org/oceanadventures.**

### Also try

- Discovery of Sound at Sea, University of Rhode Island Office of Marine Programs
  http://omp.gso.uri.edu/work1/gallery/intro.htm

- Journey North: A Global Study of Wildlife Migration and Seasonal Change
  http://www.learner.org/jnorth/tm/gwhale/Resources.html

- SeaWorld, Inc.
  www.seaworld.org/animal-info/index.htm

## CREDITS

***Jean-Michel Cousteau Ocean Adventures*** is produced by KQED Public Broadcasting and the Ocean Futures Society.

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# Further Background

**Good Vibrations Background**

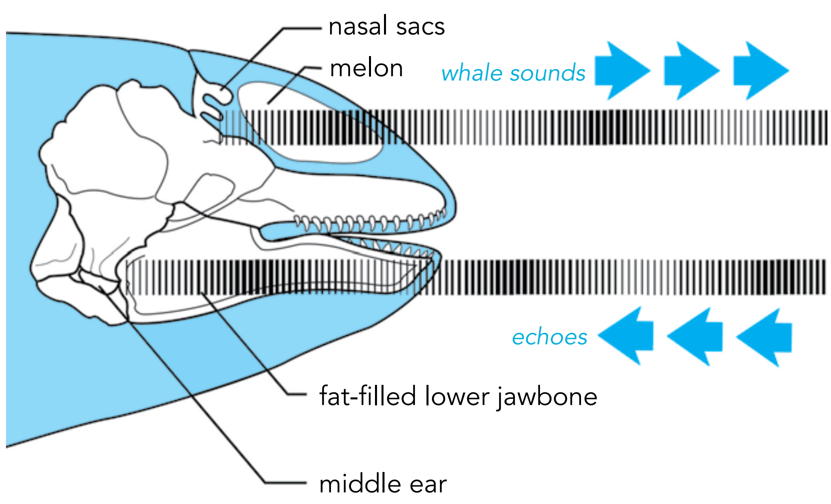
Sound is the vibration of molecules. These vibrations travel in waves, and they travel at different speeds depending on what they are traveling through. Sound travels slowest through gases, faster through liquids and fastest through solids. That's because the molecules of a liquid are closer together than the molecules of a gas, and the molecules of a solid are even more densely packed than the molecules of gases and liquids.

Sound travels through air at a speed of about 340 meters per second (0.2 mile/sec). But underwater, sound travels at approximately 1,600 meters per second (1 mile/sec).

Compare this with vision. In most circumstances, on land most mammals easily can see 100 feet ahead. But underwater, visibility is much more limited. An animal using its vision to navigate its way through the ocean needs to move relatively slowly and near the well-lighted surface.

Some toothed whales (and other animals, such as bats) use sound to navigate and to locate prey. A whale produces sounds that travel through its melon and out into the water in front of the whale. The whale listens for the echoes that bounce back. This process of sound navigating is called echolocation. Even in dark or murky water, echolocating whales can interpret the echoes they hear to tell the shape, size, speed and distance of objects in the water.

The soft tissue and bone that surround a whale's ear conduct sound to the ear. In toothed whales, the fat-filled lower jawbone is a good conductor of sound.




A killer whale's fat-filled jawbone conducts sound through the jaw to bones in the middle ears.

## Further Background (continued)

### Blubber Background

Marine mammals are warm blooded. On average, a whale's body temperature is a couple degrees warmer than that of humans' (which is 98.6°F), but varies with each whale species. Heat loss is much greater in water than in air. Insulation prevents the passage of heat out of a body. Humans are insulated by fat, aided by clothing and shelter. However, whales and dolphins, which spend all of their lives in the water, are unable to conserve body heat by curling up, seeking shelter in a protected place or putting on coats. Whales rely only on a dense layer of connective tissue containing fat, called blubber. It acts as their insulator, to conserve body heat. Blubber thickness can vary from a couple of inches thick in smaller whales and dolphins to more than a foot thick in right and bowhead whales.

### Eat like a Whale Background

Whales are divided into two groups, mysticetes, which have baleen, and odontocetes (also known as toothed whales), which do not have baleen. For the purposes of this activity, we divide mysticetes into three groups: skimmers, gulpers and bubblers. We refer to the odontocetes as biters.

Baleen hangs down from a whale's top jaw and is made of keratin, the same protein hair and fingernails are made of. Baleen is a filter through which whales strain large quantities of water to capture prey in their mouth. There are four distinct methods used by different baleen whales, three of which will be simulated in this activity. The bowhead and right whales are skimmers: They swim through the water with their mouth open. They have no baleen at the tip of their mouth in front, so as they swim, water and prey move to the back of their mouth. The force of the flowing water, helped by the whale's tongue, pushes the water out through the baleen, but the prey gets stuck inside on the baleen.

The roqual whales (blue, humpback, fin, sei, minke and Bryde's) are gulpers: They have pleats in their throat that allow them to expand their throat and take in large amounts of water and prey. Gulpers then use their tongues to push the water out between the baleen plates. Both gulpers and skimmers use their tongue to aid in pushing the water out. Humpback whales are roqual whales and feed like gulpers. Humpbacks also feed as a group using a feeding method called bubble netting, hence the term bubblers. This method is most often used to catch small schooling fish, like sand lance. The whales' bubbles are bigger than the fish. By blowing a circle of bubbles (the net) in the water column, they herd fish into a concentrated ball. The whales then swim through fish with their mouths open, filling their pleated throat. Then they strain out the fish as gulpers do.

## **Further Background** (continued)

Gray whales use the gulper method when feeding on krill from the waters off Oregon. They also use the gulping strategy when they feed on benthic (bottom-dwelling) organisms in the polar waters off Alaska. They swim along the bottom, scooping sediments into their mouths, then squeeze out the mud through their baleen, keeping the organisms inside to swallow. This specialized feeding method can be seen in *The Gray Whale Obstacle Course* episode of ***Jean-Michel Cousteau Ocean Adventures***.

Odontocetes, such as sperm whales, dolphins (which include orcas), beluga whales and porpoises, use their teeth to capture and kill their prey. They basically either capture, bite, then swallow or capture, then shake off a chunk and swallow. In this activity, the biters will use the latter method. Some orcas are known to eat other marine mammals.

Some odontocetes have developed specialized feeding methods, stunning prey with their sonar or slapping the water with their tails. Others have developed methods of herding prey onto sloping beaches, then coming partly out of the water to eat the struggling prey. In beaked whales and narwals, the teeth are actually ornamental; in some beaked whales, the teeth never erupt from the jawbone.