STUDENT GUIDE
EXPLORE 2 LESSON 11

Food and Agriculture Center for Science Education

Part 1: Our Motivation

Record the question(s) that you want to investigate.

- Why do we get thirsty during a workout?
- Why does the color of our urine change after exercise?
- What role do milk nutrients have in exercise recovery?

Part 2: Analyzing Data About Urine Color

What experiences do you have with a change in your urine color? When does it seem to happen the most?

Student responses will vary. Some responses may indicate that urine color changes when you drink a lot of water or when you are really dehydrated from being too hot.

Analyze the data set in the Urinalysis handout that shows changes to urine color before and after exercise. What changes to urine color happened to the population in this study? How does this compare to what we saw in our Module Phenomenon?

Pre-workout urine color is about a three on the color chart. Post-workout, the color of the urine is darker, around a four on the color chart. This is similar to what we saw from the athlete in our Module Phenomenon.

Observe the demonstration with food coloring in water that your teacher shares.

- What do you notice that results in the change in the color of the simulated urine?
- What do you think this model can tell us about what happens to urine when exercising and when drinking milk to recover after exercise?

When more water is added to the yellow food coloring, the simulated urine is lighter in color. When less water is added, the simulated urine is darker in color. Urine color changes during exercise because the urine has less water in it. When you drink milk after exercising, it adds water, so the urine color is a clearer color.

Part 3: Analyzing Data on Changes to the Water Content of Blood During Exercise

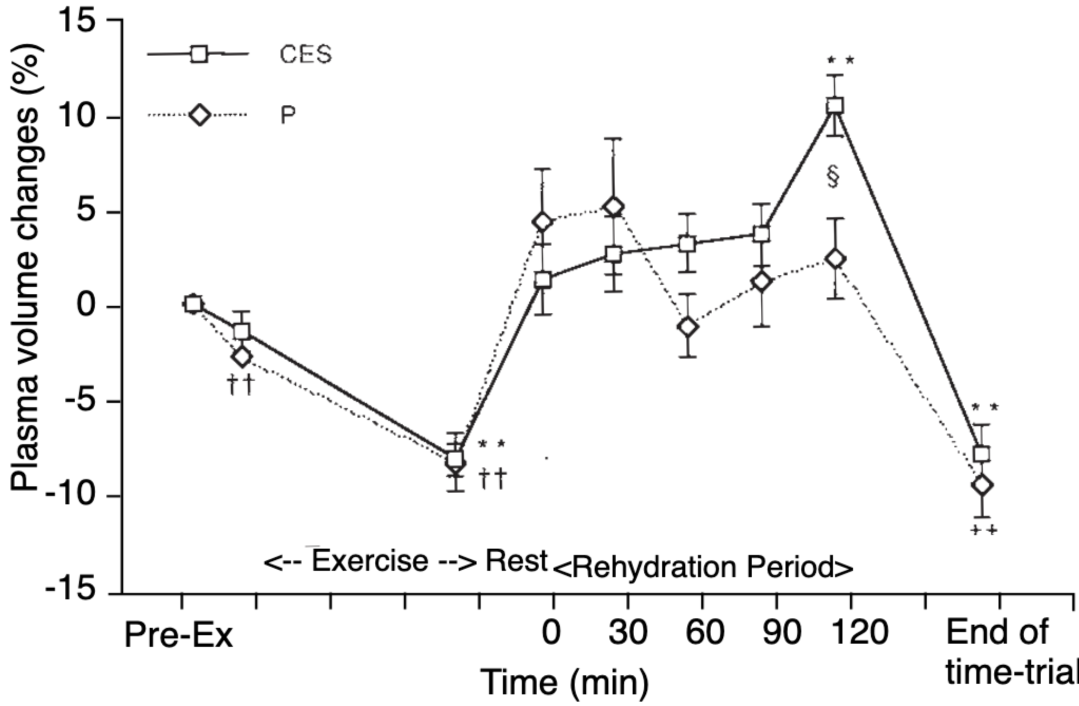
Working in pairs, analyze the following experiment design and data collected.

Thirteen healthy male competitive cyclists, triathletes, or recreational athletes participated in this study. The study aimed to test the effects of a carbohydrate beverage on the recovery of water volume in the blood after exercise. Fifteen minutes before exercise, a catheter fitted with a 3-way tap was inserted into a forearm vein for blood sampling; this catheter remained in place for the remainder of the study. An initial blood sample was obtained: this sample represented the pre-exercise state.

The subjects then exercised on a stationary bicycle in an environmental chamber (28ºC; 63% RH) at an intensity of 50% max effort for 90 minutes to dehydrate approximately 3% of body weight. The second and third blood samples were drawn 1 minute into the 50% max effort dehydration exercise and during the last minute of the dehydration exercise.

After the dehydration exercise, the subjects were allowed 10 minutes to cool off, change their clothes, and resume a seated position in a thermo-neutral environment (20ºC). Thirty minutes after exercise and after twenty minutes of sitting, a fourth blood sample was obtained. Immediately afterward, the subjects were seated and drank one of the two test drinks (CES: Carbohydrate-electrolyte solution or P: Placebo (artificial sweetener and water) in a volume (in milliliters) equal to the mass (in grams) of 50% of the fluid lost. This signaled the beginning of the 2-hour rehydration period.

After 30 minutes, the subjects drank 40% of the fluid lost; the remaining 30% of the rehydration drink, necessary to replace 120% of the fluid lost, was ingested at 60 minutes. Further blood samples were collected every 30 minutes during the rehydration period. This was followed by a time trial in which the subjects were asked to perform a maximum-effort ride on the stationary bicycle. After the maximum effort time trial, the final blood sample was collected. The scientists then measured the changes in the volume of each blood sample taken, which can indicate the changes in the amount of water in the blood sample.



Data obtained from:
https://www.researchgate.net/publication/11155143_The_effects_of_rehydration_on_cycling_performance_after_exercise-induced_dehydration

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

The experiment was designed to measure how two different recovery beverages could help restore water in the blood after exercise. The researchers had participants undergo an exercise session then they drank one of the two beverages, then they did a max effort exercise session. They collected blood samples along the way to measure how the amount of water in the blood changed.

What changes do you notice happening over time? What does this indicate about the amount of water in the blood?

As the person starts to exercise, the blood volume decreases by about 10%, indicating less water in the blood. After exercise and drinking a beverage, blood volume increased back to its original state and even gained about 10% more volume. During the max effort workout, blood volume decreased again, by about 20% this time.

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

Prior to exercise, the amount of water in the blood is at its stable state. Exercise results in a change in the amount of water in the blood as it decreases. But then, at rest and in the rehydration period, the water in the blood returned to its stable state and even increased. Then, it changed again in the max effort workout. There might be a feedback mechanism that occurs here, similar to how the body controls its temperature during exercise.

Part 4: Using a Model of Sweat, Thirst, and Urine Color Change

As a class, you will engage in a Science Theater model to determine the mechanism that controls the amount of water lost from the body.

As you review your role, record a summary of the role your cells and organ will play in regulating the amount of water in the body. Describe what function your organ has and how specialized cells contribute to its function.

How Specialized Cells Contribute: The bladder holds water and urine to be released as waste from the body. Cells in the bladder, called urothelial cells, are structured so that they can hold urine inside the bladder and so the urine doesn't leak out of the bladder.

Engage in the model. As you **enact** the model, record observations you make about the actions that various specialized cells take.

Organ & Specialized Cells: Brain: Hypothalamus and Pituitary Neurons
• Sense changes in the amount of water in the bloodstream due to sweat production. • Send a signal to the hypothalamus that says that the amount of water in the blood has changed.
Organ & Specialized Cells: Kidney & Urothelial Cells

- Receive the ADH signal from the brain.
- Take less water from the bloodstream when there is not enough water present and give a little water to the bladder for urine.

As you **observe** the model, record how different organs and their specialized cells function to regulate the amount of water in the body. Write or sketch your response as you choose.

Organ & Specialized Cells	Role of Organ and Specialized Cells in Regulating the Amount of Water in the Body
Brain	• During exercise, osmoreceptors in the brain sense a reduced amount of water in the bloodstream (due to sweat). This signals the hypothalamus to create a sensation of thirst. The pituitary neurons send a hormone called ADH to the kidney to absorb more water from the blood. • Post-exercise and after consuming milk, the brain senses a "normal" amount of water in the bloodstream. This signals the hypothalamus to reduce the sensation of thirst. The pituitary neurons send less signal (ADH hormone) to the kidney to absorb less water from the blood.
Blood Vessels	• During exercise, water in the bloodstream is lost to sweat and is given to the kidneys to become urine. • Post-exercise and after consuming milk, the water in milk enters the bloodstream (through digestion).
Kidney	• During exercise, the kidney is signaled to absorb less water from the blood, leading to less water moving to the bladder. • Post-exercise and after consuming milk, the kidney is signaled to absorb more water from the blood, leading to more water moving to the bladder.

Bladder	• During exercise, urine becomes darker in color and reduces in volume because less water comes from the kidneys.. • Post-exercise and after consuming milk, more water accumulates in the bladder and urine (increased volume) and becomes clearer in color because more water comes from the kidneys.

Record your observations from the model to explain how a negative feedback loop helps to prevent water loss in the body.

What conditions changed?	How a feedback loop functions to regulate water levels in the blood
Water is lost due to sweat during exercise.	The osmoreceptors in the brain sense the reduced amount of water in the bloodstream. The brain signals to the hypothalamus region of the brain to create a sensation of thirst. The pituitary region of the brain sends more signals via a hormone called ADH to the kidney to absorb less water from the blood, leading to less water moving to the bladder, where it is stored as urine. The urine color becomes darker. This process is a negative feedback loop and is how the body prevents additional water loss.

Water is replenished by drinking milk.	The osmoreceptors in the brain sense a normal amount of water in the bloodstream. The brain signals to the hypothalamus region of the brain to reduce the sensation of thirst. The pituitary region of the brain sends fewer signals via a hormone called ADH to the kidney to absorb more water from the blood, resulting in more water accumulating in the bladder as urine and urine color become clearer. This is a feedback loop that helps pull extra water out of the blood.