STUDENT GUIDE
EXPLORE 1 LESSON 9

Food and Agriculture Center for Science Education

Part 1: Our Motivation

Record what we were trying to figure out that led to this investigation.

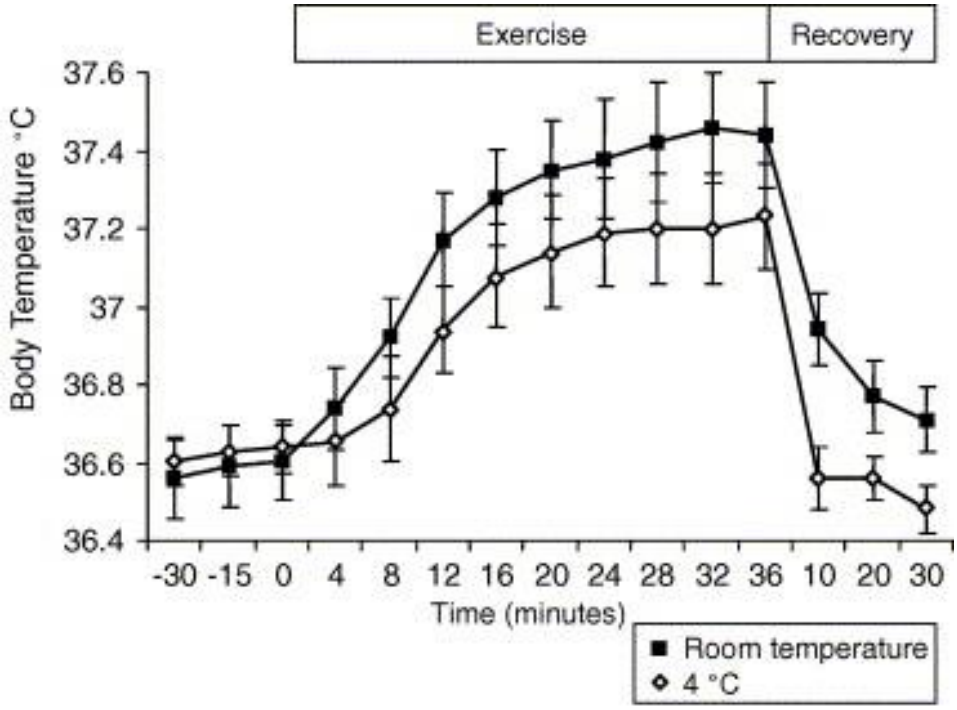
- Why does body temperature elevate during a workout?
- Why does your body temperature return to normal after it elevates?
- How long does it take body temperature to return to normal after working out?

Part 2: Analyzing Body Temperature Data

Working in pairs, analyze the following experiment design and data collected.

This study aimed to determine the changes in body temperature that occur before, during, and after exercise in two different temperature conditions. Ten healthy adult male volunteers completed an exercise session on a stationary bicycle. Prior to exercise, a thermocouple probe was inserted into the auditory canal for tympanic membrane temperature measurement (core body temperature). The probe was insulated with cotton wool held in place by a bandage.

The subject entered either the exercise laboratory, at an average temperature of 24 ± 0.5 °C, or the cold room maintained at 4 ± 0.5 °C and waited for 30 min. The −30 min temperature measurement was taken as soon as possible after entering the exercise laboratory or cold room. After 30 min, the subject mounted the bicycle and began cycling at 80 rpm for a 4-minute warm-up at a wattage equivalent to half of the power calculated as 105% of the anaerobic threshold. The exercise intensity was then doubled, and this intensity remained for 32 min before a 4-minute warm-down period, again at an intensity equal to half of the 105% anaerobic threshold. The mean work rate during both experiments was 185.2 ± 42.7 W. By design, there was no difference in work rate between the two experiments. After the cessation of exercise, the subjects were rested in the supine position in the exercise laboratory.



Graphic from: https://www.sciencedirect.com/science/article/abs/pii/S1096637406000360?via%3Dihub

Paraphrase the goal and design of this experiment in simpler, yet still accurate terms.

The experiment was designed to measure the changes in body temperature from before, during, and after exercise in two different conditions: room temperature and at 4° C. Exercisers rode on a stationary bike for 30 minutes and had their internal ear temperature taken in 15-minute intervals (before exercise), 4-minute intervals (during exercise), and 10-minute intervals (after exercise).

What trends do you see in this data set?

The core body temperature in both conditions at first at rest did not change much. Then it increased by about 0.8° C at room temperature and by about 0.6 ° C in the 4 ° C condition. Both body temperatures returned to approximately their starting temperatures during the recovery period after exercise.

How can you explain the trends in this data with the lens of stability and change?

Prior to exercise, the body temperature is stable. When the person is doing exercise, this makes the body temperature change and increase. When the person is done exercising, this also makes the body temperature change and decrease back to its original stable state.

Part 3: Using a Model of Temperature Change During Exercise

As a class, you will engage in a Science Theater model to determine the mechanism that controls temperature changes in the body.

As you review your role, record a summary of the role your cells and organ will play in the temperature change process. Describe what function your organ has and how specialized cells contribute to its function.

How Specialized Cells Contribute:

Cells in the sweat glands take up water and sodium from the bloodstream and release it onto the skin to cool the body. When you stop exercising, your temperature goes down, so the cells stop taking up water and sodium, and the sweating stops.

Engage in the model. As you **enact** the model, record observations about the actions that other organs and specialized cells take.

Organ & Specialized Cells: Hypothalamus: Neurons
• Receives nerve signals as a response to changes in body temperature during and after working out. • Nerve signals are sent to the sweat glands in the skin to start or stop the production of sweat. • Sends signals to blood vessels to make them constrict or dilate.
Organ & Specialized Cells: Sweat Glands: Myoepithelial Cells
• Sweat glands receive signals from the hypothalamus to start or stop producing sweat. • Receive the signal to secrete and produce sweat and activate the sweat token. Sweat is used to activate the release of body heat by evaporation token.

As you **observe** the model, record how different organs and their specialized cells function to respond to changes in body temperature. Write or sketch your response as you choose.

Organ & Specialized Cells	Role of Organ and Specialized Cells in Changing Body Temperature
Brain: Neurons	• During exercise, the hypothalamus detects a signal of temperature increase and sends a signal to sweat glands in the skin to produce sweat. • At rest, the hypothalamus receives a signal from the thermoreceptor and sends a signal to sweat glands in the skin to stop producing sweat.
Nerves: Thermoreceptor Neurons	• During exercise, thermoreceptors (in skin) send nerve signals to the brain (hypothalamus) that indicate that body temperature is increasing. • At rest, thermoreceptors send nerve signals to the brain (hypothalamus) that indicate that body temperature is returning to its stable state.
Skeletal Muscles: Myocytes	• During exercise, muscle cells use cellular energy to expand and contract rapidly and generate excess heat • At rest, muscle cells use less energy
Blood Vessels	• During exercise, blood vessels receive a signal to dilate to increase blood flow and transfer heat to surroundings. • At rest, blood vessels receive a signal to constrict and lower heat transfer from blood to the surrounding environment.
Sweat Glands: Myoepithelial Cells	• During exercise, sweat glands receive a signal from the hypothalamus to produce sweat. • At rest, sweat glands receive a signal from the hypothalamus to stop producing and releasing sweat.

Use your observations from the model to explain how the changes to core body temperature occur during exercise and how the body returns to its stable state.

What conditions changed?	What in the body senses the condition change?	What is/are the body's response(s) to the change?	How does the response help the condition return to the stable state?
Core body temperature increases due to exercise.	Thermoreceptors (specialized nerve cells) in the muscles and skin sense and report the temperature increase that occurs during exercise. The thermoreceptors send nerve signals to the brain.	The hypothalamus in the brain detects the signal from the nerves. The hypothalamus sends signals via nerves to sweat glands to release sweat and cool the body.	Sweat cools the body to decrease body temperature back to its stable state.
Core body temperature increases due to exercise.	Thermoreceptors (specialized nerve cells) in the muscles and skin sense and report the temperature increase that occurs during exercise. The thermoreceptors send nerve signals to the brain.	The hypothalamus in the brain detects the signal from the nerves. The hypothalamus sends signals via nerves to the vasodilatory nerves to increase blood flow from the body's core to the body's surface.	Blood flow to the body's surface makes heat move from the body to the body's surroundings, cooling the body to bring body temperature back to its stable state.
Core body temperature returns to a stable state when at rest.	Thermoreceptors (specialized nerve cells) in the skin and muscles sense and report the temperature decrease that occurs after stopping exercise. The thermoreceptors send nerve signals to the brain.	The hypothalamus in the brain detects the signal from the nerves and sends a signal to the sweat glands to stop producing sweat.	The body sweats less, helping to maintain the decreased body temperature at its stable state.
Core body temperature returns to a stable state when at rest.	Thermoreceptors (specialized nerve cells) in the muscles and skin sense and report the temperature increase that occurs during exercise. The thermoreceptors send nerve signals to the brain.	The hypothalamus in the brain detects the signal from the nerves. The hypothalamus sends signals via nerves to the vasoconstricting nerves to decrease blood flow from the body's core to the body's surface.	Less blood flow to the body's surface maintains heat in the body's internal core, helping to maintain body temperature.