STUDENT GUIDE
Lesson 3: Homeostasis Lab

Objective: To investigate how the consumption of different pre-workout and protein supplements impacts physiological parameters related to homeostasis during and after exercise.

Introduction

Driving Question: Why might someone who exercises consume whey protein?

What do we still need to know to answer the Driving Question?

- What is whey protein?
- How does taking whey protein help exercise?
- Do all whey proteins work the same way for someone who exercises?
- What is in whey protein that makes it a good choice for someone who exercises?

Part 1: Reading about Homeostasis

List any new ideas you have about the Driving Question because of the information from the reading.

- How might whey protein impact the homeostasis mechanisms described in the reading?
- Do the regulatory values in the body change when a person consumes whey protein over time?
- I am curious how consuming whey protein changes the ways in which sensors and effectors work to regulate variables in the body.

How do you think this reading relates to the phenomenon we are exploring?

The reading describes what types of physiological mechanisms change in the body. These mechanisms are values that are typically impacted by exercise, such as blood pressure and temperature. It explains how when external factors change, the internal environment of the body must respond to return them to their "set point".

Part 2: Interpreting Homeostasis Models

Complete the information in the table using each of the models.

Model	Regulated Variable	Sensor(s)	Controller(s)	Effector(s)
1	Body temperature	Nerve cells (in skin and brain)	Brain	Sweat glands (in body)
2	Blood pressure	Baroreceptors (in blood vessels)	Brain	Heart
3	Na^+ and water retention	Adrenal glands (in kidneys)	Brain	Adrenal glands (in kidneys)
4	Blood glucose	Alpha and Beta cells (in pancreas)	Insulin	Liver

Briefly summarize the homeostatic mechanism taking place in each of the models in the appropriate spaces below.

Model #1 - Body Temperature Regulation under Negative Feedback System

When body temperature exceeds 37 degrees Celsius, sensors in nerve cells in the skin and brain take note of the change. This information is communicated to the temperature regulation center in the brain. It then relays that information to the sweat glands in the body to activate them to cool the body back down, to achieve homeostasis.

Model #2 - Heart Rate Negative Feedback System

When there is an increase in heart rate due to some external factor, like giving a presentation, the change in blood pressure is sensed by baroreceptors in blood vessels. That information is sent on to the brain, which controls blood pressure. The result is an output to the heart to communicate that it needs to decrease heart rate to return the body to homeostasis.

Model #3 - Effects of Aldosterone and ADH (hormones) on Kidney Function when Fluid Levels in Body are Low

When fluid levels in the body are low, the adrenal glands in the kidneys release a hormone called aldosterone to increase water retention and Na^+ in the body. The release of this hormone is controlled by the pituitary in the brain. It releases ADH (vasopressin) to the kidneys to alert it that the body needs water to maintain homeostasis.

Model #4 - Blood Glucose Regulation under Negative Feedback System

When blood glucose levels rise, beta cells in the pancreas release insulin into the blood. This action causes the liver to take up glucose and store it as glycogen. Other body cells also take up glucose, causing blood glucose levels to decline and return to homeostasis. The set point for blood glucose is 90 mg/100 mL.

When blood glucose levels fall, alpha cells in the pancreas release glucagon. This action causes the liver to break down glycogen to release glucose into the blood, causing blood glucose levels to rise, which allows the body to return to the homeostasis set point of 90 mg/100 mL.

How do you think these models relate to the phenomenon we are exploring?

The models are all examples of different ways in which the body tries to achieve homeostasis. When you exercise, these values change and the body needs to regulate them. I think that whey protein might make these values different for people that take it when exercising, causing it to take longer/shorter time for their bodies to get back to the "set point".

Part 3: Case Study of Homeostasis in Action

To better understand how homeostatic loops and feedback mechanisms work together to maintain regulated physiological variables, complete Figure 1 by filling in information after each letter. Use Chart 1 for reference.

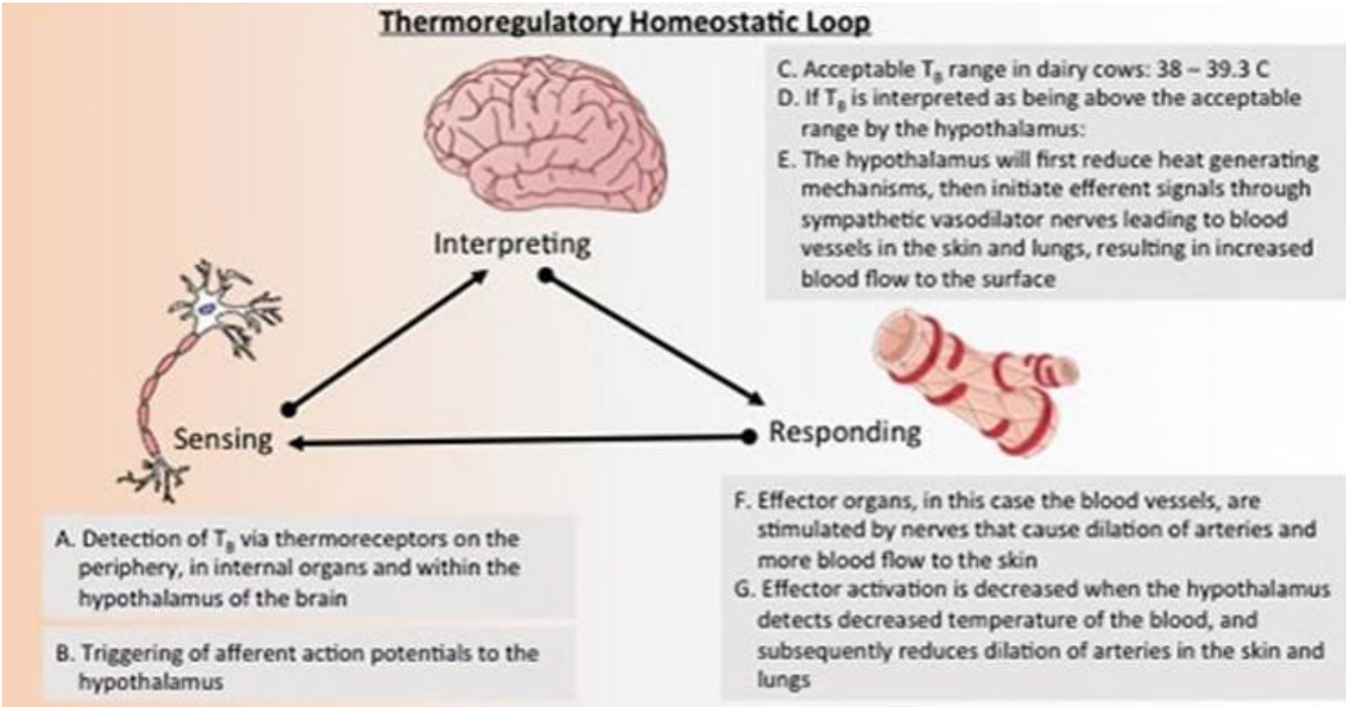

Figure 1. *Thermoregulatory homeostatic loop. Relationship between sensors, interpreters and effectors to maintain homeostasis of the regulated variable, T_B (body temperature). Temperature sensitive neurons send information to the brain, which then interprets the information and causes a response by effectors such as blood vessels in the dermis.*

Suppose you are taking the vitals of a very sick cow and notice that her body temperature is 43 °C yet none of her effectors have been activated to initiate cooling and her other vitals are within their normal range. Which components of the homeostatic loop you completed above might be different as compared to a healthy cow?

It seems that since the other vitals, like respiratory rate and heart rate, are within the normal range for the sick cow the only thing that is changing in the homeostatic loop is the detection of increased body temperature, which is now at 43°C. Knowing this, one option for the component of the loop that could be different in the sick cow when compared to a healthy one might be something wrong with the thermoreceptors in the skin. When action potentials are activated, like they would be when the sick cow experiences an increase in temperature, they send information to the hypothalamus to correct body temperature and return it to the set point of 38-39.3°C. The other option for the component of the loop that is different for the sick cow that might be different for the sick cow is the functioning of the hypothalamus in the brain. It is not recognizing that there is an increase from the set temperature of 38-39.3°C. Since the other vitals are not changing, it seems that the hypothalamus in the brain is not causing dilation of the arteries and stimulating the nerves in organs like the skin and lungs. I do not think there is anything wrong with the effector organs (the blood vessels) because heart rate and respiration rate are not changed. If they were impacted, there would be dilation of arteries, resulting in more blood flow diverted to the skin and likely increase heart rate and respiratory rate as a response. This is not happening based on the information we know about the sick cow.

Part 4: Homeostasis Lab

In the space below, summarize your experimental design. Be sure to include details about the general design of the experiment, the physiological parameters that you will be measuring, and information related to how you plan to collect your data.

Working together (in pairs), we will have 1 of us take C4 Pre-Workout or Optimum Nutrition Gold Standard Pre-Workout 30 minutes before we work out. 1 of us will not take any supplements before working out. We will measure our baseline data for the following physiological parameters: heart rate, blood pressure, body temperature, and RPE. Our data table will look like this:

Measurement (time taken)	Control Group (no supplement)	Experimental Group (pre-workout supplement)
Heart rate		
Blood pressure		
Body temperature		
RPE (Rating of Perceived Exertion)		

We will be doing the following workout circuit at a moderate level of intensity: 1 minute each of jumping jacks, squats, push-ups, mountain climbers, high knees. We will rest for 2 minutes and then repeat the circuit a second time. Immediately after we work out, we will take our data and record it in our data table. We will wait for 10 minutes and measure all of these values again to see if we have achieved homeostasis. After this, we will compare the data obtained for the control group (that did not take a supplement) to the experimental group (that did take it before working out) to see if there are any differences or similarities.

Use the space below to record your experimental results.

Baseline Measurements Pre-Workout	Control Group (no supplement)	Experimental Group (pre-workout supplement)
Heart Rate	72 BPM	75 BPM
Blood Pressure	118/76 mmHg	120/78 mmHg
Body Temperature	98.1°F	98.2°F
RPE (Rating of Perceived Exertion)	1	1

Post-Workout Measurements Immediately After Exercise	Control Group (no supplement)	Experimental Group (pre-workout supplement)
Heart Rate	142 BPM	155 BPM
Blood Pressure	136/85 mmHg	145/90 mmHg
Body Temperature	99.4°F	99.6°F
RPE (Rating of Perceived Exertion)	7	8

Post-Workout Measurements During Cool Down (10 minutes after exercise)	Control Group (no supplement)	Experimental Group (pre-workout supplement)
Heart Rate	88 BPM	95 BPM
Blood Pressure	125/80 mmHg	130/82 mmHg
Body Temperature	98.6°F	98.8°F
RPE (Rating of Perceived Exertion)	3	4

In the space below, provide a summary of your data. Use this space to organize your thoughts, using direct evidence from your experimental findings, and connect this evidence to the phenomenon and related Driving Question.

Before working out, both the control and experimental group had similar values for heart rate (72 BPM vs. 75 BPM), blood pressure (118/76 mm/Hg vs. 120/78 mmHg), body temperature (98.1°F vs. 98.2°F), and RPE (1 for both groups).

Immediately after exercising, the experimental group had higher measurements than the control group for all of those values. Heart rate was 13 BPM higher, blood pressure was higher for both systolic and diastolic values - 136/85 mmHg vs. 145/90 mmHg, body temperature was 0.2°F higher at 99.6°F, and RPE was 1 point higher at 8.

10 minutes after exercising, the values were much closer to one another again, but the experimental group was still higher than the control group. Heart rate was 7 BPM higher, both systolic and diastolic values were higher - 125/80 mmHg vs. 130/82 mmHg, both temperature was still 0.2°F higher but it was closer to "normal" at 98.8°F, and RPE was still 1 point higher, but was lower at 4.

Part 5: Constructing an Explanation About the Impact of Pre-Workout and Protein Supplements on Homeostasis During and After Exercise

Use the findings from your investigation to construct an explanation to the Driving Question: ***Why might someone who exercises consume whey protein?***

Earlier in the unit, we learned that proteins are important for many body processes. Proteins are composed of essential amino acids that can only be obtained through proper nutrition as our bodies cannot produce them.

In this experiment, we looked at how consuming a pre-workout or protein supplement might impact our bodies as we exercise. Based on the data we obtained, it seems like students who took a pre-workout supplement had higher measurements for heart rate, blood pressure, body temperature, and RPE.

Depending on the type of exercising a person is doing, they might consume whey protein to maximize the bodily effects of their workout. In the same type of activities over the same amounts of time, people who did not take a supplement before working out had lower measurements for all of those values. People who took the supplement seemed to get "more of a workout" because it is clear their bodies were working harder. The evidence we have for this is not just the increase in measurements immediately after their workout, but also that most values were still higher 10 minutes after exercising. Even though those values were much closer to the control group, they were still higher than their "normal" baseline measurements at the start of the experiment.

A person who is looking to get a thorough workout in a short amount of time might consume whey protein to achieve this.