TEACHER GUIDE
ELABORATE LESSON 13

Food and Agriculture Center for Science Education

Module Questions: ***Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?***

What We Figure Out:

We figure out that extreme losses of water from the body during exercise are dangerous and can lead to dehydration and that too much water can lead to hyperhydration. Dehydration occurs because when someone exercises, they lose water via sweat. This water comes from the bloodstream, which results in the bloodstream having a higher electrolyte concentration than the cells in the surrounding organs. When the electrolyte concentration of the bloodstream increases, water is drawn out of the cells of other organs in the body, such as those in the muscles, nerves, or skin. When cells lose too much water, it impairs their normal functions, leading to symptoms of dehydration like dry skin, dizziness, lightheadedness, headaches, or passing out. Hyperhydration occurs when there is too much water in the bloodstream, and it moves into cells, causing there to be too much water and not enough electrolytes in the cells, resulting in their functions being disrupted and leading to symptoms such as passing out or death.

3D Learning Objective:

Students use evidence from multiple sources to construct an explanation of how changes to the water composition of cells can disrupt their essential functions and cause illness and death due to overhydration and dehydration.

Time estimate:

50 minutes

Materials:

Lesson 13 Student Guide
Lesson 13 Student Handout Case Studies
Lesson 13 Student Handout Dehydration and Overhydration Texts
Lesson 13 Teacher Resource Model of Dehydration and Overhydration

- Beakers or cups (2 per group)
- Distilled water
- Salt
- Gummy bears (at least 2 per group)
- Dialysis tubes (2 per group, each approximately 3 inches in length, soaked in distilled water prior to start of activity)

		• String or clips (at least 4 per group, to tie off end of dialysis tubes) • Balance (or scale) • Paper towel Cell Membrane Simulation Lesson 13 Teacher Resource Cell Membrane Simulation

Targeted Elements

SEP:	DCI:	CCC:
CEDS-H2: **Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**	**LS1.A-H1:** **Systems of specialized cells within organisms help them perform the essential functions of life.**	**CE-H2:** **Cause and effect relationships can be suggested and predicted for complex natural** and human designed systems **by examining what is known about smaller scale mechanisms within the system.**

Directions

Part 1: Our Motivation

USE OF PHENOMENA

Between Lessons 9-12, students focused on the Module Phenomenon. In this lesson, they observe and make sense of a related phenomenon: individuals who experience overhydration and dehydration. In Lesson 14, they will return to the Anchor Phenomenon to create presentations on how milk can help athletes recover from exercise.

Return to the Driving Question Board. Share a few selected questions that align with what students will investigate in the upcoming lesson.

Example student questions or ideas could include:

- What happens in the body when too much water is lost?
- What happens if you drink too much water?
- What happens to the electrolytes from milk? Do they help with hydration?

Students can record these questions on their Lesson 13 Student Guide Part 1: Our Motivation. This will help students understand how this lesson connects to what they were trying to figure out about the Module Phenomenon.

Part 2: Observing New Phenomena

Share with students that they will now observe a new phenomenon to help them figure out what happens when someone drinks too much water or too little water. Distribute the Lesson 13 Student Handout Case Studies and share with students that they will now read about two cases of athletes who drank too little water and too much water. Share with students that they should record what they notice happened to the individuals in the case study in Lesson 13 Part 2: Observing New Phenomena.

Allow time for students to read the articles and record what they observe happening to the individuals in the case studies. Use a Think-Pair-Share protocol for students to share their findings with each other and with the class.

1. Students are given time to think independently about their responses.
2. Students will find an elbow partner.
3. Students will take turns sharing their thoughts with their partner. Each student should be given time to respond.

Facilitate the conversation so that students agree that:

- One athlete was hospitalized and died 12 days after running in extremely hot temperatures and collapsing at basketball practice.
- One athlete died from drinking too much water and Gatorade during football practice.

Building off the conversation, introduce the term **dehydration** to mean a state of the body in which a dangerous amount of water has been lost and **overhydration** to mean a state in which the body contains a dangerously excessive amount of water.

After agreeing on their observations from the two articles, introduce the questions students will investigate in this lesson, *"How could athletes die from dehydration or overhydration?"* Allow students time to write this question on their Lesson 13 Student Guide Part 2: Observing New Phenomena.

STUDENT SUPPORT

You may choose to ask students if they have experienced or if someone they know has experienced any health issues with dehydration or overhydration. Note that some students may have personal experiences with health issues related to hydration. Honor students' personal experiences by allowing them to share if they feel inclined or keep experiences private.

TEACHER SUPPORT

Death may be a difficult topic for students to work with. Consider using supports for students who may struggle to handle this topic emotionally. One option might be to identify another article that addresses dehydration and overhydration but does not result in the death of the subjects. Be sure to share with students that these are very rare cases and only happen in extreme circumstances, such as intense dehydration and intense overhydration. Explain to students that they are safe exercising as long as they maintain proper hydration periodically throughout the exercise session.

Part 3: Creating and Sharing Initial Explanations

Students will create an initial explanation to share their current answer to the Module Questions on their Lesson 13 Student Guide Part 3: Creating and Sharing Initial Explanations. Allow students time to create their explanations. As students work, circulate the room to elicit and probe student thinking. Ask questions such as:

- Can you tell me more about what you wrote there?
- What I see you saying is...Can you say more about that?
- What do you think is happening to water in the cells of this athlete?
- What do you think the cause of the athlete's death was? How do you think this happened?
- How do you think you can use what you know about water and homeostasis to try to explain what happened in these cases?

When students have finished creating initial explanations for the two different cases, use a protocol such as a Mingle-Pair-Share to have students share their ideas with each other.

1. Students will move around the classroom and find a peer who is not a part of their usual group.
2. Students will take turns sharing their explanations.
3. Students will then find a new peer and share their explanations once again.

After sharing, hold a whole-class discussion for students to share their different ideas with the class. As students share, record their different ideas on the front board. Students may have a variety of ideas, and that is okay at this stage. To facilitate the conversation so that students draw on their prior knowledge to agree at least that:

- The athletes' illnesses and deaths have something to do with the loss of too much water or the gain of too much water in the bloodstream.
- The feedback systems in the body were unable to respond well enough to bring the levels of water in the body back into balance.

TEACHER SUPPORT

Here, students are drawing on the knowledge they built in Lessons 8-12 of this module. Based on this prior learning, students should be able to articulate how dehydration could lead to loss of water in the bloodstream and overhydration leads to too much water in the bloodstream and that, in a normally functioning body, there are homeostasis mechanisms that try to bring the levels of water back to normal.

After students share, highlight the differences in student ideas to share that they will now gather additional evidence to try to figure out what happened in the bodies of these different athletes. Point out that students thought there was something going on with the amounts of water in the bloodstream affecting their condition.

Offer an opportunity for students to ask questions to figure out more about what happened to the two athletes in the case studies. Sample student questions may include:

- Does overhydration and dehydration have to do with water in the bloodstream?
- What happens to all the extra water that they drink?
- What happens in the body when it doesn't have enough water?

Part 4: Using Models to Observe How Changes to the Amount of Water in the Bloodstream Impact the Body

Share with students that they will now use two different models to explain how changes in water can affect the cells of the rest of the body.

Introduce students to the first, the Model of Dehydration and Overhydration, which uses dialysis tubing, salt water, and gummy bears. Use the Lesson 13 Teacher Resource Model of Dehydration and Overhydration to determine the required materials and set up directions for students to engage in the model. Tell students that this model is meant to show how water can move in and out of the bloodstream, interstitial fluid, and the cells of various tissues in the body. Ask students to identify which part of the model represents which part of the body. Facilitate the conversation to agree that:

- The dialysis tube can represent the bloodstream.
- The salt water around the tubing and around the gummy bears represents the interstitial fluid.
- The gummy bears represent cells of various organs of the body.

Ask students how they think they could set up the model to represent conditions of dehydration and overhydration. Students can refer to their initial explanations from Part 3 to draw ideas for how to set up these models.

Use a Think-Pair-Share to have students brainstorm and share their ideas with a peer and with the class.

1. Students are given time to think independently about their responses.
2. Students will find an elbow partner.
3. Students will take turns sharing their thoughts with their partner. Each student should be given time to respond.

Facilitate the conversation such that students agree that:

- Fill the dialysis tube with a very high salt content in low salt water to represent the dehydration case.
- Fill the dialysis tube with a low salt content and a low salt water to represent the overhydration case.

Set up two of the hands-on models as students have instructed and ask students to record their observations of the starting conditions of each of the models on their Lesson 13 Student Guide Part 4: Using Models to Observe How Changes to the Amount of Water in the Bloodstream Impact the Body.

TEACHER SUPPORT
Allow the models to rest for 24 hours for fluids in each part of the model to come to equilibrium. You may wish to end class after students have set up this model to allow it to sit for a sufficient period of time.

When students return to the model the following class period, ask them to record their observations once again. Afterward, allow students time to record their overall observations from the model. Use a Think-Pair-Share to have students share what they have found with each other and with the class.

1. Students are given time to think independently about their responses.
2. Students will find an elbow partner.
3. Students will take turns sharing their thoughts with their partner. Each student should be given time to respond.

Facilitate the conversation so that students agree that:

- The gummy bears change size over the course of the experiment.
- The amount of water in the dialysis tubing changes over the course of the experiment.
- There could be water and/or salt moving from one place to another to change the size of the gummy bears and the amount of salt inside or outside of the dialysis tubing.

Share with students that to figure out if it is water or salt moving that changes the sizes of the different compartments in the model and in the body, students will use a simulation of diffusion and osmosis across a cell membrane. Project the Cell Membrane Simulation on the front board. Use the Lesson 13 Teacher Resource Cell Membrane Simulation as a reference about what to look for before and after the simulation prior to engaging with students in the activity.

Orient students to what the simulation shows. A cell membrane runs down the center of the screen. The left of the screen represents the outside of the cell, and the right represents the inside of the cell. On the cell membrane, there are protein channels that allow atoms and molecules to move in and out of the cell. Throughout the model, students will see several different colored circles to represent water and salt (sodium chloride):

- Blue = water molecule
- Red = sodium atom
- Green = chlorine atom

Finally, the user can select what amount of salt to place inside and outside of the cell to start the model. After this introduction, ask students what conditions in this model would best represent the dehydration case and what conditions would best represent the overhydration case. Facilitate the conversation so that students agree that:

- Dehydration: High salt present outside of the cells, low salt inside of the cells.
- Overhydration: Lots of water and no salt present outside of the cells, low salt present inside of the cells

Set the simulation to the dehydration conditions students choose and allow the simulation to run and for students to record their observations. After about one minute, stop the simulation, reset it, and run it with the overhydration conditions that students chose. Use a Think-Pair-Share for students to share their observations with a peer and then with the class.

1. Students are given time to think independently about their responses.
2. Students will find an elbow partner.
3. Students will take turns sharing their thoughts with their partner. Each student should be given time to respond.

Facilitate the class share-out so that students agree that:

- Water can move in and out of the cells, not salt.
- Water moves towards the location where there is more salt.

Finally, ask students to consider what they can conclude about what both models could mean about what happens inside the body during dehydration and overhydration. Students can write their conclusions on their Lesson 13 Student Guide Part 4: Using Models to Observe How Changes to the Amount of Water in the Bloodstream Impact the Body. Facilitate the conversation such that students agree that:

- Water in the cells of the body moves into the bloodstream in the case of dehydration.
- Excess water in the bloodstream moves into the cells of the body in the case of overhydration.

Ask students what they think they have figured out so far and what more they should figure out next to help them better understand what happened to the athletes in the dehydration and overhydration case studies. Facilitate the conversation so that students agree that they have figured out that water moves into and out of the cells of the body in both of these cases. Next, it would be helpful to figure out more about whether this is somehow bad for the cells of different organs and how this might have led to the death of the athletes.

Part 5: Gathering Information from Text

Share with students that they will read the Lesson 13 Student Handout Dehydration and Overhydration Texts to gather evidence from two different texts to help figure out if and how changes to the amount of water in cells could have an impact on someone's health. Instruct

students that they will read the text and try to summarize at least three important notes from each text that can help them figure out how too much or too little water in cells could be damaging to the cells. Students can record their notes on their Lesson 13 Student Guide Part 5: Gathering Information from Text.

Allow time for students to read the text and to determine which ideas they will choose to record and summarize. As students work, circulate the room and ask pressing questions such as:

- Why did you choose this as an idea to record? How does it help answer our investigation questions?
- What changes does the text say are occurring to the cells when there is too little or too much water in the bloodstream?

As students work in groups, approach each group to look at their work. If students need additional support in finding central ideas in the text, consider:

- Using a partner-reading protocol, such as a Read-Aloud-Think-Aloud to have students unpack the text together by stopping during the reading to verbalize their thoughts in the moment.
- Redirecting students' attention to parts of the article they may have missed or overlooked.
- Providing a text annotation strategy to help students read and process the text.
- Having students record terms they are not certain about and having the class build definitions for these terms together.

After students have completed their reading and recorded central ideas from the text, use a sharing routine such as a Mingle-Pair-Share for students to share the different central ideas they have found with their peers. Students can record additional central ideas they hear from their peers during this time. The Mingle-Pair-Share routine can be implemented as follows:

1. Students will move around the classroom and find a peer who is not a part of their usual group.
2. Students will take turns sharing their arguments.
3. Students will then find a new peer and share their arguments once again.

Part 6: Constructing Explanations

Share with students that they will now return to the class list of initial explanations from Part 3. Students can review the list and evaluate each of the ideas on the list with the new knowledge they have gathered throughout the lesson. Read off the entries in the class list one at a time, and ask students to respond with a thumbs up, thumbs sideways, or thumbs down if they think they now support, partially support, or reject each of the ideas on the class list. As students share, record the class impressions next to the entries. Next, ask students if they have any new ideas to add to the list. Record a few student ideas as they are shared. Students can use this brainstorm as a basis to start constructing their explanations next.

Finally, share with students that they can now use their evaluations and additions to the class list to construct their own explanations for the questions they set out to investigate: "*How could athletes die from dehydration or overhydration?*" Students can record their explanations on their Student Guide Lesson 13 Part 6: Constructing Explanations. As students work, circulate the room to formatively assess their explanations and provide feedback by asking questions about their work.

CCSS SUPPORT

RST 9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Throughout this lesson, students are exposed to different findings from a variety of sources, and they use these findings to determine if they support or contradict their original explanations from Part 3.

FORMATIVE ASSESSMENT OPPORTUNITY

Students use evidence from multiple sources to construct an explanation of how changes to the water composition of cells can disrupt their essential functions and cause illness and death due to overhydration and dehydration.

Assessment Artifacts:

- Students' explanations of how athletes could die from dehydration or overhydration (Lesson 13 Student Guide Part 6: Constructing Explanations).

Look Fors:

- Students develop their explanations using multiple sources of evidence (CEDS-H2).
- Explanations describe how changes to the water composition of cells can disrupt their functions that are critical for life (LS1.A-H1).
- Explanations state the cause of the illness and death of the athletes as due to changes to the functions of their cells as the result of changes to the amount of water in the cells (CE-H2).

Assessment Rubric:

	Emerging	Developing	Proficient

Sample Student Response	The dehydrated athlete didn't drink enough water, so the cells lost water. The overhydrated athlete drank too much water, so the cells expanded.	In the case of the dehydrated athlete, the athlete died because his cells lost too much water. The water level in the bloodstream is far lower than the acceptable range, which would likely promote feelings of thirst. His kidneys would respond by trying not to lose more water to the urine. However, as his dehydration gets worse, the cells of the body will start to lose water. In the case of the overhydrated athlete, the athlete died due to too much water entering the cells of the brain. In this case, the bloodstream has excessive amounts of water. This results in the water in the bloodstream moving into the cells of the body.	In the case of the dehydrated athlete, the athlete died because his cells lost too much water. The water level in the bloodstream is far lower than the acceptable range, which would likely promote feelings of thirst. His kidneys would respond by trying not to lose more water to the urine. However, as his dehydration gets worse, the cells of the body will start to lose water. The salt concentration in the bloodstream will be so high that water will be pulled out of the cells of other organs like the skin, brain, muscles, and digestive organs. This will lead to these cells and organs not functioning properly, which if the dehydration of these cells worsens, can lead to death. The article *A Gruesome Death: the Macabre Science of Dehydration* says, "With less and less water, the blood in your body will thicken, and your blood pressure will drop drastically. This means that all of the oxygen and nutrients in your blood will take a lot longer to get to your organs, and so they become deprived. Your brain, heart, kidneys, and liver begin to fail. Ultimately, your brain will start to shrink from osmosis in an attempt to hydrate the body (the brain has a lot of water), which eventually will cause you to die." In the case of the overhydrated athlete, the athlete died due to too much water entering the cells of the brain. In this case, the bloodstream has excessive amounts of water. This results in the water in the bloodstream moving into the cells of the body, resulting in the body's cells having too much water and getting larger in size. The article *Strange But True: Drinking Too Much Water Can Kill* says, "Drawn to regions where the concentration of salt and other dissolved substances is higher, excess water leaves the blood and ultimately enters the cells, which swell like balloons to accommodate it." When brain cells in particular get too large and gain too much water, they are unable to function. The article also says, "'Rapid and severe hyponatremia causes entry of water into brain cells

			leading to brain swelling, which manifests as seizures, coma, respiratory arrest, brain stem herniation and death."
How to Achieve This Level	Student completes 0-1 out of 3 Look Fors	Student completes 2 out of 3 Look Fors	Student completes 3 out of 3 Look Fors

To Provide Additional Support for Students

As students work in groups, approach each group to look at their work. If students need additional support in developing their explanations, consider:

- Asking questions such as:
  - What evidence from this lesson did you use to support your explanation?
  - What changes occurred in this person's cells? How did that change the cells' functions? How did this lead to the athletes' deaths?
- Directing students' attention to evidence they may have missed from any of the activities in the lesson.
- Providing students with a graphic organizer that helps them summarize the evidence they found and how each piece of evidence could help them explain what happened to the athletes in the case studies.
- Engage students in a peer feedback session. Provide students with the Look Fors, and use a protocol such as Tell-Ask-Give or norms such as SPARK. Students can use the Look Fors to provide feedback to each other on how they can improve selected Look Fors in their work.

Hold a whole-class share out for students to share their explanations with each other. Facilitate the conversation so that students agree that:

- In the case of the dehydrated athlete, the athlete died because his cells lost too much water. The water level in the bloodstream is far lower than the acceptable range, which would likely promote feelings of thirst. His kidneys would respond by trying not to lose more water to the urine. However, as his dehydration gets worse, the cells of the body will start to lose water. The salt concentration in the bloodstream will be so high that water will be pulled out of the cells of other organs like the skin, brain, muscles, and digestive organs. This will lead to these cells and organs not functioning properly, which if the dehydration of these cells worsens, can lead to death.
- In the case of the overhydrated athlete, the athlete died due to too much water entering the cells of the brain. In this case, the bloodstream has excessive amounts of water. This results in the water in the bloodstream moving into the cells of the body,

resulting in the body's cells having too much water and getting larger in size. When brain cells, in particular, get too large and gain too much water, they are unable to function.