Name *Period* *Date*

Regulation of Body Heat

Driving Questions

Do environmental conditions affect skin temperature?

Background

Your body produces metabolic heat as a byproduct of every reaction that occurs inside you. The more active you are, the more heat your body produces. Your body must regulate the heat generated by metabolic reactions to maintain your internal temperature. Your internal (core) temperature must remain relatively constant because your enzymes work best at 37 ˚C. Your body is constantly monitoring and adjusting its processes to maintain relatively stable and constant internal conditions. This state is called homeostasis.

An organism's ability to maintain its body temperature within tolerable limits is known as thermoregulation. Some animals, including most mammals and birds, are endothermic. They regulate body temperatures internally. It is similar to a thermostat regulating the heat that keeps the temperature in a house comfortable. The biological thermostat of endotherms keeps body temperature within a normal range. When body temperature changes, receptors sense the change and trigger an adjustment. To maintain correct body temperature, mammals must be able to produce and conserve body heat in colder temperatures. Also, they must dissipate excess body heat in warmer temperatures.

The mechanisms mammals have for producing heat include shivering, cellular metabolism, and circulatory adaptations. Shivering generates heat as muscles quickly contract and shake. Cellular metabolism releases heat and warms the body from the chemical breakdown process that occurs within cells. Circulatory adaptations, such as countercurrent heat exchange, transfer heat from the core of the animal's body to the periphery by specially designed blood flow paths. From the core, warmer blood flows to colder extremities. This moderates the temperature, for instance, to an exposed arm or leg.

Animals that regulate temperature within a given range are described as endotherms. "Warm-blooded" is the more familiar term. Mammals and birds are endothermic because they maintain a relatively constant inner body temperature. The temperature of cold-blooded animals varies according to the temperature of the environment. The scientific term used to describe "cold-blooded" is ectotherm.

In humans and other mammals, temperature regulation represents the balance between heat production from metabolic sources and heat loss for a variety of reasons. Evaporation (perspiration) as well as radiation, convection, and conduction, all cause heat loss. In a cold environment, body heat is conserved first by constriction of blood vessels near the body surface and later by waves of muscle contractions, or shivering, which serve to increase metabolism. Shivering can result in a maximum five-fold increase in metabolism.

Materials and Equipment

For each student or group:

- Data collection system
- Temperature probe (2)
- Large bowl (or similar container)
- Fan
- Glove or mitten
- Tape or adhesive covers
- Ice, crushed or cube, 1 L
- Water, 1 L
- Towel (several)

Safety

Add these important safety precautions to your normal laboratory procedures:

- If the ice water causes discomfort or pain, stop data collection.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

Analyze collected data.	Attach a temperature probe to the back of a hand.	First, measure skin temperature in still air.	Next, record skin temperature in moving air, in a glove, and in ice water.	Display Temperature versus Time on a graph in the data collection system.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Note: When you see the symbol "◆" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Set Up

1. ☐ Start a new experiment on the data collection system. ◆(1.2)

2. ☐ Connect a temperature probe into a port on the data collection system. ◆(2.1)

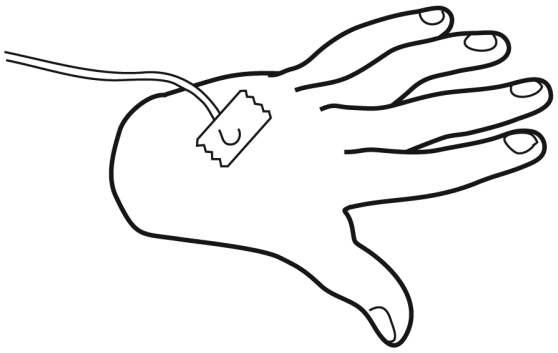
3. ☐ Connect a second temperature probe into a second port. ◆(2.2)

4. ☐ Display Temperature (˚C) on the y-axis versus Time in seconds (s) on the x-axis of a graph. ◆(7.1.1)

5. ☐ Obtain a large bowl or similar container. It will be used later to hold ice water.

6. ☐ Use tape or adhesive covers to fasten the temperature probe so the tip of the probe is on the back side of your hand.

7. ☐ Fasten the other temperature probe in the same way to the back of the other hand.



Note: Variables will be introduced on one hand. Conditions for the other hand will be kept the same.

Part 1 – In still air

Collect Data

8. ☐ Start data recording. ◆(6.2)

9. ☐ Adjust the scale of the graph to show all data. ◆(7.1.2)

10. ☐ Remind the person being measured to sit, relax, and not look at the data as it is recorded.

11. ☐ Why do you think that it is necessary to sit still?

_____

_____

12. ☐ Stop data recording after 6 minutes. ◆(6.2)

13. ☐ Name data run 1, "Still air". ◆(8.2)

14. ☐ What is the skin temperature of your hand in still air?

_____

_____

15. ☐ Why is the temperature recorded for still air called the "control"?

_____

_____

Part 2 – In moving air

Collect Data

16. ☐ Place a fan so that it will blow air across the right hand and *not* blow across the left hand.

17. ☐ Turn on the fan.

18. ☐ Remind the person being measured to sit, relax, and not look at the data as it is recorded.

19. ☐ Start data recording. ◆(6.2) Adjust the scale of the graph to show all data. ◆(7.1.2)

20. ☐ Turn off the fan after 2 minutes.

21. ☐ Continue recording data for 4 more minutes.

22. ☐ Stop data recording. ◆(6.2)

23. ☐ Name data run 2, "Moving air". ◆(8.2)

24. ☐ How does the skin temperature in moving air compare with the temperature in still air?

_____

_____

25. ☐ Allow 5 minutes for the hand to return to normal temperature.

Part 3 – In a glove or mitten

Collect Data

26. ☐ Place a glove or mitten on the right hand.

27. ☐ Why is a glove or mitten used?

_____

_____

28. ☐ Remind the person being measured to sit, relax, and not look at the data as it is recorded.

29. ☐ Start data recording. ◆(6.2) Adjust the scale of the graph to show all data. ◆(7.1.2)

30. ☐ Remove the glove or mitten after 2 minutes.

31. ☐ Continue recording data for 4 more minutes.

32. ☐ Stop data recording. ◆(6.2)

33. ☐ Name data run 3, "Glove" or "Mitten". ◆(8.2)

34. ☐ How does the skin temperature in the glove or mitten compare with the temperature in still air?

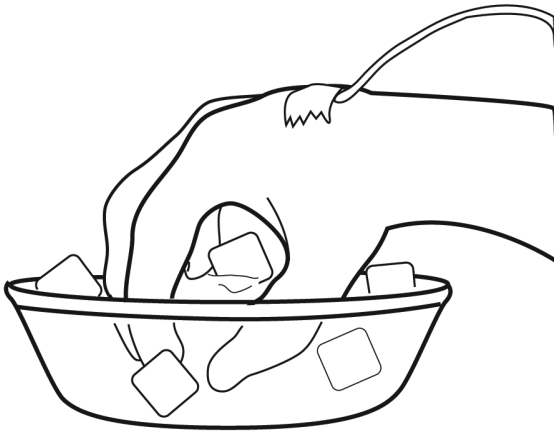
_____

_____

35. ☐ Allow 5 minutes for the hand to return to normal temperature.

Part 4 – In ice water

Collect Data



36. ☐ Put ice and water into a large bowl or similar container. Leave enough room in the container so that you can put your hand into the ice water, as instructed, without causing any to spill.

37. ☐ Place the right hand so that the palm and fingers are completely in the ice water, *leaving the back of hand and the probe above water.*

38. ☐ Start data recording. (6.2) Adjust the scale of the graph to show all data. (7.1.2)

39. ☐ Remind the person being measured to sit, relax, and not look at the data as it is recorded.

40. ☐ Remove the hand from the ice water after 2 minutes.

Note: Tell the subject that it is OK to remove the hand from the ice water before two minutes if it is too uncomfortable.

41. ☐ Continue recording data for 4 more minutes.

42. ☐ Stop data recording. (6.2)

43. ☐ Name data run 4, "Ice water". (8.2)

44. ☐ How does the skin temperature in the ice water compare with the temperature in still air?

_____

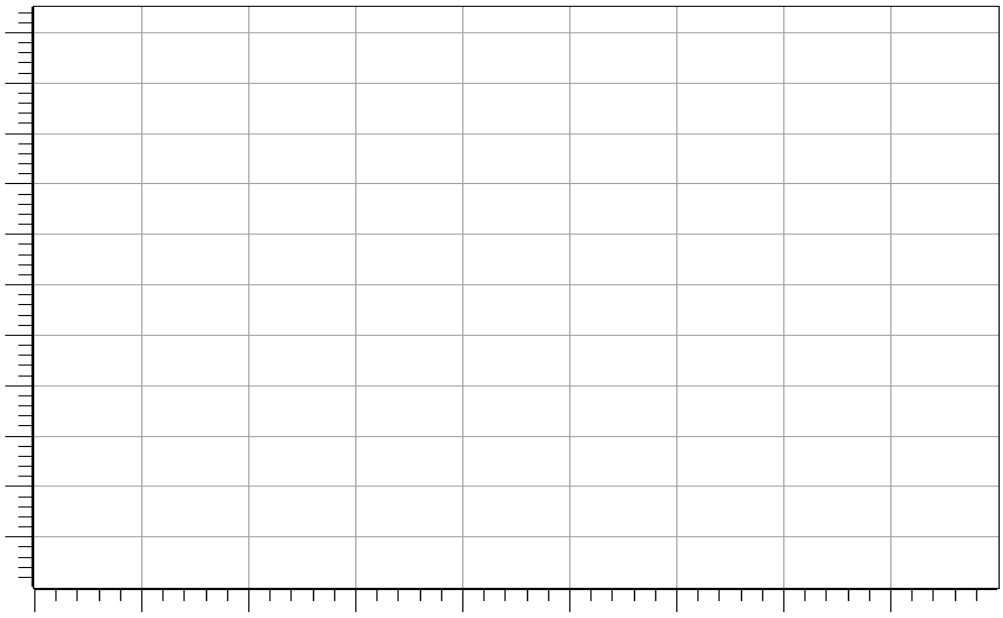
_____

_____

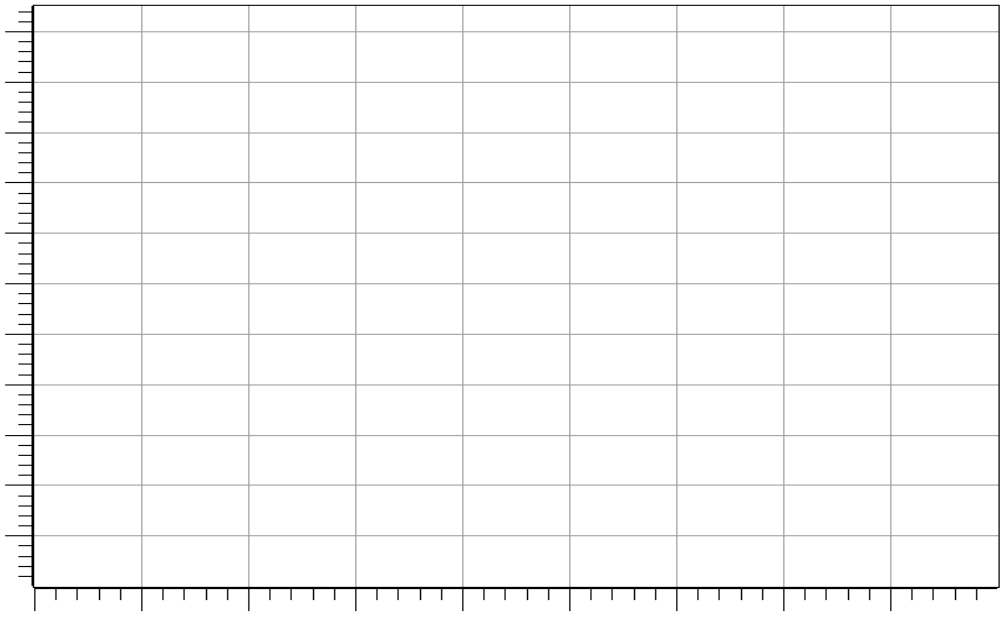
45. ☐ Save your experiment (11.1) and clean up according to your teacher's instructions.

Data Analysis

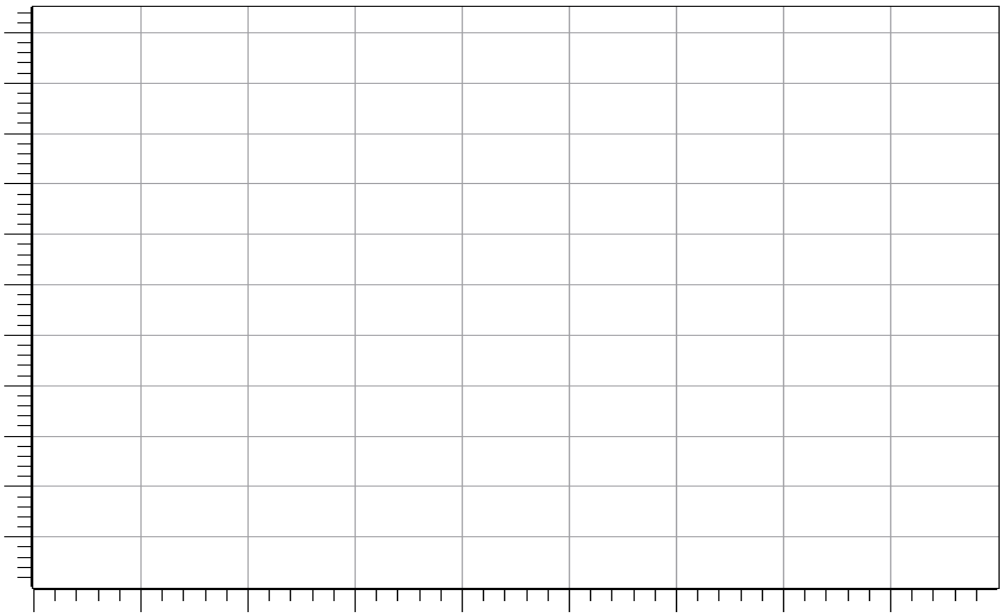
1. ☐ Make a sketch of your data for Temperature versus Time for the CONTROL. Label the overall graph, the x-axis, the y-axis, and include units on the axes.



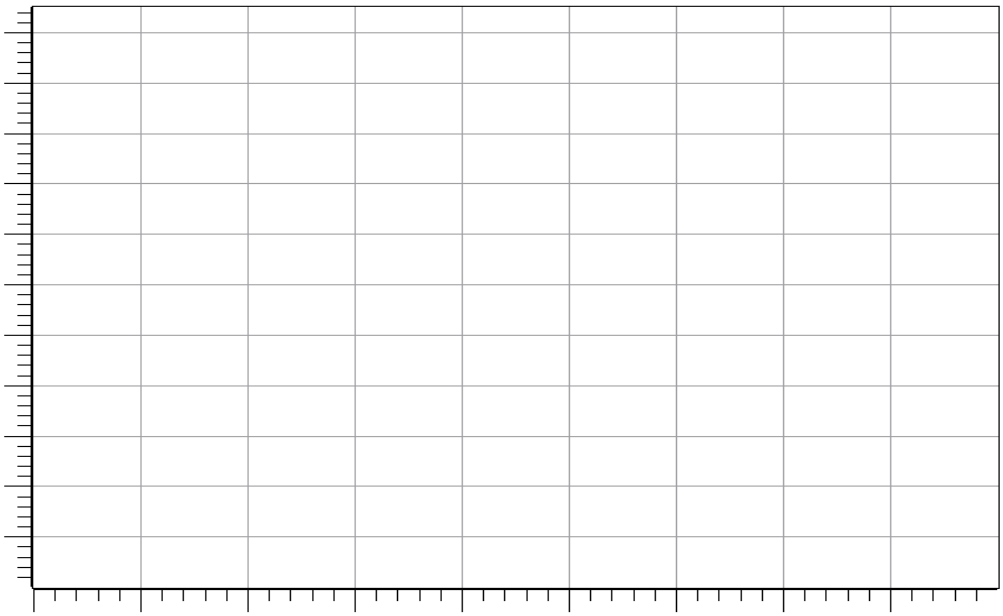
2. ☐ Make a sketch of your data for Temperature versus Time for the FAN. Label the overall graph, the x-axis, the y-axis, and include units on the axes.



3. ☐ Make a sketch of your data for Temperature versus Time for the GLOVE. Label the overall graph, the x-axis, the y-axis, and include units on the axes.



4. ☐ Make a sketch of your data for Temperature versus Time for the ICE WATER. Label the overall graph, the x-axis, the y-axis, and include units on the axes.



5. ☐ Use available tools on your data collection system ◆(9.1) ◆(9.2) to complete the following table.

Table 1: Temperature changes for hand in still air, moving air, glove, and ice water

Trial	Starting Temperature (°C)	Temperature at Time of Greatest Change (°C)	Greatest Change in Temperature (°C)
Hand (left) in still air (control)			
Hand (right) in still air			
Hand (left) in still air (control)			
Hand (right) in moving air			
Hand (left) in still air (control)			
Hand (right) in glove or mitten			
Hand (left) in still air (control)			
Hand (right) in ice water			

Analysis Questions

1. What is the reason for any difference between skin temperature in moving air and skin temperature in still air?

_____

_____

_____

2. How does the skin temperature change during the first minute after the hand is removed from the ice water?

_____

_____

_____

3. How did the change in skin temperature during the first minute after the hand is removed from the ice water compare to your prediction?

4. How can you explain any differences in the starting temperatures of each hand? How could you reduce this problem?

Synthesis Questions

Use available resources to help you answer the following questions.

1. Why is it important to have a one hand remain at room temperature in still air during every trial in this experiment?

2. How do the results in this experiment help explain homeostasis?

3. Explain how a person may get frostbite on their fingers and toes, but their core body temperature may remain relatively constant.

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. Animals capable of maintaining a constant body temperature are called:

- **A.** Poikilothermic
- **B.** Endothermic
- **C.** Cold-blooded
- **D.** Ectothermic

2. How does your body produce heat?

- **A.** Metabolism
- **B.** Cell division
- **C.** Metamorphosis
- **D.** Conduction

3. During perspiration how does the body lose heat?

- **A.** Conduction
- **B.** Radiation
- **C.** Convection
- **D.** Metabolism

4. How is temperature regulated in the human body?

- **A.** Perspiration
- **B.** Shivering
- **C.** Fever
- **D.** All of the above

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

1. Humans and other mammals are _____. That is, they maintain a relatively constant body temperature despite widely ranging environmental temperatures. Although the average human body temperature is _____ degrees Celsius (_____ degrees Fahrenheit), this temperature varies depending on individual differences, time of day, the stage of sleep, and the ovulatory cycle in women. Your body is constantly monitoring and adjusting its processes to maintain relatively stable and constant internal conditions. This state is called _____.

2. Heat flows from _____ temperature to l_____ temperature. _____ is the transfer of heat between objects that are in direct contact with each other. For instance, if a person sits on the cold ground, heat moves from the body to the cold ground. _____ is the transfer of heat by the movement of air or liquid moving past the body. This explains why a breeze across the skin may cool one down, whereas trapping air inside clothing keeps the body warm.

3. When the body is too hot, it decreases heat production and increases _____. One way of increasing heat loss is through the dilation of blood vessels in the skin. When these vessels dilate, large quantities of warm blood from the core of the body are carried to the skin, where heat loss may occur via _____, convection, and conduction. _____ of fluids from the body also causes heat loss.

Key Term Challenge Word Bank

Paragraph 1	Paragraph 2	Paragraph 3
36.7	conduction	conduction
25.8	convection	convection
98.6	evaporation	evaporation
100	higher	heat loss
conduction	lower	heat gain
endothermic	metabolism	metabolism
homeostasis	radiation	radiation
	shivering	