DOLPHIN RESEARCH CENTER
Dolphin Physiology-The Retia Mirabilia

Grade Level: 6th-8th

Objectives: Students will be able to explain how physiological adaptation allow dolphins to maintain a steady flow of blood to the brain despite the drastic increases and decreases in heart rate that occur while a dolphin is diving.

Florida Sunshine State Standards:
Science
SC.F.2.3.3 The student knows that generally organisms in a population live long enough to reproduce because they have certain survival characteristics.
Mathematics
MA.A.3.3.2 The student selects the appropriate operation to solve problems involving addition, subtraction, multiplication, and division of rational numbers, ratios, proportions, and percents, including the appropriate application of the algebraic order of operations.

National Standards:
Content Standard A (5-8) – Abilities Necessary to do Scientific Inquiry: Use mathematics in all aspects of scientific inquiry.
Content Standard C (5-8) – Diversity and Adaptations of Organisms: Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Background: Fluid physics is a branch of science that focuses on the movement of fluids. Scientists at NASA rely heavily on the study of fluid physics in order to make scientific advancements in space exploration and improve products designed for use on earth. An understanding of fluid physics helps geologists learn more about how magma moves underneath Earth's surface and how rivers carve out canyons here on the surface.

Key Terms

Retia mirabilia: A network of interwoven vessels found underneath a dolphin's ribcage in between the blowhole and the dorsal fin. These vessels help regulate blood flow to the dolphin's brain.

Living organisms are full of fluids, and biologists can use fluid physics to learn much more about these organisms. For example, an important fluid within the human body is blood. The human body contains an intricate series of blood vessels that are part of the circulatory system. The heart pumps blood into the lungs to be oxygenated. The oxygenated blood returns to the heart and is pumped into arteries, which carry the blood to tissues throughout the body. The

Dolphin Physiology-The Retia Mirabilia

oxygenated blood moves into capillaries, which have very thin walls. Oxygen, nutrients, and waste products are exchanged through the thin capillary walls. Once this has occurred, de-oxygenated blood moves into veins to be taken back to the heart. The blood will return to the lungs for re-oxygenation, and the process will repeat.

There are many things that can effect the movement of fluids through the body. The diameter of the blood vessels, the density of the liquid, and the rate of the heartbeat are just some of the factors that influence movement of fluids, and therefore our health. For example, it is essential for the brain to receive a regular supply of oxygen from the blood. The carotid arteries carry blood through the neck to the brain. (If you've ever taken your pulse in your neck, you've felt the carotid arteries at work!) If this flow of blood is disrupted, a stroke can occur. This is possible if materials build up in the arteries and narrow their diameter, or if the heart rate drops below the number of beats per minute needed to sustain the body. (This minimum number of beats per minute is known as the resting heart rate. While it varies from person to person, it is usually between 60 and 80 beats per minute.) Conversely, if excess blood is sent to the brain, swelling and other problems can occur.

In contrast to humans, dolphin bodies are built to withstand large drops in heart rate. When a dolphin dives, its heart rate drops as low as 12 beats per minute! Dolphins store large amounts of oxygen in their blood, and the decreased heart rate helps the dolphin conserve oxygen while submerging. When resurfacing, a dolphin's heartbeat can skyrocket to 120 beats per minute. A dolphin is able to handle the quick change in blood pressure because of a special adaptation called the retia mirabilia (pronounced "*reesha muh-rabola*"). The retia mirabilia is a tissue found underneath the ribcage, between the blowhole and dorsal fin area. It consists of a dense mass of blood vessels that acts like a sponge. The arteries in a dolphin feed into the retia mirabilia, rather than going directly to the brain. The diverted blood flow saturates the vessels within the retia mirabilia, like a sponge, when a dolphin's heart rate is high. The retia mirabilia then controls the flow of blood to the brain, maintaining a consistent flow no matter how much blood is contained in its vessels. The retia mirabilia acts as a buffer, protecting against a surge of blood during high blood pressure, and against a lack of blood flow during reduced heart rates. More information on the retia mirabilia and dolphin diving can be found in the ***Physiology*** information file.

Materials:

For each group:

- Two beakers (300mL or larger)
- Funnel (250mL or larger)
- Sponge
- Water
- Stopwatch

For each student:

- ***Dolphin Physiology–The Retia Mirabilia*** handout

Dolphin Physiology-The Retia Mirabilia

Teacher Prep Notes: Make copies of the ***Dolphin Physiology–The Retia Mirabilia*** handout for each student. Students will need to be divided into groups to complete the activity. Ensure that each group has all of the necessary materials.

Procedures:

1. Distribute the ***Dolphin Physiology–The Retia Mirabilia*** handout to each student. As a class, discuss the information presented in the introduction.
2. Divide students into groups and allow them time to complete the activity and conclusion questions.
3. Discuss student results and conclusions as a class. Students should notice that the sponge helps regulate the flow of blood to the brain. Human A has lots of blood pumping towards the brain (maybe a result of a high heart rate), and the students should have calculated a high rate of blood flow to the brain. Human B has less blood pumping towards the brain—result of a low heart rate—and the students should have calculated a much lower rate of blood flow to the brain than Human A. Dolphin A has a higher heart rate than Dolphin B, but the students should have calculated a similar rate of blood flow for both dolphins. This is a result of the sponge, representing the retia mirabilia, which absorbs the blood and maintains a steady flow of blood despite changes in heart rate.

Wrap Up: Ask students to complete an exit card on the way out of the room. On their cards, students should write one thing they learned during the activity and one question they still have about the retia mirabilia (or another aspect of dolphin physiology). Questions can be addressed during the next class period.

Taking it Further:

- Conduct research to find out if the retia mirabilia is unique to dolphins, or if it is present in other organisms as well. If other organisms do have a retia mirabilia, is it used for the same purpose?