Postgame Analysis

DEVELOPER: Food and Agriculture Center for Science Education

GRADE: High School | **DATE OF REVIEW:** June 2024

Educators Evaluating Quality Instructional Products

NextGen Science

WestEd

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E

TOTAL SCORE: 9

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
3	3	3

Click here to see the scoring guidelines.

This review was conducted by the Science Peer Review Panel using the EQuIP Rubric for Science.

CATEGORY I CRITERIA RATINGS			CATEGORY II CRITERIA RATINGS			CATEGORY III CRITERIA RATINGS		
A.	Explaining Phenomena/ Designing Solutions	Extensive	**A.**	Relevance and Authenticity	Adequate	**A.**	Monitoring 3D Student Performances	Adequate
B.	Three Dimensions	Extensive	**B.**	Student Ideas	Extensive	**B.**	Formative	Extensive
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Extensive	**C.**	Scoring Guidance	Extensive
D.	Unit Coherence	Extensive	**D.**	Scientific Accuracy	Adequate	**D.**	Unbiased Tasks/Items	Extensive
E.	Multiple Science Domains	Adequate	**E.**	Differentiated Instruction	Adequate	**E.**	Coherent Assessment System	Extensive
F.	Math and ELA	Extensive	**F.**	Teacher Support for Unit Coherence	Extensive	**F.**	Opportunity to Learn	Extensive
			G.	Scaffolded Differentiation Over Time	Adequate			

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EQuIP RUBRIC FOR SCIENCE EVALUATION

Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. It is obvious that this unit was thoughtfully crafted, and it has many strengths, including:

- The use of multiple levels of phenomena, including an engaging anchor phenomenon, related module phenomena, and many lesson-level phenomena that provide rich opportunities for students to engage in figuring out science ideas through the use of the practices and Crosscutting Concepts (CCCs).
- Throughout the unit, student questions are consistently elicited and revisited, providing numerous opportunities for students to express their ideas, identify gaps in understanding, and explore further questions.
- Teachers are provided with a clear assessment system, linked to each module and lesson, which includes relevant features of proficiency for each task.
- The unit provides clear explanations of what students should know across all three dimensions, building on prior learning as students develop and apply their learning.

During revisions or classroom use, the reviewers recommend paying close attention to the following:

- **Monitoring Three-dimensional Performances:** Although the unit offers many formative and summative assessments, many do not generate individual student artifacts. This reliance on group work makes it difficult for teachers to monitor individual student progress.
- **Relevance and Authenticity**. Increasing opportunities for students to incorporate their individual, family, community, and cultural experiences with exercise and recovery would strengthen the unit. Connecting the learning to other intense physical activities, such as demanding jobs, house repairs, or recreation, could further extend the learning beyond the classroom.
- **Differentiated Instruction.** Consider increasing the level and depth of differentiated instruction guidance to ensure that students with many varying learning needs can access instruction throughout the unit, especially focusing on strategies that can help students who struggle with meeting the reading and writing demands expected to show proficiency in the task and multilingual learners.
- **Scaffolded Differentiation Over Time**. Some of the claimed Science and Engineering Practice (SEP) elements do not appear to have reduced scaffolds to increase student independence in leveraging that practice to make sense of the phenomenon. Consider making modifications to push students toward making those jumps as they progress throughout the unit.
- **Consistency with the Phenomenon and the Unit Learning:** While the anchor phenomenon features mostly chocolate milk, most of the rest of the unit learning focuses on regular milk, creating an inconsistency between the anchor phenomenon and the unit learning. Engaging students in the decision about what kind of milk to explore and when could help provide coherence in matching the learning to the anchor phenomenon.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met, and purple text is used as evidence that doesn't support a claim that the criterion was met. The purple text in these review reports is written directly related to criteria and is meant to point out details that could be possible areas where there is room for improvement. However, not all purple text lowers a score; much of it is too minor to affect the score. For example, even criteria rated as Extensive could have purple text that is meant to be helpful for continuous improvement processes and an opportunity to further refine the unit to heighten student sense-making experiences; in these cases, the criterion WAS met; the purple text is simply not part of the argument for that Extensive rating.

CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

Making sense of phenomena and/or designing solutions to a problem drive student learning.

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students making sense of phenomena or designing solutions to a problem. Student learning is driven throughout the unit by the anchor phenomenon of using milk to recover from exercise. Students are provided numerous opportunities to use their questions to drive sense-making of this high-interest central phenomenon. Module-level phenomena clearly connect to this anchor phenomenon and student learning is frequently driven and motivated by student questions and connected to prior experiences. Most learning is student-driven from the perspectives of the students.

Making sense of phenomena is what drives student learning as students seek to figure out, "How can milk help athletes recover from physical exercise?" (Teacher Guide, page 1). The lessons support students in making sense of phenomena with many smaller modular-level or lesson-level phenomena that contribute to the overall concept of how exercise is accompanied by changes at the molecular- and organ-system levels and how these changes can be monitored and remedied by natural processes as well as human interventions. Students identify what they have figured out and what they still need to figure out to move to the next phenomenon or investigation in order to address gaps in their understanding. Related evidence includes:

- The unit synopsis outlines the phenomenon which will be used to drive the unit: "In this unit, students investigate how milk helps athletes recover from intense exercise. Students begin by observing a series of professional athletes undergoing intense exercise and drinking milk after their exercise sessions. These athletes claim that drinking milk helps them recover from their workouts. This leads to the Driving Question for the unit: How can milk help athletes recover from physical exercise?" (Unit Guide, page 1). The synopsis then goes on to explain how each module connects back to the driving phenomenon. For example, "Next, in the fourth module, students observe that skeletal muscle soreness is common after exercise such as lifting weights and that drinking milk after the workout can help reduce the perception of muscle soreness. Students figure out that muscle soreness is caused by microtears in muscles, which bring the muscles out of a stable condition" (Unit Guide, page 1).
- Unit Guide: The Unit Overview in the Unit Guide provides a "Connection to Anchor Phenomenon" section after each listed module that describes how what students figure out in each lesson is connected to the anchor phenomenon (Unit Guide, pages 3–10).

- Lesson 1: "Share with students that we will now observe how different kinds of professional and amateur athletes exercise and how they recover from exercise. Direct students to select two videos from the video list and record what they notice" (Teacher Guide, page 3). Eight videos are provided. Students view videos of athletes working out. Some videos show athletes drinking milk or chocolate milk. Others make statements that the athletes drink milk to help with recovery. Then students view a video explaining a study in which evidence indicates that chocolate milk can outperform other drinks in providing recovery from intense exercise that leads towards increased performance later. These videos serve as the anchor phenomenon for the unit and both the lesson and the unit focus on figuring out how this phenomenon of milk aiding recovery works (Teacher Guide, pages 3–6).
- Lessons 1 and 3: Students watch a series of videos that include athletes describing how they choose milk as a recovery drink following a strenuous workout. Six of the videos feature chocolate milk and two of the videos feature regular white milk. (Teacher Guide, page 3). The video of the study that was conducted also features chocolate milk. These videos are presented as the anchor phenomenon in student facing materials (Student Guide, Part 2: Observing the Anchor Phenomenon). However, other than in Lesson 3, in which students learn of the sucrose that is an ingredient in chocolate milk (Chemistry of Milk handout, page 3), chocolate milk is not a part of the student discussions and the figuring out of phenomena in upcoming lessons throughout the unit. Since the materials identify the videos that largely feature chocolate milk as the anchor phenomenon for the unit, yet the unit focuses on regular milk without including chocolate milk at least occasionally in the discussion, there is a disconnect between the phenomenon students experience to launch the unit and the unit learning. Lesson 3 (or possibly a subsequent lesson) represents a possible missed opportunity to further address what the sucrose in milk possibly does to help in recovery. It is also a missed opportunity to have students be a part of the decision for the unit to mostly focus on regular milk's ingredients and their role in aiding in recovery, thus resolving the disconnect between the phenomenon and the focus of the learning.
- Lesson 1: The use of a phenomenon call out box says, "... students figure out why milk and/or chocolate milk could be used as an effective exercise recovery drink. Throughout the unit, we treat milk and chocolate milk interchangeably and refer to both generically as 'milk.' Both beverages have been studied and shown to support recovery from exercise. In some cases in the unit, we refer to chocolate milk specifically when investigating the molecular components in milk because chocolate milk contains added sugar (sucrose)" (Teacher Guide, page 4). This note helps to explain to teachers why the unit focuses on the generic term "milk." However, without a student component that surfaces this idea from the students' points of view, it does not resolve the disconnect between what students experience with the anchor phenomenon (mostly chocolate milk) and what most of the learning focuses on (regular milk). There is a missed opportunity, either in this lesson, or in an upcoming lesson, to involve students in the decision that focuses on regular milk throughout the unit.
- Lesson 2: Students observe a digestion video and record observations and questions about "what they noticed happened to the food and what organs were involved" (Teacher Guide, page 3). The teacher is instructed to "build off student responses" (Teacher Guide, page 3) as students begin to figure out how milk is digested after it is consumed. Lessons 2–7 in the module focus on students making sense of the digestion process they observed in the video (Teacher Guide, page 3). While this is presented as a module-level phenomenon, it serves more as an informational video in how it is presented to the class with the narrator explaining what is going on in the video rather than students observing the video as a phenomenon without a simultaneous explanation being heard.

- Lesson 4: Students identify what they have figured out about the module question and what they still need to know by focusing on the "Module Question, How is milk digested after it is consumed?" The teacher shares "with students that they ended the last lesson by evaluating claims about which organs in the digestive system contribute to the digestion of molecules in milk" and "asks students what they have figured out so far to answer the Module Question. Example responses include: ● We know that multiple organs in the digestive system contribute to the digestion of milk. ● We know that each of the organs has specialized cells that produce enzymes that break down the molecules in milk. Ask students what they still need to know to fully figure out the Module Question. In student responses, listen for the following ideas: ● We don't know how different organs work together to digest milk. Build off student responses to share that they will now use a model of digestion to help figure out how our organs and the specialized cells in them work together to digest the molecules in milk. Finally, point to the category 'How Does My Body Digest Milk?' on the Driving Question Board (DQB). Share a few selected questions that align with what students will investigate in this lesson" (Teacher Guide, page 2). The sequence of learning activities supports students as they endeavor to figure out the anchor unit phenomenon.
- Lesson 8: Students identify additional questions that they would like to address to help understand the central phenomenon. "Introduce the Workout Video by telling students, 'We previously shared some experiences we have had with intense exercise (in Lesson 1), including sweating and getting overheated. To help us figure out how athletes recover from the effects of exercise, we will watch a video of an athlete exercising and see what we notice about these effects and how milk helps an athlete recover'" (Teacher Guide, page 3). The video shows an athlete exercising on a treadmill and displays data about the changes that occur in her during exercise and after exercise with and without drinking milk during recovery. The data include changes in her internal body temperature, skin temperature, sweat, feeling of thirst, and urine color. Students record and use these observations as the basis for beginning to figure out the 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?" (Teacher Guide, pages 3–7).
- Lesson 9: The focus of the student activities is to make sense of how the body temperature rises during exercise and returns to a stable state after exercise stops. Students analyze body temperature data from a scientific article that shows data from before, during, and after exercise (Teacher Guide, pages 3–7). Then students use a "Science Theater" activity as a model in which they enact the "physiological processes that regulate temperature change in the body in response to exercise" (Teacher Guide, pages 7–10). They then participate in a whole class discussion to share key points about what they figured out.
- Lesson 9: A use of phenomena note explains that between "Lessons 9–12, students will focus on the Module Phenomenon" and in "Lesson 14 they will return to the Anchor Phenomenon to create presentations" (Teacher Guide, page 2) that show what they have figured out about how milk can help athletes recover from exercise.
- Lesson 11: After observing a food coloring demonstration that simulates urine samples before and after exercising, students work with partners to figure out what they think the model represents about urine before and after exercise, and what they think happened during exercise to make the urine have less water in it. They use what they have learned in prior lessons and what they observed in the demonstration to figure out how they think less water is in urine after exercise (Teacher Guide, pages 8–13).
- Lesson 16: Students build upon their discussion in the prior lesson and identify current gaps in their understanding about the central phenomenon such as, "We aren't sure why the increased breathing rate and heart rate increased during exercise. Does the body need more oxygen and

nutrients during exercise? We aren't sure what is happening inside the muscles to make them fatigue and burn. We aren't sure how the body makes energy to make the muscles keep moving. We aren't sure if there is a connection between energy and the muscles getting tired" (Teacher Guide, page 2). Having students identify what they have not yet figured out about the central phenomenon keeps the "figuring out" process as the reason for the learning from the students' perspective.

- Lesson 18: Students "…recall some of the ideas they had to explain the Module Question and some of the areas of uncertainty they had. Invite a few students to share what ideas the class had. Listen for responses such as: To bring air into and out of the body, we have to breathe. If we are producing more carbon dioxide during exercise, we have to breathe more often to get it out of our body. The faster we breathe, the more carbon dioxide we have to exhale. We saw that there is more oxygen in our blood going to our muscles. If we are breathing faster, then we are also bringing in more oxygen. The heart pumps blood, so if there is more oxygen in the blood and it needs to get to our muscles, the heart would need to pump faster to get it to those places quicker. We aren't really sure yet what the increases in oxygen and carbon dioxide consumption would have to do with muscles burning and fatiguing, getting energy for exercise, or how milk helps in recovery" (Teacher Guide, page 3).
- Lessons 19: Students revisit the explanations they constructed in Lesson 18 when they used the findings from their investigation to construct an explanation to the module questions. "Invite a few students to share the explanation they constructed or one they heard. These might sound like: Blood glucose levels go up during exercise. I think this could be coming from the muscle and liver glycogen because they go down during exercise and glucose might be used during exercise for energy. When epinephrine levels increase, my heart feels like it is pounding…" (Teacher Guide, page 2). This is an example of using investigations to figure out phenomena.
- Lesson 23: "…observe a new phenomenon to help them figure out how a person who exercises for very long periods of time could get the energy to do so. Show students the Ultramarathon Runner Video of a runner completing a 56-kilometer race and ask them to record their observations on their Lesson 23 Student Guide Part 2: Observing a New Phenomenon…. After students have recorded their observations from the video, hold a whole-class discussion for students to share what they have found. Facilitate the conversation so that students agree that: ● The ultramarathon is a very long race, 56 kilometers. ● The runner completed the race without eating any extra food. ● He seemed to not really get too tired along the race. After agreeing on their observations from the video and data set, introduce the question students will investigate in this lesson, 'How does someone exercising for a long time get the energy their body needs to keep moving?'" (Teacher Guide, page 3). This is an example of using phenomena to generate questions to drive the learning that will serve to help figure out the phenomenon.
- Lesson 24: Students revisit their "Anchor Phenomenon presentations from Lessons 1, 7, and 14. Ask students how they think what they have figured out since they last updated their presentations will help them modify or add to their presentations" (Teacher Guide, page 3). Students should respond to this question in their Student Guide.
- Lesson 25: Students observe a Workout Video as the Module Phenomenon. The teacher builds off student responses to introduce the Module Question, How does milk help in muscle recovery from soreness induced by intense exercise? Students create initial explanations in small groups to articulate their current response to the Module Question and then create a class consensus explanation (Teacher Guide, pages 3–9).
- Lesson 29: Before digging into the lesson, teachers are asked to start by having "…students individually review the Explanation from their Lesson 25 Student Guide Part 4: Creating and Sharing Initial Explanations. This explanation describes how students answered the Module

Question, How does milk help in muscle recovery from soreness induced by intense exercise? This individual review is to see what gaps exist in the explanation from what they have learned so far in the module" (Teacher Guide, page 2). From there, students are expected to identify microtears as a cause of soreness or the specific ways that the body can respond to help muscles regain stability.

- Lesson 30: Students shift focus from the mechanisms of muscle recovery to try and figure out "…how muscles get stronger after exercise" (Teacher Guide, page 2).
- Lesson 30: "Share with students that they will now observe a new phenomenon to help them figure out if and how muscles could get stronger after exercise. Distribute the Lesson 30 Student Handout Data Set and share with students that they will now analyze three pieces of data from a scientific journal article in which scientists studied the changes to muscles that took place after two different kinds of workouts: an endurance workout and a resistance training workout. Share with students that they should record what they notice about the changes in muscles that occur in each piece of data on their Lesson 30 Student Guide Part 2: Observing a New Phenomenon… After agreeing on their observations from the video and data set, introduce the questions students will investigate in this lesson, 'How do muscles increase their size and strength in response to resistance exercise? How can milk help with this process?' Allow time for students to write these questions on their Lesson 30 Student Guide Part 2: Observing a New Phenomenon" (Teacher Guide, pages 2–3).

Student questions, ideas, and prior experiences related to the phenomenon motivate nearly all sense-making in the unit and create a need to learn about the broader topic of exercise and recovery from the students' perspectives. Related evidence includes:

- Lesson 1: Students write and then share past experiences they have with exercise, including how it feels after exercising. Notes are provided to help draw in experiences from students with varying physical abilities (Teacher Guide, pages 2–3). Connecting to students' own experiences helps students identify with the athletes they see in the videos they then watch.
- Lesson 1: Near the end of the lesson, student questions are generated that "help them determine what additional information they need to know to help them figure out how milk can be used for exercise recovery by athletes" (Teacher Guide, page 12). The questions are grouped into categories with the goal being that "the emerging categories correspond with the upcoming modules so that students can see that the questions motivate and drive the introduction of the following lessons" (Teacher Guide, page 13). These questions, plus others that are added in upcoming lessons, serve as the driver of the learning for the unit.
- Lesson 1: Students are informed that, "Your questions and ideas are the most important part of our classroom work together, so we will use them to decide on what our upcoming investigations will be…and to help us investigate what happens in our bodies during exercise and how milk could help with recovery from exercise" (Teacher Guide, page 14). However, since chocolate is the type of milk featured in most of the videos, including the video showing the study, and has been claimed as a recovery drink in many public media forums which students have likely seen, it would make sense that some of the student questions would be asking about chocolate milk's role in recovery and if it is different than just plain milk in assisting with recovery. These likely student questions are not listed in the possible questions students might ask. Other than a brief mention in Lesson 3 regarding the sucrose in chocolate milk, student questions regarding chocolate milk, nor the possible additional role of the sucrose in chocolate milk in aiding in recovery, are not addressed in upcoming lessons nor included in the sample student presentations or explanations when figuring out the phenomenon. This is a missed opportunity for connecting the learning to students' own questions.

- Lesson 2: The lesson begins with students returning their attention to the questions they generated in the previous lesson and determining which question categories would be most important to figure out first as they make sense of the phenomenon of milk helping athletes recover from physical exercise. Students identify questions that will move class thinking forward about how milk is digested, such as, "What happens while I exercise that causes it to need recovery? We know that milk is being used in athletic recovery; what is in milk that makes it so good at doing this?" (Teacher Guide, page 2). These questions are used to drive the learning for this module for Lessons 2–7.
- Lesson 2: Students record any questions they have based on what they observed in a digestion video. "Build off student responses to introduce the Module Question, How is milk digested after it is consumed? Share with students that they will set out to figure out the answer to this question in the following lessons" (Teacher Guide, page 3). At the end of the lesson, students "create a new list of questions that can help them determine what additional information they need to know to help them figure out how milk is digested after it is consumed" (Teacher Guide, page 9). These questions are added to the DQB to be referenced in the coming lessons.
- Lesson 8: Students are introduced to the second module (Lessons 8–14) by revisiting the DQB and asking, "what questions seem like the most pressing question to investigate next?" (Teacher Guide, page 2). The teacher builds off "student responses to point to the questions related to the effects of exercise on hydration/dehydration and how milk helps athletes recover from these effects" such as, "Why does a body need to hydrate as part of exercise recovery? How does water in milk help with recovery? ... Does the amount we sweat impact the amount of fluids we need to replenish? Does drinking specific items, like milk, increase hydration only? Are there other effects?" (Teacher Guide, page 2). This is an example of using student questions to move to the next module of learning.
- Lesson 10: Sample possible Consensus Models are provided with a note for teachers that states: "The following pages show an example of what the Class Consensus Effects of Exercise Model and Recovery Model may look like, though you will want to follow the ideas of your class rather than drive them to these exact models" (Teacher Guide, page 7). By reminding the teacher to "follow the ideas of your class," the learning continues to be driven by student ideas.
- Lesson 11: Students are asked about "what their experiences are with when their urine color changes" (Teacher Guide, page 3), share responses, and record their own observations in the Student Guide. This connects the upcoming learning to students' own experiences.
- Lesson 13: Students read about two cases of athletes who drank too little water and too much water. After reading, students discuss their observations. "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?'" (Teacher Guide, page 4). The teacher tells the students the questions they will investigate rather than facilitating the discussion so that students will pose these questions as they consider the two phenomena they have read about so that they are directing the learning path.
- Lesson 15: Students identify questions from the DQB that have not yet been addressed in the unit, emphasizing the importance of energy. Student questions are expected to include: "Do you get energy from milk? Is energy involved in exercise? What part of milk helps you get more energy to work out? How does the body use energy during exercise? How do you recover the energy you lose in exercise?" (Teacher Guide, page 3). Directions do not include suggested prompts to help students generate related questions if the DQB list lacks expected questions to drive the lesson.
- Lesson 15: Students complete a high intensity workout in the classroom and "make observations of what they are feeling and experiencing as they complete each of these workouts" (Teacher

Guide, page 4). Students record data on their heart and breathing rates, thus experiencing the phenomena of heart and breathing rate increases directly with their own classroom experience. In this lesson, students also read about an investigation involving soccer players drinking a recovery drink twice after a morning soccer workout, then doing their afternoon soccer practice. One of the recovery drinks was chocolate milk. While discussing the results, this could possibly be a missed opportunity to revisit any questions students might have had specifically about chocolate milk along with a discussion about the sucrose in chocolate milk and its possible role in aiding with recovery.

- Lesson 19: Students begin by considering what their data analysis revealed about measurable changes that take place within the body as a result of exercise. Teachers should "remind students that based on their explanations, they added several new questions to the Driving Question Board. Return to it and focus on the questions specifically added to the board at the end of Lesson 18." (Teacher Guide, page 3). Directions do not include suggested prompts to help students generate related questions if the DQB list lacks expected questions to drive the lesson.
- Lesson 22: Teachers "ask students if these explanations accurately reflect the new evidence they have about how using milk as a recovery drink contributes to recovery. Listen for responses such as: We were able to explain how exercise impacts the body to make heart rate increase, breathing rate increase, fatigue, and muscle burning occur, but we didn't figure out how milk could help with recovery. Next, point to the questions on the Driving Question Board related to milk and recovery from exercise. Share a few selected questions that align with what students will investigate in the upcoming lesson. Example student questions or ideas could include: What does milk do to help with recovery from fatigue? What does glucose do once it is in the bloodstream? How does the sugar and lactose in milk help with recovery?" (Teacher Guide, page 2). Directions do not include suggested prompts to help students generate related questions if the DQB list lacks expected questions to drive the lesson. A similar lack of suggested prompts occurs in Lesson 23, 25, and other lessons.
- Lesson 25: Students are asked to think about their prior experiences with muscle soreness and record their response in the Student Guide. Students share some of these stories and experiences with the class in a whole-class share out (Teacher Guide, page 3). A Student Support call out box provides suggestions for eliciting responses from all students, not just those involved in regular athletics or exercise.
- Lesson 25: "Introduce the Workout Video by telling students, 'We have a variety of experiences with muscle soreness and recovery. We had a lot of questions on our Driving Question Board about why muscles get sore and how they recover'" (Teacher Guide, pages 3–4). Students then watch a video of "someone who works out twice: first lifting weights and recovering without milk, and second lifting weights and recovering with milk" (Teacher Guide, page 4) and their responses are built off to introduce the module question, "How does milk help in muscle recovery from soreness induced by intense exercise?" (Teacher Guide, pages 3–4).
- Lesson 26: The teacher is instructed to, "Ask students to identify any gaps in the [class consensus] explanation that they need to figure out how milk helps in muscle recovery from soreness induced by intense exercise. Ask students to share what some of those gaps were. In student responses, listen for the following ideas: We think protein in milk has to do with recovery, but we don't know what happens to the amino acids in the bloodstream after the protein in milk is digested. We don't know what happens to muscles and/or muscle cells to make them feel sore" (Teacher Guide, page 2). Student-identified gaps in understanding drive the need to learn more from the students' perspective.
- Lesson 29: The teacher "asks students to reorient to the Driving Question for the unit, How can milk help athletes recover from physical exercise?" (Teacher Guide, page 5). Students focus on

this question to guide their collection of ideas and make revisions in their explanation and models.

- Lesson 30: Students begin the lesson by discussing the questions they ended with last lesson and still need to address before moving on. These questions could include, "how do we get stronger after exercise?" or "do proteins from milk help you get stronger?" (Teacher Guide, page 2).

Often, student sense-making of the phenomena is the reason for the students to learn from the student's perspective and student questions often drive the learning. However, in some instances, the learning is teacher-directed when it would be more appropriate for student input to drive the learning. Some relevant evidence includes:

- Lesson 1: Students are told that they will "go further than the videos did and have our presentations explain exactly how these factors are important in recovery, including what they do inside the body to help an athlete recover from exercise" (Teacher Guide, page 7). This is a major driver of the type of learning students will engage in during the unit. However, students are not engaged in questions and observations that move the students (not the teacher) toward expressing the need to know what happens inside the body in order to explain how milk can help with exercise in recovery. Having the teacher "tell" what they are going to explain prevents students seeing themselves as the driver of the learning that will help them make sense of the phenomenon.
- Lesson 13: "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 studies in Lesson 13 Part 2: Observing New Phenomena" (Teacher Guide, page 3). After reading, students discuss their observations. "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" (Teacher Guide, page 4). In this lesson, the teacher tells the students the questions to investigate rather than facilitating a discussion for students to pose these questions themselves and direct the learning path.
- Lesson 23: "After agreeing on their observations from the video and data set, introduce the question students will investigate in this lesson, 'How does someone exercising for a long time get the energy their body needs to keep moving?'" (Teacher Guide, page 3). The teacher tells the students the questions to investigate rather than facilitating a discussion for students to pose these questions themselves and direct the learning path.
- Lesson 30: After agreeing on their observations from the video and data set, introduce the questions students will investigate in this lesson, "How do muscles increase their size and strength in response to resistance exercise? How can milk help with this process?" (Teacher Guide, pages 2–3). In this example, the teacher jumps from student observations to "telling" the students the questions they will investigate. This is a missed opportunity to first have students ask questions that arise from their observations, and then have the teacher build off student questions to connect to the investigation questions in order for students to feel that it is their questions that are driving the learning and not the materials or the teacher.

Suggestions for Improvement

- Consider revising some lessons to increase student-driven learning by providing opportunities for students to ask questions based on their observations and providing prompts for teachers to guide students in generating questions that match those expected on the DQB. This will help students see themselves as the drivers of learning throughout the whole learning sequence.
- Consider including student questions about whether chocolate milk aids recovery differently from white milk to ensure consistency with the videos and the types of questions they generate.
- Consider revisiting chocolate milk after Lesson 3 to investigate the role of sucrose in recovery. Address this in sample questions, responses, and presentations to strengthen the connection between the anchor phenomenon and the unit's learning focus. One possibility would be for the learning in a lesson to support students including a sentence such as, "The sucrose in chocolate milk might have a role in aiding in recovery after exercise as it is digested and used by the body for energy" (or a similar sentence with relevant details learned in the lesson) in their explanations and presentations.
- To clarify the reason the unit's learning goes in the direction of the ingredients of regular milk and their role in aiding in recovery, consider including a discussion with students, after they learn about the role of sucrose in the body, in which the class together decides that since the rest of the ingredients in chocolate milk are pretty much the same as what is in regular milk, their investigations can now focus on the nutrients in regular milk. This will eliminate the disconnect between the anchor phenomenon and the learning that occurs in the rest of the unit.
- Consider showing the Digestion Video in Lesson 2 first without sound with a simple introduction. Later in the lesson, show the video with sound to help students track the movement through organs and understand the accompanying explanations.

I.B. THREE DIMENSIONS

Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to *develop and use* specific elements of the SEP(s).

ii. Provides opportunities to *develop and use* specific elements of the DCI(s).

iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because each of the grade-appropriate elements claimed are developed and used throughout the unit in service of student sense-making as they figure out phenomena. Students engage in many opportunities in which they build understanding of multiple SEPs and Disciplinary Core Ideas (DCIs) throughout the unit modules. Lessons

provide directed language that engages students in crosscutting thinking as they make sense of the phenomena.

Science and Engineering Practices (SEPs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the SEPs in this unit. Each of the claimed elements are sufficiently used and developed throughout the unit in the service of student sense-making. There is a strong match between grade-appropriate SEP elements that are claimed and evidence of SEP development and use in the materials. However, one element is claimed fully even though it is only developed partially, and this may lead towards potential misinterpretation of the degree to which the full element is developed and used.

SEP Category addressed (or not addressed):

Developing and Using Models

- *Develop ~~and/or use~~ multiple types of models to provide mechanistic accounts ~~and/or predict phenomena~~, and move flexibly between model types based on merits and limitations.*
    - This element is not identified as a unit focal element but is claimed within some lessons. Only a part of this NGSS SEP element is claimed in Lessons 4, 9, 11, 19, and 28. No explanation is provided in the materials to clarify that the focal element that is targeted is only a part of the full NGSS element. The element is claimed fully for Lesson 6.
    - Lessons 4, 9, 11, 19, and 28: These lessons provide opportunities for students to engage in a role play type of activity called "science theater", in which they take on the roles of organs or other structures in the body and go through a process in which they exchange cards that explain the body processes that occur during the focus phenomenon of the module. These opportunities engage students in not only using a model, but being a part of the model as they seek to figure out the "biological processes the body experiences" (Unit Guide, page 22). In Lesson 4, students act out the process of digestion (Teacher Guide, page 5). In Lesson 9, students take on the role of a "specialized cell within an organ that is involved in the way the body maintains its core temperature and responds to change in temperature" (Teacher Guide, page 8). In Lesson 11, students use this Science Theater model "to provide an explanation of how a living system's water balance changes due to exercise and how the living system responds to stabilize the water balance in the system" (Teacher Guide, page 1). In Lesson 19, students model various ways that energy can be created as needed to support the work required of given tasks such as exercise (Student Handout, Science Theater Card Set, page 35). In Lesson 28, students use this model to describe the function of organs and how specialized cells contribute their function (Student Guide, page 1).
    - Lesson 6: Students use five different models to determine what happens to the nutrients in the small intestine. Students discuss the meaning of merits and limitations (Teacher Guide, page 4), analyze each model, and record the merits and limitations of each model on a chart (Student Guide, pages 2–3), with the teacher providing prompts to deepen thinking, such as, "What do you think this model shows that the others do not? What science ideas does this model bring into focus? What is not focused on?. . .What scale does this model bring into focus? What is not focused on?" (Teacher Guide, page 5). They then use the merits of the different models to explain how they think nutrient molecules get from the small intestine to the rest of the body (Student Guide, page 4). Students determine that using multiple models to explain a process is beneficial because " ● Different models have different merits and bring different things into focus.

So, using multiple models and being able to understand the connections between the merits of one model and another can help us understand the full process" (Teacher Guide, page 5). By having students reflect on their use of the merits and limitations of multiple models in this task, students further develop their understanding of how to apply this element in making sense of phenomena. While the claimed listed element indicates that students will develop multiple types of models, this task asks students to use multiple types of models rather than develop one.

- *Develop, revise, ~~and/or use~~ a model based on evidence to illustrate ~~and/or predict~~ the relationships between systems or between components of a system.*
    - This element is not identified as a unit focal element but is claimed within some lessons.
    - Lesson 2: In small groups, students create initial models to explain how milk is digested after it is consumed. The Student Guide includes a bulleted list of model conventions for students to incorporate in their models (Student Guide, page 2), which includes the use of images, descriptions, arrows, and zoom-ins to show what is happening at a smaller scale. Students use their observations of the digestion video as well as prior knowledge to develop a model that represents different parts of the digestion system, descriptions of the process, what enters and leaves each part of the system, and what is happening at a smaller scale in parts of the system (Teacher Guide, pages 7–8).
    - Lessons 2, 5, 6, 10, 12, 20, 22, 23, and 29: The expected use of a zoom-in convention is established in Lesson 2 as one of the conventions listed for students to incorporate in their models as a way to show "what is happening on a smaller scale in each part of the system" (Teacher Guide, page 4). These conventions are explicitly reviewed in Lessons 5 and 6. However, the sample models only include plain boxes that are near the main organ, and do not include any graphical conventions that indicate that the structure described in the box represents a smaller structure that is within the organ. The Class Consensus models for Lessons 10, 12, 20, 22, 23, and 29 also include the expectation that zoom-ins will be used. However, the sample models again do not use any conventional zoom-in graphics to indicate smaller structures within an organ are being represented. The lack of conventional graphical features accompanying the zoom-ins makes it difficult to tell that the information that is provided as zoom-ins in the sample models is representing a zoom-in of smaller structures in the corresponding organs in the provided sample models.
    - Lesson 5: In small groups, students revise their initial models from Lesson 2 to "show what they have now figured out regarding the digestion of milk" (Teacher Guide, page 3). Students brainstorm the new ideas they have and what they have learned and determine how this information leads towards creating change in the model. Students are reminded of the conventions they used in Lesson 2: boxes, arrows, and zoom-ins. (Teacher Guide, page 3). Student groups revise their models to illustrate relationships between systems and between components of a system in the digestive process (Teacher Guide, page 3). During a class discussion, the class builds a consensus model (Teacher Guide, pages 3–5).
    - Lesson 6: Students use five models to determine what happens to the nutrients in the small intestine. Using the merits of each model, students develop a model that shows how nutrient molecules are absorbed by the body. In their models they show the "interactions between components of the digestive system and circulatory system, including which molecules move from one component to the next" (Teacher Guide, page 8) as a mechanistic account.

- Lessons 5 and 6: In addition to providing zoom-ins in their models, students are explicitly asked to include size indications in their models as an expected criterion: "An indication of the size (e.g., in, m, cm, mm, um, or nm) of the organs and cells shown in the model" (Student Guide, page 1). However, the sample student proficient models provided for the teacher (and as student sample proficient responses) do not include size indications. This creates a disconnect between the expected criteria for what the models show and the samples that are provided as examples of proficient models that meet the criteria. In addition, using size indications in later models throughout the unit is not listed as an expectation. Asking students to include size indications for the various sizes of structures the model represents increases students' awareness of the significant size differences of the included structures.
- Some of the lessons include models for students to use that contain very small print which is nearly impossible to read both on a screen and as a printed version. This can create difficulty for both the teacher and the students in interpreting and comprehending how the model *illustrate[s] and/or predict[s] the relationships between systems or between components of a system.* Some examples where this occurs are:
  - Lesson 3 Enzyme illustration
  - Lesson 3 Station Cards, specifically the Stomach model (page 6), the Small Intestine: Epithelial Cells model (Station Cards, page 10), the Large Intestine Model (Station Cards, page 16).
  - Lesson 9 Science Theater Cards (specifically the Hypothalamus Card)
- Many of the models provided as sample proficient student responses in both the Teacher Guides and Student Guides contain very small print that is nearly impossible to read, making it difficult to determine the types of details that are expected from student tasks.

Planning and Carrying Out Investigations

- *Plan an investigation ~~or test a design individually and~~ collaboratively to produce data to serve as the basis for evidence as part of ~~building and revising models,~~ supporting explanations for phenomena, ~~or testing solutions to problems.~~ Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.*
  - This element is not identified as a unit focal element but is claimed within one lesson.
  - Lesson 17: Students develop an investigation plan to collect data to help answer "how does intense exercise impact the amount of carbon dioxide we breathe out?" (Teacher Guide, page 3). To accomplish this, students are introduced to bromothymol blue as a proxy indicator for the presence of carbon dioxide in solution. Students are encouraged to use their materials list to create a draft of their experimental design and reflect on whether they will be able to fully evaluate the claim they made. "Did you eliminate all confounding variables? What other confounding variables may be present that you did not consider?" (Student Guide, page 2). Additional tips to support student questions are provided on the document titled "Student Handout Experiment Design Tips". Students are then given an opportunity to revise their initial plan before conducting their experiment. While lesson materials encourage students to "make a claim to predict the relationship between the amount of carbon dioxide exhaled and high-intensity exercise vs. rest", it's not clear that students are expected to use evidence or prior experiences to serve as the basis for their claim. As a result, it appears that this language usage may cause students to conflate words such as hypothesis, prediction, and claim when it would not be advantageous to do so.

- Lesson 17: The following guidance explains that students evaluate their investigation design to ensure variables are controlled and to include control groups. “Depending on the previous experiences of your students with planning investigations, spend some time reviewing the various aspects of experimental design from middle school” (Teacher Guide, page 4).

Analyzing and Interpreting Data

- *Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.*
  - Lesson 1: This element is not claimed for this lesson, but the following teacher guidance is provided for this SEP element: “Though this is not a targeted SEP in this lesson, throughout this unit, students will often engage with this element. As a part of this SEP, students will analyze the methods used in scientific exercise studies. To support students in building their proficiency with this SEP element, you may review the study design shown in the video. Students may have past experience from middle school with aspects of experiment design. You can ask students questions such as: ● What was the independent variable in this study? ● What was the dependent variable in this study? What variables were controlled? ● What was the control group comparison?” (Teacher Guide, page 5). The materials are clear that this lesson does not directly develop this SEP, but that teachers can help students build toward developing this SEP in future lessons by asking students the listed questions. This support connects students to what they learned in middle school with the **Planning and Conducting Investigations** element, *Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.*
  - Lesson 16: Students examine two studies that explore the relationship between exercise and its impact on the blood and breath within the body. As they analyze the data, students are prompted to “…compare the findings between the two studies and determine if they think the findings are consistent or not” (Teacher Guide, page 4). Students are provided with instructions as to how to look at the methods and data from the experiments: “Allow students time to analyze the methods of the two experiments and the data presented to determine if the study findings were consistent with each other and to reflect on how the study used the lens of stability and change” (Teacher Guide, page 4).
  - Lesson 18: The following additional guidance is provided for teachers regarding the development of this SEP element: “In this lesson, students are analyzing the experiment design and outcome from two scientific research articles and determining if the findings are consistent. They are then summarizing the findings of their studies, sharing them with peers, and listening to the summaries of studies from other groups. This builds on the experiences students have had in Module 1 when analyzing the methods and outcomes of single studies and on the experiences in Lesson 16 in comparing the findings of two studies for consistency” (Teacher Guide, pages 5–6). “Students reflect on why they think it is helpful to analyze the findings from multiple scientific studies to determine if the findings are consistent and determine that when you analyze the findings from multiple studies and discover that the outcomes are consistent, you can be more confident that the finding is reliable and not an accidental or mistaken finding due to potential errors in the way a single study was designed or carried out” (Teacher

Guide, page 9). Providing time for reflection on their use of this element further develops students' skills in applying it as they figure out phenomena.

- Lesson 21: "Share with students that to investigate how drinking milk could help restore glucose and glycogen in the body after exercise, they will analyze the methods and data from two scientific studies that asked similar questions" (Teacher Guide, page 3). "Students are asked to summarize the methods that they used, the data they collected, and their findings" (Student Guide, page 1). As part of this, students compare the two studies and consider "how did scientists use the lens of stability and change in designing and analyzing the results of this study? Is this consistent with how we've seen scientists use this lens previously?" (Student Guide, page 2).
- Lesson 21: The following teacher guidance is provided related to the development and use of this SEP: "In this lesson, we continue with the progression of reducing scaffolds for students to engage in this practice. In Lesson 18, students were asked a series of questions to help them analyze the methods used in both studies and the data collected and to compare the outcomes of both studies. Here, we reduce the number of prompts to two and ask students to analyze the design of the studies and the outcomes together and then, analyze if the studies are consistent in their findings" (Teacher Guide, page 4).
- Lesson 23: Students examine three figures from a journal article that highlights changes in fatty acids within the body as athletes exercise for extended durations. As part of this activity, students will "compare the three data sets. Explain if you think the findings are consistent with one another and why. What conclusions about how the body uses fatty acids during long periods of exercise can you make from these three studies? How did scientists use the lens of stability and change in designing and analyzing the results of this study? Is this consistent with how we've seen scientists use this lens previously?" (Student Guide, page 3).
- Lesson 27: Students are told that "to make progress on figuring out how muscles recover from the microtears they experience from exercise—the ones that make them sore—students will compare and contrast data on the feedback responses that the body has to the microtears" (Teacher Guide, page 3). Students examine one of three data sets, each with two different studies included, to understand more about the feedback mechanisms that take place to assist in muscle recovery (e.g., protein synthesis). Students "compare and contrast the pair of studies in this group to determine what the findings are from the data and if the findings are consistent with one another" (Teacher Guide, page 3).
- Lesson 27: The following guidance is provided regarding development of this element: "Students have had multiple opportunities throughout the unit to grow their proficiency in this SEP. Accordingly, all scaffolding in the prompts for this SEP has been removed, and students are presented with a single prompt instead. If a student is struggling, remind them of previous prompts, including those below. 1. Determine what question the scientists were trying to answer for each data set. 2. Summarize the methods used and the data collected for each study individually. 3. Compare the methods and outcomes for each study to determine if they are consistent" (Teacher Guide, pages 3–4).
- Lesson 30: Students "…analyze three pieces of data from a scientific journal article in which scientists studied the changes to muscles that took place after two different kinds of workouts: an endurance workout and a resistance training workout. Share with students that they should record what they notice about the changes in muscles that occur in each piece of data on their Lesson 30 Student Guide Part 2: Observing a New Phenomenon" (Teacher Guide, page 2).

Constructing Explanations and Designing Solutions

- *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
    - Lesson 8: This lesson is labeled as a pre-assessment of this element. Using observations of data about the effects of exercise on the body from a video of an athlete working out and their understanding of body systems, student groups create an initial explanation to answer the 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?" (Teacher Guide, page 4). Students work to create an initial explanation that addresses "…what is happening inside the athlete's body before exercise, during exercise, and after recovery" (Teacher Guide, page 5). As students work on this task, the teacher is encouraged to provide feedback prompts to support students in deepening their explanations such as, "can you tell me more about what you think causes (sweat, thirst, urine color change)?" or "how do you think sweat, thirst, and urine color could be related" (Teachers Guide, page 6). Students share their ideas, and then develop an initial Class Consensus explanation (Teacher Guide, pages 5–10). The teacher shares that "their explanations might currently seem incomplete," (Teacher Guide, page 5) but that they are laying the groundwork for using evidence later in the module as they figure out more details they can add to their explanations.
    - Lesson 10: Students integrate their learning from Lesson 9 to "…revise their initial explanations from Lesson 8 to update their answers to the 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?" (Teacher Guide, page 3). A rubric points out "What to Look and Listen For" (Teacher Guide, pages 3–4) in student revisions. The Student Guide includes the prompt: "In your explanation, be sure to include the following: ● Use at least two sources of evidence obtained from the data sets and/or the Science Theater models in Module 2. ● Describe how you think exercise changes the body temperature conditions of the body, including temperature change and sweat. ● Describe how a negative feedback mechanism responds to body temperature change and brings body temperature back to a stable state. ● Describe how specialized cells in each organ contribute to the function of the system or organ" (Student Guide, page 1). The sample student response includes references to two sources of evidence (Student Guide, pages 1–2).
    - Lesson 12: Students revise an explanation using evidence to show how the body uses feedback mechanisms to maintain stable internal conditions when those conditions begin to change (Teacher Guide, pages 1 and 3–6). The Student Guide provides a prompt that begins with the phrase "Using the evidence gathered throughout this module" and also includes a requirement that students "Cite at least two different sources of evidence, including data sets and/or the Science Theater models from Module 2" (Student Guide, page 1).
    - Lesson 13: Students use evidence from multiple sources, including case studies, models, and two different texts, 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 (Teacher Guide, pages 1 and 10–12).
    - Lesson 15: "Students construct an initial explanation to answer the module questions, Why are there so many changes to my body during exercise? How does milk help with

recovery from these changes?" (Teacher Guide, page 7). "Students collect data about their own bodies' responses to exercise and look at another data set. After a class discussion, students use all the evidence gathered to construct another explanation" (Teacher Guide, pages 5–7).

- Lesson 20: Students are asked to take their learning from Lessons 18–19 and "Using all the evidence you have gathered so far in this module, construct an explanation to answer our Module Questions: Why are there so many changes to my body during exercise? How does milk help with recovery from these changes? In your explanations, be sure to: Include explanations for the following effects of exercise, Increased breathing rate, Increased heart rate, [and] Muscle burn sensation/muscle fatigue; Describe how the muscle cells utilize anaerobic and aerobic cellular respiration to produce ATP over the course of an intense workout. Cite evidence from the data sets we analyzed and the Science Theater model we used" (Student Guide, page 1).
- Lesson 22: Students are asked to focus on the second module question, "How does milk help with recovery from these changes?" and use what they've learned so far to, "Describe how the components of milk can help recovery from exercise and provide additional energy for continued exercise. Cite evidence from the data sets analyzed" (Student Guide, page 1).
- Lesson 25: Students are asked to collaborate. "With your group, create an initial explanation to answer our Module Question, How does milk help in muscle recovery from soreness and weakness induced by intense exercise? In your explanation, be sure to describe: How you think muscles get sore from exercise. How you think the body uses a feedback mechanism to recover from muscle soreness. How you think milk could help muscles recover from soreness" (Student Guide, page 2). The teacher asks 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 body systems do you think are relevant to muscle soreness and recovery? ● What do you think represents the homeostasis of the athlete? What change occurs to bring her body out of its stable state?" (Teacher Guide, page 5).
- Lesson 25: Students share their initial explanations using a Stay and Stray strategy to provide a structure for students "…to compare and contrast their explanations with other students…[to] agree on and integrate new ideas…[and] self-evaluate the strengths and weaknesses of their explanation before implementing edits" (Teacher Guide, page 7).
- Lesson 29: Students are asked, "using all the evidence gathered throughout this module, construct an explanation of the Module Question, How does milk help in muscle recovery from soreness induced by intense exercise? In your explanation, be sure to describe: The role of muscle cells in muscle movement and what happens to muscles and muscle cells when they get sore from exercise. How a feedback response involving organs, specialized cells, and signals helps muscles recover from soreness after exercise. How protein in milk can help in the process of recovery from soreness after exercise. Cite at least two pieces of evidence from data sets and/or the Science Theater model used in this module" (Student Guide, page 1).
- Lesson 30: Students "…create an explanation for the questions they set out to investigate: 'How do muscles increase their size and strength in response to resistance exercise? How can milk help with this process?' Students. . . come to recognize that microtears that occur in muscles as a result of exercise lead to adaptations resulting in larger and stronger muscles" (Teacher Guide, pages 6–7).

- No evidence was found that students are supported in developing skills in basic ways to refer to the multiple sources they are expected to use for the *valid and reliable evidence* they should include in their explanations, nor was there evidence related to the prior skills students are expected to bring to the unit in referring to sources.

Engaging in Argument from Evidence.

- *Make and defend a claim based on evidence about the natural world ~~or the effectiveness of a design solution~~ that reflects scientific knowledge, and student-generated evidence.*
  - Lesson 3: Students make initial claims that answer the questions: "What organs most help digest milk? How?" (Teacher Guide, page 3). After obtaining evidence about what is in milk and participating in an investigation about how enzymes digest molecules in milk, students evaluate the validity of their claims by comparing them to the data they have collected and record a conclusion that supports or refutes two different claims" (Teacher Guide, pages 3–5 and 10–12). As students share the evidence they obtained that supports or refutes a claim, the teacher probes their engagement in argumentation by asking questions such as, "Can you share the evidence you found that would support or refute this claim? Can you say more about the evidence you found? Why is it relevant to this claim? What evidence do you have to argue against your peer who instead supported/refuted the claim? What evidence more clearly supports your conclusion?" (Teacher Guide, page 14).

Obtaining, Evaluating, and Communicating Information

- *Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information represented in a text by paraphrasing them in simpler but still accurate terms.*
  - Lesson 9: Students "analyze and paraphrase the experiment design" (Teacher Guide, pages 3–4) and analyze the data from a study to determine the goal of the study, the study's design, and what the scientists were measuring. They look for trends and "Paraphrase the goal and design of this experiment in simpler, yet still accurate terms" (Student Guide, page 2). Questions students answer include: "● How can you use a lens of stability and change to analyze this data? ● Where in the data did you specifically observe the information you cited as evidence in your interpretation? ● Does the data you observed match what you were expecting based on the experimental design?" (Teacher Guide, pages 3–4).
  - Lesson 11: Students analyze an experiment design and the data collected from text that describes a scientific study about the water content of blood during exercise. They paraphrase the goal and the design of the experiment using simpler, yet still accurate terms, and record changes they notice happening over time, indicating what this means about the amount of water in the blood. They engage in a whole class discussion in which they share their interpretations (Student Guide, pages 5–8).
  - Lesson 23: Students read a Student Handout, The Body's Fuel Sources. "Instruct students that they will read the text and try to choose and summarize three central ideas from the text that best help answer the investigation questions. . . As students work, circulate the room and ask pressing questions such as: ● Why did you choose this as a central idea? How does it help answer our investigation questions? ● What changes does the text say are occurring to the muscle cells as they recover and grow larger/stronger?" (Teacher Guide, page 23). The activity is listed under a subtitle

"Obtaining Information from Scientific Texts" (Teacher Guide, page 7). However, this text is an informational text, not scientific literature adapted for classroom use. The lesson does include another activity involving scientific literature adapted for classroom use from a scientific journal article of three studies, but students do not determine central ideas or conclusions or summarize evidence from these studies.

- *Communicate scientific ~~and/or technical~~ information or ideas (e.g. about phenomena ~~and/or the process of development and the design and performance of a proposed process or system)~~ in multiple formats (including orally, graphically, textually, and mathematically).*
    - Lesson 1: The following teacher guidance is provided to help guide a discussion about the value of creating presentations: "To share the value of creating presentations, share with students that scientists often share their understanding and findings in presentations. It allows scientists to share their research, stimulate discussion, and verify that it is evidence-based and not based on their own opinions. You may ask: ● When have you seen scientific information shared, and how was it presented? ● Who have you seen present scientific information? ● Why do you think they shared that information? Encourage conversations between students with previous experience with scientific presentations and those without" (Teacher Guide, pages 7–8).
    - Lesson 1: Students write their initial draft of a presentation that explains the driving question for the unit: How can milk help athletes recover from physical exercise? Students are given the option to create a video or written report, with the expectation that other diagrams or graphics be included as well. They share their initial drafts with peers, and then share the main ideas as a whole group (Teacher Guide, pages 6–12).
    - Lesson 1: The following guidance explains that in this unit, "students build on this middle school understanding to communicate scientific information in multiple formats, including text, visuals, verbally, and graphically. Throughout the unit, students develop an explanation that they will present to the class in a format that best suits a targeted audience. Students begin developing these presentations in this lesson and add on to and revise their presentations throughout Modules 1–4 and the Performance Task" (Teacher Guide, page 8).
    - Lesson 7: Students revise their initial drafts of presentations from Lesson 1 to include information and ideas they have obtained during Module 1 that can further explain how milk is digested after it is consumed. Their presentations include multiple formats (Teacher Guide, pages 2–4). Students are encouraged to consider key ideas such as, "how do you think this presentation will make sense to your chosen audience? What will be clear for them? What will be difficult? How are you communicating the idea that multiple different scales are important in digestive functions? How can orders of magnitude help you do so? How are you showing how the molecules in milk are digested? How are you showing the role of specialized cells in this process?" Students "…review and approve each group's script or outline ... to create the formal writing product [and]..., if doing a video presentation,... to rehearse and record the video product" (Teacher Guide, page 4). The Student Guide provides a list of "Look Fors" students should include in their presentations, as well as a chart in which they describe how they plan to use a list of tips for a successful multimedia presentation (Student Guide, pages 2–3).
    - Lesson 14: Students use multiple formats to revise or create a presentation that communicates how the internal conditions of the human body change in response to changes in external conditions (exercise, drinking milk). The Student Guide provides the Look For "Include multiple methods of communication, including models and evidence from the module (video plus graphics/diagrams, written report plus graphics/diagrams,

or video with narration of a slideshow)" (Student Guide, page 2). "Teacher prompts while students are working on their presentations include: ● How are you showing feedback mechanisms that help the body return to its stable state? How can you clearly communicate the idea of homeostasis in your presentation? ● What do you now know about milk's role in exercise recovery?" (Teacher Guide, pages 4–5).

- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). This task includes several key "look fors" that guide students in sufficiently completing this task. Among those requirements include the use of the ongoing revised class consensus model, any of the previously-examined data sets, or models constructed or used during the module to date.
- Lesson 31: Students revise their presentations to add ideas from their new learning. Students are provided with Look Fors, including the need to "…use the class consensus model, data sets, and/or models from any other resources from the module" and "clearly communicate scientific information in a way that is appropriate for your chosen audience" (Student Guide, page 2). Students prepare their script which is reviewed by the teacher with provided feedback. Students then share their presentations and receive peer feedback (Teacher Guide, pages 3–6).

Disciplinary Core Ideas (DCIs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the DCIs in this unit. There are sufficient elements and sufficient time that students are engaged in grade-appropriate DCI elements for the length of the materials. There is a close match between DCI elements that are claimed and evidence of DCI development and use in the materials in the service of making sense of phenomena.

LS1.A: Structure and Function

- *Systems of specialized cells within organisms help them perform the essential functions of life.*
  - Lesson 2: Students develop a model that describes how different organs function in the digestion of milk as it passes through the digestive system. This initial model serves as a pre-assessment of what students may know about specialized cells (Teacher Guide, pages 1–9). When students are creating their initial models, the following teacher prompts are provided to help students begin thinking about what is happening at the cellular level: "How do you think (organ) digests milk? What does it do? How do cells contribute to its function?" (Teacher Guide, page 4).
  - Lesson 2: Guidance is provided to explain that, "in this unit, students explain how the function of organs depends on cell specialization. In this lesson, students demonstrate their prior knowledge from middle school of the structure and function of cells in organs in the digestive system" (Teacher Guide, page 4).
  - Lesson 3: Students examine an Enzyme Illustration and determine that epithelial cells release a small molecule enzyme that breaks apart sucrose into two smaller molecules in order to digest milk. They rotate through stations that include readings and labs to determine the role of different organs in the digestion of milk, including information about specialized cells in the different organs and how they work in different ways in the digestive process (Teacher Guide, pages 8–11). The teacher facilitates the discussion "such that students agree that: ● Different organs have different types of cells that each

have a unique specialized function. In the digestive system, a series of specialized cells each create different types of enzymes to support the digestion of different types of molecules in foods" (Teacher Guide, page 11).

- Lesson 4: Students are introduced to the Science Theater to model "…what happens in the digestive system when a person drinks milk" (Teacher Guide, page 5). Students observe the model as they circulate through each station and "…record how different organs and their specialized cells function to digest the nutrients (molecules) in milk" (Student Guide, page 2).
- Lesson 5: Students work together to revise a model of the digestive system. The models describe how specialized cells contribute to the function of an organ (Teacher Guide, page 3). "Some of the pressing questions the teacher may use to push thinking are: ● What is the function of this organ? How are specialized cells contributing to the function of this organ? ● What are the sizes of the items you are representing in the model? ● What happens to (molecule) when it is in (organ)? How?" (Teacher Guide, page 3).
- Lesson 6: Students examine five different models at various scales which show how systems of different specialized cells help to break down food molecules and to aid the body in absorbing the nutrient molecules (Teacher Guide, pages 4–5). Student prompts include, "In your response, be sure to…Identify how the function of specialized cells helps move amino acids, fatty acids, and sugars from the small intestine to the rest of the body" (Student Guide, page 2). Teacher "look-fors" include, "Student revisions suggest showing how specialized cells contribute to the function of absorbing nutrients in the small intestine" (Teacher Guide, page 8).
- Lesson 7: Students create a presentation with their group that communicates the answer to the Driving Question, How can milk help athletes recover from physical exercise? They use what they figured out in Module 1 for the presentation. A Look For in the Student Guide states: "Describe how the function of multiple kinds of specialized cells contributes to the digestion of milk" (Student Guide, page 2).
- Lesson 9: Students participate in a Science Theater model in which, through the use of a card set (Student Handout Science Theater Card Set) each student takes on the role of a "specialized cell within an organ that is involved in the way the body maintains its core temperature and responds to change in temperature" (Teacher Guide, page 8). Some of the specialized cells include different types of neurons, myocytes, and myoepithelial cells.
- Lesson 9: Students participate in a Science Theater activity to model the processes that regulate temperature when exercising. The following guidance is provided explaining that in this lesson, "students explain the function of organs during exercise. In all modules of the unit, students develop and/or revise explanations and use models that include the ways in which specialized cells carry out various biological processes associated with exercise recovery" (Teacher Guide, page 9).
- Lesson 10: Students revise their initial explanations from Lesson 9 based upon their learning. The following prompt is provided in the Student Guide: "Using the evidence gathered, construct an explanation as to why we get hot and sweaty during exercise" . . . . ● Describe how a negative feedback mechanism responds to body temperature change and brings body temperature back to a stable state. ● Describe how specialized cells in each organ contribute to the function of the system or organ" (Student Guide, page 1).
- Lesson 11: Students engage in a Science Theater model and record their observations in the Student Guide. The Student Guide includes the prompt: "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" (Student Guide, page 4). In addition, the Student Guide provides the prompt: "Engage in the model. As you enact the model, record observations you make about the actions that various specialized cells take" (Student Guide, page 4). Later, another prompt states: "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" (Student Guide, page 5). The Student Guide provides a graphic organizer for students to record what they observe during the model enactment about the role of organs and specialized cells in regulating the amount of water in the body (Student Guide, pages 5–6).

- Lesson 12: The Student Guide includes the expectation that students will include a description of "how specialized cells in each organ contribute to the function of the system or organ" (Student Guide, page 1).
- Lesson 13: Students read two case studies: one which describes an individual who died from dehydration and another who died from overhydration. They use a model to observe how changes to the amount of water in the bloodstream impact the body, and then observe a cell membrane simulation. They gather information from two texts: one on dehydration and one on overhydration (Student Guide, pages 1–4). They use the evidence from these multiple sources to construct an explanation that describes how both people became sick and died. The Student Guide provides this expectation of their explanation: "Describe how changes to the amount of water in cells of the body may have caused the death of the two individuals" (Student Guide, page 5). Although the student prompts do not specifically ask for explanations about "specialized cells," the information students read and then use to write their explanations includes the fact that neurons (specialized cells in the brain) cannot expand with excess water due to being encased in the skull, and that this leads to brain edema, which can lead to "Seizure, coma, respiratory arrest, brain stem herniation and death" (Student Guide, page 5).
- Lesson 14: One of the Look Fors provided in the Student Guide asks students to, "Describe how the functions of multiple kinds of specialized cells contribute to maintaining and adjusting water levels in the body in response to changes in the body's conditions" (Student Guide, page 2).
- Lesson 19: Students engage in a Science Theater model to explore how relevant organ systems and specialized cells within those "…function to increase heart rate and breathing rate and produce fatigue and burning in the muscles" (Student Guide, page 3). As students participate in the model, they model the processes that occur in several types of specialized cells including Alveolar epithelial cells in the lungs, myocytes, pacemaker cells in the heart, muscle cells, autonomic nerve cells, somatic nerve cells, red blood cells, and more (Student Guide, pages 2–5).
- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). This task includes several key "look fors" that guide students in sufficiently completing this task. Among those requirements include the need to "describe how the function of multiple kinds of specialized cells contributes to the processes of cellular respiration and anaerobic respiration" (Student Guide, page 2).
- Lesson 28: Students engage in a Science Theater to model the mechanism in the body that helps muscles recover from soreness. The roles of various specialized cells are modeled. Students are prompted to "…record a summary of the role your cells and

organ will play in the muscle recovery process. Describe what function your organ has and how specialized cells contribute to its function" (Student Guide, page 1). A graphic organizer is provided for students to "record how different organs and their specialized cells function" and lists "Brain and Nerves, Skeletal Muscles – Myocites, Skeletal Muscles – Satellite Cells, [and] Immune cells" (Student Guide, page 2). In this activity, students will ultimately come to describe three negative feedback processes that are used to detect and repair muscle cells, specifically, "…the role of specific specialized cells in the feedback process" and "what conditions change in the body to bring it out of a stable state, and how the body responds with feedback mechanisms to return it to a stable state" (Student Guide, pages 2–3).

- Lesson 30: After reading a text about how muscle repair leads to increased muscle size and strength, students "…use a sharing routine such as a Mingle-Pair-Share Routine for students to share the different central ideas they have found with their peers." From there, the teacher is asked to facilitate a whole-class discussion so students might agree on key ideas such as, "satellite cells multiply and fuse to muscle fibers to form new muscle fiber strands" or "growth hormone and testosterone can increase the uptake of amino acids into muscles" (Teacher Guide, page 6).
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). Student presentations are expected to include a description about "…how the functions of multiple kinds of specialized cells contribute to muscle structure and function and to exercise recovery" (Student Guide, page 2).

- *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
  - Lesson 2: This element is labeled as a pre-assessment opportunity for this lesson. After creating individual initial models, students engage in a discussion to create a class consensus model. The following guidance is provided for the class consensus model: "The final Class Consensus Model should have the following features: ● Parts of the digestive system, represented as system parts, including the mouth/esophagus, stomach, small intestine, and large intestine. Arrows showing the movement of food matter from one system part to another. ● Zoom-ins that show the cells of one or more organs and some uncertainty about the function of these cells in digesting milk" (Teacher Guide, pages 7–8).
  - Lesson 3: Students examine an Enzyme Illustration showing multiple levels of scale in the human body. They determine that seeing the size relationships of structures helps them to understand the models of what is happening in the human body (Teacher Guide, pages 8–10). Students are instructed, "At each station, read the text provided to help you gather additional information on the hierarchical function of each organ in the digestive system and how its cells support this function. Then, conduct the investigation described to gather evidence on how enzymes produced by the cells of each digestive organ help to break down the different molecules present in milk" (Student Guide, page 4). Rotating through stations with readings and labs, students determine that the digestive system has many parts, such as the mouth and esophagus, the stomach, the small intestine, and the large intestine and that each of these organs is a system of smaller and smaller parts that work together in a hierarchical organization (Station Cards, pages 1–15).
  - Lesson 4: As students revise their group models and the Class Consensus Model, they indicate the systems within each organ that are part of the digestive system, with each

having numerous parts and components. After the class discussion surrounding the building of a Class Consensus Model, the teacher is directed to "point out the different scales of organization in the class model, including the digestive system, each of its organs, and the different types of cells" and to "name this relationship between the digestive system, organs, and cells as a hierarchy of organization" (Teacher Guide, page 6).

- Lesson 6: Students examine five models to determine how nutrients are able to be absorbed in the small intestine. They revise a model to describe the relationships between components of the digestive and circulatory systems, including scale relationships that show how organs are made of systems of specialized cells (Teacher Guide, pages 3–9).
- Lesson 7: Students create a segment of a presentation that explains how milk can help in recovery from exercise. The Student Guide provides a Look For to guide students in writing their presentation that states: "Describe how the hierarchical organization and function of body systems, organs, and cells contributes to the digestion of milk" (Student Guide, page 2).

- *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*
  - Lesson 1: This lesson is labeled as a pre-assessment of student understanding of this element. Students write their initial drafts about how they think milk can help the body recover from intense exercise. A DCI Support note explains how the term "recovery" is being used as "a student-friendly stand-in for the body's ability to return to homeostasis after a change in its external (exercise) and internal (depletion of some nutrient or damage to organs and tissues due to exercise) conditions" (Teacher Guide, page 11). The note further explains how students' initial presentations can be used to "understand what students already know about how the body uses feedback mechanisms for recovery" (Teacher Guide, page 11). This clarification of the use of the term "recovery" to represent the science idea of "homeostasis" helps the teacher to evaluate how student work connects to this element. Other than this note, specific guidance is not provided to ensure that this DCI feedback mechanism is used in this lesson or to serve as a foundation to support this element in future lessons.
  - Lesson 1: Guidance is provided to explain that, "in this unit, students explore how these sensory systems are used by the body to maintain homeostasis and to respond to changes in external conditions. For example, in Module 2, students figure out that the body has feedback mechanisms that are used to respond to internal changes caused by external factors" (Teacher Edition, page 11).
  - Lesson 8: This lesson is labeled as a pre-assessment for this element. Students come back to share their initial explanations about "why we get sweaty and thirsty after exercise?" as well as "why does the color of our urine change?" and "how does milk help us recover from these effects?" They then revise these explanations to include ideas such as, "There are changes happening inside of the body to the organs that control body temperature, sweat, and urine color. There is salt in sweat, so the body loses salt when sweating. Each of these changes has to do with the amount of water in the body. Sweat loses water from the body. Thirst is when we don't have enough water. Urine has water in it. Milk helps with hydration because it contains water. As you drink it, you are ingesting more water" (Teacher Guide, page 9). Teachers are told to, "Share

that their explanations might currently seem incomplete, but as they explore this module, they will feel more confident in knowing the mechanisms that cause these responses in the body" (Teacher Guide, page 5).

- Lesson 9: In the second part of the lesson, students analyze data on body temperature and its relationship to exercise by reading about an experiment that 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" (Teacher Guide, pages 3–5 and 6). In Part 3 of this lesson, students "go further into this observed change to explain the physiological mechanisms responsible for the observed changes in temperature" (Teacher Guide, page 7). Students participate in a Science Theater activity to model the processes that regulate temperature when exercising. Students then engage in a class discussion to share what they have learned (Teacher Guide, pages 7–13). At the conclusion of the lesson, student responses are used to "'introduce the term homeostasis as the processes used by the body to maintain stable internal conditions and body temperature is one measure that the body tries to maintain homeostasis' and that 'the body has negative feedback mechanisms that help the body return to its stable state of conditions' . . . In this lesson, students figured out two feedback mechanisms the body uses to respond to an increase in temperature to bring the temperature back down to normal: the sweat response and the blood vessel dilation response" (Teacher Guide, page 13).
- Lesson 10: Students revise their initial explanations from Lesson 9 based upon their learning. The following prompt is provided on the student guide: "Using the evidence gathered, construct an explanation as to why we get hot and sweaty during exercise" and lists items that refer to feedback mechanisms as the requirements to be included in the explanation, such as, "● Describe how a negative feedback mechanism responds to body temperature change and brings body temperature back to a stable state" (Student Guide, page 1).
- Lesson 11: After participating in a model in which students take on the roles of organs in the body, students describe the roles of different organs and specialized cells in regulating the amount of water in the body. They explain how a feedback loop functions to regulate water levels in the blood when conditions change such as water being lost due to sweat during exercise, and water being replenished by drinking milk (Student Guide, pages 4–7). As part of the figuring out process, the teacher asks the students "…to consider if they think the mechanisms that they figured out are similar to that of how the body responds to changes in its temperature. Build off of student responses to confirm that the body has negative feedback mechanisms that try to bring the levels of water in the bloodstream to a stable state when those levels decrease, just like the body has negative feedback mechanisms that try to bring body temperature back to a stable state when the body temperature increases. Both are examples of the body trying to maintain homeostasis and maintain a normal amount of water in the bloodstream and a normal body temperature" (Teacher Guide, page 14).
- Lesson 14: The Student Guide provides Look Fors that include: "Describe how exercise can destabilize water balance in the body and how negative feedback mechanisms in the body and the consumption of milk can help the body return water balance to its stable state" (Student Guide, page 2).
- Lesson 25: The following guidance is provided in the student guide for a requirement for students to include in their initial model: "How you think the body uses a feedback mechanism to recover from muscle soreness" (Student Guide, page 2).

- Lesson 27: The following guidance is provided regarding development of this element: "While this lesson doesn't develop knowledge of this DCI explicitly, it serves as a stepping stone toward fully working with the DCI. In this lesson, students are exposed to measurable indicators of the body's responses to microtears in muscles. In this next lesson, students will build on the knowledge of how the levels of various molecular factors change to figure out how the changes in these factors work together mechanistically as a negative feedback mechanism that responds to the injury caused by the microtears in the muscles" (Teacher Guide, page 27). The lesson material lists this DCI on page 1 without any indication that this lesson serves as a "stepping stone" that leads towards students applying this DCI in the following lesson, and that the DCI is not explicitly developed in this lesson, thus causing possible misinterpretation of the depth of the application of this element in this lesson.
- Lesson 28: Students work to complete a Science Theater model to explore the specific mechanisms that underlie muscle recovery processes and the development and decrease in soreness after exercise. Students "describe three negative feedback processes that are used to detect and repair muscle cells—specifically '…the role of specific specialized cells in the feedback process' and 'what conditions change in the body to bring it out of a stable state, and how the body responds with feedback mechanisms to return it to a stable state'" (Student Guide, page 2).
- Lesson 29: Students are asked to use "all the evidence gathered throughout this module, construct an explanation of the Module Question, How does milk help in muscle recovery from soreness induced by intense exercise? In your explanation, be sure to describe: ● The role of muscle cells in muscle movement and what happens to muscles and muscle cells when they get sore from exercise. ● How a feedback response involving organs, specialized cells, and signals helps muscles recover from soreness after exercise. ● How protein in milk can help in the process of recovery from soreness after exercise. ● Cite at least two pieces of evidence from data sets and/or the Science Theater model used in this module" (Student Guide, page 1).
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). This revised presentation is required to include a description about "…how exercise can destabilize muscle structure and function in the body and how negative feedback mechanisms in the body and the consumption of milk can help the body return muscle structure and function to its stable state" (Student Guide, page 2).

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- ~~*Photosynthesis and*~~ *cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
  - Lesson 15: This lesson is labeled as a pre-assessment of what students already know about cellular respiration as they construct an initial explanation (Teacher Guide, page 1). Guidance is provided explaining that in this unit, students "figure out that cellular energy comes not only from aerobic respiration but also from anaerobic respiration. In this module, students explore the measurable indicators of metabolic responses because of exercise, such as changes in the amounts of glucose in the bloodstream, glucose and glycogen in muscle and liver, and the way that muscle cells produce energy in aerobic and anaerobic conditions" (Teacher Guide, page 8).
  - Lesson 16: Students compare findings in two data sets from experiments scientists conducted to measure how exercise changes the amount of oxygen inhaled and used by

muscles (Teacher Guide, pages 1 and 4–6). The Student Guide includes the prompt: "What conclusions can you draw about the differences between oxygen use in moderate and intense exercise from these studies?" (Student Guide, page 3). Although students conclude that "During exercise, the body uses more oxygen than it does at rest…so it seems to make sense that you would need more blood flowing to get more oxygen" (Student Guide, page 3 sample student response), evidence of students developing or using the specific aspects of this element was not found, but rather, this lesson serves as a way for students to make observations about a study that leads towards development and use of this DCI element in future lessons.

- Lesson 17: Students plan and carry out an investigation to determine how exhaled carbon dioxide levels change during moderate versus intense exercise (Teacher Guide, pages 1 and 3–7).
- Lesson 18: The following guidance is provided in relation to this element: "While this lesson doesn't develop knowledge of this DCI explicitly, it serves as a stepping stone toward fully working with the highlighted portions of this DCI. In this lesson, students are exposed to measurable indicators of the body's metabolic responses to exercise or how it uses and produces energy for exercise. In this next lesson, students will build on the knowledge of how the levels of various molecular factors change to figure out how the changes in these factors work together mechanistically to provide energy aerobically and anaerobically for exercise" (Teacher Guide, pages 1–2). Although this clarification support note is embedded within the lesson, the listing of this element on page 2 of the Teacher Guide provides no indication that this lesson serves as a "stepping stone and not toward fully working with the highlighted portions of this DCI," thus possibly causing teachers to misinterpret the level at which this lesson engages students in the DCI.
- Lesson 19: Students use a card set to model various ways that energy can be created as needed to support the work required of given tasks such as exercise. Anaerobic and aerobic cellular respiration are introduced as means for organisms to produce energy on demand. For example, students exploring myocytes in the skeletal muscles will learn that "Muscles detect the lack of oxygen and begin anaerobic respiration to generate cellular energy (ATP) that is used by the muscles for muscle cell contraction and, thus, movement. The inputs of anaerobic cellular respiration are glucose, and the byproducts include H+ ions, lactate, and carbon dioxide" (Student Handout Science Theater Card Set, page 35).
- Lesson 20: Students are asked to take their learning from Lessons 18–19 and "Using all the evidence you have gathered so far in this module, construct an explanation to answer our Module Questions: Why are there so many changes to my body during exercise? How does milk help with recovery from these changes? In your explanations, be sure to: Include explanations for [how]…anaerobic and aerobic cellular respiration to produce ATP over the course of an intense workout. Cite evidence from the data sets we analyzed and the Science Theater model we used" (Student Guide, page 1).
- Lesson 21: Students compare findings in two data sets to determine how drinking a recovery drink leads to changes in the body that help it recover from exercise by replenishing the glucose that cells use in aerobic and anaerobic respiration (Teacher Guide, pages 1 and 3–7).
- Lesson 22: Students' focus shifts to connect the composition of milk to the need to have glucose available as an input for cellular respiration (aerobically or anaerobically). (Teacher Guide, pages 2–6).
- Lesson 23: Students are tasked with developing an explanation of how energy keeps the body moving over long distance or time intervals. Following the examination of new

sources of data derived from journal articles, students participate in a consensus-building discussion that addresses the necessary reactants to support cellular respiration at higher levels during times of prolonged energy demand (Teacher Guide, pages 10–11). A sample exemplar response says, "The ultramarathoner would engage in exercise and, at first, would get energy from using glucose for aerobic and anaerobic respiration to produce ATP. This would continue until the body runs out of glucose to use in these processes. Afterward, the runner would have needed to use fatty acids, especially since he did not consume glucose during the race. We saw in Study 1 that fatty acids are released into the bloodstream. They increased from about 300 umol/L to about 800 umol/L during exercise. The fatty acids then move into the muscle and are used to make ATP. We saw this in Study 3, where the leg fatty acid oxidation went from about 25% to over 125%" (Teacher Guide, page 11).

- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). This task includes several key Look Fors, including the need to "describe how the energy for exercise comes from aerobic and anaerobic respiration and how this energy is expended during exercise and recovered with milk (Student Guide, page 2).

Crosscutting Concepts (CCCs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs in this unit. There are sufficient elements and sufficient time that students are engaged in the CCCs for the length of the materials. There is a close match between CCC elements that are claimed and evidence of CCC development and use in the materials. Students are routinely using or developing proficiency in the targeted CCC elements to help make sense of the phenomenon and to apply this lens to support learning of the targeted SEPs and DCIs, with frequent directed prompts to think in terms of the CCCs and their value in sense-making.

Cause and Effect

- *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.*
  - Lesson 13: Students examine what happens at the cellular level to determine what causes the effects of dehydration and overhydration. Students examine two models, one of hypertonic and another of a hypotonic cell, along with a cell membrane simulation to examine the movement of particles across the cell membrane in order to determine what happened in the body that caused the athlete's deaths. Students come to ascribe the presence of higher or lower salt concentration in cells as a causative source of subsequent changes that occur within cells and, ultimately, organ systems and the organism itself. Students construct an explanation that describes how changes to the amount of water in cells of the body may have caused the death of the two individuals (Teacher Guide, pages 3–13; Student Guide, pages 1–6). Student learning centers on using the smaller-scale changes to describe more systemic observable effects.

Scale, Proportion, and Quantity

- *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.*
    - Lesson 2: This element is labeled as a pre-assessment opportunity for this lesson. Students develop a model, first in groups, and then as a Class Consensus Model, that begins to show the digestive process at different levels of scale, which builds towards future lessons that focus on using orders of magnitude to understand how models at one scale relate to a model at another scale (Teacher Guide, pages 3–9). The Student Guide prompts students to show: "Zoom-ins that show what is happening on a smaller scale in each part of the system" (Student Guide, page 2). Upon analysis and comparison of different student models, teachers ask questions such as, "what might be occurring here that we can't see? What structures in the organs are involved in that process?" (Teacher Guide, page 4).
    - Lesson 2: The following guidance is provided explaining that in this unit, "students explain relationships at various scales in a series of models. Students start showing their prior knowledge about different spatial scales present in the human body in this lesson. Students will progress towards using orders of magnitude to describe these scale relationships throughout this module" (Teacher Guide, page 8). While students do show the digestive system at various scales within their individual and class consensus model, there is no specific mention of orders of magnitude. However, this lesson is labeled as a pre-assessment for this element, and the CCC Support Note specifically states that students will progress towards using orders of magnitude, making it clear to teachers that this is just the beginning of students' learning to apply this element in their figuring out of the phenomenon.
    - Lesson 3: Students consider the different scales at which molecules move through the process of the digestive system. They develop a deeper understanding of orders of magnitude by measuring objects of different lengths, starting with those up to one meter long, and moving towards smaller and smaller objects, noting scale and magnitude differences between the previous set of objects and in relationship to a meter stick. A Student Support note suggests that students may need to review scientific notation and its relationship to orders of magnitude. Students use this understanding to examine models of different organs in the digestive system that include different scales of structures. As students work, the teacher is instructed to "circulate the room to ask questions such as: ● How can you mathematically determine the relative sizes? ● What does one order of magnitude difference indicate about size? Two? Three? . . . Then, ask students how they think determining these size relationships can help them better understand the models" (Teacher Guide, pages 8–9). Students determine that the "structures in the human body that are involved in digestion are many different sizes, including sizes we can see, such as meters, to very small sizes, such as in micrometers or nanometers" and that "orders of magnitude are a useful way to see how the size of various small objects, like organs, cells and molecules, relate to each other" (Teacher Guide, page 9). During this lesson, students are introduced to a Size & Orders of Magnitude tool which they are encouraged to use in subsequent lessons (Teacher Guide, page 9). While students are actively comparing different scales at the quantitative level, it does not appear that students are using those orders of magnitudes to meaningfully interrogate relationships between models afforded by each differing order of magnitude. This activity, as written, appears more in line with the 6–8 grade band for this CCC that states, "students use proportional relationships (e.g., speed as

the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes" than the claimed high school-level CCC element.

- Lesson 3: The following teacher guidance is provided regarding the development of this CCC element: "Throughout the unit, students will regularly observe and use models of each of the organs, tissues, glands, cells, and molecules involved in various body processes. The size relationships in these models may be difficult to interpret without making sense of the different scales depicted in each of the models. Therefore, the purpose of introducing orders of magnitude at this point in the unit is for students to begin to see the relative sizes of organs, tissues, glands, cells, and molecules so that students can begin to develop a sense of the scale relationships of these structures. Throughout the remainder of Module 1, students will continue to use SPQ-H4 as a focal element and will continue to use the Size & Orders of Magnitude tool to identify the relative sizes of different objects and structures in the body. In the remainder of the unit, students can return to this tool to remind themselves of the size relationships of different structures and molecules involved in other body processes" (Teacher Guide, page 9).
- Lesson 4: Before starting the model Science Theater activity, students use the Size & Order of Magnitude tool from Lesson 3 to "interpret the relative size of two of the objects shown in the diagrams for their organ" and then share a few examples of what they found. "Some examples may include: ● The epithelial cells in the small intestine are 10-20 um compared to the surface cells in the stomach that are 1.0-1.6 mm. If food is going through the small intestine, it must be a lot smaller than food that is in the stomach. ● The bile tube of the pancreas is close in size to the 1-3 cm diameter tube of the small intestine" (Teacher Guide, page 4). Then, students are asked how an understanding of orders of magnitude can help them understand what the different representations are in the Science Theater model and their responses are built on to confirm that "orders of magnitude can help them understand the different size relationships of the different parts of the models" (Teacher Guide, page 4).
- Lesson 5: Teachers are instructed to "point out the different scales of organization in the class model, including the digestive system, each of its organs, and the different types of cells. Name this relationship between the digestive system, organs, and cells as a hierarchy of organization" (Teacher Guide, page 6). While students work, the teacher asks questions such as, "What are the sizes of the items you are representing in the model?" (Teacher Guide, page 3). Additional teacher guidance is provided explaining how this CCC element is used in this task: "Students' models can include an indication of the size of each component of the model, as shown by scale bars. Students are using their understanding of orders of magnitude to apply the relative sizes of different length units (e.g., m, cm, um, nm) developed in Lessons 3-4 to the different structures in the digestive system" (Teacher Guide, page 5). The Student Guide prompts students to include, "An indication of the size (e.g., in, m, cm, mm, um, or nm) of the organs and cells shown in the model" (Student Guide, page 1). However, the sample student model that is provided for the teacher does not include any size indications. Although the teacher note indicates that students' models could use scale bars to indicate size differences, there is no guidance to lead students towards using this method of comparing sizes. While some student directions are related to the claimed CCC element, it appears that it is mainly the teacher who is engaging in this CCC in this lesson.
- Lesson 6: When using five models to determine what happens to the nutrients in the small intestine, students "first orient themselves to the different size scales represented in each of the models" (Teacher Guide, page 3). Students work with partners to record

the different scales shown and to "reflect on how orders of magnitude help them interpret the scale relationships between models" (Teacher Guide, page 3). Students discuss which models show which scales and show this in a table on the board. A conversation is facilitated so that students "agree that orders of magnitude can help students understand how the size of the structures and units shown in one model are related to the size and units in another" (Teacher Guide, page 4). Students use this information as they evaluate the merits and limitations of the five different models. Although the sample student response to a brainstorm of revisions that should be included in student revised models includes: "We should add the relative sizes of the structures in the bloodstream," the prompt does not necessarily lead towards students generating this idea in their responses, and the sample student model provided for teachers does not include any size indications (Student Guide, pages 4–5).

- Lesson 7: Students are encouraged to revise their ongoing draft presentations and consider key ideas such as, "How are you communicating the idea that multiple different scales are important in digestive functions? How can orders of magnitude help you do so? How are you showing how the molecules in milk are digested?" (Teacher Guide, page 4). While reviewing the different models that show what happens to nutrients in the small intestine, students are asked to "identify the scales that each model of the 'Body Systems Models' focuses on," and then, based on the information in the table they created, "describe how orders of magnitude can help you understand how the scale of one model relates to the scale of another model" (Student Guide, page 2). Despite the connection to this CCC, it's not clear that students are focusing on the nature of orders of magnitude with respect to *how a model at one scale relates to a model at another scale* beyond acknowledging that one model is at a "larger" or "smaller" scale than the other. Instead, it appears that generating an explanation within their chosen medium would be sufficient to meet the expectations for proficiency, rather than having an expectation that students will integrate models highlighting different orders of magnitude to support a larger view of the numerous cellular, tissue, organ, etc., processes that govern this phenomenon.
- Lesson 13: Students examine two models, one of hypertonic and another of a hypotonic cell, along with a cell membrane simulation to examine the movement of particles across the cell membrane. Student learning centers on using the smaller-scale changes to notice more systemic observable effects, such as the lesson's guiding question about how athletes could die from being over- or underhydrated.
- Lesson 19: Students consider the interplay between organisms, organ systems, specialized cells, and individual molecules as the body changes in response to increasing energy demand due to engaging in exercise. Students consider ideas such as, "What is the responsibility of your organ? What other organs will you interact with? What function do specialized cells carry out in your organ? What does it say you do with the (molecules?) How is your organ responding to changes in the body? How does it help the body return to a stable state? What are (specific cell type) doing at (specific organ)? What changes are happening? How do breathing and heart rate seem to be linked? What are two ways the skeletal muscle can obtain glucose for cellular respiration?" (Teacher Guide, pages 5–6). The materials do not claim this element for this lesson, but it represents a missed opportunity to develop a deeper understanding of this element when considering the interplay between these body structures by highlighting different orders of magnitude to support a larger view of the numerous cellular, tissue, organ, etc., processes that govern this phenomenon.

Structure and Function

- *The functions and properties of natural ~~and designed objects and~~ systems can be inferred from their overall structure, and the way their components are shaped ~~and used,~~ and the molecular substructures of its various materials.*
    - Lesson 26: Students are asked to decode two figures from different journal articles that show how the structure of a muscle cell will change following intense exercise and electrical stimulation (analogous to exercise). Students are asked to compare the methods and findings and determine "what conclusions can you draw from the data sets about the cause of muscle soreness and weakness? In your response, be sure to discuss how the molecular structure of muscle cells is changed when muscles are sore" (Student Guide, page 3).

Stability and Change

- *Much of science deals with constructing explanations of how things change and how they remain stable (SC-H1).*
    - Lesson 1: This element is labeled as a pre-assessment opportunity in this lesson. A CCC Support note explains how the student initial drafts of their presentations may explain how they think exercise changes their bodies and how milk helps the body to recover, and that students may not yet understand the multitude of changes that occur in the body, and that students will be figuring this out throughout the unit (Teacher Guide, page 11). Providing this information makes it clear how this element will be developed through the unit, since the lesson tasks do not specifically address how students apply this element in this lesson.
    - Lesson 11: Students analyze the data provided in Part 3: Analyzing Data on Changes to the Water Content of Blood During Exercise (Student Guide, pages 2–4). In this section, students are encouraged to consider, among other ideas, "How can you use a lens of stability and change to analyze this data?" (Teacher Guide, page 5).
    - Lesson 16: The Student Guide includes the prompt: "How did the lens of stability and change help you analyze the data in these two studies? Based on this study and others we have analyzed previously, what can you conclude about stability and change in the human body?" (Student Guide, page 3). The following teacher guidance is provided to help students focus on the stability and change aspects of this element: "In this lesson, students use data that shows oxygen levels begin at a steady state at rest and undergo change in response to exercise. Students should notice that both data sets start with a data point while participants are at rest (stable state), followed by changing levels of oxygen during exercise" (Teacher Guide, page 3). This lesson provides both student and teacher prompts to support students in thinking about the CCC, but it does not move students towards surfacing this thinking on their own. This lesson, along with the next, represent missed opportunities for moving students toward applying this CCC element more independently in making sense of phenomena by noticing and explaining how things change and how they remain stable since, at the end of this lesson, students are not prompted to keep these concepts in mind as they move to the investigations in the next lesson.
    - Lesson 17: Students conduct an investigation to examine how carbon dioxide output changes in their body during exercise, specifically how different amounts of carbon dioxide will be released from a body at rest in comparison to one that had just completed more intense exercise (Student Guide, page 3). The Student Guide asks students to, "Use the findings from your investigation to construct an explanation to the

Module Questions, *Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?"* (Student Guide, page 4). However, while stability and change are at the core of the investigation, specific student guidance is not provided to ensure thinking around this specific element during the lesson, so the idea of stability and change may not be a feature in student responses. The sample student response does not indicate an understanding of how this investigation is an application of the concept of stability and change. This is partly a result of a missed opportunity to have students surface their stability and change observations from the prior lesson as a sense-making lens for beginning, conducting, and discussing the investigation in this lesson.

- Lesson 18: Students examine one of six data sets before eventually sharing with the rest of the class and, later, compare the data in aggregate for similarities and consistency of findings. During the analysis, students are encouraged to consider whether change was occurring before, during, or after exercise as well as to generate a potential explanation following class discussion for why those may have taken place. Students "Review the data scientists collected and record your observations about how _____ (variable) changes over time during exercise and during recovery. Identify if _____ (variable) levels return to a stable state during recovery" (Student Guide, page 2). The following teacher guidance is provided to guide student discussion: "Finally, ask students to reflect on how the lens of stability and change helped them analyze the data in each of the studies" (Teacher Guide, page 9). The following additional guidance is provided about this element: "In this lesson, students viewed data on changes to several variables that exercise scientists commonly measure during rest, exercise, and recovery. This can allow them to reflect on how the study of the human body often involves figuring out measuring factors that remain stable (at rest), how the body changes in response to an external variable (such as exercise), and how the body returns to its stable state (in recovery)" (Teacher Guide, page 10).
- Lesson 19: Students use their findings from Lesson 18 relating to exercise's impact on the concentration of key biomarkers to build a model to explain how those markers can be tied to the body's need to produce additional energy to perform the work required of the exercise tasks. Through the Science Theater modeling portion of the lesson, students are asked to, "Use your observations from the model to summarize what changes in the body occur to produce cellular energy for exercise and to increase breathing rate, heart rate, and muscle burning...[and] reflect on how the lens of stability and change was useful in figuring out how the specialized cells support the body to produce cellular energy for exercise" (Student Guide, page 4).
- Lesson 21: The Student Guide includes the prompt: "How did scientists use the lens of stability and change in designing and analyzing the results of this study? Is this consistent with how we've seen scientists use this lens previously?" (Student Guide, page 2).
- Lesson 22: Students are asked to take their learning from Lessons 18–19 and "Using all the evidence you have gathered so far in this module, construct an explanation to answer our Module Questions: Why are there so many changes to my body during exercise? How does milk help with recovery from these changes? In your explanations, be sure to: Include explanations for the following effects of exercise, Increased breathing rate, Increased heart rate, [and] Muscle burn sensation/muscle fatigue; Describe how the muscle cells utilize anaerobic and aerobic cellular respiration to produce ATP over the course of an intense workout. Cite evidence from the data sets we analyzed and the Science Theater model we used" (Student Guide, page 1).

- Lesson 23: Students identify factors that lead to instability (e.g., depletion of glucose/glycogen stores) and processes that help restore a stable state (e.g., increasing rate of cellular respiration) while also examining how this operates on different time and intensity scales.
- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1).
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). Student presentations are also expected to include a description about "…how exercise can destabilize muscle structure and function in the body and how negative feedback mechanisms in the body and the consumption of milk can help the body return muscle structure and function to its stable state", as well as "describe how much of the study of the human body involves tracking how various molecular factors in the body change or remain stable" (Student Guide, page 2).

- *Feedback (negative or positive) can stabilize or destabilize a system (SC-H3).*
  - Lesson 8: This element is labeled as a pre-assessment opportunity in this lesson. The explanation that student groups create, and later that the class develops as a Class Consensus, includes ideas about the effects of exercise on a body's hydration and how milk could possibly help in recovery. Since this activity is labeled as a pre-assessment for this element, students are not expected to have a full explanation about feedback mechanisms that *can stabilize or destabilize a system*. Student ideas should include: "There are changes happening inside of the body to the organs that control body temperature, sweat, and urine color. There is salt in sweat, so the body loses salt when sweating. Each of these changes has to do with the amount of water in the body. Sweat loses water from the body. Thirst is when we don't have enough water. Urine has water in it. Milk helps with hydration because it contains water. As you drink it, you are ingesting more water" (Teacher Guide, page 9).
  - Lesson 8: The following guidance is provided to explain that this unit focuses "on how feedback can stabilize or destabilize a system. In this module, students figure out that the body uses negative feedback mechanisms to help it return to a stable state in response to an external or internal change in temperature or water availability due to exercise" (Teacher Guide, page 5).
  - Lesson 9: The Student Guide prompts students, "How can you explain the trends in this data with the lens of stability and change?" (Student Guide, page 3). Students use the trends that they noticed in the data set to explain that when the person is doing exercise, it makes the body temperature change with an increase. When the person stops exercising, the body temperature changes back to its original stable state. Teacher prompts are provided for supporting student thinking, such as, "What trends do you see in the data? How can you use a lens of stability and change to analyze this data?" (Teacher Guide, pages 3–4). Additional guidance is provided for developing this CCC element: "In this prompt, students are asked to use the concept of stability and change to explain their thinking. This is an initial support for students to begin using this lens as a way for them to see that the body has a stable state in its internal temperature, which then can change as exercise occurs or rest occurs. In Part 3, they will continue to figure

out the exact feedback mechanisms responsible for returning the body's temperature to its stable state" (Teacher Guide, page 7).

- Lesson 10: Students revise their explanations as to why we get hot and sweaty during exercise. The Student Guide lists items that refer to feedback mechanisms as the requirements to be included in the explanation, such as, "Describe how you think exercise changes the body temperature conditions of the body, including temperature change and sweat. Describe how a negative feedback mechanism responds to body temperature change and brings body temperature back to a stable state" (Student Guide, page 1). The two-class consensus revised models also include some information about feedback mechanisms.
- Lesson 11: After participating in a model in which students take on the roles of organs in the body to model the physiological processes that regulate water changes in the body in response to exercise, students describe the roles of different organs and specialized cells in regulating the amount of water in the body. They explain how a feedback loop functions to regulate water levels in the blood when conditions change such as water being lost due to sweat during exercise, and water being replenished by drinking milk (Student Guide, pages 4–7). Additional guidance is provided about development of this CCC element: Students focus "on how feedback can stabilize or destabilize a system. For example, in Module 2, students come to consensus on two models that demonstrate their understanding of the feedback mechanisms associated with temperature and water balance in the body as a response to physical activity" (Teacher Guide, page 11).
- Lesson 12: Students respond to a prompt that states, "Using the evidence gathered throughout this module, construct an explanation of the 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?" Among other items, students are told to, "Describe how you think exercise changes the conditions of the body, including temperature change, sweat, thirst, and urine color change. Describe how a negative feedback mechanism responds to water and temperature changes in the body and brings them back to a stable state" (Student Guide, page 1).
- Lesson 14: Students use exercise and/or consumption of milk to create an explanation for how they believe either stimulus influences a body's ability "…to maintain homeostasis and to regulate temperature and water loss in the bloodstream and cells so that bodily functions can still be performed when external factors change" (Teacher Guide, page 3).
- Lesson 25: The following guidance is provided in the Student Guide for a requirement for students to include in their initial model: "How you think the body uses a feedback mechanism to recover from muscle soreness" (Student Guide, page 2).
- Lesson 27: Students examine one of three data sets, each with two different studies included, to understand more about the feedback mechanisms that take place to assist in muscle recovery (e.g., protein synthesis). Students "will compare and contrast the pair of studies in this group to determine what the findings are from the data and if the findings are consistent with one another" (Teacher Guide, page 3). The Student Guide prompt reads: "Review the experiments conducted by scientists in the two studies on changes in the body after consuming protein/exercising. Analyze the data sets provided to determine their findings and if the findings are consistent with one another" (Student Guide, page 1). This prompt, and the discussion around the data sets, has a focus on whether findings are consistent with one another rather than on the element *feedback can stabilize or destabilize a system,* so evidence was not found that this element was developed or used by students in this lesson.

- Lesson 28: Students work to complete a Science Theater model to explore the specific mechanisms that underlie muscle recovery processes and the development and decrease in soreness after exercise. In this activity students will ultimately come to describe three negative feedback processes that are used to detect and repair muscle cells — specifically, "…the role of specific specialized cells in the feedback process" and "what conditions change in the body to bring it out of a stable state, and how the body responds with feedback mechanisms to return it to a stable state" (Student Guide, page 2).
- Lesson 29: Students are asked to use "…all the evidence gathered throughout this module, construct an explanation of the Module Question, How does milk help in muscle recovery from soreness induced by intense exercise? In your explanation, be sure to describe: The role of muscle cells in muscle movement and what happens to muscles and muscle cells when they get sore from exercise. How a feedback response involving organs, specialized cells, and signals helps muscles recover from soreness after exercise. How protein in milk can help in the process of recovery from soreness after exercise. Cite at least two pieces of evidence from data sets and/or the Science Theater model used in this module" (Student Guide, page 1).

Suggestions for Improvement

Science and Engineering Practices

- To help support the stated expectation in the materials that models include references to size and orders of magnitude, consider including size and orders of magnitude information in the sample student/consensus models provided for the teacher in the Teacher Guide and Student Example Guide, especially when the expected criteria include: "An indication of the size (e.g., in, m, cm, mm, um, or nm) of the organs and cells shown in the model" (Teacher and Student Guides, Lesson 5).
- Consider continuing the expectation that relative size indications are included in selected lessons throughout the unit, especially near the culmination of each module, in order to establish this as a habit for showing *the relationships between systems or between components of a system* and incorporating the *orders of magnitude* element within the model.
- Consider providing larger print in models provided for students to use in their activities so that the printed detail is large and clear enough to read so students can better observe and interpret the *relationships between systems or between components of a system*. Consider reviewing each model (both sample responses and student resource materials) in the unit with the lens of someone who does not know all the detail in the model and increase clarity when necessary. Some examples of where the size and clarity of the print detail could be improved include:
  - Lesson 3 Enzyme illustration
  - Lesson 3 Station Cards, specifically the Stomach model (Station Cards, page 6), the Small Intestine: Epithelial Cells model (Station Cards, page 10), the Large Intestine Model (Station Cards, page 16).
  - Lesson 9 Science Theater Cards (specifically the Hypothalamus Card)
- Consider adjusting the graphics on the provided sample student models and sample consensus models to incorporate conventional methods for indicating zoom-in information and visuals, so that it is clear that the zoom-in is representing smaller structures. This would serve to support student understanding and application of the practice of **Developing and Using Models** and the convention of using zoom-ins in a way that clearly indicates different levels and size *magnitudes* that *illustrate and/or predict the relationships between systems or between components of a system.*

- Consider increasing the clarity of the print in sample models by providing sample proficient student models in both the Teacher Guide and the Student Guide that contain large enough print for teachers to read in order to gain a better understanding of the types of details that are expected from student work.
- Consider providing support for how students should go about referring to the multiple sources they use for evidence in the explanations they construct, perhaps by providing sentence stems such as, "In our investigation about ____, we saw that...", or "In the Enzyme Illustration, the _____", or the class reviewing a sample explanation that includes example ways to reference sources.
- Consider clarifying the claimed portion of the element that indicates that students will develop multiple models when in actuality, students "use" multiple models.
- In Lesson 17, consider clarifying whether students are expected to use evidence or prior experiences to serve as a basis for their claim that predicts the relationship between the amount of carbon dioxide exhaled and high-intensity exercise vs. rest. This would help to avoid students' language usage conflating words such as hypothesis, prediction, and claim when it would not be advantageous to do so.
- In Lesson 1, consider revising the questions teachers use to probe student thinking to either more directly align with the element *Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations,* or to clarify that some of these questions also align with the **Planning and Conducting Investigations** element *Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*
- Consider including support for students in developing skills in how to cite the multiple sources they are expected to use for the *valid and reliable evidence* they should include in their explanations to apply the element *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
- Consider modifying some of the instructions in the Teacher Guide in order to better match the elements that are being claimed. For example, the section titled "Part 4: Obtaining Information from Scientific Texts" is inaccurately titled in that it does not have students engage with a *scientific text modified for classroom use* as the claimed element refers to, but rather, students are reading an informational text which is what is used to determine central ideas, conclusions and to obtain scientific information. Consider using the Data Set that students read earlier in the lesson as the *scientific literature adapted for classroom use* source from which they analyze and interpret data, but also which they use to determine central ideas, conclusions, and/or obtain scientific information.

Disciplinary Core Ideas

- When a lesson does not directly address an element, consider adding a note in the beginning pages of the lesson to clarify this, much like is done in Lesson 18, which outlines how learning in this unit may assist in building knowledge toward explaining the phenomena and/or the DCI understanding, for each lesson in which this occurs.

- In Lesson 1, consider providing specific guidance to ensure that the DCI feedback mechanisms element is used in this lesson or to clarify that this lesson serves as a foundation to support this element in future lessons.
- Consider checking and clarifying that when DCIs (or other dimensions) are listed in the beginning pages of the lesson, that they are labeled as Pre-Assessment opportunities, and are accompanied with a supporting note, when that is the case and they are not explicitly developed in the lesson but rather serve as a stepping stone that leads towards students applying the DCI (or SEP or CCC) in future lessons. This would help support teacher planning and avoid misinterpretation of the depth of the application of the claimed element in lessons. For example, the development and use of the Lesson 18 claimed DCI could be clarified.
- Consider in Lesson 16 indicating that this lesson serves as a way for students to make observations about a study that leads towards use of this DCI element in future lessons since evidence of the specific development or use of this element was not found.

Crosscutting Concepts

- Consider providing opportunities for students to begin their sense-making investigations with a crosscutting lens they can use during the figuring out process to strengthen students use of the CCCs as they make sense of phenomena.
- Consider providing students with explicit supports to contrast what each order of magnitude studied is capable of showing about the processes being studied. To what extent would our explanations differ if we only focused on the person? How about the digestive system as a whole? How about only the stomach? How about only the cells?
- Consider increasing the degree to which students are applying the *orders of magnitude* element by going beyond comparing different scales at the quantitative level and adding opportunities for students to use those orders of magnitudes to meaningfully interrogate relationships between models afforded by each differing order of magnitude. This would help ensure that students are going beyond the 6–8 grade band for this CCC that states *students use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes.*
- Consider more fully integrating the Size & Orders of Magnitude Tool, and the concepts in the related element, in later lessons as a means to further support the use of the claimed CCSS standard in mathematics as well as support students with this CCC.
- In order to ensure that the CCC element of *orders of magnitude* is integrated into the models that students develop to explain phenomena, consider including size and orders of magnitude information in the sample student models provided for the teacher in the Teacher Guide and Student Example Guide, especially when the expected criteria include: “An indication of the size (e.g., in, m, cm, mm, um, or nm) of the organs and cells shown in the model” (Teacher and Student Guides, Lesson 5).
- Consider supporting students in developing a deeper understanding of the *orders of magnitude* element by highlighting different orders of magnitude to support a larger view of the numerous cellular, tissue, organ, etc., processes that govern this phenomenon. One opportunity for this would be in Lesson 19. Consider identifying “missed opportunities” to support students in developing a deeper understanding of this element when considering the interplay between these body structures by highlighting different orders of magnitude to support a larger view of the numerous cellular, tissue, organ, etc., processes that govern this phenomenon.
- Consider continuing the expectation that relative size indications are included in models in selected lessons throughout the unit, especially at the culmination of each module, in order to

establish this as a habit for showing *the relationships between systems or between components of a system* and incorporating the *orders of magnitude* element within the model.

- Consider providing guidance to lead students towards the possible use of scale bars as one method to indicate size differences in their models for Lesson 5. Also, consider ensuring that student prompts provide CCC direction so that students — rather than the teacher — are fully engaged in the CCC element.
- Consider adjusting the student prompts in Lesson 6 to guide students towards generating the idea that they should add the relative sizes of the structures in the bloodstream. Also, consider adding size indications in the sample student model, since it is a listed requirement.
- Consider adjusting the student tasks and prompts in Lesson 7 to guide students towards focusing on the nature of orders of magnitude with respect to *how a model at one scale relates to a model at another scale*.
- Consider adjusting the student tasks and prompts in Lesson 27 to add a student focus on the element *feedback can stabilize or destabilize a system,* in addition to those that focus on whether findings are consistent with one another.
- Consider using strategies that capitalize on student CCC element thinking in one lesson as a lens for which to begin the next lesson's investigations. This could serve to move students toward more independently and proactively applying CCC thinking in a sense-making role while they do their investigations to seek answers to gaps in their understanding, rather than just being prompted to consider the role of a CCC at the end of an investigation. One possibility for this would be in leveraging student CCC thinking at the end of Lesson 16 by referring to that thinking at the beginning of Lesson 17 as an active sense-making lens as they do the investigation. Students could be encouraged to pause and share moments in the investigation where they see a CCC playing out in what they observe or find out. Consider employing this strategy in connecting CCC thinking in the transition between other lessons to move students toward eventually initiating this thinking on their own during their sense-making investigations and including other opportunities to surface CCC thinking at the beginning of a sense-making activity connected to a phenomenon.

I.C. INTEGRATING THE THREE DIMENSIONS

Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

Rating for Criterion I.C. Integrating the Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena or designing solutions to problems. Students have frequent opportunities to use grade-appropriate elements of each of the three dimensions together to make sense of or integrate their learning related to the central phenomenon or one of the unit's sub-phenomena.

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

Students frequently use grade-appropriate elements of all three dimensions together in order to work toward figuring out a phenomenon or solving a problem. Related evidence includes:

- Lesson 3: Students create and evaluate claims using evidence about which organ most helps digest milk (Teacher Guide, pages 3–5 and 11–14). Students integrate the following elements:
    - SEP: **Engaging in Argument from Evidence:** *Make and defend a claim based on evidence about the natural world ~~or the effectiveness of a design solution~~ that reflects scientific knowledge, and student-generated evidence.*
    - DCI: **LS1.A Structure and Function** *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
    - CCC: **Stability and Change:** *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.*
- Lesson 7: Teachers will "share that students will now have an opportunity to revise their presentations to share the new scientific information they gathered about how milk can help athletes recover from exercise. This presentation should include students' ideas about the new scientific mechanisms they have obtained evidence about in the module and how and why they think milk helps the body recover from exercise. Explain that they can build upon their presentation from Lesson 1, revise and/or add to it, or start a new presentation entirely" (Teacher Guide, page 3). Students integrate the following elements:
    - SEP: **Obtaining, Evaluating, and Communicating Information:** *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).* (**INFO-H5**)
    - DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.*
    - DCI: **LS1.A:** *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
    - CCC: **Scale, Proportion, and Quantity:** *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.* (**SPQ-H4**)
- Lesson 11: Students read a summary of a scientific study on dehydration and recovery after exercise in order to gather information (Teacher Guide, pages 5–8). Students integrate the following elements:
    - SEP: **Obtaining, Evaluating, and Communicating Information:** *Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.*
    - DCI: **LS1.A: Structure and Function:** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*
    - CCC: **Stability and Change:** *Feedback (negative or positive) can stabilize or destabilize a system.*
- Lesson 14: Students are instructed to "create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 2 to the

presentation you created in Lesson 7" (Student Guide, page 1). Students integrate the following elements:

- SEP: **Obtaining, Evaluating, and Communicating Information:** *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).* (INFO-H5)
- DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.* (**LS1.A-H1**)
- DCI: **LS1.A:** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.* (**LS1.A-H4**)
- CCC: **Stability and Change:** *Feedback (negative or positive) can stabilize or destabilize a system.* (**SC-H3**)

- Lesson 20: Students use multiple pieces of evidence to explain why heart rate and breathing rate changes during exercise to provide energy for muscles during exercise, writing their explanations in Student Guide Part 2 (Teacher Guide, pages 3–5). Students use the following elements of the three dimensions in this task:
  - DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.*
  - DCI: **LS2.B:** ~~*Photosynthesis and*~~ *cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
  - SEP: **Constructing Explanations and Designing Solutions:** *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
  - CCC: **Stability and Change:** *Much of science deals with constructing explanations of how things change and how they remain stable.*
- Lesson 24: Teachers will "share that students will now again have an opportunity to revise their presentations to share the new scientific information they gathered about how milk can help athletes recover from exercise. This presentation should include students' ideas about the new scientific mechanisms they have obtained evidence about in this module and how and why they think milk helps the body recover from exercise. Explain that they can build upon their presentations from Lessons 1, 7, and/or 14, revise and/or add to them, or start a new presentation entirely" (Teacher Guide, page 3).
  - SEP: **Obtaining, Evaluating, and Communicating Information:** *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).* (**INFO-H5**)
  - DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.* (**LS1.A-H1**)
  - DCI: **LS2.B:** ~~*Photosynthesis and*~~ *cellular respiration (including anaerobic processes) provide most of the energy for life processes.* (**LS2.B-H1**)
  - CCC: **Stability and Change:** *Much of science deals with constructing explanations of how things change and how they remain stable.* (**SC-H1**)

Suggestions for Improvement

Consider providing periodic "three-dimensional learning" call out boxes in select lessons that explain to teachers how students are expected to use all three dimensions together to make sense of a phenomenon in a task.

I.D. UNIT COHERENCE	
Lessons fit together to target a set of performance expectations. i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences. ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.	
Rating for Criterion I.D. Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that lessons fit together coherently to target a set of Performance Expectations (PEs). Each lesson begins where the prior lesson ended, typically by asking new questions or examining what has been learned so far and considering what is left to figure out at the module, lesson, or unit levels. The phenomena, including the anchor phenomenon, module phenomena, and lesson-level phenomena are sequenced coherently. The lessons help students develop toward proficiency in a targeted set of PEs.

Lessons build on prior lessons in a way that makes the links between lessons clear to students by addressing questions raised in those lessons, cultivating new questions, using what students figured out as a way to identify the next direction to pursue, or identifying gaps in what is needed to help them answer the module question. Related evidence includes:

- Lesson 1: After the class generates and categorizes a list of questions that will drive their learning as they try to figure out the phenomenon about milk's use as a recovery from exercise, students "record questions they asked or ideas they want to resolve moving forward in the unit" (Teacher Guide, page 14). By identifying existing gaps in their initial explanations, students become aware of the type of information that they will need to find out.
- Lesson 2: The lesson begins with students returning their attention to the questions that were generated in the previous lesson and determining which question categories would be most important to figure out first as they make sense of the phenomenon of milk helping athletes recover from physical exercise. Students identify questions about how milk is digested (Teacher Guide, page 2). These questions are used to drive the learning for this module for Lessons 2–7.
- Lesson 2: At the end of the lesson, students "create a new list of questions that can help them determine what additional information they need to know to help them figure out how milk is

digested after it is consumed" (Teacher Guide, page 9). These questions are added to the DQB to be referenced in the coming lessons (Teacher Guide, page 9).

- Lesson 3: Students return to the Class Consensus Model from Lesson 2 and share their ideas regarding the organs and cells they depicted. The teacher is directed to listen for the following ideas in student responses: "● While the models show similar organs, we were not sure about the function of how the organs and cells digest milk" and to "Build off student responses to share that next, we will figure out how organs and cells function in the digestive system to digest milk. Point to the 'How Does My Body Digest Milk?' category of the DQB. Ask students to identify a few selected questions that align with what they are still wanting to learn based on what they may have answered in the previous lesson" (Teacher Guide, page 2).
- Lesson 5: After building the Class Consensus Model, students are provided time to "reflect on what strengths the model shows and what still seems to be missing to help them answer the Module Question, How is milk digested after it is consumed?" (Teacher Guide, page 7). The conversation is facilitated so that students agree on ideas such as, "The model does not show what happens to some of the molecules after they are digested. For example, the lactose, amino acids, and fatty acids that go into the small intestine seem to not go anywhere else" (Teacher Guide, page 7). Identifying these gaps in understanding leads towards students generating new "questions to help them determine additional information they need to know to help them figure out how milk is digested" (Teacher Guide, page 8). These questions drive the learning in the next lesson.
- Lessons 7 and 8: Students end Lesson 7 by thinking about what they need to figure out next to understand the anchor phenomenon and identifying questions that need further investigation from the DQB (Teacher Guide, pages 5–6). Students begin Lesson 8 by returning to the DQB and, with teacher guidance, identifying the questions that are the most pressing to investigate next about the "effects of exercise on hydration/dehydration and how milk helps athletes recover from these effects" (Teacher Guide, pages 2–3).
- Lesson 8: As a final step in the lesson, students "create a new list of questions to help them determine additional information they need to know to help them figure out the changes in sweat, thirst, and urine color during exercise and how milk plays a role in recovery" (Teacher Guide, page 10). These questions drive the learning for the upcoming lessons.
- Lesson 13: "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?" (Teacher Guide, page 5).
- Lesson 18: "Return the class to explanations that students constructed in Lesson 17 Part 3: Constructing Explanations. Ask students to recall some of the ideas they had to explain the Module Question and some of the areas of uncertainty they had. . . Listen for [areas of uncertainty] responses such as: ● We aren't really sure yet what the increases in oxygen and carbon dioxide consumption would have to do with muscles burning and fatiguing, getting energy for exercise, or how milk helps in recovery. . . Return to the Driving Question Board and highlight questions related to how the body uses energy for exercise, making energy, getting energy from milk, and if muscles get tired because they are running out of energy. Building off this conversation, suggest that students view data from scientists on several markers in the body that are commonly measured when studying changes in the body that occur as a result of exercise" (Teacher Guide, page 3).

- Lesson 22: The teacher begins by revisiting key questions from the DQB, such as, "What does milk do to help with recovery from fatigue? What does glucose do once it is in the bloodstream? How does the sugar and lactose in milk help with recovery?" (Teacher Guide, page 2).
- Lesson 25: Teachers wrap up the first lesson of the final module by prompting students to add to their DQB with the intent to explore and answer those questions in later lessons. Students should "…create a new list of questions that can help them determine additional information they need to know to figure out how milk aids in recovery from muscle soreness.... Add these questions to the 'Milk Protein and Muscle Soreness' category of the Driving Question Board so they can continue to be referenced in the coming lessons" (Teacher Guide, page 9).
- Lesson 27: "As a final step in this lesson, students will create a new list of questions to help them determine what additional information they need to know to help them figure out how protein helps in muscle recovery. They can write these questions on their Lesson 27 Student Guide Part 3: Asking New Questions. Add these questions to the 'Recovery From Exercise' category of the Driving Question Board so they can continue to be referenced in the coming lessons" (Teacher Guide, page 6).
- Unit Guide: The Unit Overview in the Unit Guide includes a "Navigation to the Next Module" section between each listed module that describes the connection that students make between the lesson they just completed to the reason for learning in the next lesson (Unit Guide, pages 3–10).

Lessons are designed to help students develop proficiency in a targeted set of PEs. The NGSS targeted PEs include:

- Unit Guide: The Unit Guide explains that a conceptual bundle of the NGSS PEs was used to help guide the initial unit planning, and the DCIs in the PE bundle are used as the focal DCIs in the unit. The SEPs and CCCS from these PEs are not necessarily those chosen as focal SEPs and CCCs for the unit.
    - **HS-LS1-1**: *Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.* (Note: The materials note that not all aspects of this PE bundle are developed in this unit.
    - **HS-LS1-2**: *Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*
    - **HS-LS1-3**: *Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.*
    - **HS-LS2-3**: *Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.*

Suggestions for Improvement

None

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

I.E. MULTIPLE SCIENCE DOMAINS

When appropriate, links are made across the science domains of life science, physical science and Earth and space science.

i. Disciplinary core ideas from different disciplines are used together to explain phenomena.

ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that links are made across the science domains when appropriate. The phenomenon of milk helping in recovery from intense exercise can be fully addressed using the targeted life science domain. However, the CCCs are not used explicitly to make connections across science domains even though some lessons lend themselves readily to opportunities to do so.

The anchoring phenomenon can be explained using only the life science DCI elements from **LS1.A: Structure and Function** and **LS2.B Cycles of Matter and Energy Transfer in Ecosystems**. Related evidence includes:

- Lesson 7: Students explain how body systems and specialized cells contribute to the digestion of milk in order to create a presentation using multiple formats of communication that explains how milk can help athletes recover from physical exercise (Teacher Guide, pages 3–5).
- Lessons 14, 24, and 31: Students use multiple formats to communicate how the internal conditions of the human body change in response to changes in external conditions (exercise, drinking milk) as they add to their presentation that explains how milk can help athletes recover from physical exercise (Teacher Guide, pages 3–5).

Although students have multiple opportunities to engage in discussion or written responses that feature the usefulness of using CCCs to make sense of phenomena within the life science domain, evidence does not include specific guidance that highlights the usefulness of CCCs to make sense of phenomena across science domains. Some missed opportunities for students to engage in this thinking across science domains include:

- Lesson 17: Students are introduced to bromothymol blue as a proxy indicator for the presence of carbon dioxide in solution. Despite the connection and valid setup offered to students, the teacher demonstration of blowing bubbles (exhaling) into water containing BTB serves to highlight for students that the BTB solution changes color due to carbon dioxide. As presented, it's not clear to students that BTB is actually going through a color change in response to variations in pH of the solution. This would provide a potential opportunity to bring in an Earth or physical science DCI, such as **ESS2.D** or **PS1.B.2** as a means to integrate multiple science domains along with crosscutting thinking across the domains.
- Lesson 18: Students examine data sets to help learn about changes that occur within the body after exercise. As part of this activity, one data set features pH and H+ concentrations, which is a potential opportunity to highlight crosscutting thinking across the domains by bringing in a

physical science DCI, such as **PS1.B.2**, as pH changes can be tied to changes in the rates of the forward and reverse reaction for relevant reactions to this biological scenario.

- Lesson 22: The lesson focus shifts to connect the composition of milk to the need to have glucose available as an input for cellular respiration (aerobically or anaerobically). Within this lesson, or a lesson connected to this lesson, is a missed opportunity to highlight crosscutting thinking across the domains by integrating an additional science domain, such as **PS1.B.3**, given the focus on the depletion of a key reactant for the reaction being examined in greater detail within this module and lesson, specifically.

The CCC of **Scale, Proportion, and Quantity** is used throughout the unit. Students have an opportunity to connect this CCC to things they are familiar with, but specific guidance to connect to other science domains is not provided. Related evidence includes:

- Lesson 3: Students are provided with an order of magnitude tool which provides them with a scale to compare the relative size of objects to each other. "Build on student responses to confirm that for each factor of 10 in size difference, the order of magnitude changes by 1. Share with students that in the human body, the concept of orders of magnitude will be helpful in understanding how different parts of the body relate to each other in terms of their size. Introduce the Size & Orders of Magnitude tool by distributing the Lesson 3 Student Handout Size & Orders of Magnitude. Ask students to share what they observe about the way the tool is set up. Build on student responses to confirm that the tool shows: ● Different units used to measure the size of objects. ● Each unit is related to the next by one or more factors of 10. ● Orders of magnitude are used to relate the size of objects to each other. ● There are a few objects listed on the tool that we are familiar with, such as a grain of rice or a grain of salt. Allow students some time to label on the Orders of Magnitude tool a few of the objects that they brought up in the discussion. Ask a few students to share where they labeled the objects and how the tool shows their relative sizes by factors of ten. Confirm that as you move down each line on the scale, the size decreases by a factor of ten, and vice versa" (Teacher Guide, pages 7–8). This tool continues to be referenced throughout the unit, however specific guidance to relate it to other science domains is not provided.

Suggestions for Improvement

Consider making connections to other science domains that provide an opportunity for students to recognize the usefulness of crosscutting thinking in making sense of phenomena across science domains. Some possibilities include:

- In Lesson 17, consider providing teacher and student prompts that bring in a CCC connection to an Earth or physical science DCI, such as **ESS2.D** or **PS1.B.2,** as a means to integrate multiple science domains and have students develop clarity about whether the BTB color solution changes color in response to variations in the pH of the solution. For example, the use of BTB color change as a proxy for CO_2 concentration could be connected to students' 6–8 prior understandings about CO_2 and its circulation through Earth's systems and how this results in changes in concentration in one area (such as the oceans) as a function of a change in another sphere (such as the atmosphere). This could be useful prior knowledge or experience to elicit in order to make connections to what students are simulating in this activity.
- In Lesson 18, consider providing teacher and student prompts that bring in a CCC connection to a physical science DCI, such as **PS1.B.2**, as pH changes can be tied to changes in the rates of the forward and reverse reaction for relevant reactions to this biological scenario.

- In Lesson 22, consider providing teacher and student prompts that bring in a CCC connection to a physical science DCI, such as **PS1.B.3**, given the focus on the depletion of a key reactant for the reaction being examined in greater detail within this module and lesson.
- Consider providing student and teacher prompts that connect the CCC of **Scale, Proportion, and Quantity** across other science domains and support students in recognizing the usefulness of crosscutting thinking in making sense of phenomena across science domains.

I.F. MATH AND ELA

Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.

Rating for Criterion I.F. Math and ELA	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because explicit connections to CCSS in ELA and mathematics are provided. Students are provided with a variety of opportunities to engage in reading, writing, speaking, and listening throughout the unit. Evidence was not seen of support provided to students to connect science content with ELA or mathematics, making it unclear if students are making those connections or if the teacher is doing it without engaging students.

Materials explicitly state ELA standards that are used in the unit using "Supporting Students in Making Connections to ELA" call out boxes in most lessons. Related evidence includes:

- **WHST 9-10.2 (a)** *Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aid comprehension.*
    - Lesson 1: Students create their first draft of presentations, organize their ideas, include verbal, textual, and graphical representations, and students incorporate the use of multimedia that best suits their targeted audience for comprehension (Teacher Guide, pages 7–12). In this activity, it is not clear that students are making formatting and graphics choices to target their chosen audience.
- **WHST 9-10.4** *Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.*
    - Lesson 8: Teacher instructions emphasize that students will be making choices about "development, organization, and style in their explanations to best produce a coherent explanation" and suggest how to utilize the listed questions to provide additional support (Teacher Guide, page 6).
- **WHST 9-10.5** *Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience*.

- Lesson 7: In groups, students revise their initial presentation from Lesson 1, incorporating the information and ideas they have gained during Lessons 2–6 into their written scripts or reports, and focusing on what is most significant to include to explain the concepts to their target audience. They present and receive feedback on their presentations, which they will use as they edit their final presentation at the end of the unit (Teacher Guide, pages 3–5). Student Guide prompts include using criteria such as: "Clearly communicate scientific information in a way that is appropriate for your chosen audience," "Choose the Focus of This Module – What do you think is the most important information from this module? Stay on point – clarify your objective, never lose sight of it, and shape all of your content around it" (Student Guide, pages 2–3). Additionally, prompts support students in engaging their chosen audience, choosing appropriate media, and narrating effectively (Student Guide, page 3).
- Lesson 14: Students write their presentations using the format they have chosen for a specific audience. The teacher circulates the room, asking pressing questions to help guide students in developing their presentations, such as, "● How do you think this presentation will make sense to your chosen audience? What will be clear for them? What will be difficult? ● How are you showing feedback mechanisms that help the body return to its stable state? ● How can you clearly communicate the idea of homeostasis in your presentation? ● What do you now know about milk's role in exercise recovery?" (Teacher Guide, pages 4–5). Students are reminded that "they will have time in the final performance task of the unit to revise their presentations based on the peer and teacher feedback they receive" (Teacher Guide, page 6).
- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). Peer feedback as well as teacher feedback that includes Look Fors are provided to encourage students to rethink and edit their initial approach to addressing this task.
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). This revised presentation is expected to include the Look Fors described in the student guide and includes the need to "…use the class consensus model, data sets, and/or models from any other resources from the module" and "clearly communicate scientific information in a way that is appropriate for your chosen audience" (Student Guide, page 2). Peer feedback as well as teacher feedback are provided to students in Part 3 of this lesson to encourage them to rethink and edit their initial approach to addressing this task.

- **SL 9-10.1(d)** *Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.*
  - Lessons 2, 5, and 6: As students develop their Class Consensus Model, sentence starters are provided that students can use to come to an agreement about what information to include in the model. Discussion prompts include: "i. We agree with _____'s group, and we also want to add _____. Ii. We disagree with _____'s group because _____. Iii. We would like to change _____ because (evidence)" (Teacher Guide, Lesson 2, page 7; Lesson 5, page 5; Lesson 6, pages 9–10).
  - Lesson 2: Additional teacher prompts support students in working together to determine what to include in the Class Consensus Model: "i. What evidence do you have

for _____? Ii. How come you did not include ____ in the system? Iii. How are you defining your system in your model? Iv. How do your system components compare to ____'s?" (Teacher Guide, page 7). Students reach an agreement on the Class Consensus Model through discussion. As written, it is not clear that students are engaging with this element. Rather, it appears that the teacher is more likely demonstrating proficiency in this skill through their ability to shepherd students through this portion of the lesson.

- Lesson 5: Teacher prompts support students in working together to determine what to include in the Class Consensus Model: "i. Is there anything else that needs to be added to this component before we move on? Ii. How does this idea fit with what is currently on the model? Iii. What evidence do you have for _____?" (Teacher Guide, page 5). Students copy the final Class Consensus Model in their Student Guide (Teacher Guide, page 6). As written, it is not clear that students are substantially engaging with this element. Rather, it appears that the teacher is shepherding students through this portion of the lesson using proficient facilitation skills. This is a missed opportunity to provide students tools, such as classroom posted phrases or individual handouts, that can enable them to initiate and employ academic discourse strategies that would support their development of this element.
- Lessons 2 and 5: Steps are provided to support students in resolving disagreements (Teacher Edition, Lesson 2, page 7; Lesson 5, page 5).
- Lesson 6: Students revise their Class Consensus Model using instructions found on "Lesson 6 Student Guide Part 4: Revising a Model of How Milk is Digested" and are specifically asked to, "Us[e] all the evidence gathered, brainstorm revisions to our Class Consensus Model from Lesson 5 that answer our Module Question, *What happens to milk after it is consumed?"* (Teacher Guide, page 10). Students are encouraged to "include zoom-ins as necessary" as they create their revisions (Student Guide, page 4). The only portion of this element that is addressed centers on the *make new connections in light of the evidence and reasoning presented* portion.
- Lessons 10, 12, and 19: A CCSS Support note states: "Because student explanations may differ, it is important to emphasize that the revisions to the model are being made based on evidence. You may want to ask students to discuss the difference between evidence vs. opinion when discussing what components to include in the Class Consensus Effects of Exercise Model and the Recovery Model" (Teacher Guide, page 7). In Lesson 12, when areas of disagreement occur, students are asked to follow the same procedure as in Lesson 10 to honor differing perspectives and acknowledge areas that still require further study (Teacher Guide, pages 6–7). In Lesson 15, students work together to build a class consensus model and, when areas of disagreement occur, the materials prompt the teacher to, "Summarize the two sides of the disagreement. Ask the students to pause and reflect on their reasonings to be on that side. Prompt students to again re-discuss the area of disagreement. If students still disagree, suggest that we can represent areas of disagreement on the class explanation with question marks or other annotations of uncertainty" (Teacher Guide, page 10).
- Lesson 19: Students learn that exercise prompts a need for the body to produce an increased amount of energy and that the biomarkers explored in Lesson 18 are related to the production of energy required to complete the exercise. Students revise their prior explanations and have a discussion about how students' models align with their prior learning. Teachers should emphasize that students' understandings being shared are rooted in evidence and, when needed, "You may want to ask students to discuss the difference between evidence vs. opinion when discussing during a class discussion and analysis" (Teacher Guide, page 10).

- Lesson 20: Students follow their revision of their understanding of the Module Questions (and tentative answers) with a class discussion centered on supporting the class in adding "…to the existing Class Consensus Effects of Exercise and Recovery Models. Students can write their initial ideas for additions on their Lesson 20 Student Guide Part 3." Teachers walk students through provided class consensus discussion steps to update the model "Effects of Exercise Models" (Teacher Guide, page 7). Students contribute to this discussion and when disagreements occur, the teacher is reminded to "use the established procedure that includes strategies such as to 'summarize the two sides of the disagreement [and/or] ask the students to pause and reflect on their reasoning to be on that side.'" (Teacher Guide, page 8).

- **ELA-Literacy RST.9-10.1** *Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.*
  - Lesson 9: Students use evidence from a scientific study to analyze data and determine data trends. A CCSS Support note suggests that teachers "consider modeling and providing examples of how to extract relevant details from the text to enhance students' understanding and analysis" and to develop skills "to articulate their interpretations and insights based on the evidence gathered from the text" (Teacher Guide, page 6).
- **CCSS.ELA-LITERACY.RST.9-10.2***: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.*
  - Lesson 23: Students examine a text (Student Handout: The Body Fuel Source Article) describing different fuel sources that are able to be used for energy within the body. Students are prompted to "summarize the text in simpler but still accurate terms [and] describe how the body gets energy from different fuel sources during exercise" (Student Guide, page 4).
- **CCSS.ELA-LITERACY.RST.9-10.4***: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.*
  - Lesson 18: Students are assigned a data set relevant to changes in the body before, during, and/or after exercise. They use the data to "review the experiments that scientists conducted to measure the changes in oxygen used in moderate and intense exercise.... Compare the methods from the two investigations. Review the data scientists collected and record your observations about how _____ (variable) changes over time during exercise and during recovery. Identify if _____ (variable) levels return to a stable state during recovery. Do these studies come to the same conclusion?" (Student Guide, pages 1–2).
- **ELA-Literacy.RST.9-10.7** *Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.*
  - Lesson 11: A CCSS Support note suggests that to support students in achieving this standard, teachers can "consider modeling and providing examples of how to analyze and paraphrase relevant details from the text to enhance students' understanding and analysis. Additionally, this standard will support students in developing skills to articulate their interpretations and insights based on the evidence gathered from the text" (Teacher Guide, page 7). It appears that it is the teacher who is applying this element in the lesson, not the students.

Materials explicitly state mathematics standards that are used in the unit using "Supporting Students in Making Connections to Mathematics" call out boxes at the end of specified lessons. Related evidence includes:

- **CCSS.Math.Content.HSN.Q.A.1***: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.*
    - Lesson 3: Students engage with the "Lesson 3 Student Handout Enzyme Illustration" where teachers are asked to show students that "…this illustration shows multiple levels of scale in the human body to depict how the molecule sucrose, or table sugar, that is added to chocolate milk is broken down in digestion" (Teacher Guide, page 8).
    - Lesson 3: Using a resource ("Student Handout: Size & Orders of Magnitude"), students are asked to "…label each example of different structures, cells, and enzymes in the models…". Students are then asked to respond to individual questions such as, "how can you mathematically determine the relative size?", and "what does one order of magnitude difference indicate about size? Two? Three?" (Teacher Guide, page 9). While students are actively comparing different scales at the quantitative level, it does not appear that students are using those orders of magnitudes to do much beyond the "interpret the scale ~~and origin~~ in ~~graphs and~~ data displays."
    - Lesson 21: Students examine data presented in two separate studies to determine what the purpose of each data set is for as well as what findings would be reasonable and how they would address the given problem (Teacher Guide, page 5).
    - Lesson 23: Teacher asks "…students to convert 56 km to miles using a calculation or provide the conversion to students (56 km = 34.8 miles). In addition, you may want to provide a quick analogy of how far that distance is using local reference points or landmarks. For example, 34.8 miles = about 139 laps around a running track" (Teacher Guide, page 3).
- **6.EE.A.1** *Write and evaluate numerical expressions involving whole-number exponents.*
    - Lesson 3: Students work with multiple units and exponents and compare one measurement to another. Teachers are provided with a suggestion to further support students by reviewing scientific notation and its relationship to orders of magnitude (Teacher Guide, pages 5–8).

Suggestions for Improvement

- Consider deepening the process that students undertake to form the connection in a standard like **CCSS.ELA-SL.9.10.1(d)** when, given the nature of a class discussion, all students may not be participating equitably. Beyond the established classroom norms, consider other opportunities for students to generate evidence of their thinking for standards like this one that might allow voices of students who are not as excited to share out to still be heard.
- Consider encouraging teachers to post some of the prompts that have been provided for teachers to support student discourse so that students can initiate the "talk moves" and not just rely on a teacher-centered conversation. In addition, consider referring teachers to the supporting documents included with this unit that provide strategies that could be in handouts to students so the students can bring these out to use during discussions, during times when disagreements of ideas arise, and/or when doing class consensus work. Consider guidance for teachers that encourage students to take a lead in guiding and facilitating discussions.
- Consider providing support for students so that they can see the connections between content areas when reading, writing, or working with mathematical ideas in the unit. Consider providing

teacher and student prompts that support students in making these connections to increase their awareness and use of these connections in sense-making.

- Consider evaluating the rigorous writing demands expected for students to show proficiency in the writing tasks and provide consistent supports for students with varied readiness for the tasks.
- In Lesson 3, consider providing teacher and student prompts that support students in using the orders of magnitudes ideas they are developing to go beyond interpreting the scale, but to incorporate the "*interpret the scale and origin in graphs and data displays"* portions of this element.
- In Lesson 1, and future lessons in which students work on their presentations, consider including some specific teacher and/or student prompts that guide them in considering making formatting and graphics choices to target their chosen audience. One possibility is to provide an opportunity for students to evaluate various formats and graphics to determine which might appeal to certain audiences and not to others.
- In Lesson 6, consider either addressing more aspects of the claimed ELA element, **SL 9-10.1(d)** *Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented,* or clearly identifying the portion of the element that is addressed in the lesson, such as the "make new connections in light of the evidence and reasoning presented" portion.

OVERALL CATEGORY I SCORE: **3** (0, 1, 2, 3)	
Unit Scoring Guide – Category I	
Criteria A-F	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

II.A. RELEVANCE AND AUTHENTICITY

Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.

i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).

ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.

iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. The phenomenon of using milk as a recovery drink is presented as a relevant phenomenon that students would want to seek to explain. Students are generally able to experience the central phenomenon through media representations and, occasionally, firsthand, and students are provided with some opportunities to connect learning to their own experiences. However, opportunities are rarely provided for students to bring their funds of knowledge from their homes, communities, and cultures into the learning experience.

The anchor phenomenon used throughout the unit is something that reflects a real-world scenario to which students can relate and is important to others. Students experience various modules and lesson phenomena through the use of videos, photos, texts, case studies, data, and classroom activities. Some of the phenomena are presented in a way that misses opportunities to connect to students' own experiences or experiences they can bring in from their homes, neighborhoods, communities, or cultures. Related evidence includes:

- Lesson 1: Students watch videos showing athletes working out. Some of the videos show some of the athletes drinking milk or chocolate milk, while others make statements that these athletes use milk to aid their recovery. One of the videos shows people the same age as students watching athletes work out behind the milk section of a grocery store. Students also watch a video that explains a study that indicates that milk can be an effective recovery drink compared to other drinks (Teacher Guide, pages 3–5). Using videos for students to observe the anchor phenomenon that they will be seeking to explain throughout the unit increases relevance and authenticity in experiencing the phenomenon as directly as practical. This could be a missed opportunity to have students share experiences they or their friends have had with drinking chocolate milk, or messages they've heard or read in social media about claims about chocolate milk for recovery. It could also be a missed opportunity to ask students to share what they have used or what they have heard from other people about what they use to recover from hard workouts, athletic events, or hard physical work.
- Lesson 2: "As a class, watch the Digestion Video and record observations about how food is digested and the organs involved in the digestion process. Students can write these

observations and any questions they have after watching the video on their Lesson 2 Student Guide Part 2: Observing the Module Phenomenon. Use a Think-Pair-Share to have students share what they noticed happened to the food and what organs were involved" (Teacher Guide, page 3). "Allow students a brief time to record any questions they have based on what they observed in the video. Build off student responses to introduce the Module Question, How is milk digested after it is consumed? Share with students that they will set out to figure out the answer to this question in the following lessons" (Teacher Guide, page 3). While this is presented as a module level phenomenon, it serves more as an informational video since the sound is on with the person explaining what is happening as the camera travels along the digestive journey.

- Lesson 13: "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 [sic]" (Teacher Guide, page 3). After reading, students discuss their observations. "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?'" (Teacher Guide, page 4). The case studies present the phenomena in as direct a way as is practical. However, the way this lesson begins is a missed opportunity for students to begin the lesson by sharing their own experiences with being very thirsty from not having enough water and what that felt like, and/or with drinking too much water and what its effects were. A "Student Support" call out box after the reading suggests that teachers "may choose to ask students if they have experienced or if someone they know has experienced any health issues with dehydration or overhydration" (Teacher Guide, page 4). Because this is presented as an optional prompt, not all students may have the opportunity to share their experience.
- Lesson 15: Students "…will each complete a high-intensity workout. Students will make observations of what they are feeling and experiencing as they complete each of these workouts. Direct student attention to the list of workout options on their Lesson 15 Student Guide .... Students can choose one option from the high-intensity workout list" (Teacher Guide, page 3). This activity creates a common first-hand experience with a phenomenon which serves to drive further learning. In addition, this activity provides some student choice in selecting which workout option to do.
- Lesson 17: Students plan and carry out an investigation to test a claim or "prediction of the relationship between the amount of carbon dioxide exhaled and high-intensity exercise" (Teacher Guide, page 3). While carrying out the investigation, students observe first-hand the reaction that occurs as they compare the color differences in the cups. "I can compare the colors of the rest cup to the intense workout cup and both to the color of the control cup. This will tell me if rest or intense exercise made a change to the color of the BTB compared to the control" (Teacher Guide, page 5). In a reflection on the design of their experiment, an anticipated sample student proficient response states: "My investigation should be able to answer if I breathe out carbon dioxide and if I breathe out more of it after high-intensity exercise…" (Teacher Guide, pages 5–6). This lab experience becomes a created common student experience that they can apply to themselves personally.
- Lesson 23: Teachers will "Share with students that they will now observe a new phenomenon to help them figure out how a person who exercises for very long periods of time could get the energy to do so. Show students the Ultramarathon Runner Video of a runner completing a 56-kilometer race and ask them to record their observations on their Lesson 23 Student Guide" (Teacher Guide, page 3). The video provides a media experience with the phenomenon. There's

a potential missed opportunity for connecting to some students' digital media experiences in watching videos of extreme sports.

- Lesson 25: The teacher introduces the Workout Video by saying, "Let's watch and see what this athlete experiences" (Teacher Guide, pages 3–4). The teacher plays the Workout Video, the students record their initial observations of what is happening, and then they share with a partner. The teacher builds off student responses to introduce the Module Question for this module, "How does milk help in muscle recovery from soreness induced by intense exercise?" (Teacher Guide, pages 3–4). The workout video provides a media experience with the phenomenon.
- Lesson 26: Students examine diagrams on cards showing the structure of muscles and what happens to muscles in order to lift weights. Then students view a muscle contraction video to help them better figure out what the cards were showing about muscle contraction and realize that they still need to figure out what happens to a muscle to make it sore and weak. Students examine five photographs that are microscopical images of skeletal muscle tissue pre- and post-exercise as well as images of in vitro muscle cells that show lesions increasing over time with electrical pulse stimulation designed to mimic exercise. Viewing images showing how the structure of muscle cells changes after intense exercise and after electrical stimulation that simulates exercise provides a concrete experience with the phenomenon of muscle soreness that leads towards figuring out what causes muscle soreness. There is a possible missed opportunity to connect this phenomenon to students' own or family's experiences with how they feel after intense exercise or physical work, such as, "My muscles feel like they're torn" followed by viewing the images of the "tears" that occur in muscle tissue. There is also a missed opportunity for a connection to bringing in cultural ideas about muscle soreness and how to prevent it or provide for recovery within this lesson or others in this module.
- Lesson 30: "Share with students that they will now observe a new phenomenon to help them figure out if and how muscles could get stronger after exercise. Distribute the Lesson 30 Student Handout Data Set and share with students that they will now analyze three pieces of data from a scientific journal article in which scientists studied the changes to muscles that took place after two different kinds of workouts: an endurance workout and a resistance training workout. ... After agreeing on their observations from the video and data set, introduce the questions students will investigate in this lesson, 'How do muscles increase their size and strength in response to resistance exercise? How can milk help with this process?'" (Teacher Guide, pages 2–3). Students experience the phenomenon through reading and analyzing a data set from a study described in a scientific journal article, which is the most direct way practical. There's a potential missed opportunity to connect with possible school, community, and cultural resources, such as the high school weight room, local workout gyms, media related to body building or strengthening, and various martial arts or other physical activities and their cultural roots, on which to begin having students generate questions about building muscles.

Students are provided with some opportunities to connect the phenomena to their own experiences. However, the opportunities are often presented as optional, which limits the probability that they will be used. Furthermore, the majority of these opportunities do not explicitly serve to connect the learning to the funds of knowledge students bring from their families, neighborhoods, communities and cultural backgrounds. Related evidence includes:

- Lesson 1: The unit and this lesson start off with connecting to students' own experiences. "Encourage students to write about their exercise experiences by sharing details about the sports or physical activities they are currently engaged in or have been involved with in the past. Instruct students to write or draw their responses in Lesson 1 Student Guide Part 1: Sharing Our

Past Experiences. Hold a brief whole-class share-out for students to share their ideas. Welcome and encourage sharing from students with a variety of experiences" (Teacher Guide, page 2).

- Lesson 1: "Another activity you may choose to do is to have students brainstorm and record phenomena from their own lives they believe are related to the Anchor Phenomenon. This may look like further describing their own physical exercise and recovery experiences or describing other recovery foods or drinks students have heard of or used themselves. Allowing students to connect to phenomena from their own lives can help strengthen their connection to and interest in figuring out more about this Anchor Phenomenon" (Teacher Edition, page 13). By stating this as an optional activity, it is less likely it will occur and serve as a connection to student experiences.
- Lesson 2: Students build on the ideas they had in the previous lesson and eventually ask questions to move class thinking forward such as, "Why does my body need to recover after exercise? What happens while I exercise that causes it to need recovery? We know that milk is being used in athletic recovery; what is in milk that makes it so good at doing this?" (Teacher Guide, page 2). Phrasing the question in the first person connects students with their own experiences.
- Lesson 9: "Then, ask students to share their experiences of times when they have exercised and had similar experiences to those that the athlete in the video described, such as their experiences being sweaty, thirsty, or having a change in urine color. Acknowledge and welcome the range of student responses that they will share here based on their varied backgrounds. Throughout this conversation, press students to try to explain why they think these changes happened to their bodies as they were exercising" (Teacher Guide, page 4). This prompt provides an opportunity for students to connect the phenomenon they view in the video with their own experiences.
- Lesson 11: "First, ask students what their experiences are with[sic] when their urine color changes. Invite a few students to share their experiences. Listen for responses that share that urine color changes have something to do with drinking more or less water and when getting dehydrated or overhydrated. Share with students to record these observations on their Lesson 11 Student Guide Part 2: Analyzing Data About Urine Color, and keep these experiences in mind as we continue to figure out why urine color changes" (Teacher Guide, page 3).
- Lesson 13: "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 Guide, page 4). By indicating that this is an optional prompt to use with students, it may be skipped and a missed opportunity to connect to student experiences.
- Lesson 15: "Students might be familiar with the experimental protocols utilized in the recovery study because of their regular participation in PE physical fitness tests. Specifically, the data set represents performance on a Shuttle Run, which can also be referred to as a 'Pacer Test.' You may want to ask some students to explain or demonstrate this workout setup to the class" (Teacher Guide, page 6). This optional suggestion could provide a connection to students' own experiences.
- Lesson 16: "The experimental methods for Study 1 involve the use of a catheter. To help students understand the function of this device, you could ask if any students have donated blood and ask students to explain how the collection process works. You can also explain its function to students" (Teacher Guide, page 3). This is offered as an optional discussion.
- Lesson 25: Students are asked to think about their prior experiences with muscle soreness or discomfort and are prompted to share how they've experienced this by the teacher asking

questions such as, “what other kinds of exercises, movements, or life activities have caused you muscle soreness?” or “when else might you have experienced muscle soreness, even if not after a sporting event or a workout?” (Teacher Guide, page 3). The following teacher guidance is provided: “To help connect the Module Phenomenon to students, seek out and use students’ experiences. Elicit responses from all students, not just those involved in regular athletics or exercise. Consider asking questions such as: ● What other kinds of exercises, movements, or life activities have caused you muscle soreness? ● When else might you have experienced muscle soreness, even if not after a sporting event or a workout?” (Teacher Guide, page 3). This is a missed opportunity to connect with students’ families, communities, and cultural experiences with muscle soreness and ways to prevent and/or alleviate the soreness.

Some teacher support is provided to teachers for anticipating issues that may arise from student experiences related to the unit.

- Lesson 1: “You may need to guide the discussion on physical exercise to include students with varying physical abilities. Consider using the following questions to guide the conversation: ● How do you like to move your body? ● What are your favorite sports to watch? ● What other physical activities do you engage in, such as hiking, marching band, etc.? If students have not already incorporated this into the conversation, you can help ensure relevance to the community by asking about popular local sports or exercises. All students will have differing life experiences when it comes to exercise. This is an opportunity to continue to build on the norm for this unit that we will value the different experiences and opinions that students bring to the classroom” (Teacher Guide, page 3).
- Lesson 1: “While this unit will focus on how milk helps athletes recover from exercise, some students may not drink milk. Students may come from cultures that do not typically drink milk or may be lactose intolerant. If you think your students may not have peers who drink milk to communicate a presentation to, consider choosing yogurt as an alternative milk product to focus on in the unit. Yogurt may be an alternative to milk for people of some cultures and may be eaten by those who are lactose intolerant. Importantly for this unit, it has a similar nutrient profile to milk, which helps it fit in the context of the way the different investigations within the unit are designed. In addition, be careful to frame this presentation carefully such that we are not advertising that all athletes should consume milk. Instead, the focus is on the benefits that milk can have if that is a choice individuals would like to make. It is also important to note that milk can have some downsides for some individuals, such as those who are lactose intolerant or have a dairy allergy or sensitivity” (Teacher Guide, page 6). This is a cultural connection as well as addressing a possible issue that could arise from student experiences.
- Lesson 11: “Students may have differing experiences and levels of comfort in sharing about bodily functions. If no student is willing to share, move along with the lesson to honor their privacy” (Teacher Guide, page 4).
- Lesson 13: “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” (Teacher Guide, page 4).
- Lesson 13: A Teacher Support call out box states, “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" (Teacher Guide, page 4).

- Lesson 17: "In this experiment, be mindful of students with varying exercise abilities, and allow groups to modify the experimental design to fit the needs of those students" (Teacher Guide, page 6).

Although a few suggestions are made that connect instruction to the students' homes, neighborhoods, communities, and/or cultures at the beginning of the unit, evidence is lacking that shows that these types of connections are made consistently as the unit progresses, especially in the area of family, culture and community. The following are the few instances of related evidence:

- Lesson 1: "If students have not already incorporated this into the conversation, you can help ensure relevance to the community by asking about popular local sports or exercises. All students will have differing life experiences when it comes to exercise. This is an opportunity to continue to build on the norm for this unit that we will value the different experiences and opinions that students bring to the classroom" (Teacher Guide, page 3).
- Lesson 1: Students talk about someone they know who is an athlete, exercises, or engages in a lot of physical activity, and discuss whether these people could benefit from knowing how to better recover from exercise. Teachers are directed to "build off this idea to share that, in this unit, students will design a presentation, choosing the audience and format to explain how milk can help the body improve recovery from exercise" (Teacher Guide, page 6). This discussion provides a connection to the reason for developing presentations as a connection to people in the community or someone students know.
- Lesson 8: Students are asked to "share their experiences of times when they have exercised and had similar experiences to those that the athlete in the video described, such as their experiences being sweaty, thirsty, or having a change in urine color." The teacher is directed to, "Acknowledge and welcome the range of student responses that they will share here based on their varied backgrounds" (Teacher Guide, page 4).
- For additional examples of missed opportunities for making connections to families, neighborhoods, communities, and cultures, refer to "missed opportunities" cited with evidence bullets earlier in this criterion for examples of lessons in which opportunities to elicit ideas about or from the home, neighborhood, community or culture could be made but aren't evident in the lesson materials beyond the first few lessons of the unit.
- Lessons 2–31: No direct references to students' "communities" were found in the lesson Teacher Guide and references to home or culture are rare.

Suggestions for Improvement

- In Lesson 1, consider providing a chance for students to bring up questions they have about the "chocolate" part of the chocolate milk and if it makes a difference in recovery, especially since it is likely at least some students have heard this claim in social media or social conversations. Consider revisiting "chocolate milk" at some point in each module to keep the experience students have with the anchor phenomenon consistent with the learning they experience as the module progresses. Consider providing an opportunity for students to share experiences they or their friends have had with drinking chocolate milk for recovery from intense workouts, athletic events, or hard work, or messages they've heard or read in social media about claims about chocolate milk. This will give students an opportunity to share that milk is one thing that they've heard about being used.

- In Lesson 2, in order to increase the sense that the Digestion Video is students viewing a phenomenon instead of an informational video, consider showing the video the first time without sound with a simple introduction about what it is showing so that they do not hear the explanation about what is happening but concentrate on what they observe. This then becomes a media experience with a phenomenon. One option is that the video can simply be introduced by stating that a camera is being swallowed so it will follow the digestive journey that food follows. Later in the lesson, show the video with sound so students can track the movement through the different organs with the accompanying description of what organs the camera is traveling through. Consider reviewing the sequence of some of the instruction in some of the lessons in order to provide an opportunity for students to share their own experiences connected to a phenomenon before watching a video, reading, or experiencing a phenomenon during the lesson. The "missed opportunities" listed in the evidence above are not all intended to be addressed but are intended to provide possibilities for consideration.
- In Lesson 13, before students read about the two athletes who died, consider connecting to students' own experiences with being very thirsty and what it felt like, or drinking too much water and how it felt.
- Consider providing suggestions for additional connections related to the prevalence of student media use, such as viewing extreme sports, as well as providing meaningful opportunities for students to bring their experiences with home, neighborhood, community and/or culture into the classroom learning experience, including work that is physically demanding, local events that require intense physical effort, high school weight room resources and sports, community resources such as workout gyms, or regional opportunities.
- In Lesson 26, consider connecting to students' own or their family's experiences by providing an opportunity for students to share the kinds of things they've heard people say after intense exercise or physical work, which might surface a statement such as, "My muscles feel like they're torn." This will provide a direct connection to later viewing the microscopical images of micro tears in muscle tissue.
- Consider changing "optional" activities and prompts to be a part of the regular instructional sequence to increase the likelihood that students' own experiences as well as family, neighborhood, community, or cultural experiences are brought into the learning experience.
- Consider reviewing lessons for potential connections that could bring in experiences from neighborhood, community and or cultural resources, such as could be done in Lesson 30 with the high school weight room or local gyms, body building represented in media, or connections to martial arts, and other physical activities from various cultural backgrounds.

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

II.B. STUDENT IDEAS	
Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.	
Rating for Criterion II.B. Student Ideas	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. The lessons and unit resources provide a wide range of routines, tools, protocols, and supports for students to express, clarify, interpret, justify, and represent their ideas in a variety of ways. Students have numerous opportunities to show how their thinking has changed over time and to respond to peer and teacher feedback.

Students are provided with many opportunities to show how their thinking has changed over time. Related evidence includes:

- Lesson 1: Students individually "create an initial draft to show their initial understanding of how milk might help athletes recover from physical exercise." Students later compare and contrast their initial presentations with that of their peers and "...identify similarities and differences between their presentations and record them." Students are encouraged to view these presentations as works in progress to be added to and revised in the coming lessons/modules and to collect their presentation drafts in a portfolio to see how their presentations progress over time (Teacher Guide, page 9).
- Lesson 7: Students are encouraged to revise their ongoing draft presentations and consider key ideas such as, "how do you think this presentation will make sense to your chosen audience? What will be clear for them? What will be difficult? How are you communicating the idea that multiple different scales are important in digestive functions? How can orders of magnitude help you do so? How are you showing how the molecules in milk are digested? How are you showing the role of specialized cells in this process?" Teachers support students as they are directed to, "…review and approve each group's script or outline," (Teacher Guide, page 4) and to revise based on feedback. A "Peer Feedback Form" provides an opportunity for students to give and receive feedback (Peer Feedback Form). A Self-Assessment form is also provided for students to use their self-reflections to revise their work (Student Self-Assessment).
- Lesson 14: Students develop a presentation to communicate what they've learned throughout this module related to "…how and why they think milk helps the body recover from exercise" (Teacher Guide, page 3). As part of this process, students "…use a peer feedback protocol to have students provide feedback on each other's presentations" (Teacher Guide, page 5). The last pages of the Lesson 14 Rubric provide guidance for teachers on how to discuss norms on what features of high-quality student presentations look like and how to support students in the use of the Peer Feedback Form (Rubric, pages 7–8). In addition, a suggestion is made that teachers "can collect student presentations and provide feedback to each group using the provided Rubric and Look Fors" (Teacher Guide, page 5). Using the peer and/or teacher feedback, students are encouraged to revise their thinking to deepen the substance of their response.

- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). This task includes several key "Look Fors" that guide students in sufficiently completing this task. Peer feedback as well as teacher feedback are provided to students in Part 3 of this lesson to allow students to receive input necessary to encourage them to edit or rethink their initial approach to addressing this task.
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). Required "Look Fors" are described in the Student Guide and includes the need to "…use the class consensus model, data sets, and/or models from any other resources from the module" and "clearly communicate scientific information in a way that is appropriate for your chosen audience" (Student Guide, page 2). Peer feedback as well as teacher feedback are provided to students in Part 3 of this lesson to allow students to receive input necessary to encourage them to edit or rethink their initial approach to addressing this task.
- Lesson 32: Students are instructed to "create a final presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should revise the content from all of your presentations based on the feedback you have been provided" (Student Guide, page 1). This assessment is intended to measure student progress on key unit SEPs (**INFO-H5**), DCIs (**LS1.A-H1**, **LS1.A-H3**, **LS1.A-H4**, **LS2.B-H1**), and CCCs (**SC-H1**, **SC-H3**, **SPQ-H4**). Self-Assessment and Peer Feedback forms are provided as another opportunity for students to give, receive, and respond to feedback from peers.

Lessons provide routines that support students in expressing, sharing, clarifying, justifying, interpreting, and representing their ideas. Lessons also provide other means for sharing ideas visually. Some examples include:

- Students use a "Mingle-Pair-Share Routine" regularly during lessons to share ideas with peers. In this strategy, students share with two or more peers by moving around the room to connect with a partner who is not a part of their usual group, then moving again to a new partner to share again (Teacher Guide, page 7). Related evidence includes:
    - Lesson 1: Students first use this routine to share their observations from videos they watched with two different peers and record similarities they noticed (Teacher Guide, page 4). Later, students move around the room using this same strategy to share their initial responses to the Driving Question on their Student Guide, taking turns and then finding new peers to share again (Teacher Guide, page 7).
    - Lesson 23: After students have completed their reading and recorded central ideas from the text, they use a sharing routine such as a Mingle-Pair-Share to share the different central ideas they have found with their peers. They record the central ideas they hear from their peers (Teacher Guide, page 10).
- Students use a "Stay and Stray Strategy" to share their models. In this strategy, student groups: 1. Discuss how they can adjust their group's models or explanations, 2. Have one person stay at their table to explain, 3. Have the rest of the group "stray" to other groups, 4. Ask questions, and 5. Rotate who stays and who strays (Teacher Guide, page 6). Some examples include:
    - Lesson 2: After groups create their initial models of the digestive system, groups share their models with this strategy. Students are encouraged to ask questions of others'

models, and then discuss with their group whether to integrate these ideas into their own group model (Teacher Guide, page 6).
    - Lesson 8: Students use this strategy to share their initial explanations about the module phenomenon with their peers, then record the "parts of the explanations they agree with and those they disagree with" (Teacher Guide, page 8) before determining what revisions to make in their own work.
    - Lesson 15: Students "construct an initial explanation in small groups to answer the Module Questions, Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?" with teacher instructions to "Read the expectations checklist together with the class," and remind students that "at this point, any ideas are acceptable, and they don't need to worry about getting the 'right' answer—just sharing what they think right now" (Teacher Guide, page 7). Students write their initial explanations, then use the Stay and Stray Strategy to share similarities and differences with peers (Teacher Guide, page 9).
- Student pairs use a "Domino Share Routine" to share information from readings and observations. As a spokesperson from a group shares, all other students serve in a "listener" role, noting patterns or ideas that emerge. After each group's spokesperson has shared, the facilitator holds a whole class discussion and invites the "listening" students to share what was similar or unique across the responses (Teacher Guide, page 5). Some related evidence includes:
    - Lesson 3: Student pairs nominate a spokesperson and use a Domino Share Routine to have students share the types of molecules they identified in milk from a reading (Teacher Guide, page 5). Students use this routine again later in the lesson to share out what they found out at each station (Teacher Guide, page 11).
    - Lesson 8: Students share their observations from watching an exercise video using this routine after using a Think-Pair-Share Strategy (Teacher Guide, page 3).
    - Lesson 25: After watching a workout video and recording their initial observations of what is happening, students build off each other's contributions from a Think-Pair-Share strategy by using a Domino Share Routine (Teacher Guide, page 4).
- Students use a "Think-Pair-Share Strategy" to share information and ideas by thinking independently of their responses and taking turns sharing their thoughts with their partner. Related evidence includes:
    - Lesson 8: Students share with partners what they noticed from the video (Teacher Guide, page 3). Later, they share with a partner their ideas about why they think the exercise-induced changes they observed occur and how they "think milk helps an athlete recover" (Teacher Guide, page 5) from the changes.
    - Lesson 9: With partners, students share their summaries of the experiment design and the trends they found in the data set. Then, they again share how they can use the lens of stability and change to analyze the results of this experiment (Teacher Guide, page 6).
    - Lesson 11: Students share with partners what they notice about the urine color change demonstration and what they think the model represents (Teacher Guide, page 4).
    - Lesson 25: After watching a workout video and recording their initial observations of what is happening, students use a Think-Pair-Share strategy to share what they noticed from the video, followed by using a Domino Share Routine to build off each other's contributions (Teacher Guide, page 4).
- Students use a "Tell-Ask-Give" protocol to provide peer feedback. Some examples include:
    - Lesson 3: The following suggestion for additional support is provided: "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" (Teacher Guide, page 13). However, this is presented as a possible support and is not a required activity.

- Lesson 26: Students "view figures from two scientific journal articles showing how the structure of muscle cells changes after two different types of stimulation: intense exercise and electrical stimulation that simulates exercise" (Teacher Guide, page 4). They compare and contrast the methods of the two experiments and the data presented. For students who may be struggling as they analyze the data sets, teachers are given the suggestion to "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" (Teacher Guide, page 4).

- The materials provide varied student response visual tools, and sometimes alternatives to writing, for sharing their ideas. Examples of these include:
  - Lesson 3: Students make an initial claim that answers the question, "What organs most help digest milk? How?" (Teacher Guide, page 3). Students then create a sticky bar graph using their responses. The following teacher guidance is provided: "The 'Sticky-Bar Graph' is a visual tool that provides an opportunity to quickly see the distribution of the class responses to a focus question. You can also have students add a written response to their sticky notes, which allows an additional formative assessment opportunity. Students can also put their names on their sticky notes so you can refer to and revisit their responses later" (Teacher Guide, page 3).
  - Lesson 9: The student prompt includes the option to, "Write or sketch your response as you choose" (Student Guide, page 5).
  - Lesson 13: Students engage in a class discussion to share their ideas about the answer to the Module Questions: "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" (Teacher Guide, pages 9–10).

Teacher resources are included in the unit materials that support teachers with a variety of tools and strategies for supporting student academic talk and sharing of ideas in the classroom. These resources include:

- High School Science Classroom Discourse & Argumentation Supports: This document includes strategies and protocols such as: Teacher Talk Supports, Student-to-Student Support, Talk Protocols, and Argumentation Strategies (pages 2–12).
- Facilitating Meaningful Student-Student Discourse: This document includes strategies and protocols such as: Supporting Small Group Discussions, Teacher Discourse Moves, and Facilitating Whole Class Discussion (pages 1–8).

Supports and reminders are provided for teachers to increase awareness of learning needs that may affect student willingness to share ideas, and to create an environment which provides a safe space for sharing. Some related evidence includes:

- Lesson 8: A "Student Support" call out box explains the need for allowing students space to reflect individually and then share their thoughts in small groups and that this increases access for all learners who are not comfortable speaking in front of a large group. An alternate strategy

for their thoughts and opinions to get elevated to large group discussions is provided (Teacher Guide, page 5).

- Lesson 11: A "Student Support" call out box states that, "Students may have differing experiences and levels of comfort in sharing about bodily functions. If no student is willing to share, move along with the lesson to honor their privacy" (Teacher Guide, page 4).

To help ensure student ideas that may be in disagreement are included in class consensus work such as for models or explanations, the teacher is provided with steps to help resolve the disagreement or other strategies for including varied student ideas.

- Several lessons include the following steps to help resolve disagreements. These include: "● Summarize the two sides of the disagreement. ● Ask the students to pause and reflect on their reasoning to be on that side. ● Prompt students to re-discuss the area of disagreement again. ● If students still disagree, suggest that we can represent areas of disagreement on the class explanation with question marks or other annotations of uncertainty" (Teacher Guide, pages 8–9). Some examples:
    - Lesson 8: Teachers are provided directions for using steps to help students come to agreement as they develop a Class Consensus Explanation about, "Why do we get sweaty and thirsty after exercise? Why does the color of our urine change?" and "How does milk help us recover from these effects?" (Teacher Guide, pages 1 and 8–9).
    - Lesson 10: Teachers are provided directions for using steps to work through disagreements as the class builds the Recovery Model and the Exercise Effects Model (Teacher Guide, page 7).

Discussion prompts, sentence starters, and other strategies help elevate a variety of student ideas while building consensus work. An example:

- Lesson 10: While building the consensus model, sentence starters are provided, such as: "i. We agree with _____'s group, and we also want to add _____. ii. We disagree with _____'s group because _____ iii. We would like to change _____ because [evidence]". In addition, discussion prompts are provided, such as asking the class: "i. Is there anything else that needs to be added to this component before we move on? ii. How does this idea fit with what is currently on the model?" (Teacher Guide, page 6).

Suggestions for Improvement

None

II.C. BUILDING PROGRESSIONS

Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions

ii. Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials identify and build on students' prior learning in all three dimensions. Expected prior learning for all three dimensions is explicitly identified and how the prior learning for each element will be built upon is clearly explained. However, evidence of explicit support provided to teachers to clarify potential alternate conceptions was not found.

The materials explicitly identify prior student learning expected for the SEP elements, and clearly explain how this prior learning will be built upon. The claimed SEP elements are listed below with some relevant examples of how prior learning is described in the materials:

- *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).*
    - Unit Guide: "In middle school, students communicate scientific and/or technical information in writing and/or through oral presentations. In this unit, students build on this middle school understanding to communicate scientific information in multiple formats, including text, visuals, verbally, and graphically. Throughout the unit, students develop a presentation that they will present to the class in a format that best suits a targeted audience. Students begin developing these presentations in Lesson 1 and add on to and revise their presentations throughout Modules 1-4 and the Performance Task" (Postgame Analysis Unit Guide, page 22; Teacher Guide, page 8).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations* (Unit Guide, page 21).
- *Use a model to provide mechanistic accounts of phenomena.*
    - Lesson 4: An "SEP Support" call out box explains that in middle school, students develop models to predict and/or describe phenomena, and that in this unit, students "build on this middle school understanding to use models to provide mechanistic explanations of phenomena" (Teacher Guide, page 5). Students engage in a Science Theater activity to "help figure out cellular- and molecular-level mechanisms that occur in the body in response to exercise and as a part of recovery from exercise" (Teacher Guide, page 5).
    - Lesson 9: In an "SEP Support" call out box, the materials explain that in middle school, students "develop models to predict and/or describe phenomena" and that in this unit, students build on that understanding to "use models to provide mechanistic

explanations of phenomena" (Teacher Guide, page 10). It further states that, "A similar mechanistic-modeling activity occurs in all other unit modules as well" (Teacher Guide, page 10).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Develop and/or use a model to predict and/or describe phenomena* (Unit Guide, page 21).
- *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
    - Lesson 8: An "SEP Support" call out box explains the middle school focus on student explanations, and that in this high school unit, students build on this to construct explanations using evidence from a variety of sources, and that across the unit, "students will develop proficiency in how to add a variety of sources of evidence to their explanations" (Teacher Guide, page 9). It also further clarifies that in this lesson, students are not yet required to have evidence to support their explanations since it is their initial explanation before exploring evidence. However, the materials do not provide information about the prior learning to expect from students about how to cite the resources they refer to in their explanations, nor do they address how this skill will be built upon or developed during the unit.
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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* (Unit Guide, page 21).
- *Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.*
    - Unit Guide: "In middle school, students analyze and interpret data to identify similarities and differences in findings. In this unit, students build on this middle school understanding to compare the findings from two different studies to determine the consistency of measurements (methods) and outcomes (data). For example, in Module 3, students analyze and interpret the data from two studies. They are provided with the methods and data and are asked to compare the two studies to determine if their methods and findings are consistent" (Postgame Analysis Unit Guide, page 22).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Analyze and interpret data to determine similarities and differences in findings* (Unit Guide, page 21).
- *Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.*
    - Lesson 17: An "SEP Support" call out box explains that in middle school "students planned investigations in which they identified independent and dependent variables and controls, what tools were needed to do the gathering, and how measurements would be recorded. Here, we are giving students an opportunity to both engage with this middle school practice and to build towards the high school-level practice by asking students to evaluate their investigation design to ensure variables are controlled and to include control groups. Depending on the previous experiences of your students with

planning investigations, spend some time reviewing the various aspects of experimental design from middle school" (Teacher Guide, page 4).

- Unit Guide: A table lists the Unit Focal High School SEP elements beside their corresponding middle school SEP elements to compare the differences in the vertical alignment (Postgame Analysis Unit Guide, pages 20–21).

The materials explicitly identify prior student learning expected for the DCI elements, and clearly explain how this prior learning will be built upon. The claimed DCI elements are listed below with some relevant examples of how prior learning is described in the materials:

- *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*
    - Lesson 1: A "DCI Support" call out box states the prior learning students will have experienced learning how the brain processes inputs and how it uses sense receptors and nerve signals to transmit these signals and respond. Then it explains how this middle school understanding will be built on as students learn how these sensory systems are used to maintain homeostasis through feedback mechanisms (Teacher Guide, page 10).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories* (Unit Guide, page 23).
- *Systems of specialized cells within organisms help them perform the essential functions of life.*
    - Lesson 2: A "DCI Support" call out box explains what students learn about the body's subsystems and specialized cells during middle school, and how these understandings are built on during the unit to explain cell specialization. In this lesson, students "demonstrate their prior knowledge from middle school of the structure and function of cells in organs in the digestive system" (Teacher Guide, page 4).
    - Lesson 9: A "DCI Support" call out box explains that in middle school, "students learned that the body is made up of interacting subsystems that contain organs, tissues, and cells and that tissues form organs that have specialization for particular body functions. In this lesson, students build on this middle school understanding to explain the function of organs during exercise. In all modules of the unit, students develop and/or revise explanations and use models that include the ways in which specialized cells carry out various biological processes associated with exercise recovery" (Teacher Guide, page 9).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *In multicellular organisms the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions* (Unit Guide, page 22).
- *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
    - Unit Guide: "In middle school, students learned that the body is made up of interacting subsystems that contain groups of cells called tissues and that tissues form organs that have specialization for particular body functions. In this unit, students build on this middle school understanding to explain the hierarchical structural organization of the body and body systems. For example, in Module 1, students learn about the individual

components of the digestive system and also develop an understanding of how various kinds of specialized cells within different organs contribute to the function of the whole system" (Postgame Analysis Unit Guide, page 24).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *In multicellular organisms the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions* (Unit Guide, pages 22–23).
- *Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
    - Lesson 15: A "DCI Support" call out box explains that in middle school "students learned that cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. In this unit, students build on this middle school understanding to figure out that cellular energy comes not only from aerobic respiration but also from anaerobic respiration" (Teacher Guide, page 8). It further describes that "in this module, students explore the measurable indicators of metabolic responses because of exercise" (Teacher Guide, page 8).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials* (Unit Guide, page 23).
- Unit Guide: A table lists the Unit Focal High School DCI elements beside their corresponding middle school DCI elements to compare the differences in the vertical alignment (Postgame Analysis Unit Guide, pages 20–21).

The materials explicitly identify prior student learning expected for the CCC elements, and clearly explain how this prior learning will be built upon. Relevant examples include:

- *Much of science deals with constructing explanations of how things change and how they remain stable*
    - Lesson 1: A "CCC Support" call out box explains what students will have learned in middle school about stability and change over time, processes, and different scales. It then explains what students will be adding to this understanding as they study how various factors in the body change or remain stable in response to exercise (Teacher Guide, page 11).
    - Unit Guide: The corresponding middle school element for this high school element is listed as: *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale* (Unit Guide, page 24).
- *Feedback (negative or positive) can stabilize or destabilize a system.*
    - Lesson 11: A "CCC Support" call out box explains that in middle school "students learn that system stability is due to a balance of inputs and outputs that maintain dynamic equilibrium. This unit builds on this middle school knowledge by focusing on how feedback can stabilize or destabilize a system. For example, in Module 2, students come to consensus on two models that demonstrate their understanding of the feedback mechanisms associated with temperature and water balance in the body as a response to physical activity" (Teacher Guide, page 11).

  - Unit Guide: "In middle school, students learn that system stability is due to a balance of inputs and outputs that maintain dynamic equilibrium. This unit builds on this middle school knowledge by focusing on how feedback can stabilize or destabilize a system. For example, in Module 2, students develop two models that demonstrate how feedback mechanisms in the body respond to temperature and water balance changes in the body during physical activity. They see that the body uses negative feedback mechanisms to help it return to a stable state in response to an external or internal change in temperature or water availability due to exercise" (Postgame Analysis Unit Guide, page 25).
  - Unit Guide: The corresponding middle school element for this high school element is listed as: *Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms* (Unit Guide, page 24).
- *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.*
  - Lesson 2: A "CCC Support" call out box explains that in middle school, "Students learn that time, space, and energy phenomena can be observed at small or large scales using models. In this unit, students build on this idea by using orders of magnitude to explain relationships at various scales in a series of models. Students start showing their prior knowledge about different spatial scales present in the human body in this lesson. Students will progress towards using orders of magnitude to describe these scale relationships throughout this module" (Teacher Guide, page 8).
  - Unit Guide: The corresponding middle school element for this high school element is listed as: *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small* (Unit Guide, page 25).
- Unit Guide: A table lists the Unit Focal High School CCC elements beside their corresponding middle school CCC elements to compare the differences in the vertical alignment (Postgame Analysis Unit Guide, pages 20–21).

Suggestions for Improvement

- Within periodic "Student Support" call out boxes, consider including supports for common anticipated alternative conceptions that students may enter the unit with or may be at risk for developing throughout the course of the unit. Consider providing suggestions to help address those alternate conceptions as they surface.
- In lessons that develop or use the SEP element that involves students constructing explanations based on evidence from a variety of sources, consider including information about the prior learning to expect from students about how to cite the resources they refer to in their explanations, and how this skill will be built upon or developed during the unit.

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

II.D. SCIENTIFIC ACCURACY	
Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.	
Rating for Criterion II.D. Scientific Accuracy	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials use scientifically accurate and grade-appropriate scientific information. Information presented in the materials is generally derived from reliable articles or sources and with very few exceptions, support students' learning with little risk of fostering unintentional alternate conceptions.

Nearly all scientific information in the materials is accurate. Specific teacher guidance is provided to clarify aspects of what students are learning and what may be missing, as well as to provide important information regarding scientific accuracy. Related evidence includes:

- Lesson 3: Students examine information about the components of milk, including data cited from reliable sources, such as the Dairy Processing Handbook (Teacher Guide, page 5).
- Lesson 8: Students examine a color chart that identifies a different coding scheme for urine of varying concentrations and sources from a journal article adapted for this unit (Student Handout Urine Color Chart).
- Lesson 13: Students examine two case studies, one from a recent *Forbes* article and the other from a CBS news article in 2014 (Student Handout Case Studies).
- Lesson 16: Students examine a data set derived from a journal article published in *The Journal of Physiology* and another from the *Spinal Cord Journal*, both peer-reviewed articles. (Teacher Guide, pages 2–6).
- Lesson 16: The definition of a catheter that teachers might share with students reads: "Share that a catheter is any kind of thin, flexible tube inserted into a blood vessel with a needle and syringe. They are used to draw out fluid, such as blood, from the body. A catheter can collect blood samples without the need to reinsert a needle into a vein each time blood is drawn. Scientists can use catheters for the same things when performing investigations and collecting data on how different kinds of nutrients and molecules change in the blood before, during, and after exercise" (Teacher Guide, page 3). This explanation is slightly misleading, in that a catheter is not limited to insertion into a blood vessel. It can also be inserted into body parts such as the urethra as a means to drain urine.
- Lesson 17: Students develop an investigation plan to collect data to help answer "how does intense exercise impact the amount of carbon dioxide we breathe out?" (Teacher Guide, page 3). To accomplish this, students are introduced to bromothymol blue as a proxy indicator for the presence of carbon dioxide in solution. Despite the clearly appropriate use of this activity, there is no guidance to support the teacher in providing students with the clarification needed to understand why this substance is able to change colors in the presence of carbon dioxide. As presented, it's not clear to students that BTB is actually going through a color change in response to variations in pH of the solution, and as such, could lead towards students' developing alternate conceptions about the cause.

- Lesson 21: Students examine case studies containing data adapted from two different articles published in the *Journal of Applied Physiology*. In the teacher support call out box, students are told that while the provided data is not for milk itself, "…researchers might be interested in the general effects of carbohydrates and proteins on recovery, not necessarily the specific components found in a single food source like milk. Carbohydrate-protein beverages can also be carefully controlled to ensure consistent amounts of carbohydrates and proteins across participants in the study. This helps to isolate the effects of these nutrients on recovery" (Teacher Guide, pages 3–4).
- Lesson 25: Teachers are encouraged to "be careful to distinguish muscle soreness that occurs 24+ hours after exercise from muscle burn and muscle fatigue that occurs during extended exercise. Only muscle soreness and recovery from muscle soreness are addressed in this module. Students have already figured out the causes of muscle fatigue and muscle burn in Module 3" (Teacher Guide, page 3).

Suggestions for Improvement

- Consider modifying the definition of the term "catheter" so it is not limited to the "kind of thin, flexible tube inserted into a blood vessel with a needle" but includes a more general definition of what a catheter is as well as its uses.
- Consider clarifying the purpose of the bromothymol blue solution in Lesson 17 to clarify its changes and why it could be a useful proxy indicator for the presence of carbon dioxide (in our experiment or blood) and any potential changes it might undergo over time.

II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.

ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.

iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide guidance for teachers to support differentiated instruction. Although supports are provided for students who may struggle with meeting the targeted expectations, evidence was not found that the supports address the needs of varied learners deeply enough to ensure access to instruction and performance tasks. While there is some differentiation guidance, it is unlikely to be sufficient for multilingual learners and students who read below grade level. There is at least one opportunity for advanced students to extend their learning beyond the unit's scope, while others identify passages that are more complex for differentiating assignments, but do not go beyond the scope of the unit.

A few differentiation strategies are provided that are specifically for multilingual learners. However, the materials do not provide multilingual learners with language development opportunities that develop and refine their language for sense-making or significantly increase student access to the materials and the task. Related evidence includes:

- Lesson 1: "Ensure that the videos are optimized for viewing by turning on closed captioning if available" (Teacher Guide, page 43). While this strategy could support some multilingual learners by providing an additional modality to receive the information, it may not be useful for multilingual learners who are not yet reading the English language at grade level.
- Lesson 2: "For multilingual students or students who are internal processors, it's helpful to allow time or opportunity for students to process information individually or by using non-linguistic processing modes before group share-outs" (Teacher Guide, page 3). While this suggestion is helpful, it does not include suggestions for non-linguistic processing modes that would apply in this lesson.
- Lesson 3: "Share with students that they will now make a claim that answers the question, 'What organs most help digest milk? How?' They will choose between the mouth/esophagus, stomach, small intestine, and large intestine. They can choose one organ or more than one organ and write their responses on their ... Student Guide" (Teacher Guide, page 3). A sentence

stem for making the claim is provided on the Student Guide (Student Guide, page 1). Sentence stems can be a valuable differentiation strategy for many student groups.

- Lesson 18: "If a student is struggling to ask new questions, suggest the following sentence stems: ● Does the change in (variable a) cause (variable b) to change? ● What happens to _____ when _____ changes? ● Could _____ be the reason why _____ changes? ● How does a change in _____ cause _____? ● How does the body return _____ to a stable state?" (Teacher Guide, pages 11–12). Sentence stems can be valuable for multilingual learners and other student groups as well.
- Lesson 27: "Allowing students space to reflect individually and then share their thoughts in small groups increases access for all learners who are not comfortable speaking in front of large groups. For their thoughts and opinions to get elevated to large group discussions, you can alter this whole-group share-out by instructing speakers to share what they heard their partners share instead of repeating their own thoughts and questions" (Teacher Guide, page 6). While this support would be effective for multilingual learners, it is not specified as such in the materials.

Some differentiation strategies are provided for learners with disabilities or limited exercise abilities. Related evidence includes:

- Lesson 1: "You may need to guide the discussion on physical exercise to include students with varying physical abilities. Consider using the following questions to guide the conversation: ● How do you like to move your body? ● What are your favorite sports to watch? ● What other physical activities do you engage in, such as hiking, marching band, etc.? ... All students will have differing life experiences when it comes to exercise. This is an opportunity to continue to build on the norm for this unit that we will value the different experiences and opinions that students bring to the classroom" (Teacher Guide, page 3).
- Lesson 1: "Ensure that the videos are optimized for viewing by turning on closed captioning if available" (Teacher Guide, page 43).
- Lesson 15: "Prior to sharing the workout list with students, review the list of workouts in the Lesson 15 Student Guide and revise the list based on the needs of your classroom and school in regard to space and time available. Additionally, consider any physical limitations specific students may have and suggest appropriate workout choices or alternatives for these students" (Teacher Guide, page 3).
- Lesson 17: "In this experiment, be mindful of students with varying exercise abilities, and allow groups to modify the experimental design to fit the needs of those students" (Teacher Guide, page 6).

Differentiation strategies are provided for struggling students. Related evidence includes:

- Lesson 3: "Depending on students' previous mathematics experience, you may need to review what scientific notation indicates and its relationship to orders of magnitude. Consider writing out the full fraction and/or decimal for several examples and demonstrating that each scientific notation number is ten times smaller than the previous number as you move down the scale" (Teacher Guide, page 8).
- Lesson 4: "In Science Theater, the roles have varying levels of complexity. You may choose to use the following role-specific complexity levels to differentiate your role assignments. ● Less Complex: Pancreas ● More Complex: Small Intestine. Depending on the number of students in your classroom, you may assign one student to each role, or a pair or trio of students can complete each role. Placing your more 'outgoing' students in the first acting rotation may also be helpful. Additionally, if a student needs more time to observe the process in action before

participating, allow them to participate as an observer first so they can feel more comfortable when participating in a role in the second round of implementation" (Teacher Guide, pages 4–5).

- Lesson 6: "To help students understand what the merits and limitations of models are, you may want to show them an example, such as two or more different maps of the same geographical region (for example, a topographic map vs. political maps vs. a road map). Share with students that these maps are all models, or representations, of a real-life geographical area, but they each bring some different features into focus while obscuring others. Ask students to describe what information each map best shows and how they can combine it to better understand the region compared to just looking at one map. When using analogies, be sure to consider what kind of analogy will be most relevant to the lives of your students" (Teacher Guide, page 4).
- Lesson 8: "If students need additional support making observations from the video, consider replaying the video at specific moments when the athlete discusses the changes happening to her body. Additionally, the video can be periodically paused to provide students time to capture the details of the changes or when the data tables are displayed on the screen" (Teacher Guide, page 3).
- Lesson 9: "If you think your students still need additional support to move from one scale to another when analyzing these models, you can ask students to refer back to their Lesson 3 Orders of Magnitude tool and/or to record several examples of the structures shown in these models on the tool" (Teacher Guide, page 9).
- Lesson 18: "This is an opportunity ... for you to assign them based on the complexity of the data set. ... ● If you choose to assign articles to students by complexity, use the suggestions below to differentiate your assignments. ○ Data Set 3: This data set is less complex than others. The data sets for blood glucose have similar methods. This data set might better lend itself to students who would benefit from being able to grasp one experiment and then note slight changes in the methods of the second investigation. Data Set 4: This set includes workout intensities that were determined by VO2 max in one study and based on one repetition maximum for another. Prompting a student to look closely at the total reps completed and the total power output may be useful" (Teacher Guide, pages 4–5).
- Lesson 18: "If a student is struggling to ask new questions, suggest the following sentence stems: ● Does the change in (variable a) cause (variable b) to change? ● What happens to _____ when _____ changes? ● Could _____ be the reason why _____ changes? ● How does a change in _____ cause _____? ● How does the body return _____ to a stable state?" (Teacher Guide, pages 11–12).
- Lesson 19: "Depending on the number of students in your classroom, you may choose to assign one student to each role, or each role can be completed by a pair or trio of students. You may also want to assign roles based on student ability or interest. The role of the Brain & Somatic Nerves is the least complex role to play, and the Skeletal Muscle is the most complex role in this Science Theater model" (Teacher Guide, page 6).
- Lesson 19: "If you think your students still need additional support to move from one scale to another when analyzing these models, you can ask students to refer back to their Lesson 3 Orders of Magnitude tool and/or to record several examples of the structures shown in these models on the tool" (Teacher Guide, page 5).
- Lesson 20: "Throughout this discussion, it is possible that students may focus on the impact of proteins on recovery instead of glucose or the combination of glucose and proteins. If this is the case, ask students to return to their explanations from Lesson 20 and look for mentions of molecules in milk they are familiar with. This should prompt them to focus on glucose and glycogen. Share with students that they can place their ideas and/or questions about how

protein helps in recovery on the Driving Question Board, and those questions will be investigated in Module 4" (Teacher Guide, page 10).

- Lesson 25: "If students need additional support finding observations from the video, consider replaying the video at specific moments when the narrator discusses her muscles getting sore or drinking milk as a recovery drink" (Teacher Guide, page 4).
- Lesson 27: "When students are choosing their data sets to compare and contrast, Data Set C is likely the least complex when it comes to comparing the findings of the studies. Consider assigning groups specific data sets based on student ability or interest" (Teacher Guide, page 3).
- Lesson 28: For students struggling to make connections between feedback mechanisms relating to recovery from exercise, teachers are encouraged to prompt students to wonder "what conditions changed? What in the body senses the change? How do cells respond to the change?" (Teacher Guide, page 8).

Some differentiation strategies are provided for students who have already met expected learning, or to differentiate based on student interest. However, these strategies offer limited opportunities to extend learning beyond the unit's scope. One lesson suggests a few options for richer, extended sense-making experiences. Other strategies identify passages that are more complex for differentiating assignments that do not go beyond the scope of the unit. Related evidence includes:

- Lesson 18: The materials explain that "This is an opportunity for students to choose articles based on their interests..." (Teacher Guide, page 4) and then explain a process for doing this with student pairs.
- Lesson 18: The materials explain that this is an opportunity for articles to be assigned based on the complexity of the data set and explain the possibility of some of the data sets providing an opportunity for students to go beyond the learning expectations of the unit. "● If you choose to assign articles to students by complexity, use the suggestions below to differentiate your assignments. ... ○ Data Set 5: This is likely the most complex data set. The data set has some small nuances that, with prompting, could allow for an opportunity for further sense making. ● For example, one figure shows pH, and another shows the concentration of H+ ions. The ability to explain why these are measures of the same thing would be a chance for deeper sensemaking and a look at mathematical relationships. ● Additionally, one study was able to measure both the interstitial pH levels and those of the surrounding blood. While the patterns in the data for those measurements are similar, prompting a student to think about the reason for the differences and why they might be important for scientists could be meaningful and contribute to sensemaking on a deeper level. These are specifically called out in the front material of the study. It would be an opportunity for a student to have a bit more exposure to scientific literature" (Teacher Guide, pages 4–5). These options could provide rich opportunities for students to experience learning that goes beyond the expectations of the unit.
- Lesson 19: "...You may also want to assign roles based on student ability or interest. The role of the ... Skeletal Muscle is the most complex role in this Science Theater model" (Teacher Guide, page 6).
- Most opportunities for students who have met proficiency give suggestions for providing more complex tasks for some students.

The level of detail in science content reading and the extent of the writing demands of many of the tasks drives a need to provide supports for students who read and write below grade level to have other means to access and complete the task. Evidence of a consistent use of these types of supports was not found.

- Lesson 9: Students use evidence from a scientific study to analyze data and determine data trends. A CCSS Support note suggests that teachers "consider modeling and providing examples of how to extract relevant details from the text to enhance students' understanding and analysis and to develop skills 'to articulate their interpretations and insights based on the evidence gathered from the text'" (Teacher Guide, page 6). This lesson represents a missed opportunity to introduce a specific graphic organizer or data analysis strategy that would support students who read or write below grade level, and then refer to it in future lessons. The Teacher Resource materials that describe various strategies to support students are not specifically referenced here.
- Lesson 23: Students examine a text (Student Handout: The Body Fuel Source Article) describing different fuel sources that are able to be used for energy within the body. Students are prompted to "summarize the text in simpler but still accurate terms [and] describe how the body gets energy from different fuel sources during exercise" (Student Guide, page 4). This lesson represents a missed opportunity to offer teachers more concrete ideas about how to facilitate a Read-Aloud-Think-Aloud protocol or a specific text annotation strategy to increase student access to the text. These are referred to in the Teacher Guide, but do not provide details that show how these strategies can be used for this text. A reference to the source materials that describe details about these support strategies is not provided here, nor in Lessons 13 and 30.

Suggestions for Improvement

- Consider providing additional guidance outlining how strategies provided may be valuable for multilingual learners, and providing additional meaningful strategies that can provide opportunities for multilingual learners to access the material and complete the tasks.
- Consider providing alternate means of representing understanding of science ideas for learners who may struggle with the writing demands expected for showing proficiency. It may be valuable to refer to a resource on Universal Designs for Learning (UDL) to identify such strategies.
- Consider alternative ways for students to obtain information other than reading for students who read far below grade level. Also, consider providing alternative texts and/or additional scaffolding for students who read well below grade-level.
- Consider providing an additional extension opportunity for sense-making beyond the expectations of the unit for students who may have already reached proficiency. Additionally, consider providing extension opportunities for students with a high degree of interest in this topic to pursue those interests.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

Supports teachers in facilitating coherent student learning experiences over time by:

i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).

ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

Rating for Criterion II.F. Teacher Support for Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time. Strategies are provided throughout the unit that link student engagement across lessons in a way that leads to future lessons and helps students connect related phenomena across lessons. Strategies are provided to ensure that student sense-making is linked to learning in all three dimensions over time as students progress toward explaining phenomena. In addition, teacher supports throughout lessons provide connections from lesson to lesson with curated questions and identification of gaps in learning, from lessons to the anchor phenomenon, and from the module and lesson phenomena to the anchor phenomenon provide coherence from lesson to lesson, module to module, and in the unit as a whole.

Strategies are provided for linking student engagement across lessons by cultivating new student questions that lead toward future lessons. Guidance is provided for supporting students in how to recognize what they have figured out so far in a lesson or lessons, what their gaps in understanding still are, what questions are left unanswered, and what new questions could be answered in the next investigation. Some relevant evidence includes:

- Lesson 4: At the beginning of the lesson, students attend to the Module Question, “How is milk digested after it is consumed?” The teacher shares that they ended the last lesson by evaluating claims about which organs in the digestive system contribute to the digestion of molecules in milk. Students are then asked what they have figured out so far to answer the question, and then what they still need to know to more fully figure out the Module Question. As students propose the idea that they don’t know how different organs work together to digest milk, the teacher builds off these responses to share that they will now use a model of digestion to figure this out (Teacher Guide, page 2).
- Lesson 9: At the beginning of the lesson, students share some of the gaps in understanding that they identified at the end of Lesson 9. Teacher guidance includes a direction to “listen for the following ideas” (Teacher Guide, page 3) followed by a list of the types of ideas students could identify as gaps in their learning that can serve as a launch toward this lesson or other upcoming lessons. Some examples include: “● We don’t know why body temperature goes up during exercise. ● We don’t know why body temperature goes back down after exercise. ... ● We still don’t know how milk can help an athlete recover from exercise” (Teacher Guide, page 3). The teacher guidance states: “Build off student responses to share that we will now gather evidence

on how body temperature change during and after exercise plays a role in producing sweat" (Teacher Guide, page 3) and directs teachers to hold a class discussion which identifies questions from the DQB they can explore. The teacher facilitates the conversation to get students to focus on questions related to temperature changes during and after exercise (Teacher Guide, page 3). This routine for helping students to identify gaps in understanding and to build off student responses to share what types of evidence students will gather next is used to connect the learning from lesson to lesson in other lessons in the unit.

- Lessons 10 and 11: At the end Lesson 10, students create a new list of questions to help them determine what additional information they need to know to help them figure out the Module Questions. They write these questions in their Student Guide and add them to categories on the DQB to be referenced during the coming lessons. The materials provide a Question Formulation Technique to support students in generating a list of questions (Teacher Guide, page 10). At the beginning of Lesson 11, students are reminded that they "concluded the last lesson by developing Class Consensus Effects of Exercise and Recovery Models that show the impacts of exercise on the body and the ways in which milk helps the body recover from these impacts" and students "review these models and determine if they fully answer the Module Questions" (Teacher Guide, page 2). Student responses are built off of to begin the next activity of gathering evidence on how body temperature during and after exercise plays a role in producing sweat and its connection to questions about "Why do we get thirsty during a workout?", "Why does the color of our urine change after exercise?", and "What role do milk nutrients have in exercise recovery?" (Teacher Guide, page 3).
- Lessons 15 and 16: At the end of Lesson 15 after students have drafted a Class Consensus Explanation, students reflect on gaps in understanding present in the explanation, such as gaps in the scientific mechanisms of the explanation. The teacher asks questions like, "Take a closer look at the class explanation. What seems to be missing from our description to help us explain why these changes occur in the body during exercise?" (Teacher Guide, page 11). Students are reminded that in the upcoming lessons, they will figure out more about these gaps in the explanation. A Question Formulation Technique is used to guide students in generating "a new list of questions to help them determine what additional information they need to know to help them figure out the Module Question" (Teacher Guide, page 12). Lesson 16 begins with students being reminded that they concluded the previous lesson by identifying gaps in their explanations. Students share what some of these gaps were, and their responses are built off of to share that they will now gather evidence on whether the increase in breathing during exercise results in more oxygen getting into the body (Teacher Guide, page 2).
- Lesson 25: The teacher introduces this module by returning to the DQB and asking students what questions seem most pressing to investigate next. The conversation is facilitated such that students agree that most of the remaining questions have to do with how protein in milk helps with recovery and how muscles get sore after exercise, and the teacher confirms that students will investigate these questions next (Teacher Guide, page 2).
- The Student Guide for each lesson begins with a section titled "Our Motivation." In this section, students write questions, gaps in information, and other ideas that move them into the learning for the lesson (Usually page 2 of each lesson).
- Unit Guide: The Module Pacing and Summaries section of the Unit Overview provides Navigation strategies to move from one module to the next. For example, "Students observed that the various molecular components of milk (amino acids, fatty acids, sugar, water, and electrolytes) get into the bloodstream, but they don't know what happens to them after that or what they do to help in recovery. Students use this as a motivation to further investigate what happens to these molecules" (Unit Guide, page 5).

Teacher guidance is provided for linking learning across lessons to ensure that students see learning as coherent as they make sense of phenomena. Some related evidence includes:

- Lesson 1: Teachers are reminded, within the "Use of Phenomena" call out box, that, "This video shows the second half of the Anchor Phenomenon for this unit: milk is confirmed to be an effective exercise recovery drink for athletes. This video, together with the previous set of videos, should help students begin to raise questions about how and why milk could be used for exercise recovery" (Teacher Guide, page 5).
- Lesson 2: Teachers are reminded, within the "Use of Phenomena" call out box, that, "Students ended the previous lesson by asking questions they wanted answers to in order to understand how drinking milk helps athletes recover after exercise. The introduction of this module will help guide students to agree that first figuring out what happens to the milk after it is drunk is the best first step in investigating more about how milk helps athletes recover after exercise. In this module, students will begin by observing a module-level phenomenon about how food is digested. This phenomenon will help students figure out what happens to each of the different molecular components of milk before they are used in the rest of the body in exercise recovery" (Teacher Guide, page 2).
- Lessons 7, 14, 19, 24, 26, and 31: Teachers are reminded, within the "Use of Phenomena" call out box, that, "In this lesson, students will use what they have figured out about the Module Phenomenon to return to the Anchor Phenomenon and develop a presentation of this new scientific information to the selected audience" (Teacher Guide, page 2). An updated connection of each module learning to the anchor phenomenon occurs at selected points within and near the end of each module in lessons 14, 19, 24, 26, 31, and 32.
- Lesson 8: Teachers are reminded, within the "Use of Phenomena" call out box, that, "Students ended the previous lesson by identifying questions that need further investigation to understand the Anchor Phenomenon and revisiting the Driving Question Board. Students identified questions related to how the nutrients in milk, once they reach the bloodstream, help athletes recover from exercise. Therefore, in this module, students will start by observing a Module Phenomenon that asks students to observe specific physiological changes that happen during exercise. Students will then try to figure out how milk nutrients help the athlete recover from exercise-induced changes. Figuring out this Module Phenomenon will help students progress on answering their questions about the overall Anchor Phenomenon and Driving Question for the unit, How can milk help athletes recover from physical exercise?" (Teacher Guide, page 2). This explanation connects the learning in one module with the learning in the next module with the figuring out of the anchor phenomenon.
- Lesson 19: Teachers are reminded, within the "Use of Phenomena" call out box, that, "Between Lessons 16-20, students will focus on the topic of exercise from the Module Phenomenon. In Lessons 21-22, they will focus on the topic of recovery from the Module Phenomenon. In Lesson 23, they will investigate a related phenomenon. They will return to the Anchor Phenomenon in Lesson 24 and revise their presentations to help their peers understand how milk can help them recover from exercise" (Teacher Guide, page 2).
- Lesson 26: Teachers are reminded, within the "Use of Phenomena" call out box, that, "Between Lessons 26-30, students will focus on the Module Phenomenon. In lesson 31, they will return to the Anchor Phenomenon and create presentations to help their peers understand how milk can help them recover from exercise" (Teacher Guide, page 2).

Teachers are provided with guidance to support students in connecting their learning in all three dimensions, to their sense-making. Teacher supports include, among other strategies, prompts related to the three dimensions that are embedded into several parts of the lesson teacher directions, features

such as "Look Fors" that are embedded within the Formative Assessment Opportunity guidance boxes, and call out boxes that are labeled as "SEP Support", "DCI Support", or "CCC Support". Guidance is frequent for supporting learning in each dimension throughout the unit. Some related evidence includes:

- Most lessons: Many lessons include SEP, DCI, and/or CCC Support notes that provide strategies for teachers that separately support learning in the different dimensions. However, these Support notes address each dimension separately and do not necessarily show how learning in all three dimensions together is linked to support sense-making (SEP, DCI, and CCC Support notes throughout the unit).
- Lesson 1: An "SEP Support" call out box explains that the SEP element, *Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations,* is not a targeted SEP in the lesson, but that students will often engage with this element. It suggests supporting students in building their proficiency with this SEP element by reviewing the study design shown in the video students watch and asking them questions about aspects of the experiment design (Teacher Guide, page 5). This guidance helps teachers support students in building proficiency in the element that will be targeted in future lessons by including this foundational connecting activity.
- Lesson 1: A DCI Support all out box explains that the DCI element about feedback mechanisms maintaining a living system's internal conditions is supported in this lesson and through the unit with the use of the term recovery as a student-friendly stand-in for the body's ability to return to homeostasis after a change in its external (exercise) and internal (depletion of some nutrient or damage to organs and tissues due to exercise) conditions. In upcoming lessons, students will figure out that the body responds to exercise by using a variety of negative feedback mechanisms and that the process of recovery by drinking milk involves returning the conditions of the body to their normal state" (Teacher Guide, page 11). This support also applies to the CCCs related to *feedback mechanisms ... can stabilize or destabilize a system.*
- Lesson 3: A "CCC Support" call out box about the element related to *orders of magnitude* explains that "Throughout the unit, students will regularly observe and use models of each of the organs, tissues, glands, cells, and molecules involved in various body processes. The size relationships in these models may be difficult to interpret without making sense of the different scales depicted in each of the models. Therefore, the purpose of introducing orders of magnitude at this point in the unit is for students to begin to see the relative sizes of organs, tissues, glands, cells, and molecules so that students can begin to develop a sense of the scale relationships of these structures" (Teacher Guide, page 9). Teachers are supported in seeing how what students are doing with the SEP related to *mechanistic models* incorporates the CCC related to *orders of magnitude* along with the DCI element related to *specialized cells*.
- Lesson 9: When students are analyzing body temperature data, the lesson materials provide prompts such as, "● What was the goal of the study? How was the study designed? What were the scientists measuring? ● What trends do you see in the data? ● How can you use a lens of stability and change to analyze the data?" (Teacher Guide, pages 3–4). The Look Fors include: "● Students accurately paraphrase the experimental design of the experiment from scientific literature (INFO-H1). ● Students use evidence from the data to support their response (INFO-H1). ● Students describe the stable state and changes that occur in body temperature before, during, and after exercise (LS1.A-H4, SC-H3)" (Teacher Guide, page 4). Included are ideas that support the sense-making students have done in all three dimensions, such as, "The responses of the body during and after exercise related to sweat and body temperature are based on negative feedback mechanisms that help regulate the body and help it return to its stable state of conditions" (Teacher Guide, page 13). This statement includes connections to the targeted

SEP, DCI, and CCC elements of the lesson. The guidance for leading towards students using all three dimensions in their sense-making is embedded throughout the lesson with prompts and assessment Look Fors, making using all three dimensions an integrated feature of student learning.

- Lesson 11: When students are analyzing data, the materials support teachers with "pressing questions to help with their interpretation of the experiment design and the data" (Teacher Guide, page 5). The questions, which are similar to those in Lesson 9, prompt students to analyze the study design, to notice trends in the data, and to use the lens of stability and change to analyze this data. The Look Fors address all three dimensions, including, "Students describe the stable state and changes that occur in blood volume before, during, and after exercise, using evidence from the data (LS1.A-H4, SC-H3)" (Teacher Guide, page 5). Teacher supports during a whole-class discussion include a list of ideas to draw from what they figured out that include ideas from all three dimensions, such as, "The body has a stable state for the amount of water in the blood, and drinking a recovery beverage can help the amount of water in the blood return to that stable state" (Teacher Guide, page 8). Another set of three-dimensional Look Fors and discussion supports occurs later in the lesson that extend the figuring out to go further in developing all three elements as they connect the learning from each investigation using the CCC that *feedback loops can stabilize or destabilize a system*. Distributing a variety of teacher guidance throughout the lesson that leads students to use all three dimensions in their sense-making ensures that the learning experience is three-dimensional in a way that coherently makes sense to students.
- Lesson 15: A SEP Support call out box regarding the SEP element about *obtaining scientific information in order to paraphrase them in simpler but still accurate terms* and the SEP element about *comparing and contrasting data sets* explains that although these elements are not claimed in this lesson, "students are here engaging in a similar practice that they previously did in Module 2. Students analyze the experimental design and outcomes of an authentic scientific research article…. To prepare students for comparing studies, support students in their skills in reading the complex scientific methods text and in using what they know about the methods to analyze the results of the experiment" (Teacher Guide, page 5). This guidance helps the teacher see the connection between the way students engaged in a practice in a previous lesson in the module connects and supports how students engage in a practice in this lesson.
- Lesson 15: In addition to an SEP Support call out box, a CCC Support call out box regarding the CCC element *Much of science deals with constructing explanations of how things change and how they remain stable* explains that in this lesson, "students construct explanations of why they think bodily changes occur throughout the exercises happen in the way they do. Throughout this module, students will figure out how various cellular- and molecular-factors in the body change during exercise, which will help them figure out the biological mechanisms by which bodily changes occur during exercise" (Teacher Guide, page 9). This guidance helps teachers see the connection between the explanation of why some things change in one lesson helps students figure out how other changes occur in the next lesson and the biological mechanisms by which they occur. This guidance also supports the SEP elements related to *constructing explanations* and *communicating scientific information.*
- Lesson 18: Within the "DCI Support" call out box for **LS2.B-H1**, teachers are reminded that, "While this lesson doesn't develop knowledge of this DCI explicitly, it serves as a stepping stone toward fully working with the highlighted portions of this DCI. In this lesson, students are exposed to measurable indicators of the body's metabolic responses to exercise or how it uses and produces energy for exercise. In this next lesson, students will build on the knowledge of how the levels of various molecular factors change to figure out how the changes in these

factors work together mechanistically to provide energy aerobically and anaerobically for exercise" (Teacher Guide, pages 3–4). This guidance helps teachers see the connection of how the foundational information in one lesson supports students in figuring out more about this DCI element, and the phenomenon in the next lesson.

Suggestions for Improvement

- Consider using the orders of magnitude tool to connect lessons to provide an opportunity for coherence in learning CCC elements.
- Consider periodically providing some three-dimensional learning support boxes that explain how learning using all three dimensions together to figure out phenomenon during a lesson supports student sense-making.
- To increase students seeing the usefulness of CCCs in making sense of phenomena, consider beginning an investigation or a Science Theater model activity by connecting first with student ideas from the previous lesson about a CCC element that they saw in their learning, such as *Feedback (negative or positive) can stabilize or destabilize a system.* Build off these responses to prompt students to consider this CCC while they are doing the next investigation or participating in the Science Theater model. Consider providing opportunities for students to pause during the investigation or model enactment and share how the CCC is helping them in their sense-making or how it is represented in the actions they do in the Science Theater model.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.

Rating for Criterion II.G. Scaffolded Differentiation Over Time	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjusts supports over time. The materials provide clear descriptions of how student scaffolds are provided as students first begin engaging in an SEP in the unit, and this scaffolding is clearly reduced over time for use of several of the targeted SEP elements in order to increase student independence. The teacher materials provide guidance for where and when to add and remove supports to move students towards independence in using some, but not all, of the SEPs for sense-making. However, teacher supports do not address the needs of all students.

Scaffolding is reduced over time for the targeted SEP elements, and sometimes the complexity of the related tasks is increased. There is one SEP element for which reduced scaffolding over time is not clearly indicated, and another (models) for which the differentiation appears to mainly be due to a familiarity with the routine rather than an increase in proficiency using the element. Related evidence includes:

Developing and Using Models

- *Use a model to provide mechanistic accounts of phenomena.*
    - Student engagement in the "Science Theater "model that is used to provide mechanistic accounts of phenomena changes over the course of the unit as students progress to more complex tasks and as supports and scaffolds are gradually removed.
        - Lesson 4: A "Teacher Support call out box clarifies 'the scope of content and the progression of students' learning for Science Theater in this lesson and throughout the unit'" (Teacher Guide, page 8). A table shows the progression of how students' engagement in the model will change over time through each module. The table clearly describes how the tasks become more complex over time, beginning with a simple single body system, moving to multiple interacting body systems, and then multiple systems with multiple steps and mechanisms. In addition, the table indicates how supports and scaffolds are gradually removed as the Modules progress as students become increasingly responsible for making sense of phenomena.
        - Module 2, Lessons 9 and 11: The task increases in complexity such as, "● Addition of multiple interacting body systems ● Addition of non-linear model interactions ● Addition of exercise and recovery states" (Teacher Guide, page 9 Table). The supports continue. Evidence for teacher support about how the complexity increases and the supports remain in these models was not found within these lessons; it was found in the Lesson 4, page 9 Table.
        - Module 3, Lesson 19: The task increases in complexity with fewer scaffolding cues: "Science Theater models multiple interacting systems with multiple steps and mechanisms. ● Role card instructions are less scaffolded with few bulleted cues" (Teacher Guide, page 9 Table). Evidence for teacher support about how the complexity increases and the supports are reduced in the use of this model in this lesson was not found within the lesson; it was found in the Lesson 4, page 9 Table.
        - Module 4, Lesson 28: "Science Theater models multiple interacting systems, and some student scaffolds are removed. ● Role card instructions do not contain bulleted cues ● Multiple specialized cells play key roles in an organ ● Student Guide cues are reduced for observers" (Teacher Guide, page 9 Table).
        - Lesson 28: "The scaffolding on role cards for this lesson has been reduced to allow students to demonstrate progression for this practice. While actions of each organ and/or specialized cell can be found in the text of the role card, the bulleted details have been removed. If a student is struggling to understand their role, prompt them to: 1. Scan their Organ/Specialized Cell Role Card, looking for the steps they will carry out during the model. Encourage them to highlight these if needed. 2. Take inventory of the tokens at their table and match these up to the steps highlighted. 3. Use cues and support from fellow students in other roles to assist in sequencing each step" (Teacher Guide, page 4).
        - While this reduction in scaffolding results in greater student opportunity to independently navigate this SEP element, it's not clear that it rises above students simply becoming proficient with the Science Theater routine or if it represents an increased proficiency with the SEP element itself as could be applied independently with other types of models.

Analyzing and Interpreting Data

- *Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.*
    - Student engagement in this SEP element changes over time with increasing the complexity of the tasks and reducing scaffolds as the unit progresses.
        - Lesson 1: Students are provided with a callback to their "…past experience from middle school with aspects of experimental design. You can ask students questions such as: what was the independent variable in this study? What was the dependent variable in this study? What variables were controlled? What was the control group comparison?" (Teacher Guide, pages 5–6).
        - Lesson 18: Students are asked a series of questions to provide supports as they analyze the methods used in two studies and the data collected to compare the outcomes of both studies (Teacher Guide, pages 4–8; Student Guide, pages 1–8).
        - Lesson 21: There are fewer prompts than in prior lessons, omitting overt suggestions to summarize methods and findings. Instead, students are expected to be able to elicit these ideas on their own (Teacher Guide, page 4).
        - Lesson 23: Students increase the rigor of their engagement with this practice by increasing the number of data sets they must compare and contrast from two (in Lessons 18 and 21) to three. In addition, the number and wording of the prompts on their Student Guide has been further reduced, such that students have a somewhat less scaffolded task compared to previous lessons (Teacher Guide, page 4).
        - Lesson 27: Students are prompted to utilize this SEP to examine one of three data sets, each with two different studies included, to understand more about the feedback mechanisms that take place to assist in muscle recovery (e.g., protein synthesis). As in previous instances of utilizing this practice, students will compare and contrast the pair of studies in this group to determine what the findings are from the data and if the findings are consistent with one another. In contrast to prior lessons that employ this element, students are expected to accomplish the task with fewer guiding prompts and have now progressed to the point that a single prompt is offered, which states, "Analyze the data sets provided to determine their findings and if the findings are consistent with one another" (Student Guide, page 1).

Constructing Explanations and Designing Solutions

- *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
    - It's not clear that scaffolding is reduced or removed for students attempting to demonstrate proficiency in this SEP element.

Obtaining, Evaluating, and Communicating Information

- *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).* (**INFO-H5**).

- Student engagement in this SEP element changes over time with increasing the complexity of the tasks and reducing supports and scaffolds as the unit progresses towards students working with less guidance as the unit progresses.
  - Lesson 7 and 14: A scaffold table is provided with hints for preparing a presentation.
  - Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). This task includes several key "Look Fors" that guide students in sufficiently completing this task. Peer feedback as well as teacher feedback are provided to students in Part 3 of this lesson to allow students to receive input necessary to encourage them to edit or rethink their initial approach to addressing this task. To increase student autonomy and remove initial supports, "the scaffold table for preparing a presentation previously included in Lessons 7 and 14 is intentionally not included in the Lesson 24 Student Guide. This is to give students an opportunity to develop their script independently. You have the option to share the scaffold table with any students who may still need the additional support" (Teacher Guide, page 4).
  - Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). This revised presentation is required to include the Look Fors described in the student guide and includes the need to "…use the class consensus model, data sets, and/or models from any other resources from the module" and "clearly communicate scientific information in a way that is appropriate for your chosen audience" (Student Guide, page 2). Students are not explicitly given access to the scaffold table as they had been in Lessons 7 and 14. Instead, teachers "…have the option to share the scaffold table with any students who may still need the additional support" (Teacher Guide, page 4).

- *Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.*
  - Student engagement in this SEP changes over the course of the unit with increased complexity in tasks and texts.
    - Lesson 9: A "SEP Support" call out box explains that students "will repeat the use of this SEP in Lesson 11" and that, "Later, in Modules 3 and 4, they will progress to comparing the design and outcomes from two or more scientific research studies when using SEP DATA H4" (Teacher Guide, page 6). It suggests that teachers "monitor for students who may need support in analyzing the design and outcomes of an experiment and provide support so that they are ready to progress to the more complex analysis in Modules 3 and 4" (Teacher Guide, page 6). Students critically read one scientific article and determine the central ideas.
    - Lesson 11: A "SEP Support" call out box explains that similar to the practice they used in Lesson 9, "students are analyzing the experimental design and outcome from one scientific research article" (Teacher Guide, page 7). It continues to say

that that in Modules 3 and 4, students will progress from analyzing one scientific research article "to comparing the design and outcomes from two or more scientific research studies" (Teacher Guide, page 7).

- Lesson 23: The complexity of the task increases as students critically read two different scientific articles, determine their central ideas, and share them with two different peers using a sharing routine (Teacher Guide, pages 7–10).
- Lesson 30: The complexity of the task increases with students analyzing three different pieces of data from a science journal article and then also reading another scientific article and determining its central ideas (Teacher Guide, pages 2–5).

Suggestions for Improvement

- Consider offering students additional opportunities to use **MOD-H5** outside of the "Science Theater" to verify that they have increased in sophistication with utilizing this SEP element.
- Consider developing additional opportunities for students to reduce scaffolding in place for **CEDS-H2**.
- Consider including the information in the table in Lesson 4, page 9, in each of the corresponding lessons (9, 11, 19, and 28) to support teachers in understanding how the current lesson fits in the design for reducing scaffolds and/or increasing complexity through the course of the unit.
- Consider providing clear explanations about how all SEPs are reduced in scaffolds over time or, conversely, providing an explanation about those for which supports and scaffolds are not reduced, such as **Constructing Explanations and Designing Solutions**. Consider providing a similar explanation for how tasks that apply the SEP elements are increased or not increased in complexity over time.

OVERALL CATEGORY II SCORE: **3** (0, 1, 2, 3)	
Unit Scoring Guide – Category II	
Criteria A-G	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

III.A. MONITORING 3D STUDENT PERFORMANCES

Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

Rating for Criterion III.A. Monitoring 3D Student Performances	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with DCIs and CCCs to make sense of phenomena or design solutions to problems. While there are many three-dimensional assessments, lesson materials do not consistently monitor individual learning, as collaborative work is the primary method for producing learning artifacts. Often, students can copy group or class work into their individual guides rather than apply their own thinking to sense-making tasks.

The materials elicit evidence that students are integrating the three dimensions in service of making sense of phenomena. Many of the learning artifacts may be in individual student guides. However, often students are directed to "Record our Class Consensus Explanation [or model] in the space" provided for a student's response (Student Guide, page 3), so individual students are simply tasked with copying the group or class information down without having contributed to the thinking that produced the response. Related evidence includes:

- Lessons 2, 5, and 6: In groups, students create (Lesson 2) or revise (Lessons 5 and 6) an initial model explaining what they believe happens when milk is digested (Teacher Guide, pages 3–9). Students later record the Class Consensus Model (Student Guide, pages 2–3). The initial models are done as a group, so they cannot be used as a pre-assessment of individual student learning. Since students are simply "recording" the Class Consensus Model in all three lessons, the second model artifact does not serve to monitor student progress. Additionally, a CCC element is not being used at a high school level. Students integrate the following elements to produce a group artifact:
    - DCI: **LS1.A Structure and Function** *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
    - SEP: **Developing and Using Models** *Develop, ~~revise, and/or use~~ a model based on evidence to illustrate ~~and/or predict~~ the relationships between systems or between components of a system.*
    - CCC: **Scale, Proportion, and Quantity** *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.* The group work does not use this element at a high school level.
- Lesson 8: Students work with a group to construct an initial explanation to answer these 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?" The student guide provides a three-column graphic organizer for this initial group explanation (Student Guide, page 2). Students share their group explanations, and then "work together to make a Class Consensus

Explanation" (Teacher Guide, page 8). The teacher uses this information to "begin creating a Class Consensus Explanation on the board" as group's share descriptors (Teacher Guide, page 8). The student guide prompts students to "Record our Class Consensus Explanation in the space below" (Student Guide, page 3). This lesson is labeled as a pre-assessment of the three-dimensional elements. However, with students working as a group to construct an initial explanation in their student guides, and no other method being employed to note individual performance, the student explanation artifact does not provide a way to monitor individual starting points in proficiency. Since later the students are directed to "record" the Class Consensus Explanation, this student artifact is not useful as evidence to monitor individual responses. Students integrate the following elements, however, there is no artifact produced that can serve to monitor individual student performances:

  - DCI: **LS1.A Structure and Function** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*
  - SEP: **Constructing Explanations and Designing Solutions** *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
  - CCC: **Stability and Change** *Feedback (negative or positive) can stabilize or destabilize a system.*

- Lesson 10: Students use information they have discussed as a class and the ideas and annotations they place on the graph in a think-pair share in their groups, and then they write the explanation as individuals while referring to the sources (including data sets), so their responses can be used to monitor individual learning. The majority of the evidence indicates that this task requires students to use grade-appropriate elements from all three dimensions to respond to the prompt and that it is in service of making sense of "why we get hot and sweaty during exercise" (Student Guide, page 10). Students integrate the following elements:
  - SEP: *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
  - DCI: *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.*
  - CCC: *The functions and properties of natural ~~and designed objects and~~ systems can be inferred from their overall structure, and the way their components are shaped ~~and used,~~ and the molecular substructures of its various materials.*
- Lesson 13: The student prompt states: "Using the evidence you have gathered, explain how both people became sick and died. In your response, be sure to: Describe how changes to the amount of water in cells of the body may have caused the death of the two individuals. Cite evidence from at least two different sources from this lesson" (Student Guide, page 5). This prompt requires students to use elements from three dimensions in order to make sense of why the two

people died and write their explanation. Students write their initial explanation of "why you think the two athletes had the medical problems you read about" (Student Guide, page 2) as individuals, so the first artifact can serve as an individual assessment of what students can explain based on the understandings they have gained thus far in Lessons 8–12. The second artifact is produced after completing activities such as using hands-on models, discussing their observations, gathering more information from two different articles, and as a class, and adding more ideas to the list of ideas from their initial explanations. Students individually explain "how both people became sick and died," so this task and artifact can be used to monitor student progress in the three dimensions. Students use the following elements of the three dimensions in this task:

  - DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.*
  - SEP: **Constructing Explanations and Designing Solutions:** *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
  - CCC: **Cause and Effect:** *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.*

- Lesson 20: Teachers are provided with this three-dimensional learning goal: "Students revise an explanation using multiple pieces of evidence to show how increased rates of aerobic and anaerobic respiration provide energy for muscles during exercise, resulting in changes in the body during exercise" (Teacher Guide, page 4). In this lesson, students use multiple pieces of evidence from prior lessons to explain why heart rate and breathing rate changes during exercise to provide energy for muscles during exercise, writing their explanations in Student Guide Part 2. The Student Guide prompts, "Using all the evidence you have gathered so far in this module, construct an explanation to answer our Module Questions: Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?" (Student Guide, page 1). Students are provided with a list of items that need to be in the explanation, which includes elements from all three dimensions. This prompt requires students to integrate all three dimensions in service of sense-making. Students individually complete their explanations. Students use the following elements of the three dimensions in this task in service of sense-making:
  - DCI: **LS1.A:** *Systems of specialized cells within organisms help them perform the essential functions of life.*
  - DCI: **LS2.B:** ~~*Photosynthesis and*~~ *cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
  - SEP: **Constructing Explanations and Designing Solutions:** *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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.*
  - CCC: **Stability and Change:** *Much of science deals with constructing explanations of how things change and how they remain stable.*
- Lesson 32: Students use multiple formats to communicate how the internal conditions of the human body change in response to changes in external conditions (exercise, drinking milk) (Teacher Guide, page 1). During the Performance Task, students work in groups to create their

final presentation to explain how drinking milk aids in recovery from exercise. The prompt states, "Create a final presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? To an audience of your choosing" (Student Guide, page 1). Students integrate knowledge of the following elements, although they may not be actively engaged in some of them for sense-making because they may be copying explanations from prior lessons and group tasks, rather than being presented with a new scenario which requires students to use three-dimensional elements in the service of making sense of phenomena. Students work together in groups to create final presentations (Teacher Guide, page 1), so without employing methods that indicate individual student proficiency, this artifact does not serve to monitor three-dimensional student performances of these elements for the final assessment of the unit.

- DCI: **LS1.A Structure and Function** *Systems of specialized cells within organisms help them perform the essential functions of life.*
- DCI: **LS1.A Structure and Function** *Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.*
- DCI: **LS1.A Structure and Function** *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and function even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system.*
- DCI: **LS2.B Cycles of Matter and Energy Transfer in Ecosystems** ~~*Photosynthesis and*~~ *cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
- SEP: **Obtaining, Evaluating, and Communicating Information** *Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).*
- CCC: **Scale, Proportion, and Quantity** *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.*
- CCC: **Stability and Change** *Much of science deals with constructing explanations of how things change and how they remain stable.*
- CCC: **Stability and Change** *Feedback (negative or positive) can stabilize or destabilize a system.*

Evidence was not found that students are provided an opportunity to take what they have learned and apply the three dimensions independently, such as with a new, possibly related, scenario and task that requires them to use the SEPs with DCIs and CCCs to make sense of phenomena as they apply elements from the three dimensions. This limits the degree to which students' individual learning can be monitored.

Suggestions for Improvement

- Consider including one or more checkpoint assessments that allow students to transfer their learning to a new scenario or context. This could include providing authentic scenarios for some of the formal summative tasks, and especially at the end of the unit, so that students have an opportunity to apply the three dimensions independently with a new, possibly related, scenario and task that requires them to use practices with DCIs and CCCs to make sense of phenomena. This would provide a means for determining whether individual students have gained

proficiency in using the elements together to figure out phenomena. Short authentic scenarios could also be considered for periodic formative tasks.

- Consider providing more individual opportunities for measuring student progress toward proficiency, and explaining to teachers how the opportunity provides a means for monitoring individual student performance of each dimension. A consideration could also be given to provide alternative means for individual progress to be ascertained with group tasks, such as teacher observations of individual students. Related to this, consider modifying some of the Student Guide prompts and corresponding teacher directions that direct students to "record" consensus work so that students are less likely to "copy" group or class consensus work, but to synthesize what the group/class does in their own way. This suggestion is not intended to be applied to all such prompts, but for sufficient prompts so that more assessment opportunities provide an artifact that can be used for individually monitoring three-dimensional performances.
- Consider clarifying teacher supports that explain how tasks elicit direct, observable evidence of three-dimensional learning as they are used together by students to make sense of phenomena. This could include providing periodic teacher support call out boxes, or three-dimensional call out boxes that clarify the difference between a three-dimensional task that integrates all three dimensions with the purpose of figuring out a phenomenon and a task with three dimensions that uses an SEP to represent previously learned information as they complete a task, but not necessarily to figure out phenomena.
- Consider ensuring that individual student artifacts are produced when an assessment opportunity is intended to be a pre-assessment in order to evaluate the prior learning that individual students bring to the unit. Alternatively, provide an explanation that describes the reason a pre-assessment opportunity is being used to evaluate the overall prior learning students are bringing to the unit.
- To modify the writing demands for some tasks, consider providing some alternative means for students to show their three-dimensional understanding, such as using graphics or visuals, or organizing and presenting their thoughts in a different way to show what they figured out about the phenomenon.

III.B. FORMATIVE	
Embeds formative assessment processes throughout that evaluate student learning to inform instruction.	
Rating for Criterion III.B. Formative	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. The materials include frequent formative assessments with actionable teacher feedback to help students progress towards proficiency. However, much of that guidance is specific to the assessment task rather than adjusting future instruction to move students towards building proficiency in future opportunities. Each module and each lesson have one or more assessment opportunities that include student sample responses for

teachers to use along with a list of "Look Fors" teachers can use to interpret student responses and inform instruction for each element of the targeted lesson goal. Most formative assessment tasks utilize writing as the primary means of assessment.

The materials include numerous assessment opportunities that are explicitly described and occur throughout each lesson. Teachers are provided with clear guidance in the form of prompts and actions that can be used to modify instruction based on student responses. However, most of these assessments ask students to respond in writing and do not vary in modality to ensure access for all students. In addition, the guidance for informing instruction is targeted for what can be done while students are engaged with the formative task, and do not include guidance about modifications to make in future lessons based on what is seen or not seen in student artifacts. Related evidence includes:

- Lesson 2: Students develop a model at multiple scales that describes how different organs function in the digestion of milk as it passes through the digestive system. A list of possible next steps to consider is provided to move students forward if additional support is needed (Teacher Guide, pages 5–6).
- Lesson 3: Students "defend a claim about how multiple organs and their specialized cells produce enzymes to digest food molecules into smaller molecules, describing them using orders of magnitude" (Teacher Guide, page 12). Next steps for instruction are included in additional support ideas to move students further in expressing their understanding as they defend or refute claims (Teacher Guide, page 13). Students also participate in an activity that helps them to visualize how the class supported or refuted each claim (Teacher Guide, pages 13–14).
- Lesson 5: Students revise their models in small groups and the teacher circulates to ask students pressing questions such as: "● What new ideas did you add to your model? What are you trying to show? ● What is the function of this organ? How are specialized cells contributing to the function of this organ? ● What are the sizes of the items you are representing in the model? ● What happens to (molecule) when it is in (organ)? How? ● What evidence from the previous lessons did you use to add this to your model?" (Teacher Guide, page 3). These prompts move students towards developing increased proficiency in applying three-dimensional elements to complete the task.
- Lesson 8: Students construct an initial explanation to answer these 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?" (Teacher Guide, page 4). The following additional guidance is provided for giving feedback to students: "As students work, circulate the room to elicit and probe student thinking. Ask questions such as: ● Can you tell me more about what you think causes (sweat, thirst, urine color change)? ● What I read in your explanation is _____. Can you say more about that? ● How do you think sweat, thirst, and urine color could be related? ● What do you think water has to do with each of these effects? ● What do the nutrients in milk do to help the body recover from (sweat, thirst, urine color change)?" (Teacher Guide, page 6). However, guidance is not provided to inform future instruction based on what is seen or not seen in student artifacts, beyond the task at hand.
- Lesson 11: Students use a model to make observations and describe how feedback loops operate to maintain water balance in the bloodstream, recording their observations and descriptions in the Student Guide Part 4 (Teacher Guide, pages 8–13). A list of "Look Fors" is provided that include ideas from the targeted three-dimensional elements, and a Rubric is provided that includes Sample Student Responses for Emerging, Developing, and Proficient levels. Additional support ideas are provided for students who need support in "engaging with the model or in understanding what components, relationships, or processes the model is demonstrating" (Teacher Guide, pages 11–13).

- Lesson 13: Students create an explanation about how athletes could die from dehydration or overhydration. During this formative assessment, students are expected to utilize a targeted SEP, DCI, and CCC element in order to sufficiently address the guiding question (Teacher Guide, pages 10–12). Teachers are then encouraged to provide students with supports to further refine their explanations. Suggested questions include: "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?" (Teacher Guide, page 12).
- Lesson 19: Students use their findings from Lesson 18 relating to exercise's impact on the concentration of key biomarkers to build a model to explain how those markers can be tied to the body's need to produce additional energy to perform the work required of the exercise tasks. For students that struggle to synthesize this learning, teachers are encouraged to push students to consider "pausing the enactment of the model as needed and asking students to review the description of their organ's function or of their role. Building in intentional pauses in the model for students to record what they observe and what they are doing. Having students read their role cards as a group and rehearsing what they will do before enacting the model" (Teacher Guide, pages 6–7).
- Lesson 22: Students revise an explanation using multiple pieces of evidence by synthesizing their learning related to the components of milk and its potential for serving as a source of some of the inputs required for the body to undergo cellular respiration. For struggling students, teachers are asked to consider, "Providing students with time to organize the evidence they found, come up with a list of evidence as a class, and discuss which pieces of evidence are most relevant to the explanation of how our muscles recover after exercise" (Teacher Guide, page 5). However, guidance is not provided to inform future instruction, based on what is seen or not seen in student artifacts, beyond the task at hand.
- Lesson 24: Students create a presentation with their group that "communicates the answer to our Driving Question, how can milk help athletes recover from physical exercise?" (Student Guide, page 1) to an audience of their choosing. They add the new content from Module 3 to the presentation they created in Lesson 14. This task includes several key "Look Fors" that guide students in sufficiently completing this task. Peer feedback as well as teacher feedback are provided to students in Part 3 of this lesson to allow students to receive input necessary to encourage them to edit or rethink their initial approach to addressing this task. Additionally, teachers are encouraged to support students after they submit their work and receive feedback and a grade by holding a session for students to "norm on the features of high-quality work" (Rubric, page 7). Students analyze three samples of student work (one Emerging, one Developing, and one Proficient) by annotating the features of the work that are high-quality examples of the listed Look Fors. The class builds a class list of features of high-quality work, then students use it to revise their work and resubmit it for a revised grade (Teacher Resource Rubric, page 7). Though this formative assessment follows a similar format to its predecessors, the guidance is included on a separate document rather than the Teacher Guide. This makes navigation of materials confusing as it appears that this assessment may be different from past ones, though the materials do not distinguish it as so.
- Lesson 27: "Instruct students to record their analysis of the data on their Lesson 27 Student Guide Part 2: Analyzing and Interpreting Data. Allow students time to find trends in the data and to compare the findings across studies. As students analyze the data, circulate the room to support students in their analysis. Ask questions to support student thinking, such as: ● What was the goal of this experiment? ● What was the experiment design? What were they measuring? How did they set up the experiment? ● What is on the X and Y-axis of the graph? ● What trends do you see in the data on the graph? ● What would you look for to decide if the

findings of the two studies are consistent? How would you determine that?" (Teacher Guide, page 4). These prompts guide students to further develop this element as they complete the task. However, guidance is not provided to inform future instruction.

The materials include a description for teachers about how formative assessments can be used to assess understanding and provide feedback.

- Unit Guide: Teachers are provided with lesson-level formative assessment opportunities where students complete a task or "…produce an artifact that shows their performance of the targeted three-dimensional learning objective for that lesson. The teacher can use these artifacts to assess students' understanding of the lesson goal by providing formative feedback and/or a grade or by having students give each other feedback on their artifacts" (Postgame Analysis Unit Guide, page 16).

Guidance for responding to students and providing feedback to improve student performance is provided in a section of the rubrics titled "To Provide Additional Support for Students" and includes actionable supports to provide for students as they perform the task. However, evidence was not found for suggestions related to planning and adjusting upcoming instruction in future lessons to further develop three-dimensional elements based on student responses. Related evidence includes:

- Lesson 1: Information is provided about how to provide additional support for students. For example: "Press students to say more about what is happening inside of the body after exercise and after drinking milk to help recovery" (Teacher Guide, page 10). The suggestions do not include ideas for planning and adjusting for future instruction.
- Lesson 7: The Rubric provides suggestions to, "Support Students in Revising Their Tasks Based on Peer or Teacher Feedback" which include holding a session for students to "norm on the features of high-quality work" (Rubric, page 5) in which they analyze and annotate sample student work. The suggestions do not include ideas for planning and adjusting for future instruction beyond the lesson, only instruction while students are doing the task or immediately afterwards.
- Lesson 9: Teachers are encouraged to support students' analysis of data or interpretation of experimental design by: "● Providing students with a graphic organizer that helps them identify the goal of the study, the independent variable, the dependent variable, the controlled variables, and the way data is being gathered; ● Providing students with a data analysis strategy, such as breaking the graphs into approximately four parts and annotating what changes they see in each part of the graph; ● Providing sentence stems for data analysis, such as: As _____ increases/decreases, we see _____ increasing/decreasing. This graph shows that, over time, _____ was increasing/decreasing. One major trend I saw in this graph was…; ● Provide access to this 'How to read line graphs' video starting at the 5:00 mark to offer extra support" (Teacher Guide, page 5). The suggestions do not include ideas for planning and adjusting for future instruction.
- Lesson 28: Suggestions for providing additional support for students as they engage with the model to understand the components, relationships, or processes the model demonstrates are included for providing feedback (Teacher Guide, pages 6–7). The suggestions do not include ideas for planning and adjusting for future instruction.

Suggestions for Improvement

- Consider including formative assessments that provide students opportunities to demonstrate their learning in various modalities other than writing.

- Consider providing increased guidance as to how instruction can be modified in the future based on what is seen or not seen on student formative assessment artifacts or during the formative process to help students build proficiency in all three dimensions.
- Consider providing an explanatory note to teachers in the Teacher Guide when guidance for student support is provided on a separate document, such as a rubric, in order to increase the ease of navigating the resource materials.

III.C. SCORING GUIDANCE

Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Rating for Criterion III.C. Scoring Guidance	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the included aligned rubrics and scoring guidelines help the teacher interpret student performance for all three dimensions. Teacher guidance in scoring is provided for each identified formative and summative opportunity throughout the unit. The materials provide three-dimensional targets for each assessment, key "Look Fors" for evaluating student responses, student sample responses/exemplars that represent various proficiency levels, and concrete strategies to offer feedback to students that can be used to revise thinking. However, scoring guidance for interpreting growth in each dimension as the unit progresses is not provided.

Assessment targets are clearly stated and incorporated into the scoring guidance for each identified assessment opportunity in "Formative Assessment Opportunity" call out boxes throughout the unit. These targets include all three grade-appropriate elements of all three dimensions being used together. Related evidence includes:

- Lesson 10: The three-dimensional assessment target is stated as: "Students use evidence from a variety of sources to construct an explanation of how feedback mechanisms maintain a living system's internal conditions and stabilize the system" (Teacher Guide, page 3). The three-dimensional elements in this target are incorporated in the aligned Look Fors for scoring guidance.
- Lesson 16: The three-dimensional assessment target is stated as: "Students compare findings in two data sets to determine how exercise changes the amount of oxygen inhaled and used by muscles" (Teacher Guide, page 4). In this assessment opportunity, students analyze data and use it to determine how changes in exercise influences the amount of oxygen inhaled and used by muscles within the body. Although this is presented in the teacher materials as a grade-appropriate three-dimensional task, it is not clear that the high school-level DCI is being used as students are not yet aware of how cellular respiration uses oxygen acquired from breathing and circulated through the blood (Teacher Guide, pages 4–5).
- Lesson 19: The three-dimensional assessment target is stated as: "Students use a model to explain how increased rates of aerobic and anaerobic respiration lead to changes in the body during exercise" (Teacher Guide, page 6). Students use their findings from Lesson 18 relating to

exercise's impact on the concentration of key biomarkers to build a model to explain how those markers can be tied to the body's need to produce additional energy to perform the work required of the exercise tasks (Teacher Guide, page 7). The three-dimensional elements in this target are incorporated in the aligned "Look Fors" for scoring guidance.

- Lesson 28: The Assessment target is stated as: "Students use a model to help explain how feedback mechanisms can help muscle fibers return to a functional state after damage" (Teacher Guide, page 6) and it is incorporated in the aligned Look Fors for scoring guidance.

"Look Fors" that are aligned to the three dimensions provide guidance to teachers for interpreting student performance along the three dimensions. An Assessment Rubric provides three sample student responses to represent what student work may show at the emerging, developing, and proficient levels, along with scoring guidance that indicates "how to achieve this level" for each level of student response. These work together to provide some guidance for interpreting student performance along the three dimensions. However, scoring guidance for interpreting growth in each dimension as the unit progresses is not provided.

- A rubric along with sample student responses for each level (Emerging, Developing, and Proficient) are provided for each time students update their presentation (Lessons 1, 7, 14, 24, 31, and 32). Although "Look Fors" aligned to the three dimensions are provided, the student samples do not clearly show how student performances can be interpreted in relation to each of the three dimensions
- Sample Student Models are provided for the class consensus models for each lesson in which they are updated (Lesson 2, pages 8–9; Lesson 5, pages 6–7; Lesson 6, pages 10–12; Lesson 10, pages 7–8; Lesson 12, pages 8–11; Lesson 20, pages 8–10; Lesson 22, pages 6–8; Lesson 23, pages 13–14; and Lesson 29, pages 7–9).
- Lesson 7: A scoring rubric is provided for evaluating student proficiency in using elements from three dimensions to develop their presentations. Sample student responses are provided for emerging, developing, and proficient level student work, along with possible samples that include graphical media (Rubric, pages 1–5). These sample student responses provide concrete examples of what different levels of responses from students may or may not include which supports scoring of student artifacts.
- Lesson 10: The assessment artifact is identified as being in the "Lesson 10 Student Guide Part 2: Developing an Explanation of Sweat and Temperature Changes During Exercise and Recovery" section of the Student Guide (Teacher Guide, page 3). Teachers are encouraged to look and listen for evidence that, "● Students construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources, including data sets and the Science Theater model from Lesson 9 (CEDS-H2). ● Students describe how they think exercise changes the body temperature conditions of the body, including temperature change and sweat (LS1.A-H4, SC-H1). ● Students describe how a negative feedback mechanism responds to body temperature change and brings body temperature back to a stable state (LS1.A-H4, SC-H3). ● Students describe how specialized cells in each organ contribute to the function of the system or organ (LS1.A-H1)" (Teacher Guide, pages 3–4).
- Lesson 12: Teachers are encouraged to look for evidence from each targeted element, requiring all four elements to be present for a student response to be considered proficient. Sample student responses and scoring based on the identified "Look Fors" are included in the Teacher Guide (Teacher Guide, pages 3–6).
- Lesson 15: Some proficient student responses require a three-dimensional answer while less-than-proficient responses can include student evidence of grade-appropriate use of only one or two dimensions, as shown in the corresponding leveled "Sample Student Responses". Scoring

guidelines based on the identified Look Fors are included in the rubric (Teacher Guide, pages 7–8).

- Lesson 22: Sample student responses and scoring based on the identified "Look Fors" are included in the Teacher Guide. Look Fors include: "● Students use evidence from a variety of sources, including data sets and the Science Theater model (CEDS-H2). ● Student explanations describe how milk helps the body recover from intense exercise to have glucose available to produce cellular energy via aerobic and anaerobic respiration (LS1.B-H1). ● Student explanations describe how levels of glycogen in muscles change upon recovery (SC-H1)" (Teacher Guide, pages 3–4).
- Lesson 28: An Assessment Rubric provides sample student responses for three proficiency levels as students use a model to help explain how feedback mechanisms can help muscle fibers (specialized cells) return to a functional, stable state after damage. The sample student responses provide clear guidance for teachers in scoring student work (Teacher Guide, pages 6–7).

Resources are provided for students to track their progress in learning throughout the unit. Students are provided with opportunities to monitor their progress in learning around each sub-question by identifying what they currently understand and what gaps they have in their understanding. Related evidence includes:

- Lesson 12: At the beginning of the lesson, students examine the learning they've done throughout the module/lesson and identify gaps in their current understanding related to the causes of sweat, thirst, changes in the color of urine, and how milk might support recovery from these effects, and identify questions they still need to investigate (Teacher Guide, pages 2–3). At the end of the lesson, to facilitate the development of questions to address "additional information they need to know to help them figure out the Module Questions" (Teacher Guide, page 11), teachers are encouraged to use an instructional strategy, the Question Formulation Technique. This strategy serves as a resource that students can use to generate a list of collaboratively-determined questions to drive subsequent learning in subsequent lessons (Teacher Guide, page 11).
- Lesson 7: Students are encouraged to revise their ongoing draft presentations and consider key ideas such as, "how do you think this presentation will make sense to your chosen audience? What will be clear for them? What will be difficult? How are you communicating the idea that multiple different scales are important in digestive functions? How can orders of magnitude help you do so? How are you showing how the molecules in milk are digested? How are you showing the role of specialized cells in this process?" Teachers support students as they are directed to "…review and approve each group's script or outline" (Teacher Guide, page 4). These prompts provide students with opportunities to respond in ways that can be used to measure student progress.
- Lesson 31: Students are instructed to revise the presentation that they created in Lesson 24 to "…add new content from Module 4 to the presentation" (Student Guide, page 1). This revised presentation is required to include the Look Fors described in the Student Guide and includes the need to "…use the class consensus model, data sets, and/or models from any other resources from the module" and "clearly communicate scientific information in a way that is appropriate for your chosen audience" (Student Guide, page 2). Student use of the Look Fors and their use of the module resources provide an opportunity to measure their progress toward fully meeting the expectations of their learning.
- For the presentations students work on throughout the unit, the following guidance is provided: "As students revise their presentations across the unit, ask them to collect each of

their presentation drafts in a portfolio. This will allow students to see how their presentation has progressed over the course of the unit" (Teacher Guide, page 9).

- Students are provided with "Look Fors" they can use when creating their final presentation. However, students are not provided with other ways to measure their progress in learning outside of the presentation (Teacher Guide, pages 1–3).

Suggestions for Improvement

- Consider providing additional ways for students to track their own progress in learning.
- Consider providing scoring guidance for interpreting student growth in applying each dimension over the course of the unit so that progress in an element of a dimension (or lack of progress) can be clearly seen as the unit progresses.
- Consider providing a means that identifies the three different dimensional elements in student responses and in the suggestions for additional support, or, alternatively, provide periodic teacher support call out boxes that explain how the "Look Fors" can be connected to the sample student responses to help interpret three-dimensional performances.
- Consider providing, along with the group presentation students develop, a means to measure individual progress in learning.

III.D. UNBIASED TASK/ITEMS

Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

Rating for Criterion III.D. Unbiased Task/Items	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples. Most tasks use accessible, grade-level vocabulary and texts, often accompanied by visual aids such as graphs to convey information. Tasks provide opportunities for students to respond with varied modalities, including talking about their learning, creating visual representations, writing both short and complex answers, and presenting their understandings to other students. While students have a choice in modality for the major assessment in the unit, there is little choice in modality for other tasks.

Some scaffolding is provided to ensure students are able to access tasks throughout the unit. Most information is presented using texts, such as from science studies and articles, but some information is presented in a variety of ways, including videos, data sets represented with graphs, "Science Theater Cards" with colorful images, and photos. Related evidence includes:

- The provided student guide for each lesson often provides supports such as scaffolding questions and graphic organizers. For example:
    - Lesson 4: Structured tables are provided for students to record their thinking from the Science Theatre activity (Student Guide, pages 2–3). Similar structured tables are provided for students each time students participate in a science theatre activity.

- Lesson 22: Students are provided with additional guidance as to what to include in their explanation. "Using all the evidence you have gathered so far in this module, construct an explanation to answer the second part of our Module Questions, Why are there so many changes to my body during exercise? How does milk help with recovery from these changes? In your explanations, be sure to: Describe how the components of milk can help recovery from exercise and provide additional energy for continued exercise. Cite evidence from the data sets analyzed" (Student Guide, page 1).
- Although the assessment prompts in the Student Guide often do not include visuals, sometimes the supporting materials are accompanied by visual representations such as diagrams, models, graphs, photos, or other visual means of conveying meaning along with the assessment text prompts. Lesson 3: Students develop their understanding of orders of magnitude using graphic organizers and colorful tools. While the student guide lacks visuals, other necessary materials include text with visuals like zoom-in diagrams, pie charts, and molecular structure diagrams. The Station Cards feature colorful illustrations with zoomed-in representations of organs, glands, and cells, with labels showing relative orders of magnitude. The enzyme illustration aids in visualizing text explanations (Teacher Guide, pages 5–11; Enzyme Illustration, Orders of Magnitude Tool)
- Lesson 26: Students record their student response to the formative assessment task in their Student Guide, which does not include visuals. However, photos of muscle cells are included in the science articles students use to compare data sets as they do the assessment task, and the Weightlifting Sequence cards provide colorfully labeled representations of muscle structures at different scales (Student Guide, pages 1–4; Data Set, page 2; Weight Lifting Sequence cards, pages 2–10).

Tasks in the unit use vocabulary and texts that are grade-level appropriate with support provided for students to access tasks when needed. Related evidence includes:

- Unit Guide: The "Student Support" call out box is used within specific lessons to "…provide additional suggestions for how to support all learners in the classroom via differentiation strategies or other tips. For example, this box may provide an explanation of a strategy, a new series of questions, an additional prompt, or sentence starters" (Postgame Analysis Unit Guide, pages 13–14).
- Unit Guide: The "Define Terms" call out box is used within specific lessons "…when a teacher formalizes the definition of key terminology for all students to be familiar with throughout the remainder of the lesson(s)" (Postgame Analysis Unit Guide, page 14). Vocabulary is introduced after students have developed a conceptual understanding of the science idea it represents through doing the sense-making activities.
- Lesson 7: Students have access to a "scaffold table" that provides students with concrete ideas and tips for ensuring their presentation is successful and prompts students to notate how they plan to use these ideas in their own presentations. Categories include, "choose the focus of this module…engage your chosen audience…choose appropriate media…[and] narrate effectively" with each section containing multiple sub-criteria for students to consider (Student Guide, page 3).

While most tasks throughout the unit do not offer a choice in modality for students to respond and show their understanding, the major task in the unit (creation of a presentation) allows students to use the modality of their choice. Some other tasks provide some options for student responses, but many

tasks are completed by writing explanations or drawing models with limited choice offered. The specific modality is most often determined by the teacher rather than the student. Related evidence includes:

- Lesson 1: "Direct students to their Lesson 1 Student Guide Part 3: Communicating Initial Ideas to begin their draft. To start, students will choose presentation formats and a target audience and create an initial draft to show their initial understanding of how milk might help athletes recover from physical exercise. Share that students will be able to add to and revise their presentations throughout the unit and that it is okay if they are a draft right now. Students' initial presentations should show their own ideas. There is no need to do outside research at this time" (Teacher Guide, page 9).
- Lesson 2: Students create an initial model explaining what they believe happens when milk is digested (Student Guide, page 2).
- Lesson 5: Students return to the Class Consensus Model of how milk is digested from Lesson 2 and in groups revise their models to show what they have now figured out regarding the digestion of milk. Students are reminded to use conventions such as boxes, arrows, and zoom-ins. Students use resources from throughout the module to help them revise these models (Teacher Guide, page 3).
- Lesson 8: Students construct an initial explanation to answer the 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?" (Teacher Guide, page 4).
- Lesson 15: Students construct an initial explanation in small groups to answer the module questions, "Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?" Students read the expectations checklist together and are reminded that "at this point, any ideas are acceptable, and they don't need to worry about getting the 'right' answer—just sharing what they think right now" (Teacher Guide, page 7).
- Lesson 17: Students engage with an active investigation requiring more than paper and pencil work, though they do record information on their Student Guide sheets (Student Guide, pages 1–3)
- Lesson 18: Students analyze data obtained from peer-reviewed journals to explore how exercise can impact a variety of biomarkers (e.g., pH or glycogen) (Teacher Guide, pages 4–8).
- Lesson 19: Students use a model to develop an explanation for how exercise prompts the need for additional energy production within the body. Students use the card set to connect cause and effect relationships to energy production as well as the location of organs associated with each biomarker of energy demand/production (Student Handout Science Theater Card Set; Teacher Guide, pages 3–10).
- Lesson 24: Students create a written or multimedia presentation to communicate the results of the learning within the module that relate back to the anchoring phenomenon, how can milk help athletes recover from physical exercise? (Student Guide, page 1).
- Lesson 28: Students work to complete a Science Theater model to explore the specific mechanisms that underlie muscle recovery processes and the development and decrease in soreness after exercise. In this activity students will ultimately come to describe three negative feedback processes that are used to detect and repair muscle cells — specifically, "…the role of specific specialized cells in the feedback process" and "what conditions change in the body to bring it out of a stable state, and how the body responds with feedback mechanisms to return it to a stable state" (Student Guide, page 2).

Suggestions for Improvement

- Consider increasing the variety of ways in which information is conveyed to students in order to increase access for all students to the information. For example, consider providing more visuals in formative assessments that will aid students in understanding what is expected by the task.
- Consider providing students with a choice of which modality to use as they attempt to complete a particular task, such as each instance of constructing explanations for a guiding question within a module.
- Consider providing integrated supports for tasks that require complex reading comprehension skills and rigorous writing demands so that all students can access the tasks.

III.E. COHERENT ASSESSMENT SYSTEM

Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Rating for Criterion III.E. Coherent Assessment System	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. All four types of assessments are present through the materials and are connected to stated learning goals.

The assessment system includes pre-assessment measures that assess three-dimensional learning, usually in the first lesson of each of the four modules and are meant to be used by the teacher to "obtain a formative assessment on what prior knowledge students have of using these elements" (Unit Guide, page 17). Related evidence includes:

- Lesson 1: The targeted elements for the lesson from each dimension are identified as pre-assessment opportunities (Teacher Guide, page 2). Students write an initial presentation draft to explain how milk can help athletes recover from physical exercise. Bulleted "Look Fors," identified with elements from each targeted element, are clearly stated for looking at student work on their initial drafts. An Assessment Rubric is provided with sample student responses to guide teachers in determining student proficiency in working towards the three-dimensional learning objective for the lesson. Bulleted ideas for additional support for students are provided (Teacher Guide, pages 9–10). A DCI support box states that teachers "can use students' initial presentations of how the body uses milk to help recover from exercise as a pre-assessment to understand what students know about how the body uses feedback mechanisms for recovery" (Teacher Guide, page 11). Students are told that they "will be able to add to and revise their presentations throughout the unit and that it is okay if they are a draft right now. Students' initial presentations should show their own ideas. There is no need to do outside research at this time" (Teacher Guide, page 8).
- Lesson 2: The targeted elements for the lesson from each dimension are identified as pre-assessment opportunities (Teacher Guide, page 1). Students are prompted to "create an initial

model that shows how you would currently answer our Module Question, How is milk digested after it is consumed?" (Student Guide, page 2). A DCI Support note explains what students learn about the body's subsystems and specialized cells during middle school, and that in this lesson, students "demonstrate their prior knowledge from middle school of the structure and function of cells in organs in the digestive system" (Teacher Guide, page 4) as they develop their initial models. Another DCI Support note explains that students have the opportunity to demonstrate what they know from middle school about tissues and the organs they form that specialize in particular body functions (Teacher Guide, page 4). The product of this initial explanation would be integrated into the building draft presentation and serves as a pre-assessment for this next module focusing on feedback mechanisms.

- Lesson 8: The identified Pre-Assessment Opportunity provides a three-dimensional Learning Objective, Look Fors that include each of the three dimensions, and Sample Student Responses that show explanations that require the use of all three targeted elements (Teacher Guide, pages 6–7). Students "work to create an initial explanation that addresses '…what is happening inside the athlete's body before exercise, during exercise, and after recovery'" (Teacher Guide, page 5). The product of this initial explanation would be integrated into the building of the final draft presentation and serves as a pre-assessment for this next module focusing on feedback mechanisms.
- Lesson 15: The Targeted Elements for the SEP, DCI, and CCC are identified as pre-assessment opportunities, and the student task of constructing an initial explanation to describe how muscles get energy for exercise and the changes that occur to the body during different forms of exercise is labeled as a pre-assessment opportunity for students to show what they know (Teacher Guide, page 1 and pages 7–9).
- Lesson 25: The Targeted Elements for the SEP, DCI, and CCC are identified as a pre-assessment opportunity, and the student task of developing an initial explanation for how feedback mechanisms can help the body recover from soreness induced by exercise is labeled as a pre-assessment opportunity (Teacher Guide, pages 1 and 5). However, the lesson does not include ideas for how the teacher might use what they see or do not see in this pre-assessment student work to adjust the three-dimensional instruction for Module 4.

The assessment system includes instructionally-embedded formative assessment measures that present students with tasks that assess three-dimensional learning. Related evidence includes:

- See examples of three-dimensional formative assessment measures in criterion III.B.
- The Unit Guide explains that teachers are provided with lesson-level formative assessment opportunities where students complete a task or "…produce an artifact that shows their performance of the targeted three-dimensional learning objective for that lesson. The teacher can use these artifacts to assess students' understanding of the lesson goal by providing formative feedback and/or a grade or by having students give each other feedback on their artifacts" (Postgame Analysis Unit Guide, page 16).
- The Unit Guide explains that within each formative assessment call out box, a three-dimensional learning goal is provided along with key Look Fors that are communicated to students and serve as the basis for determining if the student had reached proficient based on the descriptors provided in the scoring guide (Postgame Analysis Unit Guide, pages 16–17).

The assessment system includes summative measures at the end of each module that assess three-dimensional learning. Some of these assessments also serve as formative assessments in that they can be built on and improved upon as part of the End of Unit Performance Task.

- Lesson 7: At the end of Module 1, students use multiple formats of communication and orders of magnitude to explain how body systems and specialized cells contribute to the digestion of milk (Teacher Guide, page 1). Students revise their presentations from Lesson 1 to share the new scientific information they have gathered during Module 1. This draft presentation can be improved upon at the end of the unit as students assemble and revise the four different components of the presentations for Lessons 7, 14, 24, and 31 (Teacher Guide, pages 3–4; Rubric, pages 1–4).
- Lesson 14: At the end of Module 2, students use multiple formats to communicate how the internal conditions of the human body change in response to changes in external conditions (exercise, drinking milk) (Teacher Guide, page 1). Students develop a presentation to communicate the scientific information they have learned in Module 2 to answer the 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? This presentation will be a component of the end of unit presentation that will answer the Driving Question: "How can milk help athletes recover from physical exercise?" (Teacher Guide, page 1).
- Lesson 24: Students are directed to, "Create a presentation with your group that communicates the answer to our Driving Question, How can milk help athletes recover from physical exercise? to an audience of your choosing. Here, you should add the new content from Module 3 to the presentation you created in Lesson 14" (Student Guide, page 1). Student presentations answer the questions: "Why are there so many changes to my body during exercise?" and "How does milk help our bodies recover from these changes?" (Teacher Guide, page 1). This is the third component of the student presentation that will answer the Driving Question for the unit.
- Lesson 31: At the end of Module 4, students develop a presentation to communicate scientific information that answers the Module 4 question, How does milk help in muscle recovery from soreness induced by intense exercise? Developing the presentation requires the use of elements from three different dimensions, and the learnings from Module 3 (Teacher Guide, pages 1–5).
- Lesson 32: Performance Task, Part 2 (this part is evaluated): Students work together in groups to "create final presentations of what happens in the body during exercise and how the milk that athletes consume after physical activity can help them recover" (Teacher Guide, page 1) as they answer the Driving Question: How can milk help athletes recover from physical exercise? Students are encouraged to use the feedback they received from peers and/or the teacher in Lessons 7, 14, 24, and 31, as well as the drafts they created for each module to produce their final presentation (Teacher Guide, pages 1–5). The task requires students to apply grade-appropriate elements from one SEP, four DCIs, and three CCCs (Rubric, Performance Task Lesson 32, pages 1, 5, 12, and 19).

The assessment system includes self-assessment measures that assess the SEP **Obtaining, Evaluating, and Communicating Scientific Information;** some self-assessments showed evidence of some reflection on the DCI and CCC dimensions.

- Lesson 14 Student Self-Assessment: Students self-reflect on their engagement in the SEP **Obtaining, Evaluating, and Communicating Scientific Information.** Students indicate items they completed, such as, "I read and summarized scientific journal articles" (Student Self-Assessment, page 1), describe a success, describe an area with room to grow, and explain why it is important to use this SEP "to make progress on challenging real-world problems" (Student Self-Assessment, page 2). Students also self-reflect on their presentation (Student Self-Assessment, page 3). While this self-assessment is present in the materials and offered to the students, it is an optional activity which may not necessarily be utilized in classes adopting this unit.

- Lesson 24 Student Self-Assessment: On page 1, students self-reflect on their engagement in the SEP **Obtaining, Evaluating, and Communicating Scientific Information.** Students indicate which items listed under this SEP they completed. Some examples include: "I summarized complex text(s) in more simple but still useful language," "I evaluated the quality and relevance of sources of information," and "I researched multiple sources of information to address a scientific question" (Student Self-Assessment, page 1). "Students describe a success they had using this SEP, describe an area where they have room to grow, and explain why it is important to use this SEP to help make progress on challenging real-world problems" (Student Self-Assessment, pages 1–2). Students also self-reflect on constructing their explanation, noting items they completed, such as, "I included multiple methods of communication, including models and evidence from the module" (Student Self-Assessment, page 3). While this self-assessment is present in the materials and offered to students, it is an optional activity which may not necessarily be utilized in classes adopting this unit.
- Lesson 32 Performance Task Student Self-Assessment: In the first part of the self-reflection task, students reflect on components of the focus element for **Obtaining, Evaluating, and Communicating Scientific Information** by filling out a checklist indicating which items they completed. They then describe a success they had with this SEP element, an area where they have room to grow, and why they think it is "important for us to obtain, evaluate, and communicate scientific information to help us make progress on challenging real-world problems?" (Performance Task Self-Assessment, page 2). In another part of the Self-Assessment, students reflect on what they had a chance to do for each Module, with the checklist including aspects of elements from the Information SEP and the focal DCIs and CCCs for each module. While this self-assessment is present in the materials and offered to students, it is an optional activity which may not necessarily be utilized in classes adopting this unit.

The assessment purpose and rationale are coherent across the materials and are explicitly described in most instances for all three dimensions. The assessment system components work together to provide information about student learning and the Unit Overview provides the purpose and rationale for parts of the assessment system.

- Unit Guide: The unit guide includes an Assessment System Overview which outlines the different assessment types found in the unit and for some of them, explains how teachers can use them. Teacher instructions state: "After students complete a formative assessment: ● The teacher can collect the student artifact, score it, and provide feedback on which Look For students accomplished and which they can improve on. ● The teacher can give students an opportunity to revise their artifacts based on feedback from their peers or from the teacher" (Unit Guide, page 17). However, the description of how the assessments work together coherently is not completely described for all three dimensions.
- Throughout the unit, formative assessment call out boxes are found which describe the purpose of each formative assessment and how it is aligned to three-dimensional learning outcomes.
- All lessons include assessment opportunities that match the learning targets for each lesson.

Suggestions for Improvement

- Consider embedding purposeful use of self-assessment as a tool to monitor changes in student thinking, progress, or skill rather than a simple checklist that may or may not be completed.
- Consider increasing the level of detail in the provided purpose and rationale for each type of assessment to show how they provide feedback to teachers to inform instruction and students to inform learning throughout the materials, as well as how they work together as a whole.

III.F. OPPORTUNITY TO LEARN

Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.

Rating for Criterion III.F. Opportunity to Learn	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of DCIs and CCCs. Students are provided with many iterative opportunities to demonstrate their learning in all three dimensions in the unit for some of the claimed elements. Students give and receive feedback with time to revise their thinking and use the new understanding to continue to deepen their skill using the practices with targeted DCI and CCC elements throughout the unit. The reiterative nature in which the unit provides opportunities for students to develop and use each element is illustrated in the Unit Guide.

Related evidence includes:

- The Unit Guide states that, "Students are given multiple opportunities to build their proficiency with the focal elements for this unit" (Unit Guide, page 25) and provides a "Focal Element Map" in the form of a chart that indicates each element, and which lessons focus on developing and using that element (Unit Guide, pages 26–27). Examining this "Map" can support the teacher in identifying which three-dimensional elements are used together. For example:
    - **SC-H3**: The CCC **Stability and Change** element *Feedback (negative or positive) can stabilize or destabilize a system*, is listed for lessons 8, 9, 10, 11, 12, and 14, and then revisited again in lessons 25, 27, 28, 29, and 32).
    - **LS1.A-H1**: The DCI **LS1.A** element *Systems of specialized cells within organisms help them perform the essential functions of life,* is listed for lessons 2,3,4,5,6,7, 9, 10, 11, 12, 13, 14, 19, 20, 22, 25, 26, 28, 29, 30, 31, and 32. Several of these lessons overlap the lessons for the **Stability and Change** element.
    - **CEDS-H2**: The SEP **Constructing Explanations and Designing Solutions** element *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, 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* is listed for Lessons 8, 10, 12, 13, 15, 20, 22, 24, 25, 29, and 32.
    - In the above examples, these three elements intersect and are developed and used together in lessons 10, 12, 25, 29, and 32.

Students have iterative opportunities to demonstrate their performance of the following SEP, DCI, and CCC elements together: SEP **Obtain, Evaluate, and Communicate Information element** *Communicate scientific and/or technical information or ideas (e.g., about phenomena ~~and/or the process of development and the design and performance of a proposed process or system~~ in multiple formats (including orally, graphically textually and mathematically*) connected with their understanding of the

DCI **LS1.A Structure and Function** element *Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and function even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system* and the CCC **Stability and Change** element *Feedback (negative or positive) can stabilize or destabilize a system.* Some examples include:

- Lessons 5, 6 and 7: In Lesson 5, students revise their Lesson 1 models both as individuals and then as a Class Consensus Model to include learnings from the lessons in Module 1 (Teacher Guide, pages 3–7). In Lesson 6, they obtain more information about another system involved in the digestive process and develop a Class Consensus Model that incorporates concepts from this system within the model they developed in Lesson 5 (Teacher Guide, pages 7–10). In Lesson 7, student groups use information from the module, including the Class Consensus Models, to develop their presentations (Teacher Guide, pages 1–5). They incorporate information and science ideas they obtained during Module 1 lessons in their models, including concepts of scale and orders of magnitude, the hierarchical organization and function of body systems, organs, and cells, and the functions of multiple kinds of specialized cells. After students submit their presentations, they are given the opportunity to improve their work using both teacher and peer feedback. After building a class list of features of high-quality work, students are given time to revise their work and resubmit it for a revised grade (Teacher Guide, pages 3–5; Student Guide, pages 1–3, and Student Handout Peer Feedback Form, pages 1–2). Revisiting and revising models with different levels of independence and group work supports students with multiple opportunities to learn new materials and demonstrate their performance of practices to show their understanding of DCIs and CCCs.
- Lesson 14: Students revise their presentations that explain the anchor phenomenon from Lessons 1 and 7 by adding a "mini-presentation" that shares the new scientific information they have figured out about the Module Phenomenon that *communicates scientific information in multiple formats* (SEP) that explains how *feedback mechanisms (DCI)* work together to maintain a body's temperature and water balance, and that sometimes *feedback can stabilize or destabilize a system* (CCC). The included Look Fors, Prompts to Support Students in Improving on Look Fors, and the suggestions for supporting students in revising their tasks provide feedback to help students improve their proficiency for future opportunities to demonstrate their learning in these three dimensions (Rubric, pages 1–8). The Student Guide provides Tips for a Successful Multimedia Presentation that supports the SEP element and provides Look Fors that support the DCI and CCC elements (Student Guide, pages 2–3). The Student Guide also provides an opportunity for students to share their presentation drafts and receive feedback (Student Guide, page 9). Student Self-Assessment and Peer Feedback forms also provide opportunities for students to receive feedback that can improve their proficiency in these three elements.
- Lesson 31: Students *communicate scientific information in multiple formats* (SEP) as they revise and/or create a presentation that explains how exercise can *destabilize* muscle structure and function in the body and that *negative feedback mechanisms* in the body and the consumption of milk can help the body return muscle structure and function to its *stable* state (DCI and CCC) (Student Guide, page 2). The Rubric provides a Sample Student Response that addresses the elements of these three dimensions, as well as Look Fors, Prompts to Support Students in Improving on Look Fors, and suggestions for supporting students in revising their tasks (Rubric, pages 1–7). Self-Assessment and Peer Feedback forms also provide opportunities for students to receive feedback aligned with these elements of three dimensions.
- Lesson 32 Rubric – Task 2: Students *communicate scientific information in multiple formats* (SEP) as they develop a presentation that explains what happens in the body during and after exercise

as *conditions change* and the body uses *feedback mechanisms* to strive to return its body temperature and water balance to levels that allow it to *remain alive (DCI)*. The presentation includes how *feedback* can be *negative or positive* and *can stabilize or destabilize a system* (CCC) (Rubric, pages 5–11). Look Fors and Prompts to Support Students in Improving on Look Fors support students in improving their proficiency in applying these elements (Rubric, page 24), and the Student Guide and Self-Assessment also provide a means to receive feedback (Student Guide, page 2; Student Self-Assessment, pages 1–3).

Suggestions for Improvement

None

OVERALL CATEGORY III SCORE: **3** (0, 1, 2, 3)	
Unit Scoring Guide – Category III	
Criteria A-F	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

SCORING GUIDES

SCORING GUIDES FOR EACH CATEGORY

UNIT SCORING GUIDE – CATEGORY I (CRITERIA A-F)

UNIT SCORING GUIDE – CATEGORY II (CRITERIA A-G)

UNIT SCORING GUIDE – CATEGORY III (CRITERIA A-F)

OVERALL SCORING GUIDE

Scoring Guides for Each Category

Unit Scoring Guide – Category I (Criteria A-F)	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

Unit Scoring Guide – Category II (Criteria A-G)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Unit Scoring Guide – Category III (Criteria A-F)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Postgame Analysis

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL SCORING GUIDE	
E	**Example of high quality NGSS design—**High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9)
E/I	**Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7)
R	**Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)
N	**Not ready to review**—Not designed for the NGSS; does not meet criteria (total 0–2)