CLASS ACTION WHALE

FOR THE TEACHER

Discipline
Biology

Themes
Evolution, Scale & Structure

Key Concept
Through 50 million years, whales have evolved from land mammals into mammals adapted for a completely aquatic existence.

Synopsis
Students learn to act out specific body parts of whales, then put the parts together to act out several behaviors and adaptations.

Science Process Skills
communicating, comparing, inferring

Social Skill
encouraging

Vocabulary

Cetacean	odontocete	mystecete
Rostrum	blowhole	pectoral flipper
Flukes	dorsal fin	peduncle
krill		

MATERIALS

For INTO the Activities:
• pictures from books or magazines of several land mammals
• slides, pictures, models or posters of whales
• pens and paper
For THROUGH the Activities
• a large picture or model of a blue whale
• pens and paper

INTRODUCTION

During the age of the dinosaurs, many groups of large reptiles lived in and exploited ocean resources. When the large reptiles left the scene, this niche was left vacant, and many groups of mammals began to return to the ocean to take advantage of this vast, untapped source of food. These groups were the ancestors of modern whales, dolphins, porpoises, seals, sea lions, walruses, sea otters, manatees, dugongs and polar bears.

Prevailing wind-driven oceanic currents cause localized, seasonal upwellings which result in productivity unmatched on land. This extreme productivity, over which there was little competition, allowed mammals to grow larger, in body size and population size, than would have been possible on land. The ocean, however, is a hostile environment for warm blooded, air breathing, live bearing mammals. Each group of mammals underwent, and continues to undergo, evolutionary changes which help them to survive better in the marine environment. Adaptation through natural selection has resulted in many changes in marine mammal body plans and behaviors. Marine mammals must have adaptations for: breathing air in a water environment; staying warm in cold water; swimming quickly and efficiently; capturing prey; migrating to find seasonally available food; fasting or changing their diet when that food is unavailable; nursing and giving care to offspring; avoiding predators; communicating underwater; sensing the environment when sight is not possible; and surviving without access to fresh water.

The ancestors of the Order Cetacea (whales, dolphins, porpoises) were small, horse or dog-like animals, which returned to the ocean 50-60 million years ago, long before the other marine mammal groups, and so, are the most highly adapted for life in the ocean. Their bodies have become long and fusiform or torpedo-shaped. Their nostrils have migrated from the front of their face to the top of their skull and now are referred to as a "blowhole." The upper jaw in baleen whales has become a long, flat and streamlined rostrum. Whales have a thick layer of blubber to insulate them against the cold, to protect them against shark and orca bites, and most importantly, to provide a storehouse of energy when food is not available. The pectoral flippers of whales are modified front legs. They have all the same bones as our arms, hands and digits. The

digits have become extremely long and covered with skin, and serve as paddles for steering. The hind limbs of whales have externally disappeared, but vestigal hind limbs still are present, floating in tissue near the pelvis. Tails have become extremely powerful, driven the peduncle, the world's strongest muscles, and have huge, horizontal "flukes" on the end. The tail and tail flukes are the whales' only means of locomotion.

Early on in their return to the ocean, the whales diverged into two distinct sub-orders, the Odontocetes (toothed whales) and the Mysticetes (baleen or "mustached" whales). Toothed whales include dolphins, porpoises, beaked whales, narwhals and belugas and sperm whales. They catch individual prey items, usually fish and squid, with their teeth. For this reason they are limited in the total amount of food they can eat at any one time. Though sperm whales and some beaked whales are exceptions, toothed whales as a group tend to be generally smaller than the baleen whales. Because toothed whales hunt individual prey, and because they are small enough to have several predators, they tend to be highly gregarious, having strong social bonds within groups, and highly advanced systems of communication. Toothed whales produce sounds in their nasal passages which are directed out through the fatty melon on their forehead in a narrow beam into the environment. These sounds bounce off of any object in the water and send an echo back which is received through the toothed whale's lower jaw. The echo vibrates oily fluid in the lower jaw which in turn vibrates inner ear bones just behind the hinge of the jaw. Using "echolocation" toothed whales can "hear a picture" of anything in front of them--prey, predators, rocks, boats or each other. The picture is quite detailed, providing much more information than our eyes ever could. Dolphins can "see" a one inch ball bearing at 200 meters. Not only can they see an outline of objects, but, to some degree, they can also see inside them, since sound will travel as well through an animals soft tissue as it does through the water, but then will bounce off of bones or other hard parts. Sound travels faster and further through water than air, and since light travels quite poorly through water, toothed whales rely primarily on their sense of hearing. Echolocation abilities are so advanced that many scientists believe that toothed whales not only have the capability of finding prey, but also of producing sounds so loud that they can actually stun or kill prey as well. Sound production and reception, and sophisticated communication require relatively large brains. Many toothed whales have larger brains in relation to body size than do humans, and sperm whales possess the largest brain in the history the animal kingdom.

Mysticetes have no teeth, but rather a long row of parellel plates of baleen hanging from the gums in their upper jaw, like the teeth of a comb. These plates are made of keratin, and the inner edge of each is frayed like the bristles of a broom while the outer edge of each is solid. The frayed edges line up side by side forming a brush around the inside perimeter of the whale's mouth. The whale can strain huge volumes of water through their mouth, trapping swarms

of plankton and schools of small fish in the brush of their baleen. This highly specialized adaptation allows the great whales to eat low on the food pyramid. Baleen whales graze the oceans much as wildebeests and elephants graze the Serengetti. This is a key to their evolutionary success since so much more energy is available at such a lesser cost at the lower trophic levels. Just as grasses are only seasonally available in the Serengetti, so are the great waves of productivity in the ocean. Baleen whales stereotypically undertake long annual migrations, a behavioral adaptation, from the high latitudes near the poles in the summer,to equatorial waters in the winter. With 24 hour sun contacting cold, nutrient rich water at the poles, productivity explodes in the summer, causing immense blooms of phyto- and zooplankton which support populations of fish, birds, whales and other marine life. As fall approaches, the days shorten and the ocean begins to freeze. The whales, sated and often carrying an extra foot or more thick layer of blubber, migrate to warmer climes to give birth and to mate. In some cases, whales find areas at temperate lattitudes, such as the coast of California, where significant productivity exists due to upwelling. In these cases,they need not make it all the way to a pole in the summer. Baleen whales, as a group, tend to be less social, have smaller brains and fewer predators than toothed whales.

INTO
THE ACTIVITIES

Silent Mingle

1. What are the characteristics of mammals?
2. What are some examples of mammals? Where do they live?
3. What are the strangest mammals you can think of? Why are they strange?
4. Why would it be difficult for a cow or a giraffe or a dog to live in the ocean?
5. Choose a land mammal. How would you need to change or "adapt" it to allow it to survive living in the ocean.

Think/Pair/Share

Have students take a seat with their final Silent Mingle partner, and look together at a picture of a land mammal. First, have them think silently, and jot down notes or drawings to answer the question, "How could you change or adapt the land mammal in your picture to live successfully in the ocean?" Now in pairs, have students discuss the changes needed, and make some labeled drawings of the same animal 50 million years after returning to life in the ocean. Have each pair join another pair to make a foursome. They can compare their results, then think generally about adaptations that any land mammal would need to survive in the ocean.

Class Brainstorm

Display all pairs' drawings. Then conduct a class brainstorm and record the categories of changes which any land mammal would have to make in order to be adapted to life in the ocean, e.g., adaptations for swimming, breathing,

moving fast, finding food, staying warm, caring for babies, avoiding predators, etc.

Now show a large picture of a whale to the whole class. Brainstorm what adaptations this mammal has for life in the ocean. Ask students what other marine mammals they know of.

Portfolio Assessment
• participation in Silent Mingle
• drawings from Think/Pair/Share

THROUGH THE ACTIVITIES

1. Show slides or give an illustrated lecture about various groups of marine mammals, and various species of whales. Show their adaptations which are different from land mammals. Discuss the process of adaptation by natural selection over millions and millions of years. Explain the differences between baleen and toothed whales.

2. Tell students to get ready to become a class action whale. Blue whales are the largest animals ever to live on Earth. They grow 80 feet long in the northern hemisphere and 100 feet in the southern hemisphere. Ask for student volunteers to act out the following blue whale parts one at a time:

ROSTRUM (2 students): Two students stand facing each other 2-3 feet apart. Have them put their right arms out to their sides and join right hands to make a point. Put their heads down to shoulder level to be streamlined. This is the large, flat upper jaw or rostrum. On a real blue whale it would be over 15 feet long. Show a rostrum in a picture or on a model.

LOWER JAW (2 students): One student kneels next to the right hip of each half of the rostrum, facing each other. They extend their right arms so that their right hands meet under the rostrum. They can curve their arms to make the lower jaw wider. Practice opening and closing the whale's mouth by having the lower jaw raise and lower their arms together. The lower jaw opens and closes--the rostrum remains stationary.

BLOWHOLES and BLOW (6 students): Baleen whales have two blowholes or nostrils, toothed whales also have two nostrils, but just one erupts at the surface of their head--we say they have only blowhole. Have the two trios cluster side by side a few feet behind the mouth. In each trio, one student will be the blow, or breath of the whale, and two will be the blowhole itself. Have the blow crouch between the sides of the blowhole which face each other,

kneeling, and joining arms around the blow. When the whale is diving underwater, the nostrils are in their relaxed position--shut tight. This prevents water from getting into the whale's nose. Both students at each blowhole should squeeze their arms close together over the head of the blow. When the whale surfaces to breathe, yell, "BLOW" or "THAR SHE BLOWS!" The arms of both blowholes open up wide, in unison, and the blow springs up to its feet, exhales hard and loud, sucks in as much air as it can and kneels back down quickly. The blowhole snaps shut. Try a sequence of 4-5 blows until both blowholes can time their breathing to be synchronous. A blue whale might blow 5 times in 3 or four minutes, then dive for 5-15 minutes while it is travelling or searching for food.

EYES (2 students): One student can stand facing out on each side of the mouth just behind the blowhole. The eyes stick out quite a ways from the side of the whale's head so that they can rotate forward and see ahead and to the side, and so that, when its jaws are open, the eyes can look directly inside its mouth.

PECTORAL FLIPPERS (4 students): Two students stand side by side, angling back from just behind the eyes on each side of the whale. They can hold their arms up and join hands. Their job is to balance the whale as it swims forward, and to steer it to the right and left when it wants to turn. When the whale turns to the left, the left flipper goes down, and the right flipper goes up high. When the whale turns right, just the opposite. The flippers may look small compared to the overall size and length of a blue whale, but each is over 10 feet long. Ten kids could sit side by side on each flipper. Have students practice turning right and left and balancing the whale.

DORSAL FIN (1student): Blue whales have a very small, sickle-shaped dorsal fin located three fourths of the way back down its back. The dorsal fin helps keep the whale righted in the water, like the skag on a surfboard. Have a student stand well behind the blowhole and pectoral flippers. S/he can stand facing back toward the flukes, bending over slightly to represent the falcate shape of the dorsal fin. When a blue whale surfaces to breathe, we see its blowhole first, then its long back rolls through the water, and finally the dorsal fin emerges well after the blowhole has disappeared back under water. This is diagnostic of blue whales--other whales show their dorsal fin at the same time as their blowhole. Have the student practice hunkering down underwater, then arching up out of the water after each blow.

PEDUNCLE (2 students): These muscles run the length of the whale's tail and attach to the flukes. The peduncle is the engine which drives the whale forward at speeds up to 25 knots--providing all its power for locomotion. It is the strongest group of muscles in the animal kingdom. Have the peduncles sit aft of the dorsal fin on either side of the spine, facing back toward the flukes with their legs stretched out in front of them. They sit at an angle to one

another so that their feet are together, but their bottoms are 2-3 feet apart--narrowing toward the flukes. Each student peduncle is attached to one of the tail flukes.

FLUKES (2 students with strong stomach muscles): Each fluke sits, legs out, facing the peduncle, also at an angle so that their bottoms are 4-5 feet apart, but their feet each touch the feet of the peduncle. When the peduncles push their feet synchronously forward, this is the powerful downstroke of the tail. Both the flukes now lay down on their backs. When the peduncles bend their ankles back, pulling back their toes, the flukes do a sit-up. Practice a few times until the peduncles can drive the flukes up and down in unison without talking.

FISH or KRILL (all remaining students): They can school or swarm in front of the whale. When the whale is at the end of its migration near a pole (or off Central California), it will do most of its feeding. It opens its mouth agape and swallows a whole school of fish at once. The fish can go into the whale's mouth and down into its stomach.

3. Now that everyone has learned their particular role, try to put the whole whale together. Call out each behavior as you choreograph the movements of the whale. Have it start migrating north from the equator, with the flukes beating, mouth closed, flippers balancing, etc. Have it turn to the right, then to the left. Have it come to the surface to breathe 5 or 6 times, the dorsal fin emerging above the surface each time, then deep diving. The whale can arrive in Alaska or Monterey or The Gulf of the Farallones, the eyes can see food, it opens its mouth, swallows fish, and swims on. Can the whale at lunge, mouth open, through a swarm of krill at the surface or breach (unusual for blue whales, but it happens)? Can two adults feed cooperatively, herding prey toward one another? Now that it's September, it's getting cold, so you should migrate south to Mexico. When you get there (if you are a female) you can give birth. Add a calf to swim along with its mom. The calf will need to nurse from the mom's teats on her underside back by the dorsal fin.

4. Have students return to their seats and take out some paper and pens. Have them draw some illustrations of blue whales. They can choose a particular part of the blue whale's migration to illustrate. They can highlight the part of the whale and the behavior which they acted out. Now they can write a story about a day in the life of a blue whale, focusing on particular adaptations.

BEYOND
THE ACTIVITIES

Whale Books
Have pairs of students each choose another whale, dolphin or porpoise to research. Go to the library, look for posters, videos, call or write experts, look for National Geographic articles. After students have had plenty of time to do independent research, ask them to write a story or report about their whale. It should focus on what group of whales it belongs in, what are its closest relatives, from what group of land animals did it evolve, and what are some of its special adaptations for surviving in the ocean, does it migrate or have a local home range, is it social or solitary. The story should be completely illustrated. Pairs can divide up the writing by category (e.g., one writes about ancient ancestors and evolution, the other about the whale as it is now; or one writes about the whale's life in winter, the other about summer). Then they can edit each others' work. These stories can be bound together in a class book, with each pair authoring a chapter.

Whale Charades
Divide the class into cooperative teams of about 10-12. Each team can choose a specific whale. They must now divide up and do as much research about this whale as possible, and come back together to discuss what they have learned.
Now they must decide on a method of acting out their whale, as they did with the blue whale. Can they choreograph a role play? They must decide what adaptations, body parts and behaviors are most important about their whale and focus on those. One student can be the director to assist the group in putting it all together.
Each group can perform their whale for the others, either as a charade or as a skit. Once the groups get good enough, you can take the class on the road and perform for other classes or even at an assembly.

Evolution My Way
Have each pair of students select and draw a picture of a specific LAND mammal--a goat, lion, horse, gorilla, gopher, deer, etc. Have them do just a little preliminary research so that they know some of the adaptations and habits of this mammal. Pretend that there is a long slow, natural change in our weather pattern that results in this mammal's food slowly disappearing. Some members of the species try to return to the seashore to look for food in the ocean, and just a few are successful. They survive to reproduce and pass on their successful traits to their offspring.

Now pretend that it is 10 million years and perhaps a million generations later. Natural selections has begun to change this species. Draw a new picture of the animal. How has it changed to become slightly more adapted to an oceanic lifestyle?

Make several drawings, each one 10 million years apart, until you have a highly specialized marine mammal, that can survive completely in the ocean without ever coming ashore. Write a description to go with each picture.