HOMEOSTASIS

Background

The human body is exquisitely sensitive to fluctuations in temperature. As a result, in spite of exposure to dynamic temperature shifts in one's surroundings, the core body temperature remains at approximately 98.6 °F. This condition of maintaining a stabilized internal temperature is known as homeostasis (*homeo*, "similar" and *stasis*, "standing still"- hence, standing at the same temperature). Warm-blooded animals exert diverse strategies for keeping body temperature at a specific set point. These mechanisms are collectively referred to as thermoregulation.

The brain and nervous system play an important role in the body's response to external stimuli and or other events that change internal conditions in some way. The hypothalamus is the integrating center for thermoregulation, as it receives information about the external environment, interprets that information, and responds to changes by sending signals to multiple organ systems. For example, the hypothalamus may send signals that adjust blood flow to compensate for changes in the body's core temperature: vasodilation (widening of the vessels) increases the surface area available for heat to be released; and vasoconstriction reduces the surface area for heat loss. In addition, sweating cools the body, while shivering generates warmth.

In this lab you will analyze the body's response to a cold stimulus using a temperature probe to measure the surface temperature of the skin, then relate the results to thermoregulation.

Driving Question

What happens to the temperature of the hands when exposed to a significant drop in external temperature? Is the process of thermoregulation observable and reproducible?

Materials and Equipment

Use the following materials to complete the initial investigation. For conducting an experiment of your own design, check with your teacher to see what materials and equipment are available.

- PASCO Temperature Sensor
- Large shallow bowl or pan[1] (for submerging a hand in ice water)
- Ice
- Water
- Dry paper towels
- Standard alcohol thermometer

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.
- If you experience severe discomfort, you should remove your hand from the ice bath. While there will be some discomfort, most students can tolerate the cold water for 40 seconds without issue.
- Never submerge their hand in ice water for more than 60 seconds. The risk of frostbite is minimal, but prolonged numbness in the hand could occur if left in the ice bath for too long.
- If you design an experiment requiring the use of gloves, use non-latex gloves to eliminate any risk posed from allergies to latex gloves.

Initial Investigation

Complete the following investigation before designing and conducting your own experiment. Record all observations, data, explanations, and answers in your lab notebook.

1. Put on your safety goggles.

2. Connect the Temperature Sensor. Open the Homeostasis lab file from the experiments menu in SPARKvue under High School > Advanced Biology

   If the configuration file is not available, set up a table of time and temperature and collect data every 10 sec.

3. Prepare ice bath by filling a shallow bowl or pan with water to a depth of approximately 3 cm, then add ice. Test the water height, as it needs to cover the knuckles. After 5 min, the temperature should be between 4 °C and 8 °C for data collection (add or remove ice as needed). Use a standard alcohol thermometer to confirm the temperature.

4. Determine which student in the group will be the *test subject*. Prepare the test subject for data collection by explaining the procedure fully. Have the test subject sit comfortably in a chair, relaxed with both hands resting on the surface of the table or lab bench.

5. Establish the baseline temperature of each hand to serve as the control. Place the metal probe on the palm of hand with fingers wrapped closely around the metal. Record the temperature for 3 minutes. Restore the probe to room temperature by running it under tepid water. Dry the probe completely. Switch to the left hand and repeat. What factors determine the accuracy of the temperature reading?

Control	Temp (degrees C) after 3 minutes
Right hand	
Left hand	

6. Follow the sequence of steps outlined in the table below. Begin with the 1st immersion of the experimental (right) hand for 40 seconds in the ice bath with the knuckles completely covered by water. At the same time, start recording the temperature such that the probe is capturing room temperature.

   NOTE: It is expected that the test subject will experience discomfort. However, if the cold becomes too painful, the subject may withdraw their hand and continue with the next step.

Time	Step
0 – 0:40 min	1st ice water immersion with experimental (right) hand
0:40 - 1:00 min	Dry hand
1:00 – 2:00 min	1-minute recovery period
2:00 – 2:40 min	2nd ice water immersion with opposite (left) hand
2:40 – 3:00 min	Dry hand
3:00 – 6:00 min	3-minute recovery period
6:00 – 9:00 min	Switch probe to opposite (left) hand for 3 minutes

7. Dry off the hand quickly and thoroughly (requires 10-20 sec). Then record the temperature of the hand for 60 seconds.

8. Immerse the experimental hand a second time into the ice bath for another 40-second period. Afterwards, dry off the hand quickly and thoroughly (10-20 sec). What is the purpose of a second ice water immersion?

9. Record the hand temperature for a 3-minute recovery period.

10. Switch the temperature probe now to the opposite (left) hand and measure for an additional 3 minutes.

11. Analyze the temperature profile for observable trends. Calculate the rate of change in temperature for every 20-second interval. Average the values across multiple trials.

Time (sec)	Step	Average temp (n=)	Average rate of change (n=)
0 20 40	1st immersion dry hand		
60 80 100	1-min recovery		
120 140 160	2nd immersion dry hand		
180 200 220 240 260 280 300 320 340	3-min recovery		
360 380 400 420 440 460 480 500 520 540	opposite hand/ 3minutes		

12. How did the baseline temperature readings compare between the right hand and the left hand?

13. Did the hand temperature differ following the first immersion and the second immersion in ice water?

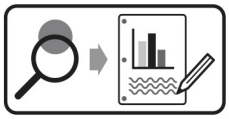
13. Did the temperature of the experimental (right) hand recover to the baseline control temperature following the 3-minute recovery period? Explain the temperature profile during the 3-minute recovery period.

14. What was the maximum rate of change in temperature of the experimental (right) hand over the course of the 3-minute recovery period? How did the rate of change compare to that of the opposite (left) hand?

15. Did the temperature of the opposite (left) hand recover to the baseline control temperature?

Design and Conduct an Experiment

In addition to temperature, other parameters are carefully regulated within the body, such as blood pressure and heart rate. The hypothalamus plays an important role in maintaining homeostasis for all of these parameters. Consider additional variables to test related to thermoregulation, or plan and carry out an experiment to investigate homeostasis with regards to other physiological parameters.



Design and carry out your experiment using either the Design and Conduct an Experiment Worksheet or the Experiment Design Plan. Then complete the Data Analysis and Synthesis Questions.

Design and Conduct an Experiment: Data Analysis

1. From your observations and your data:

   a. Describe how the independent variable you manipulated affected the dependent variable of your experiment. Does the data support your hypothesis? Justify your claim with evidence from your experiment.

   b. Based on the evidence you collected, explain why the results occurred.

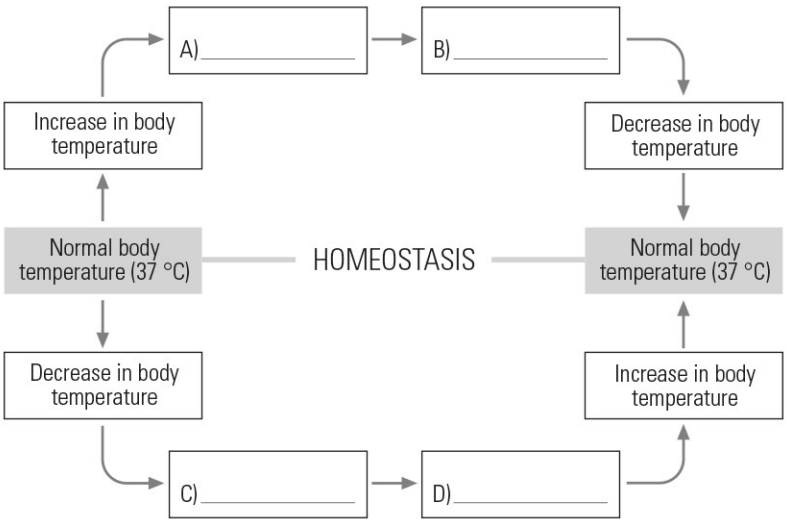
2. Is there any evidence in your data or from your observations that experimental error or other uncontrolled variables affected your results? If yes, is the data reliable enough to determine if your hypothesis was supported?

3. Identify any new questions that have arisen as a result of your research.

Synthesis Questions

1. If someone is exposed to cold weather for extended periods of time, where are they most likely to get frostbite? Use the results of the Initial Investigation to support your answer.

2. Below is a diagram of thermoregulation in the human body. The body detects a change from normal body temperature and responds to maintain homeostasis. Copy and complete the diagram by identifying A, B, C, and D. In other words, what responses can help bring body temperature back to normal?



3. The nervous system plays a critical role in maintaining homeostasis for an organism. The system detects external stimuli, transmits and integrates information about the stimuli, and produces one or more responses.

   a. Describe the basic structure of the neurons that compose the nervous system and explain how neurons detect stimuli and transmit information to various parts of the body.

   b. Draw a diagram to illustrate the connection between the following structures during the body's response to a cold stimulus: hypothalamus, efferent and afferent nerves, smooth muscles that surround arteries, and thermoreceptors.

   c. Vasoconstriction occurs when the smooth muscles surrounding arteries contract. How do nerves cause muscle contraction?

4. Vertebrates have evolved a variety of strategies to deal with thermoregulation: the ability to maintain homeostasis with regard to body temperature.

   a. Ectothermy and endothermy are two different approaches to thermoregulation. Define each approach and describe the benefits and costs associated with each one.

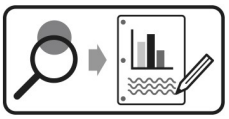
   b. Mammals are endotherms and have evolved a wide variety of adaptations to deal with the different challenges to thermoregulation in the world's biomes. Identify three biomes with distinctly different climates. For each biome, name a mammal that lives there and list at least two adaptations each mammal has that relate to thermoregulation.

   c. Smaller mammals have higher basal metabolic rates (BMR) than larger mammals. Explain the relationship between body size, BMR, and thermoregulation.

NAME PERIOD DATE

Design and Conduct an Experiment Worksheet

In addition to temperature, other parameters are carefully regulated within the body, such as blood pressure and heart rate. The hypothalamus plays an important role in maintaining homeostasis for all of these parameters. Consider additional variables to test related to thermoregulation, or plan and carry out an experiment to investigate homeostasis with regards to other physiological parameters.



Develop and conduct your experiment using the following guide.

1. Based on your knowledge of homeostasis, what environmental factors (abiotic or biotic) could affect homeostasis in the human body?

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2. Create a driving question: choose one of the factors you've identified that can be controlled in the lab and develop a testable question for your experiment.

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3. What is the justification for your question? That is, why is it biologically significant, relevant, or interesting?

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4. What will be the independent variable of the experiment? Describe how this variable will be manipulated in your experiment.

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5. What is the dependent variable of the experiment? Describe how the data will be collected and processed in the experiment.

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6. Write a testable hypothesis (If…then…).

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7. What conditions will need to be held constant in the experiment? Quantify these values where possible.

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8. How many trials will be run for each experimental group? Justify your choice.

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9. What will you compare or calculate? What analysis will you perform to evaluate your results and hypothesis?

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10. Describe at least 3 potential sources of error that could affect the accuracy or reliability of data.

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11. Use the space below to create an outline of the experiment. In your lab notebook, write the steps for the procedure of the lab. (Another student or group should be able to repeat the procedure and obtain similar results.)

12. Have your teacher approve your answers to these questions and your plan before beginning the experiment.