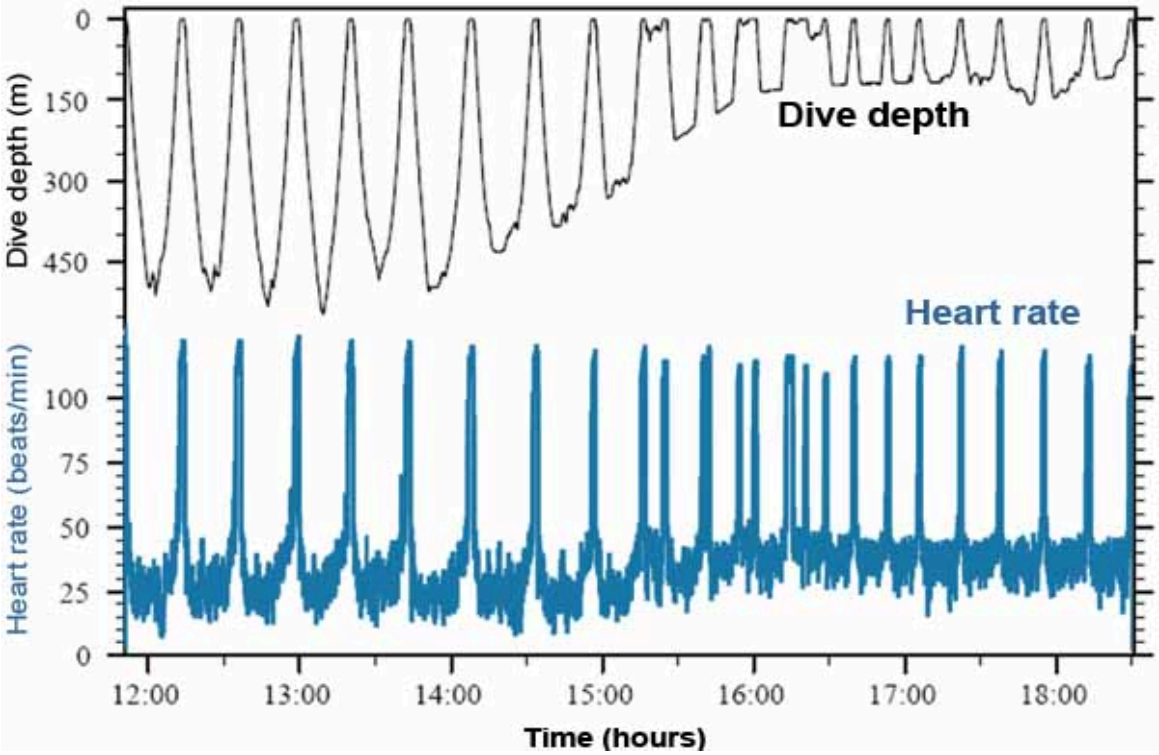
Name: _____

**Dive Response - Data Set 1**

The following graph shows how heart rate changes during diving in an elephant seal.

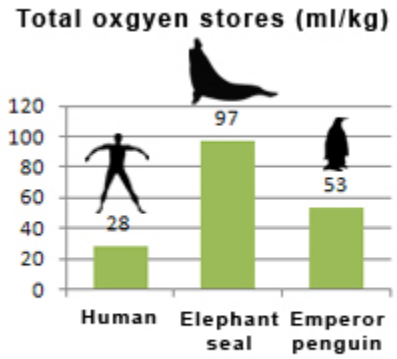



1. On the graph, what patterns do you see? Highlight/color code regions of the graph that show the patterns you see. Make sure to describe the patterns below.

2. Using Google Search, define mammalian diving response.

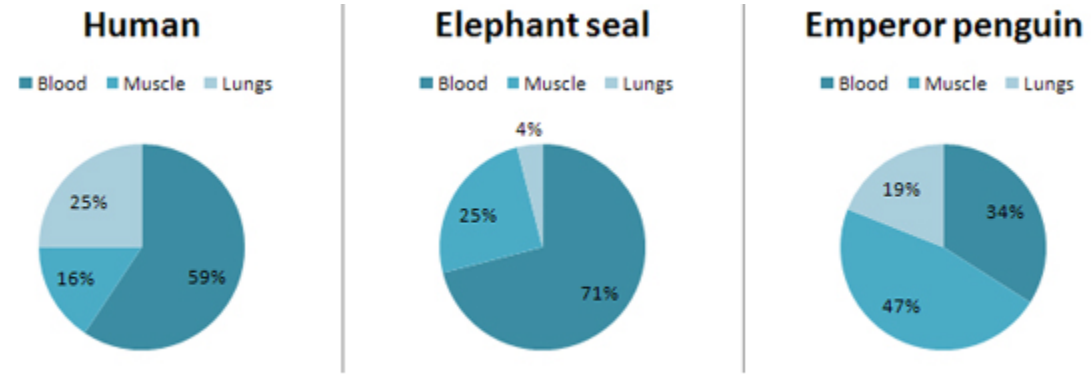
3. Predict why the trend noticed in the graph (from #1) is a homeostatic mechanism to conserve oxygen.

When an aquatic mammal begins to dive, it actually exhales and pushes oxygen out of its lungs. This decreases its buoyancy so it doesn't have to use any much energy to fight the tendency to rise to the surface. So, how can these animals stay underwater for so long if they aren't "holding their breath"?




**Comparison of total oxygen stores.**
Data sources - [43, 44, 45, 46].

**3X the oxygen concentration of humans** - Elephant seals carry more than three times the amount of oxygen for every unit of body mass relative to humans. But they don't store and carry it as a gas in their lungs. They store $O_2$ in blood and muscle by attaching it to special protein molecules called **globins**. Avoiding gas in their lungs prevents some problems such as decompression sickness.




**Comparison of stored oxygen distribution.**
Data sources - [43, 44, 45, 46].

4. Compare the <u>total oxygen stores (explained in the first graph)</u> as well as **where** the three animals (2 mammals and 1 bird) **store their oxygen (explained in the second graph)**.

5. What major process requires oxygen? _____
    a. What molecule does this process create? _____
    b. What is the molecule from 5a used for?

6. What process does oxygen use to move from the atmosphere (or water) into the cells of each organism? _____

Name: _____

**Dive Response - Data Set 2**

**How do aquatic animals hold their breath for so long?**

Oxygen allows animals to use metabolic processes such as cellular respiration to provide energy for cells, and therefore to the entire body. In order for life to continue, then, oxygen must always be available. When organisms start running low on oxygen, they can switch to anaerobic respiration but much less energy is available and fatigue sets in. So, how is it that aquatic, air-breathing mammals can spend so much time underwater without coming up for air?

Comparison of dive statistics for air-breathing animals.

| Species | Maximum depth (meters) | Maximum duration (minutes) | Total oxygen stores (ml/kg> | Hemoglobin (g/dl) | Myoglobin (g/100g) | Blood volume (ml/kg) |
|---|---|---|---|---|---|---|
| **Humans** *Homo sapiens* | 214 | 9[1] | 28 (20 | 14.5 | 0.3-0.4 | 70 |
| **Leatherback turtle** *Dermochelys coriacea* | 1230 | 67.3 | 27 | 15.6 | 4.9 | 77 |
| **Bottlenose dolphin** *Tursiops truncatus* | 390 | 8 | 36 | 14 | 3.3 | 71 |
| **Emperor penguin** *Aptenodytes forsteri* | 564 | 23.1 | 53 | 18 | 6.4 | 100 |
| **Northern elephant seal** *Mirounga angustirostris* | 1,581 | 119 | 97 | 25 | 6.5 | 250 |
| **Beaked whale** *Ziphius cavirostris* | 1,888 | 85 | unknown | unknown | 4.3 | unknown |
| **Sperm Whale** *Physeter macrocephalus* | 2,250 | 138 | 77 | 22 | 5.0 | 200 |

1. What patterns do you see in the data above? Try to come up with 2-3 patterns to write about.

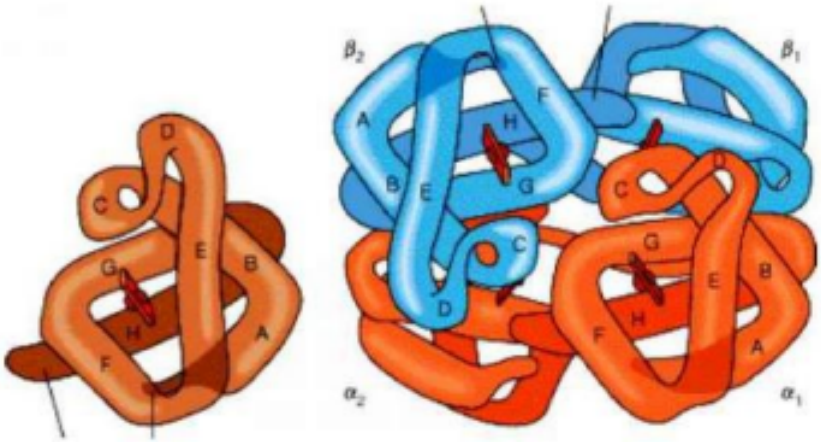
2. What factor(s) seem to influence the dive depth and dive time of the organisms? How can you tell?

3. What factor(s) are the most significant in how long an animal can stay under water? Why do you think that?

4. Predict the function (what does it do?) of hemoglobin.

5. Predict the function of myoglobin.

The figure below shows models of myoglobin and hemoglobin side by side. **The rectangles in the middle of each substructure is a "heme" group. Each heme group contains an iron atom that can bind one molecule of oxygen.** The prefix "myo-" means "muscle" in Greek. The prefix "hemo- " means "blood" in Greek.




6. Where would you expect myoglobin to be found in the body? _____

7. Where would you expect hemoglobin to be found in the body? _____

8. How many oxygen molecules are carried by myoglobin? _____

9. How many oxygen molecules are carried by hemoglobin? _____

10. Why would **<u>blood volume</u>** play an important role in how long an organism can stay underwater?

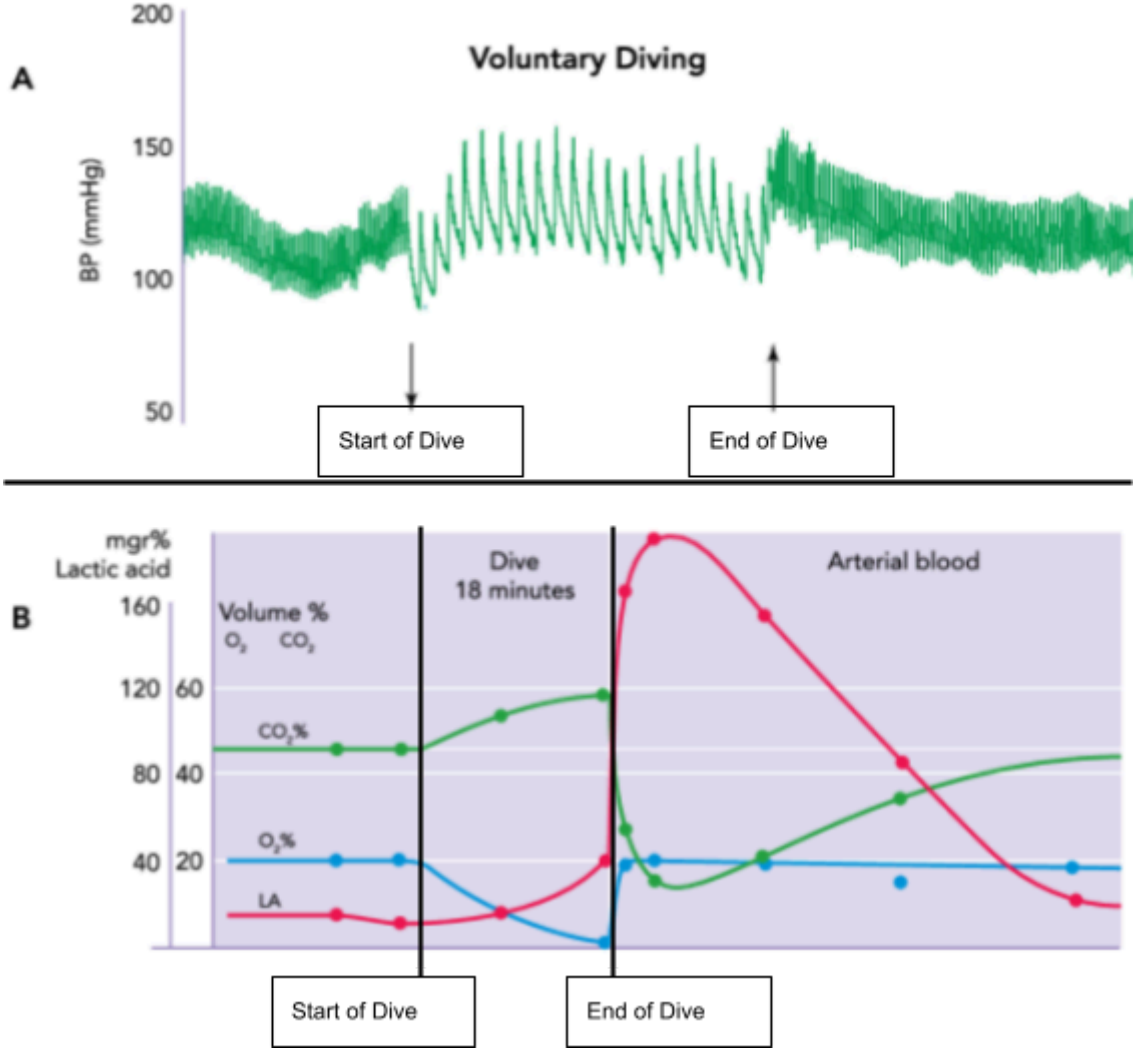
11. Fill out the following table using the data in the data table on the first page. The three shaded boxes do not have data in the table on the first page **BUT you are to estimate the numbers based on what you see with the other three organisms.** Think about who the beaked whale is most similar to?

| | **Human** | **Elephant Seal** | **Emperor Penguin** | **Beaked Whale** |
|---|---|---|---|---|
| **Maximum Dive Duration** | | | | |
| **Total Oxygen Stores (ml/kg)** | | | | |
| **Hemoglobin (g/dl)** | | | | |
| **Myoglobin (g/100g)** | | | | |
| **Blood Volume (ml/kg)** | | | | |

Name: _____

**Dive Response - Data Set 3**

Graph A shows the change in blood pressure before, during, and after a dive. Graph B shows the amount of oxygen, carbon dioxide, and lactic acid before, during, and after a dive.




1. Based on Graph A, did blood pressure return to normal immediately after the 18-minute dive? How do you know?

2. Look up and define lactic acid.

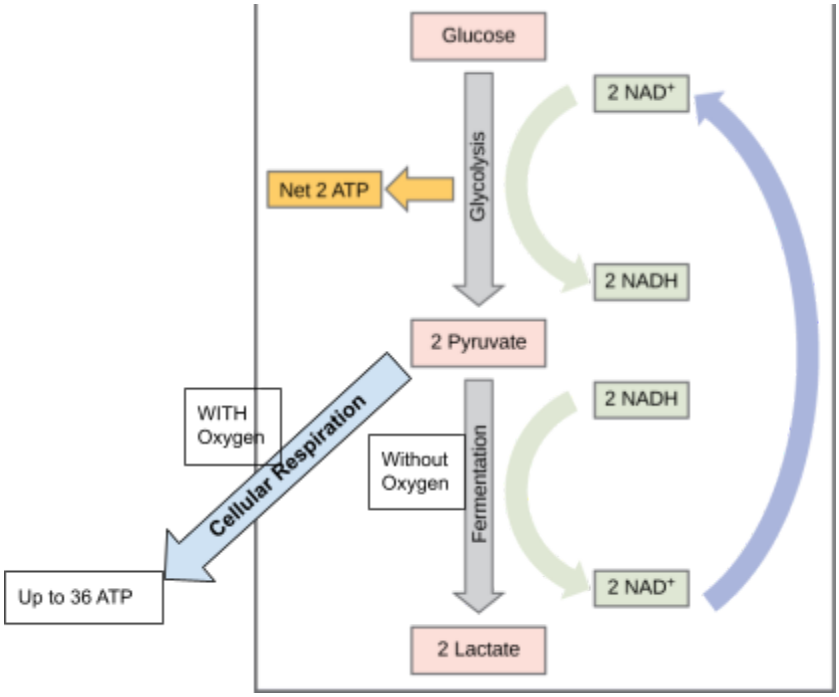
3. Based on Graph B, when would lactic acid be produced?

4. What happens to the lactic acid once the organism resurfaces?

5. Why is the $CO_2$ level going down after the organism resurfaces?

| Based on Graph B,describe the relationship between the following variables: | |
|---|---|
| $O_2$ and $CO_2$ | |
| $CO_2$ and Lactic Acid | |
| $O_2$ and Lactic Acid | |

Take a few minutes to analyze the flow chart below. Cellular Respiration is the process of using glucose to make energy when oxygen is available to the cells. BUT when oxygen is depleted in cells, animals must go through a process called fermentation to continue to make ATP.




6. What is the TOTAL number of ATP molecules produced from cellular respiration (start from the glucose molecule and follow the flow chart to the end of CR)? _____

7. What is the TOTAL number of ATP molecules produced from fermentation? _____

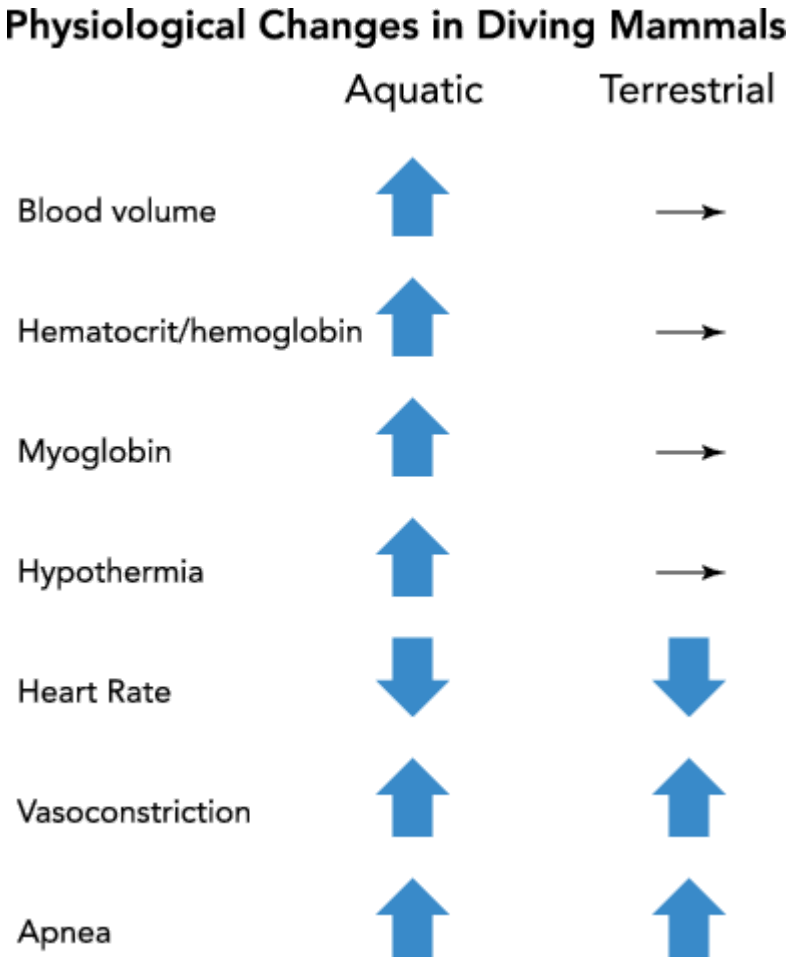
8. Which process - cellular respiration or fermentation - would result in a greater amount of glucose breakdown? WHY?

9. Which process - cellular respiration or fermentation - is more beneficial to an organism? Why?

Name: _____

**Dive Response - Data Set 4**

Compare the physiological changes in aquatic and terrestrial diving mammals.




1. What variables of the dive response are exactly the same between aquatic and terrestrial mammals?

2. **Predict why** an aquatic mammal would need to increase its blood volume during a dive?

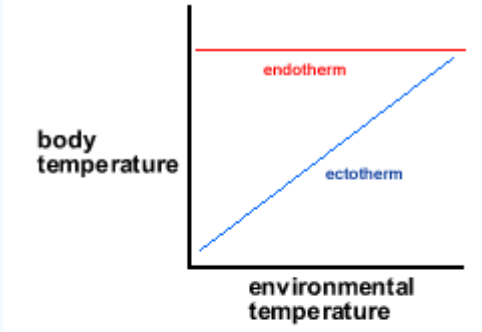
3. **Predict why** an aquatic mammal would need to increase both hemoglobin and myoglobin during a dive?

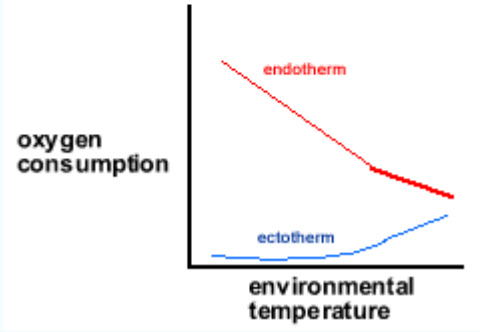
4. How would an increase in hypothermia be beneficial to aquatic mammals during a dive? (You may need to research this)

5. Explain the following statement in reference to the diagram provided above: “The mammalian diving response is a remarkable behavior that overrides basic homeostatic reflexes.”

Name: _____

**Dive Response - Data Set 5**



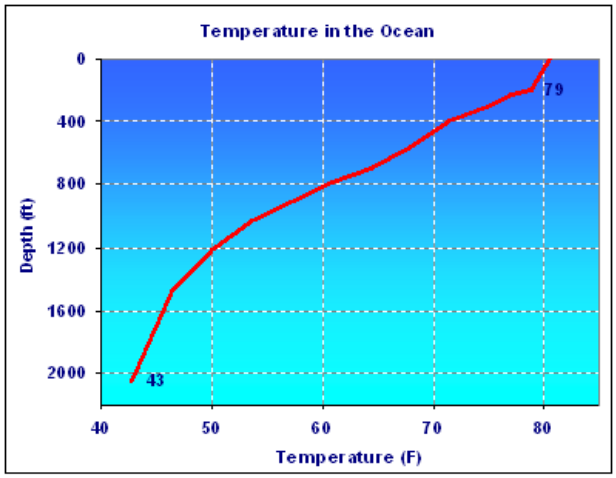

There are two ways that different types of animals control their body temperature, or thermoregulate: **ectothermy ("cold-bloodedness")** where the organism doesn't spend any of its energy on maintaining its body temperature, and **endothermy ("warm-bloodedness")** where the organism uses some of its energy to keep its body temperature constant. Birds and mammals, including humans, are endotherms. Sea urchins are an example of an ectotherm.

1. Explain the difference in the reaction to environmental temperature between endotherms and ectotherms.

2. Oxygen consumption is an indirect measure of metabolic rate. Explain what the graphs above tell you about metabolic rate in endotherms and ectotherms in different temperatures.

3. How did you come to this conclusion in #2? Cite specific evidence from the graphs.

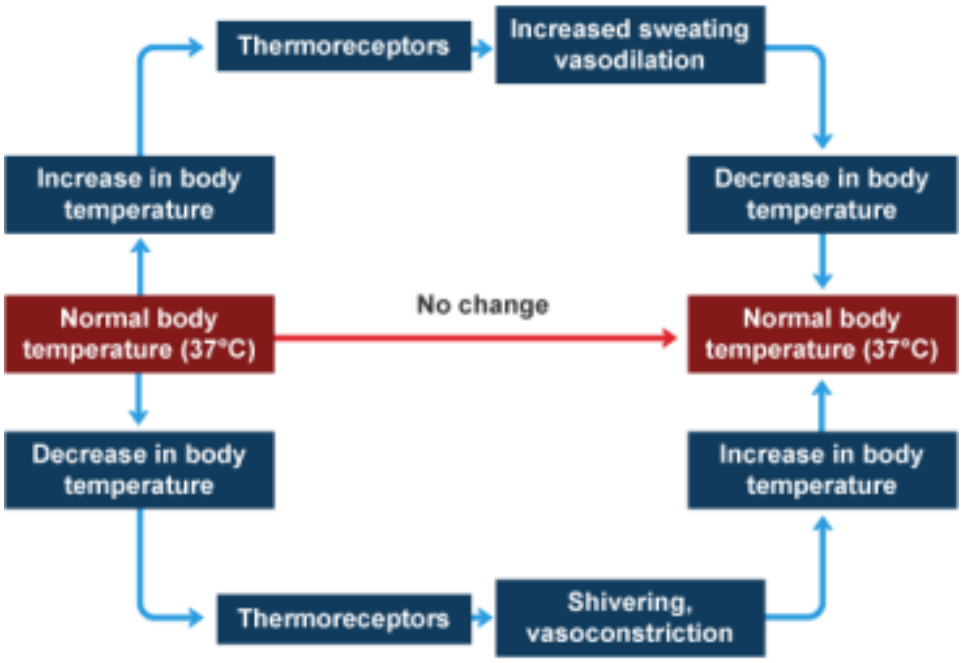
4. What is the relationship between depth and temperature of the ocean water in the following figure?



Name: _____

**Dive Response - Data Set 6**

**Thermoregulation** is a mechanism by which mammals maintain body temperature with tightly controlled self-regulation independent of external temperatures. **Vasoconstriction** and **vasodilation** are opposite reactions and refer to the diameter of the blood vessels. In **vasoconstriction**, the diameter gets **smaller** so that less blood can flow through the vessels. In **vasodilation**, the diameter gets **larger** so that more blood can flow through the vessels.




1. Based on what you see, how does the body return you to normal temperature if you are cold?

2. Based on what you see, how does the body return you to normal temperature if you are hot? ‘

3. Explain how the diagram relates to homeostasis in humans and other mammals.

4. Vasodilation and vasoconstriction do not occur equally throughout the body. If you are cold, where in the body would it be an advantage to have vasoconstriction occur? Why?

5. If you are cold, where in the body would it be an advantage to have vasodilation occur? Why?

6. Dogs, cats, and birds, for example, don’t sweat. How do they compensate when temperatures rise?

7. Aquatic mammals don’t sweat either. They are usually swimming in water that is much colder than their body temperature. What are some adaptations they have to help them control their body temperature in cold waters?