Deep Diving

activity TWO

Objective: Students will use the scientific method to investigate and understand two physical principles (bradycardia and myoglobin storage) involved in a dolphin's deep-diving adaptations.

In The Film: As we catch glimpses of the world of the dolphin, we see how incredibly well their species has adapted to a marine lifestyle. Watching their smooth bodies glide through the water, we forget these mammals breathe air like humans. They rise to the ocean surface often to gulp breaths of air. There are obvious physical adaptations that allow the dolphin to live entirely surrounded by water. Fin placement and body covering are only some of the adaptations that aid in it's survival. Internal organ adaptations are not evident on film but their benefits can be understood as the sleek mammals plunge to the ocean depths.

Materials: Per four students:
- Stop watches (use watches with second hands as alternatives)
- Copies of Dolphin Data Grid
- Pencils

Teacher Prep Notes: Students will take and record pulse rates. One way to take a pulse measurement is to lightly hold the right arm of another person. Gently grasp the arm by the wrist with the fingers. Place the tip of the middle finger over the artery located inside the wrist near the tendons that run along the center. Adjust the placement of the fingers along the wrist until the gentle throbbing of the pulse is felt. If there is a limited number of stop watches available, allow students to record a 15-second test and multiply the result by four to determine a one minute score.

Pulse rates can also be taken at the carotid artery. Locate the carotid artery at the front of the neck just below the jaw.

Students can use Data Grids provided or lay out their own to record data.

NOTE: To get an accurate pulse measurement, DO NOT use the thumb because its large blood vessels confuse pulse measurements.

Background: Like most marine mammals, dolphins have special adaptations that allow them to dive deep in the ocean and remain underwater for long periods of time. In fact, bottlenose dolphins are able to stay under water for eight minutes and can dive to depths of 1,640 feet (500 meters)! The dolphin's adaptations allow it to survive in a marine environment where the oxygen needed to exist is not accessible.

In order to live underwater, a dolphin's body must conserve oxygen for the duration of each long dive. One way oxygen is conserved is through a process called bradycardia, which slows the animal's heart rate. When the heart rate slows, the body uses less oxygen. During bradycardia, blood is also diverted to where it is most needed (heart, lungs and brain).

During a dive, the dolphin's blood is diverted to the heart, lungs and brain from the muscles. The animal is not in danger thanks to another adaptation that allows their muscles to use stored oxygen for energy. The dolphin's body has adapted to use myoglobin throughout the body when air from the surface is not available. Myoglobin is a protein, like hemoglobin, that assists in the storage of oxygen. Myoglobin can actually store as much as four times the number of oxygen atoms than hemoglobin. Because their muscles have adapted to retain high levels of this special protein, dolphins naturally store more oxygen in their muscles. Large amounts of myoglobin found in the muscles allow a dolphin to conserve oxygen from each breath and to survive long dives. Without the elevated levels of myogobin, a dolphin would have to wait after each deep dive until their muscles gathered more oxygen from the blood stream before they could dive again.

Relate this to how a human feels after a long swim or a deep dive. Compared to dolphins, humans have a low level of myoglobin in their muscles. The extreme fatigue felt after a rigorous underwater workout illustrates the need for oxygen. When we swim under water, we limit the amount of oxygen we breathe, and the amount of breaths we inhale (as with regulated breathing intervals). Our muscles become fatigued. When our muscles become fatigued they require even more oxygen rich blood to be pumped by the heart.

To Do: Divide students into groups of six. Give each group a copy of the Data Grid and a pencil. Make sure that one person in each group has a stopwatch. Discuss how the dolphin adaptations of bradycardia and the levels of myoglobin aid the animal. Explain that they will be performing a series of tests to illustrate the differences between humans and dolphins demonstrating how dolphin adaptations help them to survive long, deep dives.

1. Write the names of team members in the spaces provided on the grid. Measure the resting pulse rates (one-minute test) for each team member. Record results in the designated space on the grid. Resting pulse rates give a starting point for the tests in the investigations.
2. Team member pairs will now test and record pulse measurements after holding their breath for 15 seconds. One student in each pair will hold his or her breath while the other student measures their pulse. Multiply the 15-second test number by four to convert the pulse rate to beats-per-minute. Record the beats-per-minute in the appropriate space on the grid. Repeat the process so each student has data recorded in the grid. Discuss the findings of this activity. What did students experience? Discuss the benefits of having a slower heart rate.
3. Next, have team member pairs test and record how long they can continuously flex and extend their index finger. (Generally it takes about one to two minutes.) Have students record the length of time (minutes and seconds) it took for the finger to become immobile in the designated location on the grid.
4. Repeat the process for each remaining team member. Who could participate for the longest time with the flex/extension exercise? What did the students experience? Discuss the importance of myoglobin found in a dolphin's muscles.
5. Share results of group data sheets with other groups. Discuss the similarities and differences in the data collected.
6. Have students take another resting heart rate 30 to 60 seconds after they have completed the experiments listed above. How does the heart rate recorded at the beginning of the activity relate to records taken at the end?

What's Going On & Why? In this activity, when students hold their breath they simulate diving. Student findings for this portion of the activity will show that the pulse rate for humans increases when regular breathing does not occur. The heart rate will increase as the heart, brain and muscles demand more oxygen. In contrast, a dolphin's heart rate slows as it dives, conserving oxygen.

Key Words:

adaptation the modification of an organism or its parts that make it better fit for existence under the conditions of its environment.

bradycardia a term used to describe a heart rate that is slowing down.

myoglobin a muscle protein/pigment that carries oxygen. Myoglobin is known as muscle hemoglobin.

The part of the activity involving the finger movements illustrates what happens when oxygen is depleted from muscles. As the finger muscles flex, they use oxygen. As the amount of oxygen gets used up, the muscles no longer are able to function. If the test permitted a rest period between flexes, the muscles would have time to store oxygen needed; but when the flexing continues the amount quickly becomes depleted. This illustrates that humans have small amounts of myoglobin in their bodies. An average person could not make long dives under water without coming to the surface for air. A dolphin, however, can exercise its muscles for longer periods of time under water without fatigue, due to the amount of myoglobin present in their muscles.

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DATA GRID

name	resting pulse rate	pulse rate after holding breath