

DOLPHIN RESEARCH CENTER

Temperature Regulation

Grade Level: 6th-8th

Objectives: Students will be able to explain how dolphins regulate body temperature by conducting a laboratory investigation.

Florida Sunshine State Standards:

Science

SC.F.1.3.1 The student understands that living things are composed of major systems that function in reproduction, growth, maintenance, and regulation.

SC.H.1.3.2 The student knows that the study of the events that led scientists to discoveries can provide information about the inquiry process and its effects.

National Science Education Standards:

Content Standard A (5-8) - Abilities Necessary to do Scientific Investigations:

Develop descriptions, explanations, predictions, and models using evidence; Think critically and logically to make the relationships between the evidence and explanations; Communicate scientific procedures and explanations.

Content Standard C (5-8) - Regulation and Behavior: Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required for survival.

Background: Animals can be classified into two groups according to the way they regulate their body temperature. Ectothermic animals (also referred to as poikilotherms, or cold-blooded animals) are animals whose body temperature varies with the external environment. Endothermic animals (also referred to as homiotherms, or warm-blooded animals) are animals whose body temperature is maintained by internal metabolic processes, and this body temperature is usually warmer than the external environment. Birds and mammals are the only organisms that are endothermic. Although these animals regulate body temperature internally, heat can be lost to the environment quite easily.

It is especially important for marine mammals to have adaptations allowing them to keep body heat from escaping because water draws heat away from the body much more quickly than air. Seals, sea lions, polar bears, and sea otters all have hair covering their bodies, and this acts as an insulator to help them keep warm. Dolphins and whales must remain streamlined, and hair would slow them down. Instead of hair, these cetaceans have two other adaptations that allow them to stay warm in their watery environment. A layer of

Key Terms

Endotherm: An organism whose body temperature varies with the external environment.

Ectotherm: An organism that generates heat to maintain its body temperature.

Insulator: A material that prevents heat loss.



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fat called blubber insulates the bodies of dolphins and whales. The thickness of this layer depends on the species and environment. A bowhead whale, living in cold arctic waters, can have a layer of blubber 20 inches thick! Dolphins have a layer of blubber that ranges from $\frac{3}{4}$ " to $1\frac{1}{4}$ " thick. In addition, dolphins utilize a process called counter-current heat exchange. A detailed description of this process is found in the **Physiology** information file and **Anatomy** diagram.

Materials:

For each group:

- Hot water, room temperature water, and ice water
- One plastic container or baking pan (to hold water)
- Two film canisters
- Two plastic cups
- One spoon
- Solid vegetable shortening
- Two thermometers

For each student:

- **Temperature Regulation** handout

Teacher Prep Notes: Students will need to be placed in cooperative learning groups for this lesson. Ensure that students will have access to both hot water and ice water during this activity. Make sure there is an example of each experiment set up at the front of the class so that you are able to model the procedures for the students. Copy the **Temperature Regulation** handout.

Procedures:

1. Discuss with students the different ways that animals can regulate body temperature. Some animals are ectothermic, and their body temperature varies with the external environment. For example, an ectothermic animal could warm itself by moving to a sunny area. Endothermic animals maintain their body at a constant temperature as a result of chemical processes occurring within the body.
2. Ask students if humans are ectothermic or endothermic. Facilitate discussion, guiding students to the conclusion that humans are endothermic. Share with students that although humans-and other mammals-are endothermic, they still need ways to make sure that too much heat is not lost to the environment.
3. Have the class brainstorm how a person might keep warm on a snowy winter day. Students may suggest ideas such as wearing warm clothes, huddling together, staying inside, or shivering. Explain to students that many of these options are not available to whales and dolphins in their marine environment.
4. Raise the question of heat loss in air versus heat loss in water. Humans live in air, while dolphins live in water. Is it possible that less heat is lost in water than in air? Have



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students discuss this in groups. Each student should record his/her hypothesis on the **Temperature Regulation** handout.

5. Have students test their hypotheses by following the directions for Part A on the handout.
6. Once the students have completed the conclusion questions for Part A, the class can discuss their conclusions. Students should see that heat is lost much more rapidly in water than in air. Therefore, cetaceans must have a VERY effective method of retaining body heat.
7. Fur is a very effective way of conserving heat. Why wouldn't cetaceans want hair? (To remain streamlined.) Ask students to share their ideas of alternative ways dolphins and whales could conserve body heat. Among some of the ideas shared should be the presence of a fat or blubber layer. Tell students that they will be collecting data to determine how effective blubber is as an insulator for endotherms that live in a marine environment.
8. Have each group complete the activity in Part B of the handout.
9. Have students share their observations from Part B of the handout. It should now be clear to students that blubber is a very effective insulator for dolphins and whales. However, the marine environment changes temperature with the seasons. Not only do dolphins and whales need a way to store heat in colder waters, but they also need a way to release heat during the hotter summer months. Ask students to share ideas about how this might be done.
10. Have students think of areas of their body that get cold very quickly (i.e. hands and other extremities). These areas do not have much fat, and heat is lost quickly. Dolphins do not have blubber in their pectoral fins, dorsal fins, and tail flukes, so these are good places for them to release heat in warmer water. Dolphins are able to cool themselves by increasing blood flow to the extremities. Conversely, dolphins are able to conserve body heat in colder water by reducing blood flow to these areas. Relate these concepts to the insulation activity—the cup of shortening showed how heat is retained in areas containing blubber, while the cup without shortening showed how heat can be released in areas not containing blubber. Also, discuss the concept of counter-current heat exchange. Find more information in the **Physiology** information file and **Anatomy** diagram.
11. This discussion of thermoregulation can be supplemented with a thermal image from a journal article listed in the resource section. The article includes a color image showing the large amounts of heat being released from the tail flukes in comparison to the peduncle area. Also, the video cited below includes a two-three minute clip on thermoregulation in dolphins. The clip can be found approximately 30 minutes into the video.

Wrap Up: Ask each student to complete an exit ticket before leaving the room. On the exit ticket, students should write one thing they learned during the class period and one thing about which they still have a question. These can be addressed in the next class period.



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Taking it Further:

- Students can experience the effectiveness of a blubber layer first-hand using additional vegetable shortening and latex gloves. Have each student put gloves on both hands, and then cover one hand with vegetable shortening. Students should then place an additional glove over the coated hand. By submerging both hands in ice water, students will see how fat is able to reduce heat loss.
- For some practice with graphing, have students graph the data they collected.
- Allow students to experiment with other insulators such as wool, cotton, newspaper, etc. and compare their effectiveness.
- Sea lions are marine mammals with lots of fur covering their bodies, and they spend part of their time on land. Have students research how these and other factors allow sea lions to regulate their body temperature.

Resources:

Video

- ***The Ultimate Guide: Dolphins***. The Discovery Channel, 1999.

Journal Article

Williams, T.M., Noren, D., Berry, P., Estes, J.A., Allison, C., and Kirtland, J. (1999) The diving physiology of bottlenose dolphins (*Tursiops truncatus*), III. Thermoregulation at depth. *Journal of Experimental Biology* 202: 2763-2769.

(The above article can be accessed at the following website:

<http://bio.research.ucsc.edu/people/williams/publications/index.htm#Dolphins>)

