Inheritance and Variation

DEVELOPER: OpenSciEd

GRADE: High School **| DATE OF REVIEW:** July 2023

Educators Evaluating Quality Instructional Products

Inheritance and Variation of Traits

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E
TOTAL SCORE: 8

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
2	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	Extensive	**A.**	Monitoring 3D Student Performances	Adequate
B.	Three Dimensions	Adequate	**B.**	Student Ideas	Extensive	**B.**	Formative	Extensive
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Adequate	**C.**	Scoring Guidance	Extensive
D.	Unit Coherence	Extensive	**D.**	Scientific Accuracy	Extensive	**D.**	Unbiased Tasks/Items	Extensive
E.	Multiple Science Domains	Adequate	**E.**	Differentiated Instruction	Adequate	**E.**	Coherence Assessment System	Extensive
F.	Math and ELA	Extensive	**F.**	Teacher Support for Unit Coherence	Adequate	**F.**	Opportunity to Learn	Extensive
			G.	Scaffolded Differentiation Over Time	Adequate			

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 is strong in several areas, including using student generated questions to drive learning in the unit, building opportunities for students to receive feedback from peers and using that feedback to revise their work and/or thinking, and providing formative assessment guidance for teachers.

During revisions, the reviewers recommend paying close attention to the following areas:

- **Differentiation**: The unit provides differentiation guidance for a variety of learners. This would be strengthened further by providing additional guidance for supporting multilingual learners and learners with disabilities.
- **Scaffolded Differentiation Over Time:** The unit provides numerous opportunities for students to use grade-appropriate elements of Science and Engineering Practices (SEPs), particularly those related to **Developing and Using Models**. The development of SEPs could be strengthened by providing a clear removal of scaffolds for all targeted SEP elements throughout the unit to help students build independence in their use.
- **Mathematics and English Language Arts (ELA):** The unit contains many strong connections to CCSS ELA and mathematics. This could be strengthened by ensuring accurate alignment to CCSS standards within the materials.

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. 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. In these cases, the criterion definitely 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

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 and/or designing solutions to a problem because the materials are organized so students figure out a central phenomenon related to why certain individuals are more likely to get cancer. Throughout the unit, students regularly return to the phenomena.

The focus of the unit is to support students in making sense of the phenomenon. Students regularly revisit the phenomenon throughout the unit. Related evidence includes:

- The front matter of the materials contains a section titled “What is the anchoring phenomenon and why was it chosen?” The section contains the following information: “In the anchoring phenomenon, students explore cancer statistics including rates of new cases by cancer and state. They notice some differences that are hard to explain. Then, they investigate factors such as age and height and figure out the people in different demographics groups have higher and lower risk of cancer. They hear from a scientist who has studied cancer and are introduced to animal models. They read about incidence of cancer and discover that there is something called p53 that might prevent cancer in other organisms. They develop initial models and generate questions that need to be answered to fully explain it. This phenomenon was chosen as the anchor because it generated high student interest across racial and gender identities in a national survey” (Teacher Edition, page 13).
- Lesson 1: The phenomenon is introduced by experiencing data about cancer through graphs and reading selections. The investigative question of “Why do people get cancer?” is developed.
- Lesson 2: Students update the classroom consensus model to answer the question, “why do people get cancer?” “Revise the class consensus model. Say, You all have made a lot of progress in figuring out answers to our lesson question: What is cancer? at multiple levels of organization. Let’s take a moment to update our class consensus model. Direct student attention to the class consensus model and call on a few students to suggest revisions to the model based on what they figured out in the lesson. After calling on each student, ask the rest of the class to accept or suggest changes to the revision before adding it to the model” (Teacher Edition, page 50).

- Lesson 2: "Introduce the Progress Tracker. Say, Before we move on, let's take a moment to capture what we figured out so we can track our progress over the course of the unit. Distribute Progress Tracker to each student. Display slide R. Give students a few minutes to fill in the unit questions and the rows for Lesson 1 and 2. Plan for next steps. Call on a few students to share their answers for the questions they still have. Guide students toward questions that will help the class make progress on the first unit question, Who gets cancer and why? Say, How did what we figured out from the differences between non-cancer and cancer cells and how lung cancer makes us sick help us answer our lesson question What is cancer?" (Teacher Edition, page 51). A sample Progress Tracker containing a sample student response is provided.
- Lesson 3: At the end of the lesson, students update their class consensus model and Progress Trackers.
- Lesson 5: Students update their Progress Trackers. "Update Progress Trackers. Ask students to take out Progress Tracker. Display slide A. Say, In Lesson 4 we figured out a lot of big ideas about DNA replication, mutations, p53 and how cells can end up with differences in their chromosomes. Let's take a few minutes to track our progress. Give students a few minutes to record their thinking including the questions they still need to answer. Call on a few students to share their thinking. Use the sample Progress Tracker below as a guide" (Teacher Edition, page 91). A sample student response is provided.
- Lesson 6: "Lead a discussion about what we have figured out so far. Display slide A. Say, We have figured out a lot of big science ideas over the past week or two! What are some of the ways that we make sense of a lot of ideas? How do we make connections between ideas that we have? Pause to give students an opportunity to share their ideas about what practices they might engage in. Listen for ideas such as: We develop written explanations. We create models to explain relationships between components and ideas. We communicate our ideas with others. Say, Today we are going to take what we have learned to develop a class model that tells the story of what we have figured out" (Teacher Edition, page 101).
- Lesson 6: Students fill out their Progress Trackers. A sample student response is provided. "Revisit the Progress Tracker. Display slide B. Say, Since we have figured out so many great ideas, let's review the Progress Tracker so that we can build our Gotta-Have-It Checklist. Let's look back at the consensus model we started in Lesson 2. We will need to make a new one since we have lots of very big ideas but it is a good place to start. What are some of the biggest ideas that we have figured out since Lesson 2? Call on volunteers to review the ideas on the Progress Tracker and the Gotta-Have-It Checklist" (Teacher Edition, page 101).
- Lesson 7: "Have students individually develop initial models in their science notebooks that explain our lesson question: Why are some kinds of cancer more common than others in older and taller people? Remind students that models include components, interactions, and mechanisms. Let students know that since these are initial models, we are still determining all components and how they are related. Suggest adding question marks where they know something is happening but do not know what. Encourage them to refer back to their science notebook for ideas" (Teacher Edition, page 113).
- Lesson 7: Students update their Progress Trackers. A sample is provided. "Update Progress Trackers. Celebrate with students how much progress they have made, not only on why some kinds of cancer are more common than others? but also on the unit question Who gets cancer and why? Display slide M. Ask students to turn to the Progress Trackers in the science notebooks to update them on their progress in their thinking related to our unit question: Who gets cancer and why? Ask students to take a minute and think about what questions they still

need to answer to make progress and what new questions have come up for them" (Teacher Edition, page 117).

- Lesson 8: "Introduce the cases of Lakita and Lauren, cancer survivors. Display slide B. Say, I have an interview with two cancer survivors that I want to share with you. I think it will help us answer some of our questions. Let's revisit our Community Agreements and think about how they can help us as we listen to these young women describe their experiences with cancer" (Teacher Edition, page 124).
- Lesson 8: "Introduce Lakita's family pedigree. Say, We heard that Lakita and Lauren's family had something called Li-Fraumeni Syndrome, and Lauren told us it has something to do with the p53 gene. Since Lakita shared more about her family, let's take a look at a model of her family and see if we can figure out what is going on. Distribute Lakita's Family Pedigree to each student. Display slide G. Explain that scientists that study genetics in families use family trees called pedigrees. Remind students that pedigrees show matings that result in offspring. Review how pedigrees are organized and give students time to add a definition to their personal glossaries" (Teacher Edition, page 126).
- Lesson 9: Students update their Progress Trackers. "Update Progress Trackers. Display slide CC. Ask students to turn to Unknown material with identifier: bi.l1.ho2 and update their Progress Trackers based on what they figured out about how environmental factors can lead to cancer" (Teacher Edition, page 155).
- Lesson 10: "Turn and Talk. Display slide A. Say, We have done a lot of sensemaking[sic] over the last several lessons. Let's pause to take stock of our progress. Review the ideas that we figured out in Lessons 7-9 with your partner. Facilitate a discussion about what we have figured out so far. Display the class consensus model from Lesson 6. Display slide B. Call on a few students to remind the class of the progress the class made in Lesson Set 1. Say, We are going to get new chart paper so that we can add to our consensus model because we have so much new information. Then call on a few students to share the progress we made in Lesson Set 2" (Teacher Edition, page 161).
- Lesson 10: Students are asked to individually reflect on the following in their science notebooks: "Who gets cancer and why? Where should we focus efforts on treatment and prevention? Are our unit questions. How can what we figured out help us make progress on that?" (B.3 Lesson 10 Slides, Slide J).
- Lesson 11: "Introduce new cancer data. Display slide C. Let students know that while cancer is a concern a lot of progress has been made in their lifetimes to reduce the number of deaths that result from cancer. Treatment is one part of the cause for that reduction. Revisit Lakita and Lauren's cancer story. Display slide D. Remind students that they were introduced to Lakita and Lauren and their families in Lesson 8. Ask students to turn and talk to a neighbor and share what they remember. Then, call on a few pairs to share with the class. Refer back to the videos from Lesson 8 if students have trouble remembering. Share interviews with Lakita and Lauren describing their cancer treatments. Let students know that you will share additional pieces of the interviews with Lakita and Lauren. Say, As we watch the video, complete the Notice and Wonder chart, paying particular attention to personal accounts of costs, access to treatment, treatment process, decisions that have to be made, and any recommendations. Remind students that in Lesson 8 we added a column to capture feelings that the video brings up. Encourage students to capture their feelings in this space. Display slide E and play the video. After watching the video, call on a few students to share with the class. See sample student responses in the table below" (Teacher Edition, page 174).

Student questions and ideas are used to motivate sense-making in the unit and teacher support is provided to guide students in asking questions that will lead to further understanding of the phenomenon. Related evidence includes:

- Lesson 1: "Stop and Jot. Display slide C. Ask students to take a few minutes to write about what they know about cancer in their science notebooks. This may include their personal experiences, events, and/or feelings. Let them know that while you are asking them to reflect on these experiences and feelings in writing, they will not be required to make those experiences and feelings public" (Teacher Edition, page 28).
- Lesson 1: "Identify gaps that the model cannot yet explain. Say, We have made great progress on our initial model to explain who gets cancer and why? We also have questions that we need to answer to make progress. Display slide V. Ask students to brainstorm in small groups a list of as many questions as they can think of that they would need to answer to make additional progress on the question Who gets cancer and why? Pass back the questions students identified on day 1 to remind students of the questions they had after investigating the data. Encourage them to include any of their original questions that remain unanswered" (Teacher Edition, page 37). These questions are then used to make a Driving Question Board (DQB).
- Lesson 1: "Collect student exit tickets and look for questions related to the data as a formative assessment opportunity. Keep student questions until students are ready to develop the DQB. Provide written feedback to support question revision for DQB. Use Supporting Questioning to support students with question development" (Teacher Edition, page 31). However, the reference document is not included in the unit materials.
- Lesson 1: "What to do: Support individual students by asking probing questions about how the components of the models are related. Focus on the language of cause and effect, such as What do you think the cause of cancer is for taller or older people? or What effect might where you live have on incidence of cancer? Probe them to think about and represent the smaller-scale mechanisms that they cannot see in their models" (Teacher Edition, page 36).
- Lesson 2: "Generate ideas for investigation. Congratulate students on generating a productive board full of great questions. Let them know that the next step is to brainstorm ideas that will help us figure out how to answer those questions. They should focus on one group of related questions at a time and generate ideas for how they could go about answering each question. Their first instinct may be to 'do research.' Prompt them to be more specific and answer questions about what specific data they would need to answer each question. Consider modeling an example to get them started" (Teacher Edition, page 39).
- Lesson 2: "Call on a few students to share their answers for the questions they still have. Guide students toward questions that will help the class make progress on the first unit question, Who gets cancer and why? Say, How did what we figured out from the differences between non-cancer and cancer cells and how lung cancer makes us sick help us answer our lesson question What is cancer?" (Teacher Edition, page 51).
- Lesson 3: "Stop and Jot. Display slide K. Acknowledge that the class has figured out a lot about how cells grow and divide. Ask students to stop and jot in their notebooks about what we still need to know about How do non-cancer cells become cancer cells? Students should recognize that although they understand how non-cancer cells make more cells, they do not yet know how those cells could become cancer cells" (Teacher Edition, page 62).
- Lesson 6: Students revisit the DQB. "Revisit the Driving Question Board. Display slide K. Say, Now that we have reviewed the ideas that we have learned, it is a good time to look back at the Driving Question Board. Let's review the questions that we have answered so far. Ask students to scan the questions silently for 1 minute. Have them share with their partners the questions that they believe that we have answered so far. Call on volunteers to read the questions that

you have answered to share with the whole class. When students identify questions that have been answered, mark the sticky note with a star or move the answered questions to one side of the board" (Teacher Edition, page 107).

- Lesson 8: "Set up a notice and wonder chart. Display slide D. Ask students to set up a notice and wonder chart in their science notebooks to capture their ideas as they watch the video. Invite students to add an additional column to capture their feeling about what they see and hear in the video. Play the videos found on slide E and give students several minutes to capture their ideas. Share notice/wonder/feel about Lakita and Lauren's stories. Ask students to share some of their thoughts with a partner and then with the class. See some possible student responses in the table below" (Teacher Edition, page 125).
- Lesson 8: The following question is on the Electronic Exit Ticket: "How has the day's lesson helped you make progress toward a question that you contributed to the Driving Question Board (or to a related phenomenon on the DQB)?" (B.3 Lesson 8 Answer Key Electronic Exit Ticket, page 3).
- Lesson 9: "Elicit ideas about next steps. Remind students that the mechanism we figured out so far only accounts for some of the cancer that occurs in the United States, but not the majority of cancers. Ask them to consider what we might investigate to figure out what factors might be responsible for other types of cancer that occur more frequently. Refer to the Driving Question Board and focus on students' questions connected to the environment, and its possible link to cancer. Listen for responses such as: We need to look at things in the environment. We should look at things like smoking, the sun, or pollution" (Teacher Edition, page 142).
- Lesson 9: "Motivate an Investigation. Display slide J. Say, We noticed some interesting patterns regarding skin color, exposure to UV radiation from sunlight, and who tends to get skin cancer. It seems like we think there may be a connection between cancer and our environment, in this case exposure to the sun. One way to answer some of our questions and to gather more information is to conduct an investigation. Read the prompt on the slide and ask some students to share their ideas. If questions or ideas about using sunscreen or sunblock to protect against skin cancer came up earlier, resurface those now. Guide students to think about how we might investigate those questions as well" (Teacher Edition, page 144).
- Lesson 10: "Update Progress Tracker. Display slide M and Say[sic], I think it is time for us to keep a record of what we did today. Take out your Unknown material with identifier: bi.l1.ho2. Generate ideas for new investigations. Display slide N. Say, We have so many ideas to explore! How could we start to investigate the answers to some of these new and unanswered questions? Revisit your original Ideas for Investigations in your science notebook or title the next page in your science notebook 'Ideas for Investigations.' Choose one question or category of questions from our Driving Question Board and talk with a partner or partners near you to consider how we might find the answer—what investigation could we design, what data should we gather, and how could we figure this out in our classroom? Keep track of your ideas in your notebook. After you have discussed one question, move on to another. We will work for about three minutes, then we will share with the group. Accept all ideas and add them to the Ideas for Investigations chart paper. Student ideas may include the following: Thank students for sharing their ideas and tell them that the class will start the next lesson by thinking about medical treatments and other ways to treat cancer" (Teacher Edition, page 167).
- Lesson 11: "Review the Driving Question Board. Display slide A. Have students join a Scientists Circle with their science notebooks. Ask students to consider which group of questions they have already answered and which questions remain. Ask students to mark the questions with a check if they have been or can be and add a question mark if they are unanswered. Use the

following prompts as a guide: …Add any new questions to the DQB. Encourage students to write new questions on a sticky note and add them to the DQB" (Teacher Edition, page 173).

Student prior learning is used to motivate sense-making in the unit. Related evidence includes:

- Lesson 1: "Turn and Talk. Display slide D. Ask students to turn and talk to a neighbor about what they know about cancer. Remind them that they may have written about personal stories and feelings in their science notebooks and it is up to them to decide if what they share includes this. Let students know they will participate in a whole-class discussion where they share a summary of their conversation with their partner and they should make sure not to share anything their partner would prefer to keep private. Facilitate an Initial Ideas Discussion. Call on a few student pairs and ask them to share their ideas. Record these ideas on the whiteboard. Encourage students to build on each others' ideas using prompts such as, Did any pair discuss similar ideas? or Who can build on this idea?" (Teacher Edition, page 29).
- Lesson 2: "Before we do, let's take a minute to talk about what we already know about cells" (Teacher Edition, page 45).
- Lesson 3: "Stop and jot about how cancer cells form. Display slide B and ask students to stop and jot in their science notebooks about how non-cancer cells can turn into cancer cells. Then ask students to turn and talk to a partner about their ideas. Call on a few pairs to share their responses" (Teacher Edition, page 58).
- Lesson 4: "What do you already know about chromosomes?" (Teacher Edition, page 79).
- Lesson 9: "Introduce cancer statistics. Say, It sounds like you have some ideas about environmental conditions that might affect cancer. Display slide B and then slide C and read students the quotes about lung and skin cancer. Stop and Jot. Display slide D. Ask students to think about how smoking or sunlight might cause those cancers. Display the class consensus model from Lesson 7 and prompt students to review the mechanisms they figured out about mutations resulting in changes in DNA and protein. Give students a minute or two to write their ideas down in their science notebooks. Turn and Talk. Ask students to talk to their neighbors and share the ideas they have written down. Make sure each student has time to share. To help ensure equity, tell students to be prepared to share their partner's ideas with the class. Once partners have had time to share, call on a few pairs to share with the class. Listen for ideas such as the environment: could cause the mutations due to changes in the DNA sequence (bases). could change the shape of the protein. could make the DNA or proteins work differently. Consider adding sticky notes to the class consensus model to represent the ideas students have about what the mechanism could be" (Teacher Edition, page 142).
- Lesson 11: "Ask students to turn and talk to a partner about what they know about cancer treatments" (Teacher Edition, page 173).

Suggestions for Improvement

N/A

I.B. THREE DIMENSIONS

Inheritance and Variation of Traits

EQuIP RUBRIC FOR SCIENCE EVALUATION

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students have a chance to use grade-level-appropriate SEP, Crosscutting Concept (CCC), and Disciplinary Core Idea (DCI) elements throughout the unit. However, some claimed focus SEP and CCC elements are not adequately developed in the materials.

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

The reviewers found adequate evidence that students have the opportunity to use or develop the SEPs in this unit because while there is a strong match between SEP elements claimed and used throughout the materials, there are a few missed opportunities to develop some of the claimed SEP elements throughout the materials.

Asking Questions and Defining Problems

- This is identified as a focus SEP.
- *Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.*
  - This is identified as a SEP element which is intentionally developed within the unit.
  - Lesson 1: Students look at cancer data and fill out a notice wonder chart before engaging in a large group discussion. The following teacher guidance is provided: “Whole-group discussion. Display slide H. Facilitate a whole-group discussion to capture what students noticed and wondered about the data. Make a three-column chart on the board and ask small groups to share what they notice and wonder. Head each column with the following: Ideas We Agree On, Ideas We Disagree On, and New Ideas to Consider” (Teacher Edition, page 30). Students then complete the following Exit Ticket: “Exit Ticket. Display slide I. Ask students to turn to a new piece of loose-leaf paper in their science notebooks and answer the questions on the slide: What is one question that you have whose answer will help us make progress on our lesson question: Who gets cancer?” (Teacher Edition, page 31).
  - Lesson 1: “Identify gaps that the model cannot yet explain. Say, We have made great progress on our initial model to explain who gets cancer and why? We also have questions that we need to answer to make progress. Display slide V. Ask students to brainstorm in small groups a list of as many questions as they can think of that they would need to answer to make additional progress on the question Who gets cancer and why? Pass back the questions students identified on day 1 to remind students of the questions they had after investigating the data. Encourage them to include any of their

original questions that remain unanswered" (Teacher Edition, page 37). These questions are then used to make a DQB.
    - Lesson 8: While this SEP element is not explicitly claimed for this lesson, there is some opportunity for students to further develop this element. "What did we figure out in the last class? The more your cells divide the more chances you have for a mutation so older and taller people have more cancer. What questions do we still have? The mutations you accumulate in your lifetime only account for 66% of cancer, what else causes cancer?" (Teacher Edition, page 124).
    - While this is identified as a SEP element that is intended to be developed throughout the unit, no additional opportunities are claimed or provided for its development.
- *Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.*
    - This is identified as a SEP element that is intended to be developed within the unit.
    - Lesson 2: Students engage in a discussion about cells. Within the discussion the following teacher prompt is provided: "To figure out what cancer is, what questions do we need to answer about cells?" (Teacher Edition, page 46). However no specific guidance is provided to ensure questions can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources. In addition, the following guidance is provided in the assessment opportunity box:
      "What to look for/listen for in the moment: Questions (SEP: 1.6) that will help students investigate patterns (SEP: 1.6)
        - in cancer and non-cancer cells such as: What do cancer and non-cancer cells have in common?(DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
        - What differences are there between cancer and non-cancer cells across cell types?(DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
        - How do cancer cells look when they are in different cell types?(DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
        - Do cancer cells disrupt the cells in the different cell types?(DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
        - How does cancer disrupt the cells and the system? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)" (Teacher Edition, page 47).
  - Lesson 9: "Develop an investigative question. Support students to move from a general question, towards an experimental or investigative question. Distribute the Unknown material with identifier: bi.l9.ho1. Explain that scientists develop questions that they can test by collecting evidence about a phenomenon or problem. In order to do this, they need to know what to observe or measure that would answer their question. Tell students that the Unknown material with identifier: bi.l9.ho1 will help them develop an investigative, testable question which we will use to guide our next investigation" (Teacher Edition, page 146).
  - This unit does not address the second half of the element: "…*and, when appropriate, frame a hypothesis based on a model or theory."* This element is presented in full in the unit overview. However, in Lesson 2, this section is crossed out. It is unclear if this should be the case for the element for the entire unit.

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.*

- This is identified as a SEP element that is intended to be developed within the unit.
- Lesson 1: "Develop individual models. Say, We have figured out a lot about who gets cancer based on the data we investigated and in the article we just read. How can we begin to make sense of our developing ideas? Listen for students to share ideas related to developing models. Prompt them to think about the practices they used in previous units if they do not suggest modeling. Display slide Q. Ask students to take a few minutes to stop and jot their initial models in their science notebooks" (Teacher Edition, page 36). While there is no specific guidance provided to ensure the model is used to predict or illustrate the relationship between systems, teacher guidance is provided to look for these interactions and to probe students during creating their model. "Support individual students by asking probing questions about how the components of the models are related…Probe them to think about and represent the smaller-scale mechanisms that they cannot see in their models" (Teacher Edition, page 36). Students then review models to identify gaps and mark places where more information is needed before sharing their models with classmates. "Turn and talk about initial models. Display slide S. Ask students to take out their initial models and turn and talk to a partner about what their model explains and what additional information they still need to answer the question Who gets cancer and why? Let students know when half the allotted time has passed so that they each have time to share" (Teacher Edition, page 36). Students then develop small group models. "Develop small group models. Display slide T. Organize students into small groups of 3-4. Distribute whiteboards or chart paper and markers to each group and ask them to share their individual models one at a time. Students should look for the components and interaction that all or most of the models share as well as the unique features of the modes [sic]. They should come to consensus on what to include and develop a single group model. Revisit your classroom agreements and ask students to recall what equitable participation looks like in small groups" (Teacher Edition, page 37). Finally, students work as a class to develop an initial consensus model.
- Lesson 2: "Develop a model to explain: How does cancer make us sick? Use pictures, symbols, and words in your model to help explain your ideas. Pick one cell type and think about how the cells are organized as tissues -> organs -> systems -> organisms. How do the cancer cells interact in those levels? What effects do the interactions have on the whole system? What mechanisms explain those interactions?" (B.3 Lesson 2 Slides, Slide J).
- Lesson 3: Students play the Cell Game which acts a model to explain how cells divide. Students are provided with building understanding questions to complete in small groups after round 1. Students participate in a building understanding discussion. The following teacher guidance is provided: "Purpose of this discussion: To help students relate the steps in the game to the steps in the cell and to begin to build understanding about the role that p53 plays in controlling cell division. Listen for these ideas: Cells acquire resources such as nutrients, organelles, and chromosomes, which contribute to their growth. (DCI: LS1.B.1; CCC: 2.2) Once a cell has adequate resources, it divides via mitosis. (DCI: LS1.B.1; CCC: 2.2) At checkpoints, p53 regulates the cell cycle, making sure it has what it needs before it divides. (DCI: LS1.B.1; CCC: 2.2)" (Teacher Edition, page 61). Students then play a second round of the game to determine how cancer cells form. Students are asked the following questions: "1. What happened in Round 2 that was different from in Round 1?", "2. How did the differences change the outcome of the game?", "3. How was the role of p53 different?", and "4. How does this game help

answer the question, How do non-cancer cells become cancer cells?" (B.3 Lesson 3 Handout Round 2 Scorecard, pages 1–2).

- Lesson 5: Students use their Kinesthetic model to make a connection between the code in the DNA and the protein made. "What is the relationship between the DNA and the p53 protein? (SEP 2.3; DCI LS1.A.2; CCC 6.2)" (Teacher Edition, page 93).
- Lesson 6: The following information regarding use of this SEP is found in the Where We Are Going section of the lesson: "Students use the science practices developing and using models by developing a consensus models as a class where they establish connections between all of the components, interactions, and mechanisms that they had been investigating up to that point. Students review the ideas that they figured out from their Progress Tracker where they have to gather evidence from several different types of models that they have engaged in up to this point. Then they create a Gotta-Have-It Checklist as a way to include the necessary components, interactions, and mechanisms" (Teacher Edition, page 100).
- Lesson 6: Students create a class consensus model to explain the genetic basis of cancer based on the information they have gathered in the first five lessons. Students begin by working with a partner to create a "Gotta-Have-It Checklist. "Develop a Gotta-Have-It Checklist. Display slide C. Say, If we are going to make a detailed model to explain the genetic basis of cancer, we need to revisit what we have figured out. Have students title a new page Gotta-Have-It Checklist in their science notebook. Say, In your notebook, you will need a wide column on the left and 2 thinner columns on the right. The wide column should be titled 'What is the genetic basis of cancer?' The two right columns are 'Used' and 'Not Used.' You can check off which of these items were actually used in the model so that you can have them for updating the model later. Turn and Talk. Display slide D. Say, Working with your partner, go through your science notebook, use your Progress Trackers, and handouts and complete the first column on the Gotta-Have-It Checklist. We will complete the rest of this checklist later. The row for Lesson 2 is filled out for you. Give students a few minutes to complete the first column of their Gotta-Have-It Checklist. Please see the sample checklist below" (Teacher Edition, page 102). Students then work as a class to brainstorm components to develop their consensus model. While creating the classroom consensus model, teacher guidance is provided in the class discussion to ensure all components of the model are present. For example: "Ask students to recall what they figured out in Lesson 5. Listen for responses related to gene expression and how mutations in DNA lead to differently shaped proteins that do not have the same function. Say, How could this be represented in our model? Prompt students to explain their thinking in the context of p53. Listen for ideas about how p53 in the A or butterfly shape can attach to DNA and repair errors. Other versions of p53, which result from mutation, cannot perform this function. Add new components to the model" (Teacher Edition, page 106).
- Lesson 7: Students create an initial model that explains "Why are some kinds of cancer more common than others in older and taller people?" Students begin by brainstorming some ideas with a partner and then create an individual model. "Initial model construction. Display slide C. Have students individually develop initial models in their science notebooks that explain our lesson question: Why are some kinds of cancer more common than others in older and taller people? Remind students that models include components, interactions, and mechanisms. Let students know that since these are initial models, we are still determining all components and how they are related. Suggest adding question marks where they know something is happening but do not know what. Encourage them to refer back to their science notebook for ideas" (Teacher

Edition, page 113). Students then use an online simulation to further investigate why cancer might occur more frequently in older and taller individuals.
  - Lesson 10: Students develop a Gotta-Have-It Checklist individually to determine what should be included in their model to explain who gets cancer and why. Students work with a partner to create the checklist. “Turn and Talk. Display slide D. Say, Working with your partner, you will go through your science notebook, Progress Tracker, and handouts to complete the first row of the Gotta-Have-It Checklist. We will complete the rest of this checklist later. Give students a few minutes to complete the first column of their Gotta-Have-It Checklist. Please see the sample checklist below” (Teacher Edition, page 161). Students then work in small groups to create a consensus model. “Develop a small group consensus model. Display slide E. Organize students into small groups of 3-4. Have students bring their science notebooks and their completed Gotta-Have-It Checklists with them to their group. Provide each group with materials for developing their model and ask them to explain Why do people in different groups and places get cancers at different rates?” (Teacher Edition, page 163). Once students create their small group models, they create a consensus model as a class.
  - Lesson 11: Students revisit the Cell Cycle game in small groups and add cards to represent the cancer treatment options. “Revisit the Cell Cycle Game. Say, Now that you have some ideas about how treatment affects how cancer cells grow and divide, what tools have we used to model cell division that could help us investigate this? Listen for students to recall the Cell Game from Lesson 3. Display slide J. Remind students of the set up of the Cell Game. Ask students to generate ideas about how they can use the Cell Game model to predict how cancer treatments work. Listen for students to share ideas about where, when or how the treatments could be added to the game. Add treatment options to the game. Explain to students that they will use what they now know about treatment options to add treatments to the game. They will write a card for each treatment and will have to use evidence from the reading to determine where the card will be added to the game and what action it will ask players to take. Display slide K. Distribute a copy of Game Card Template to each group and ask each group to develop their game cards. Students will need to use information from DNA and p53 to figure out where in the cell cycle the game cards should be placed and what the actions will be” (Teacher Edition, page 176).
- *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 is identified as a SEP element that is intended to be developed within the unit.
  - Lesson 3: Students use the Cell Game, cell images, a model showing the amount genetic material in the cell, and an M-phase card sort to further develop their explanation for why cancer cells form. Students use a T-chart in their notebook to compare the three models and how they relate to the Cell Game. However, there is no consideration of the merits and limitations of the different types of models.
  - Lesson 6: Although this specific SEP element is not claimed in the lesson, the following additional teacher guidance is provided while students brainstorm components for their classroom consensus model: “Students will participate in the development of the class consensus model based on evidence they have collected in Lesson Set 1 to illustrate the genetic basis of cancer. The evidence they have collected is from multiple types of models including computer simulations, kinesthetic simulations, and a game model. Ask students to consider the merits and limitations of each of these types of models” (Teacher Edition, page 103).

- Lesson 8: Students model the inheritance of the p53 gene in a family with a history of Li-Fraumeni Syndrome but recognize the limitations of this model since it is unable to model the inheritance of p53 and BRCA1 genes for a different pedigree. Students create a new model using crossing over to explain the p53 and BRCA1 pedigree.
- Lesson 8: The key for the Electronic Exit Ticket claims that three of the questions align with this SEP element. Q1 and Q4 do not expect students to consider multiple models. In answering Q5, students consider multiple models, but they do not evaluate the merits and limitations of those models.
- While this is identified as a SEP element which is developed throughout the unit, no additional opportunities are claimed or provided for its development.

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.*
  - This is identified as a SEP element that is key to sense-making in the unit.
  - Lesson 4: Students construct an explanation to answer the lesson questions, how do cancer cells end up with differences in their chromosomes and what is the role of the p53 gene in preventing the differences? Students use evidence from a game, a computer simulation, and a reading as sources for their explanations. Students work to develop a checklist of what should be included in the explanations which is revised when new information is received. "Introduce the reading. Say, We have a lot of great evidence from our simulation and other activities from the unit. I heard you identify places where you need additional information and I have a reading that I think will help you fill in some of the gaps in evidence that you identified on the checklist. Display slide O and distribute DNA and Chromosomes to each student. Give students time to read individually using whatever reading strategy is in place in your classroom. Add evidence from the reading to the Gotta-Have-It Checklist. Display slide P. Organize students into small groups of 3-4. Challenge each student to choose a piece of evidence from the reading that they think will address the needs they identified on the checklist. They should discuss that evidence with the group, get feedback and revise what they include in the checklist based on the small group discussion" (Teacher Edition page 84). During the computer simulation, students are asked, "The processes modeled in the simulation were explained by scientists in the 1950s and have been observed and documented in cells many times since. How does this information affect how you think about the model you worked with in class today?" (Simulation Guidance Handout). Students are supported to revise their explanations based on feedback. Students are then provided with an opportunity to give and receive peer feedback before revising their explanation. "Revise explanations using peer feedback. Display slide S. Then, provide students with time to revise their explanations using the feedback from their peers. Some students may have minor revisions that can be completed on their original explanation while others may need a new piece of loose-leaf paper to rewrite their explanation. When students are finished, collect their peer feedback, initial draft (if on separate loose-leaf), and their revised explanation" (Teacher Edition, page 85).
- *Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.*
  - This is identified as a SEP element that is key to sense-making in the unit.

- Lesson 12: After exploring data on social determinants for health, students brainstorm a list of possible solutions. After engaging in a classroom discussion about possible solutions, the following teacher guidance is provided to guide students to further explore one of the possible solutions which is focused on helping loved ones navigate the healthcare system. "How we help our loved ones navigate the healthcare system. Display slide U. Say, You all have a lot of ideas about solutions. I heard of something called health navigators that might be a solution that includes a lot of your ideas. This can be a role that you can take on for family or a close friend. Explain that health navigators are people who help educate patients and their families, schedule and provide transportation, and ask questions of healthcare providers. Let students know that in order to be a navigator a person needs a lot of information both from the person they are supporting and the health care providers they see. Say, How do you think the role of health navigator fits into the overall healthcare system?" (Teacher Edition, page 190). Students use what they have learned throughout the unit to develop interview questions which can be used to help understand family and friend's cancer needs. "Introduce the interview protocol. Display slide Y. Say, We will be working to create an interview protocol to understand our family or friend's cancer and needs in our preparation to support them as an effective health care navigator for a loved one who is visiting a doctor about a disease with a genetic component. Distribute Designing Interview Protocols. Consider using the Gotta-Have-It Checklist to complete an example row in the interview protocol together as a class. Say, You will complete the Interview Protocols handout. For each question, say what you hope to learn and why you are asking it. When developing your justification for why it is important to ask each question you propose, draw on what you have learned in this unit about genetics. Also, draw on what you have learned about how both disease and healing from disease are shaped by genetics and the environment" (Teacher Edition, page 194). While this is used as a potential solution, unanticipated effects are not considered. In addition, students are not guided to apply scientific ideas, principles, and/or evidence.

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.*
    - This is identified as a SEP element that is key to sense-making in the unit.
    - Lesson 9: After collecting their data, students are asked to answer the following questions: "1. Looking at the class data, what patterns do you notice? 2. How does the class data compare to the scientific study we investigated Skin Cancer Data. 3. Make and defend a claim based on evidence to respond to your investigative question. 4. Do you have enough evidence to say that the variable you investigated caused the change you observed? Explain your thinking" (B.3 Lesson 9 Handout Data Collection, page 2).
    - Lesson 10: The following question is found on the transfer task "Currently Victoria's risk is low; however, it is possible for Victoria to be diagnosed with AMD later in life. Choose one of the claims below. Support this claim with evidence that could explain how Victoria could get AMD. 3. Circle one: Claim 1: Victoria gets AMD caused by random mutation Claim 2: Victoria gets AMD caused by exposure to the environment. Provide evidence to support your claim below. Use pictures and/or words" (Lesson 10 Assessment Genetics Transfer Task Teacher Edition, pages 2–3). However, student-generated evidence is not used.
    - Lesson 10: The following instruction is found on the transfer task: "4. While these factors are correlated with AMD, we do not have evidence that they cause or prevent

AMD. Choose the evidence below that would best support the following claim: Diet causes AMD. A. Data that shows how the ages of people are in each country. B. Data that show the mechanism that causes the interaction between AMD and diet. C. Data that shows how many people live in each country. D. Data that shows what people eat in each country" (B.3 Lesson 10 Assessment Genetics Transfer Task, page 3). However, student-generated evidence is not used.

- Lesson 12: "Let them know that you will ask them to read one of the summaries and then share what they figure out about the relationship between where you live, your health and how location impacts cancer care. Say, As you read the studies, think about what evidence supports the claim that this social determinant matters for who gets cancer treatment? What evidence is there that this social determinant matters for health equity? What evidence is there that this social determinant is a constraint for cancer treatment and health equity?" (Teacher Edition, page 188). "As you examine the summaries of research, consider: What evidence supports the claim that this social determinant matters for who gets cancer treatment? What evidence is there that this social determinant matters for health equity? What evidence is there that this social determinant is a constraint for health equity and treatment?" (B.3 Lesson 12 Slides, Slide O). While students find evidence to support a given claim, students do not make a claim themselves.

Obtaining, Evaluating, and Communicating Information

- *Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.*
    - This is identified as a SEP element that is key to sense-making in the unit.
    - Lesson 5: Students participate in a kinesthetic model of protein synthesis to gain an understanding of the process. After completing questions related to the model, students engage in a reading for further learning. "Introduce a reading. Display slide L. Pass out DNA and p53. Say, I have a reading that can help you answer some of your questions. Give students several minutes to read and annotate individually using whatever reading strategy is in place in your classroom. Small group sensemaking about the reading. Say, Based on the reading, what would you like to add to our mapping tool? Organize students into small groups of 3-4 and give them time to fill in the last two columns of the mapping tool in Kinesthetic Model using the heading from slide M as a guide" (Teacher Edition, page 93). The following additional teacher guidance is provided: "Use this opportunity to make explicit the benefits and limitations of using physical/kinesthetic representations and informational text as sources of information for answering questions. Ask students to think of the benefits and limitations as you are mapping the model to the system. Benefits of the kinesthetic model might include being able to simulate cellular processes without microscopes and other technology. A limitation might include that other factors are not accounted for in the simulation or that we are not using real cells. The informational text may provide information about how the components of the model function in the real world" (Teacher Edition, pages 93–94).
- *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 (e.g., orally, graphically, textually, mathematically).*
    - This is identified as a SEP element that is key to sense-making in the unit.

- Lesson 11: Students watch interviews with Lakita and Lauren discussing their cancer treatments. “Share interviews with Lakita and Lauren describing their cancer treatments. Let students know that you will share additional pieces of the interviews with Lakita and Lauren. Say, As we watch the video, complete the Notice and Wonder chart, paying particular attention to personal accounts of costs, access to treatment, treatment process, decisions that have to be made, and any recommendations. Remind students that in Lesson 8 we added a column to capture feelings that the video brings up. Encourage students to capture their feelings in this space. Display slide E and play the video. After watching the video, call on a few students to share with the class. See sample student responses in the table below” (Teacher Edition, page 174). Students then investigate cancer treatments through readings and record their notes in an organizer. For each treatment, the organizer has them note the mechanism, side effects, costs, and other considerations. Students then build a class organizer. “Build a class organizer. Display slide G. Assign each group, pair, or individual student to be responsible for a row or cell in the organizer depending on the size of your class. Try to ensure that everyone has a role. Create a class organizer on the whiteboard, chart paper, or other public space in your classroom for students to contribute to. As each member of the class shares, press for an understanding of the following: How does the treatment disrupt the cell cycle for cancer cells? How do disruptions to non-cancer cells lead to side effects at the cellular and system levels? What additional considerations are there? Revise individual organizers. Give students an opportunity to revise their organizers following the class build” (Teacher Edition, pages 174–175). While students build their ideas both individually, in small groups, and as a class, it is not clear that multiple formats are used when communicating the information.

Disciplinary Core Ideas (DCIs) | **Rating: Adequate**
The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit because most of the DCI elements claimed are used and developed. However, some elements are not completely addressed.

LS1.A: Structure and Function

- *Systems of specialized cells within organisms help them perform the essential functions of life.*
  - This is identified as a focal DCI element within the unit.
  - Lesson 1: The Where We Are Going section in this lesson notes the following related to this DCI element: “Student questions will set the stage for figuring out DCI HS LS3.B.2 Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. And HS LS 1.A.1 Systems of specialized cells within organisms help them perform the essential functions of life” (Teacher Edition, page 27). It is not, however, made clear how student questions will lead to these DCI elements.
  - Lesson 2: Students engage in a cancer reading. In the reading the following information is provided: “Cells are usually found in groups that work together to do the same function. When these groups of cells work together, they form a tissue. Tissues that work together to perform the same function form an organ. Organs work together in systems to support the functioning of the whole organism. What does an example look like? For example, cells known as epithelial cells come together to form epithelial tissue. This tissue makes up the lungs. The lungs are in the respiratory system. The respiratory system, which includes the lungs, airways, and blood vessels, works with the circulatory

system to get oxygen into the body and remove carbon dioxide from the blood in an animal" (B.3 Lesson 2 Reading Cancer, page 1). Information in the reading is more closely aligned to the following Grade 6–8 element: *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.*
  - Lesson 6: While this DCI element is claimed in the materials, specific evidence of its development or use was not found.
- *All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.*
  - This is identified as a focal DCI element within the unit.
  - Lesson 5: Students engage in a building understanding discussion after completing the kinesthetic model and reading. Teacher prompts are provided to guide the discussion. In addition, the following information is provided: "Purpose of this discussion: To support students in building an understanding about how DNA codes for protein and how mutations can impact the structure and function of proteins. Listen for these ideas: The differences in DNA sequences created the different forms of p53. The words (amino acid sequences) were sometimes different, even when the DNA sequence was the same. There were mistakes in the process that represent mutations" (Teacher Edition, page 95).
  - Lesson 6: The class develops a checklist of important ideas from previous lessons to consider in developing a model of the genetic basis of cancer. "Lesson 5: A mutation in DNA causes changes in protein structure which could change the function of the protein. A mutation in p53 DNA causes a change in the p53 protein which changes the function of p53. If p53 fails, then cancer will result" (Teacher Edition, page 102).
  - While the relationship between the structure of the protein and a cellular process is addressed, the ideas that all cells contain genetic material in the form of DNA molecules and proteins carry out most of the functions of cells is not fully explored.
- *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.*
  - This is identified as a focal DCI element within the unit.
  - Lesson 2: Students engage in an initial discussion about cells. Teacher guidance is provided regarding the purpose of the discussion. "Purpose of this discussion: To elicit student ideas to identify productive ideas that students can build on as well as areas where students may need additional support. Listen for these ideas: All cells have some common features like a cell membrane. In our bodies, cells are specialized for particular functions. Similar cells group together to form tissues or organs" (Teacher Edition, page 46).
  - Lesson 2: The following teacher guidance is provided: "As students voice prior understandings about cells they may use terms such as tissue, organ, and body systems. These terms can help students think about hierarchical organization, where cells make up tissues and tissue makes up organs and organ systems as part of an organism. When this happens, pause to let students know that they are describing what scientists call hierarchical organization and give them an opportunity to co construct this definition. Once they come to consensus, give them an opportunity to add it to their personal glossary" (Teacher Edition, page 47).
  - Lesson 2: Students engage in a cancer reading. In the reading the following information is provided: "Cells are usually found in groups that work together to do the same

function. When these groups of cells work together, they form a tissue. Tissues that work together to perform the same function form an organ. Organs work together in systems to support the functioning of the whole organism. What does an example look like? For example, cells known as epithelial cells come together to form epithelial tissue. This tissue makes up the lungs. The lungs are in the respiratory system. The respiratory system, which includes the lungs, airways, and blood vessels, works with the circulatory system to get oxygen into the body and remove carbon dioxide from the blood in an animal" (B.3 Lesson 2 Reading Cancer, page 1).
    - Lesson 6: Although the sample consensus model in the Teacher Edition (page 106) shows a slight connection to this element, (Cancer Cells > > Tumors Invade Tissues > > Sick), students do not use or develop this element in this lesson.

LS1.B: Growth and Development of Organisms

- *In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.*
    - This is identified as a focal DCI element within the unit.
    - Lesson 3: Students play the Cell Game which acts a model to explain how cells divide. Students are provided with building understanding questions to complete in small groups after round 1. Students participate in a building understandings discussion. The following teacher guidance is provided: "Purpose of this discussion: To help students relate the steps in the game to the steps in the cell and to begin to build understanding about the role that p53 plays in controlling cell division. Listen for these ideas: Cells acquire resources such as nutrients, organelles, and chromosomes, which contribute to their growth. (DCI: LS1.B.1; CCC: 2.2) Once a cell has adequate resources, it divides via mitosis. (DCI: LS1.B.1; CCC: 2.2) At checkpoints, p53 regulates the cell cycle, making sure it has what it needs before it divides. (DCI: LS1.B.1; CCC: 2.2)" (Teacher Edition, page 61). After this discussion students are introduced to the cell cycle and watch a video of cell division. The following teacher guidance is provided: "Students may also have heard the term mitosis and may bring it up here. They may notice it in the figure on slide H. When students bring this up, pause to co-construct an initial definition. Students will add to this definition later in the lesson. Definitions may look something like: A series of steps that result in two cells [they may or may not have ideas about them being identical] from one" (Teacher Edition, page 62). The following parts of the element are not claimed in this lesson, and as such are not addressed: *The organism begins as a single cell (fertilized egg) that divides successively to produce many cells... Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism."*
    - Lesson 6: Students create a classroom consensus model. The following is provided as teacher guidance as to what to look for in the Gotta-Have-It Checklist: "Lesson 3: Cells grow and repair in the cell cycle when one cell forms two new cells. p53 maintains the checkpoints in the cell cycle by checking to make sure that the cell has enough nutrients and resources. If cells skip checkpoints, they will develop cancer. Cancer cells have differences in their chromosomes" (Teacher Edition, page 102). The following part of the

DCI element is claimed but not used by students in this lesson: *The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells.* The part of the element related to differentiation is not claimed or addressed in this lesson.

- Lesson 7: Students use an online simulation to gather evidence to figure out why cancer is more frequent in older and taller individuals. The simulation shows cell division in multiple cell types, however, the part of the element that states, "*cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism"* is specifically claimed in this lesson but evidence of its development or use was not found in this lesson.
- Lesson 11: Students revisit the Cell Cycle game in small groups and add cards to represent the cancer treatment options. "Revisit the Cell Cycle Game. Say, Now that you have some ideas about how treatment affects how cancer cells grow and divide, what tools have we used to model cell division that could help us investigate this? Listen for students to recall the Cell Game from Lesson 3. Display slide J. Remind students of the set up of the Cell Game. Ask students to generate ideas about how they can use the Cell Game model to predict how cancer treatments work. Listen for students to share ideas about where, when or how the treatments could be added to the game. Add treatment options to the game. Explain to students that they will use what they now know about treatment options to add treatments to the game. They will write a card for each treatment and will have to use evidence from the reading to determine where the card will be added to the game and what action it will ask players to take. Display slide K. Distribute a copy of Game Card Template to each group and ask each group to develop their game cards. Students will need to use information from DNA and p53 to figure out where in the cell cycle the game cards should be placed and what the actions will be" (Teacher Edition, page 176). Although claimed in the lesson, students do not use the following part of the DCI element: *Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.* The following parts of the element are not claimed in this lesson, and as such are not addressed: *The organism begins as a single cell (fertilized egg) that divides successively to produce many cells... Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.*

LS3.A: Inheritance of Traits

- *Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.*
    - This is identified as a focal DCI element within the unit.
    - Lesson 5: Students engage in a building understanding discussion after completing the kinesthetic model and reading. Teacher prompts are provided to guide the discussion. In addition, the following information is provided: "Purpose of this discussion: To support students in building an understanding about how DNA codes for protein and how

mutations can impact the structure and function of proteins. Listen for these ideas: The differences in DNA sequences created the different forms of p53. The words (amino acid sequences) were sometimes different, even when the DNA sequence was the same. There were mistakes in the process that represent mutations" (Teacher Edition, page 95). Specific information related to gene expression regulation and parts of DNA not coding for protein was not found.

LS3.B: Genetic Variation

- *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.*
    - This is identified as a focal DCI element within the unit.
    - Lesson 4: Students engage in an initial ideas discussion. Teacher prompts are provided to guide the discussion to align with the following guidance: "Purpose of this discussion: Elicit student ideas about the relationship between DNA and what happens during the S phase of mitosis. Listen for these ideas: Chromosomes are made of DNA. Chromosomes/DNA get made or copied during the S phase of mitosis. Non-cancer cells have identical chromosomes at the end of mitosis. Cancer cells have differences in their chromosomes. Some kind of mistake (mutation) happens that makes them different" (Teacher Edition, page 79). Students then complete an online simulation showing DNA replication and the role of p53. Students also complete a reading which outlines the role of DNA and chromosomes and the process of DNA replication. The following is found in the reading: "Occasionally, there are mistakes in this copying process. These are known as mutations. In the simulation, you saw evidence of a type of mutation called a substitution. Whenever there are changes to the DNA, there are changes in the chromosomes that end up in the new cells that form after replication" (B.3 Lesson 4 Reading DNA and Chromosomes, page 2). The following parts of the element are not claimed in this lesson, and as such are not addressed: *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation... Environmental factors can also cause mutations in genes, and viable mutations are inherited.*
    - Lesson 7: Students complete an online simulation which simulates cell divisions of various cell types to figure out why cancer is more common in older and taller individuals. In the simulation, mutations are tracked as part of the data collected. As part of the building understanding discussion, the following is identified as a purpose of the discussion: "Cells that divided more often had more mutations than those that divided less often" (Teacher Edition, page 115). In the reading, the process of crossing over is presented. "The X-shaped chromosomes line up in the middle of the cell. At this point, the pairs are lined up together. This means that all the copies of chromosome 1 are together, all of the copies of chromosome 2 are together, and so on. Here, a process called crossing over happens, where the pairs come together and swap chromosome sections. This process introduces additional variation in the chromosomes and the gametes. Crossing over also helps to stabilize chromosomes during meiosis, ensuring that each resulting germ cell has the correct number of chromosomes. The swapping of chromosome sections that occurs during meiosis can also repair mutated DNA in the chromosomes. (Saponaro, 2010) See the swapping of dark and light gray replicated chromosomes in the image" (B.3 Lesson 8 Reading Inheritance, pages 1–2).

  - Lesson 8: Students read an article, "Inheritance" which describes the process of meiosis. Students model the process of meiosis with pipe cleaners, including mutations. During a class discussion, students are asked, "How is additional variation introduced to gamete cells?" (Student Procedure Handout).
  - Lesson 10: The sample Gotta-Have-It Checklist includes the following ideas which should be included in the class consensus model: "Crossing over happens during meiosis randomly causing mutations and genetic variation", and "UV radiation can cause mutations in DNA that can cause cancer. Mutations from radiation can change the protein structure and function leading to cancer" (Teacher Edition, page 162).
  - Lesson 10: The following questions are found on the transfer task: "Without mutation or crossing over, write the combinations of Lactase and Celiac that José could inherit from his parents. 2. José's doctor tells him that he has inherited BOTH Celiac 4 and Lactase 2. Explain using pictures and/or words what could have caused this" (B.3 Lesson 10 Assessment Genetics Transfer Task, page 2).
- *Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.*
  - This is identified as a focal DCI element within the unit.
  - Lesson 1: Students look at cancer data, including maps which show cancer incidence and geographic location. "Share data related to cancer incidence and geographic location. Display slide G. Allow students to look at the map for a minute and stop and jot what they notice before asking them again to turn and talk with their partners. Encourage students to keep track of their thinking in their science notebooks. Call on a few pairs to share what they notice and wonder about the map. Listen for ideas related to differences in cancer rate based on geographic location. Students should notice that the incidence of cancer is not the same in all of the states and wonder why that is the case" (Teacher Edition, page 30).
  - Lesson 9: Students conduct an investigation and engage in a reading to determine the effect of UV radiation on skin cancer. After both of these are concluded, the class participates in a building understanding discussion. The following teacher guidance is provided: "Purpose of this discussion: To build understanding of the mechanism of DNA damage caused by UV radiation, and the protective role of melanin in skin cancer. Listen for these ideas: UV radiation contains energy that causes changes in our DNA. The energy changes one base (C) into another base (T). When this happens, proteins with different amino acids may result, thus changing the structure and function of the protein. A change in the structure and function of p53 in skin cells contributes to a greater likelihood of developing skin cancer. Melanin protects DNA from UV radiation by absorbing its energy and releasing it as heat" (Teacher Edition, page 153).
  - Lesson 12: Students look at cancer incidence and mortality data from different areas. "Review national cancer incidence and mortality data. Display slide D. Ask students to review the maps in National Cancer Data in small groups. Distribute Calculating Survival Rates and ask students to calculate the mortality and survival rate for sample states and other states they are interested in and answer the questions. Display slide E. Once students have had a chance to discuss and record their answers, call on a few groups to share their thinking. Draw on examples that students shared in the whole-class discussion. For example, in some states, like Montana, the survival rate is 68%. In other states, survival rates are different. Encourage students to look carefully at the differences between rates of new cancers and rates of death" (Teacher Edition, page

185). Students then engage in an initial ideas discussion. The following teacher guidance is provided: "Purpose of the discussion: To help students grapple with national cancer data as evidence that geography in fact impacts a person's ability to be diagnosed and survive cancer. Listen for these ideas: Some states have high incidence rates, but high survival rates. Some states have low incidence rates, and they have high survival rates. Some states have high incidence rates and low survival rates. For cancer incidence and survival, it seems to matter what state you live in" (Teacher Edition, pages 183–184). Later in the lesson, students are asked to brainstorm what might lead to these differences. "Stop and Jot. Display slide I. Ask students to summarize what they figured out about differences by state in cancer occurrence and mortality and to brainstorm a list of ideas of additional factors, beyond cost and access that could contribute to these differences" (Teacher Edition, page 186).

ETS1.B: Developing Possible Solutions

- *When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.*
  - This is identified as a focal DCI element within the unit.
  - Lesson 11: Students watch interviews with Lakita and Lauren discussing their cancer treatments. "Share interviews with Lakita and Lauren describing their cancer treatments. Let students know that you will share additional pieces of the interviews with Lakita and Lauren. Say, As we watch the video, complete the Notice and Wonder chart, paying particular attention to personal accounts of costs, access to treatment, treatment process, decisions that have to be made, and any recommendations. Remind students that in Lesson 8 we added a column to capture feelings that the video brings up. Encourage students to capture their feelings in this space. Display slide E and play the video. After watching the video, call on a few students to share with the class. See sample student responses in the table below" (Teacher Edition, page 174). Students then investigate cancer treatments through readings and record their notes in an organizer. For each treatment, the organizer has them note the mechanism, side effects, costs, and other considerations. While it is possible that safety, reliability, social, cultural, and environmental impacts will be considered, no specific guidance is provided to ensure they will be addressed.
  - Lesson 12: Students consider possible solutions to address a constraint of social determinants of health and why they could be effective solutions. "Develop a list of possible solutions. Display slide R. Say, You all have done a great job with thinking about all of these bigger systems that have bigger impacts on our health than the parts that we can actually control. Let's use what we know to propose some solutions to the constraints that these social determinants of health have on cancer treatment and survival. Have students work in pairs and record their ideas in their science notebooks. Share possible solutions. Call on volunteers to share their ideas. Record some of their ideas on the whiteboard to compare with the list of solutions that you are going to offer them. Display slide S. Say, There are some groups who have also been thinking about these ideas as well and have come to some of their own conclusions. The ideas on the slide are from the American Society for Clinical Oncology. Ask students to review the solutions on the slide. Say, How do our ideas compare to their ideas? What are some considerations that we made that they did not? Remember this is not a complete list but we can see if we are on the right track. Exit ticket. Display slide T. Ask students to complete an exit ticket where they write down the number of the solution they think

they would be most likely to be able to help with personally and why" (Teacher Edition, page 189).

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

The reviewers found adequate evidence that students have the opportunity to use or develop the CCCs in this unit because while there is a strong match between SEP elements claimed and used throughout the materials, there are few opportunities to develop some of the claimed CCC elements throughout the materials.

Patterns

- *Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.*
  - This is identified as a CCC element which is key to sense-making in the unit.
  - Lesson 2: Students engage in a discussion about cells. Within the discussion the following teacher prompt is provided: "To figure out what cancer is, what questions do we need to answer about cells?" (Teacher Edition, page 46). While the following guidance is provided in the assessment opportunity box, specific student-facing teacher prompts are not provided to connect student questions to patterns or to have students ask questions which have students look at patterns at different scales:
    "What to look for/listen for in the moment: Questions (SEP: 1.6) that will help students investigate patterns (SEP: 1.6)
      - in cancer and non-cancer cells such as: What do cancer and non-cancer cells have in common? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
      - What differences are there between cancer and non-cancer cells across cell types? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
      - How do cancer cells look when they are in different cell types? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
      - Do cancer cells disrupt the cells in the different cell types? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)
      - How does cancer disrupt the cells and the system? (DCI: LS1.A.1 & LS1.A.3; CCC: 1.1)" (Teacher Edition, page 47).
  - Lesson 2: Students fill out a notice and wonder chart to look for similarities and differences between normal and cancer cells. The following teacher prompts are provided to engage students in a discussion: "What similarities and differences did you notice?", "What is the relationship between cancer cells and non-cancer cells in the different cell types?", "At which levels of organization did we gain understanding about cancer?", and "What levels do we still need more information about?" (Teacher Edition, page 48).

Cause and Effect

- This is identified as a focus CCC.
- *Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.*
  - This is identified as a CCC element that is intended to be developed within the unit.
  - Lesson 9: After collecting their data, students are asked the following questions: "1. Looking at the class data, what patterns do you notice? 2. How does the class data compare to the scientific study we investigated Skin Cancer Data. 3. Make and defend a

claim based on evidence to respond to your investigative question. 4. Do you have enough evidence to say that the variable you investigated caused the change you observed? Explain your thinking" (B.3 Lesson 9 Handout Data Collection, page 2). The following additional teacher prompts are provided to help students with development of this element: "Defining causation. Display slide BB. Explain that scientists often investigate whether two things are connected in some way, that one has something to do with the other. However, sometimes scientists want to know more than whether two things are connected (correlation), they want to know if one thing actually may cause the other to occur (causation). Say, In order for scientists to determine whether something is a cause, they need to have empirical evidence. This type of evidence often comes from the documentation of observations, patterns, and data collected through investigation. Co-construct a definition for causation. Call on a few students to contribute their ideas for a definition of causation and create a public record on the whiteboard of chart paper. Prompt students work together with their group to complete the remaining Making Sense questions" (Teacher Edition, pages 153–154).

- Lesson 10: Three of the questions on the transfer task involve thinking about cause and effect. "2. José's doctor tells him that he has inherited BOTH Celiac 4 and Lactase 2. Explain using pictures and/or words what could have caused this. The child inherits half their genetic material from each parent. One chromosome came from the mom. Eggs from the mom could only have a chromosome with alleles 1 and 3. One chromosome also came from the dad. Sperm from the dad could have four different possibilities: alleles 1 and 4 or 2 and 3 (like dad's chromosomes) or 2 and 4 or 1 and 3 if crossing over occurs during meiosis. 3. Circle one: AMD. Victoria gets AMD caused by random mutation. Claim 2: Victoria gets AMD caused by exposure to the environment. Provide evidence to support your claim below. Use pictures and/or words 4. While these factors are correlated with AMD, we do not have evidence that they cause or prevent AMD. Choose the evidence below that would best support the following claim: Diet causes AMD. A. Data that shows how the ages of people are in each country. B. Data that show the mechanism that causes the interaction between AMD and diet. C. Data that shows how many people live in each country. D. Data that shows what people eat in each country" (Teacher Edition, pages 263–265). It is unclear if students use the knowledge of the difference between correlation and causation in this task.
- While this is identified as a CCC element which is developed throughout the unit, no additional opportunities are claimed or provided for its development.

- *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.*
  - This is identified as a CCC element that is intended to be developed within the unit.
  - Lesson 1: Students create initial models to explain who gets cancer based on the data and the article they have read. The following teacher guidance is provided for interpreting their model: "Support individual students by asking probing questions about how the components of the models are related. Focus on the language of cause and effect, such as What do you think the cause of cancer is for taller or older people? What effect might where you live have on incidence of cancer? Probe them to think about and represent the smaller-scale mechanisms that they cannot see in their models" (Teacher Edition, page 36).
  - Lesson 2: Students are asked to individually develop models to explain how cancer causes illness. "Develop individual models. Display slide J and ask students to develop an

initial model in their science notebooks to explain how cancer makes us sick.✱= Encourage them to choose a single cell type from the images previously investigated and to consider how the cancer cells will interact with the non-cancer cells in the system" (Teacher Edition, page 48). The following guidance is provided on the accompanying slide to encourage cause and effect thinking: "Use pictures, symbols, and words in your model to help explain your ideas. ● Pick one cell type and think about how the cells are organized as tissues -> organs -> systems -> organisms. ● How do the cancer cells interact in those levels? ● What effects do the interactions have on the whole system? ● What mechanisms explain those interactions?" (B.3 Lesson 2 Slides, Slide J).

- Lesson 3: Students investigate processes within the cell that can form cancer cells. "Purpose of this discussion: To help students relate the Cellular Chance cards in the game (SEP: 2.3) to a disruption to the cell cycle that can cause cancer cells to form. Listen for these ideas: When p53 was working properly in the cell cycle, cells that did not have all of the requirements could not pass the checkpoints and divide. (DCI: LS1.B.1; CCC: 2.2) When the cell cycle is not working properly, cells can pass checkpoints without meeting the requirements. (DCI: LS1.B.1; CCC: 2.2) If a cell that does not have all the resources it needs and divides anyway, it can form a cancer cell. (DCI: LS1.B.1; CCC: 2.2)" (Teacher Edition, page 65).
- Lesson 4: Student explanations include the cause of differences in chromosomes due to smaller scale mechanisms of base pairing in DNA replication and the occurrences of mutations via substitutions and the role of p53 in correcting mutations.
- Lesson 6: Students brainstorm components for the classroom consensus model. The following additional teacher guidance is provided: "SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT Although students are working with cause and effect elements related to small scale mechanisms in this lesson, encourage them to recognize that we identified the need to establish empirical evidence to support our claims. Ask them to revisit their definition of empirical evidence from Lesson 1 and look for examples of the use of empirical evidence in the class consensus model", "SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT Students will explain the cause-and-effect relationship between mutations in DNA and the structure and function of proteins by looking at small scale changes such as changes in bases in DNA lead to changes in amino acids which change the structure and function of the protein. In this case, if p53 is not able to attach to the DNA strand because of a change in shape, then it can not[sic] repair the DNA which will lead to cancer" (Teacher Edition, page 104).
- Lesson 7: After using the computer simulation, the discussion asks questions relating to cause and effect by looking at changes within the cell. "*What did you notice about the mutation rate of different types of cells*? The cells that divided more frequently had more mutations, and the cells that divided less frequently had fewer mutations. *How do these mutations relate to cancer?* After the cells had a lot of mutations, they sometimes got cancer. This happened more frequently in tall, older people. Most of our positive cancer results happened in older people. As they got older, they accumulated more mutations per cell" (Teacher Edition, page 115).
- Lesson 8: "Use of pipe cleaners and beads to show meiosis including crossing over as a mechanism for creating sperm with chromosomes that could produce offspring with different phenotypes than their parents. (SEP: 2.4; DCI: LS3.B.1; CCC: 2.2)" (Teacher Edition, page 134) The class engages in a discussion of the investigation. "*What effect*

does crossing over have on genes and alleles on chromosomes? Crossing over produced chromosomes with the same number of genes. The genes on the chromosomes stayed the same The[sic] alleles got mixed up. New combinations of alleles were made that were not present in the dad's chromosomes. In the dad, all cancer-associated alleles (B and D) were on the same chromosome. After meiosis and crossing over, some cancer-associated alleles were on a chromosome with non-cancer-associated alleles" (Teacher Edition, page 135).

- Lesson 8: The following question is found on the Electronic Exit Ticket: "How did examining what is happening at the scale of chromosomes and genes help you make sense of why inheritance causes some cancers to run in families over multiple generations?" (B.3 Lesson 8 Answer Key Electronic Exit Ticket, page 7).
- Lesson 9: The following teacher guidance is provided: "Defining causation. Display slide BB. Explain that scientists often investigate whether two things are connected in some way, that one has something to do with the other. However, sometimes scientists want to know more than whether two things are connected (correlation), they want to know if one thing actually may cause the other to occur (causation). Say, In order for scientists to determine whether something is a cause, they need to have empirical evidence. This type of evidence often comes from the documentation of observations, patterns, and data collected through investigation. Co-construct a definition for causation. Call on a few students to contribute their ideas for a definition of causation and create a public record on the whiteboard of chart paper. Prompt students work together with their group to complete the remaining Making Sense questions" (Teacher Edition, pages 153–154).
- Lesson 10: When creating the Gotta-Have-It Checklist the following teacher prompt is suggested for teachers: "Guide students to return to the sensemaking they have done throughout Lessons 7-9. Prompt students with questions such as: How can you use cause and effect to think about what is happening here?" (Teacher Edition, page 162). In addition, the following teacher guidance is provided when students are creating their classroom consensus model: "SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT It is important to note that this part of the consensus model is a 'zoom-out' from the mutations portion of the previous consensus model that explains the smaller scale mechanisms of the random, inherited, and environmentally based mutations that cause the changes in the structure and functions of the proteins that lead to cancer. Students see specifically that an inherited mutation in the p53 on chromosome 17 increases the cancer risk for these people to much higher rates than seen in the general population. Additionally, people with Li-Fraumeni Syndrome get cancer at younger ages, which contradicts what they learned in Lesson 7" (Teacher Edition, page 164).
- Lesson 11: In a card game, students recognize how treatments may affect the growth of cancer cells. "What to look for/listen for in the moment: Cards designated in a part of the model that predicts relationship between cell cycle and treatments. (SEP: 2.3 ; CCC: 2.2) For example: Taxol should be placed in the M phase. Carboplatin should be placed in the S phase. Radiation should be placed in the S phase. Surgery and immunotherapy could be placed anywhere" (Teacher Edition, page 177). The lesson lacks a student prompt that will illicit these student responses.

Systems and System Models

- *Systems can be designed to do specific tasks.*
  - This is identified as a CCC element that is key to sense-making in the unit.

  - Lesson 12: While this CCC element is claimed in the materials, no evidence of its use or development was found.
- *Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.*
  - This is identified as a CCC element that is key to sense-making in the unit.
  - Lesson 3: Students play the Cell Game to develop an initial understanding of how cancer cells form. After the game, the following guidance is provided: "Reflect on the limitations of the Cell Game model. Say, Our model helped us figure out a lot, but it left us with some questions. Display slide P and ask students to turn and talk with a partner about where the model helped us make progress and the limits of the model. Ask them to record their answers in their science notebooks. Once students have had a chance to discuss their responses, call on a few pairs to share. End the discussion by focusing on ideas for next step" (Teacher Edition, page 65). The following teacher prompts are provided to guide the discussion: "What did the model help us explain?", "What questions do we still have that the model COULD NOT help us answer?", and "How can we make progress on those questions?" (Teacher Edition, pages 65–66).
  - Lesson 7: After using the online simulation, the following question is found on the accompanying handout to address a possible limitation of the model: "Compared to the human systems modeled in the simulation, the mutation rate in real life is lower. How does this difference affect what the model can tell us?" (B.3 Lesson 7 Handout Cell Growth Simulation, page 8).

Structure and Function

- *The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.*
  - This is identified as a CCC element which is intentionally developed within the unit.
  - Lesson 5: Students engage in a building understanding discussion which builds to the idea that the structure of DNA relates to the structure of a protein. The following guidance is provided for the discussion: "Purpose of this discussion: To support students in building an understanding about how DNA codes for protein and how mutations can impact the structure and function of proteins. Listen for these ideas: The differences in DNA sequences created the different forms of p53. The words (amino acid sequences) were sometimes different, even when the DNA sequence was the same. There were mistakes in the process that represent mutations" (Teacher Edition, page 95).
  - While this is identified as a CCC element that is developed throughout the unit, no additional opportunities are claimed or provided for its development.

Suggestions for Improvement

Science and Engineering Practices

- Consider providing additional opportunities for students to develop elements related to **Asking Questions and Defining Problems** and **Developing and Using Models** (specifically related to moving flexibly between model types).
- Consider developing a protocol for students to use whenever they evaluate the merits and limitations of multiple models. As an example, use T-charts to itemize merits and limitations.
- Consider striking out the part of SEPs not used or add to the lesson to fully address the SEP element.

Disciplinary Core Ideas

- Consider revising the document "Disciplinary Core Ideas (by Lesson)". In the rationale column, tell what the students are doing to understand the science idea, similar to the sections on SEPs and CCCs. As an example, the first entry about **LS1.A.1** for Lesson 1 could describe how students come to understand the DCI element. "Students generate questions to figure out who gets cancer and why. They begin considering what happens at the cellular level that causes cancer."
- Consider striking out the part of DCIs not used or add to the lesson to fully address the DCI element.

Crosscutting Concepts

- Consider providing additional opportunities for students to develop elements related to **Cause and Effect** and **Structure and Function**.
- Consider a strategy that students can routinely use to differentiate correlation from causation which builds upon strategies from the OpenSciEd middle school curriculum which have students determine causation.

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 and/or designing solutions to problems because there are numerous instances of students using grade-appropriate elements of all three dimensions in service of sense-making.

Throughout the unit, students use grade-appropriate elements of all three dimensions together in service of making sense of the phenomenon. Related evidence includes:

- Lesson 2: Students create a model to explain why cancer makes people sick. In this activity, students integrate the following elements of the three dimensions:
  - 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.*
  - 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.*

- 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 3: Students use four models (the Cell Game, cell images, a model showing the amount of genetic material, and a card sort) to build an understanding of cell division and explain how cancer cells form. In this activity, students integrate the following elements of the three dimensions:
  - SEP: **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.*
  - DCI: **LS1.B: Growth and Development of Organisms** *In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.*
  - 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.*
  - CCC: **Systems and System Models** *Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.*
- Lesson 4: Students use information from an online simulation and a reading, along with other information gathered throughout the unit to construct an explanation to the question: "How do cancer cells end up with differences in their chromosomes and what is the role of p53 preventing the differences?" (Teacher Edition, page 83). In this activity, students integrate the following elements of the three dimensions:
  - 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.*
  - DCI*:* **LS3.B: Genetic Variation** *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.*
  - 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 6: Students work as a class to explain the genetic basis of cancer. In this activity, students integrate the following elements of the three dimensions:
  - 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.*
  - DCI: **LS1.A: Structure and Function** *All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.*

  - DCI: **LS1.B: Growth and Development of Organisms** *In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.*
  - DCI: **LS3.A: Inheritance of Traits** *Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.*
  - 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 7: Students use an online simulation which simulates five different cell types in a growing/aging individual to help figure out why cancer is more common in older and taller individuals. In this activity, students integrate the following elements of the three dimensions:
  - 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.*
  - DCI: **LS1.B: Growth and Development of Organisms** *In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.*
  - 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.* However, this CCC element is not specifically claimed for this lesson.
- Lesson 9: Students investigate how the environment might explain cancer not accounted for by random and germline mutations. Students investigate scientific data related to incidence of skin cancer and design and carry out their own investigations. Students read about the mechanism of UV radiation causing mutations in cells and about a protective mechanism in skin. Students facilitate a Building Understandings Discussion about the investigation and reading, and to reach consensus around the causal link between the environment and skin cancer. In this activity, students integrate the following elements of the three dimensions:
  - 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: **LS3.B: Genetic Variation** *Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.*
  - CCC: **Cause and Effect** *Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.*

Suggestions for Improvement
N/A

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) because lessons build on each other coherently from a student perspective and numerous high-leverage strategies are used throughout this unit to create a coherent sequence of learning. Students build proficiency in most, but not all, of the targeted PEs.

Each lesson builds directly on prior lessons and makes links between lessons explicit to the students. Related evidence includes:

- Lesson 1: “Share exit ticket data with students. Say, I had a chance to look through your exit tickets from our last class. It seems like many of you noticed that people who live in different places have different rates of cancer and we do not really know why. Adjust what you share with students based on the actual exit ticket data you collected and give students an opportunity to share any additional thoughts or questions with the class” (Teacher Edition, page 31).
- Lesson 1: “Prioritize next steps. Ask students to tear a half sheet of notebook paper and write down which questions make sense to investigate first. Remind them that the unit questions are Who gets cancer and why? and Where should we focus efforts on treatment and prevention? Collect their exit tickets” (Teacher Edition, page 39).
- Lesson 2: “Lead a discussion about what we figured out in the last class. Say, Yesterday, you all generated a lot of questions about who gets cancer and why. In your exit tickets, I noticed that some of you suggested we start our unit by figuring out what cancer is. Display slide A and use the prompts below as a guide” (Teacher Edition, page 45). The following teacher prompt is provided: “What ideas do you have about how we can figure out what cancer is?” (Teacher Edition, page 45). This is used to motivate the next step in the lesson. “Initial ideas discussion about cells. Say, Some of you suggested that we look at cells to figure out what cancer is. I was able to find some images of cancer and non-cancer cells for us to look at. Before we do, let’s

take a minute to talk about what we already know about cells. Display slide B and use the prompts below as a guide" (Teacher Edition, page 45).

- Lesson 2: "Plan for next steps. Call on a few students to share their answers for the questions they still have. Guide students toward questions that will help the class make progress on the first unit question, Who gets cancer and why? Say, How did what we figured out from the differences between non-cancer and cancer cells and how lung cancer makes us sick help us answer our lesson question What is cancer?" (Teacher Edition, page 51).
- Lesson 3: "Review what we figured out in our last lesson. Display slide A. Ask students to turn and talk to a partner and then ask a few pairs to share their answers. Prioritize next steps. Ask students to recall what questions they still had in Unknown material with identifier: bi.l1.ho2 and what questions will help the class make progress on figuring out Who gets cancer and why? Listen for students to identify that although they figured out what cancer cells are and how they can make people sick, we still need to know how non-cancer cells become cancer cells or where cancer cells come from" (Teacher Edition, page 58).
- Lesson 4: The lesson begins with the following: "Review what we figured out and what new questions we have. Display slide A. Use the following prompts to guide the discussion" (Teacher Edition, page 78). The following prompts are provided to guide the discussion: "What did we figure out in our last class?", and "What question do we still need to answer?" (Teacher Edition, page 78).
- Lesson 4: "Generate ideas for next steps. Display slide T. Ask students to record their ideas for what questions the class should pursue next" (Teacher Edition, page 86).
- Lesson 5: "Introduce the kinesthetic model. Say, You all have a lot of great ideas about where p53 comes from and why there are different versions. I have a way we can investigate and figure out the answers to these questions. Let students know that you have a kinesthetic model, where they will get up and move around just like they did with the wildebeest and grass in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit), that can help us figure it out" (Teacher Edition, page 92).
- Lesson 6: "Lead a discussion about what we have figured out so far. Display slide A. Say, We have figured out a lot of big science ideas over the past week or two! What are some of the ways that we make sense of a lot of ideas? How do we make connections between ideas that we have? Pause to give students an opportunity to share their ideas about what practices they might engage in. Listen for ideas such as: We develop written explanations. We create models to explain relationships between components and ideas. We communicate our ideas with others. Say, Today we are going to take what we have learned to develop a class model that tells the story of what we have figured out" (Teacher Edition, page 101).
- Lesson 6: "Say, It sounds like we understand the genetic basis of cancer. What are the questions that we have left to answer? Can any of those questions help us make progress on filling in what our model does not explain? Give students a moment to identify key questions and share in their small groups. In addition, challenge students to add new questions that have come up for them. Consider asking students to nominate questions we could investigate next to continue making progress on the question Who gets cancer and why? Call on volunteers to share their questions and ideas for investigation with the class. Listen for ideas such as: We saw data about being older and taller giving you cancer too. Our model does not show us how that happens. Our model does not show anything about how cancer gets passed on in families. Our model also does not show how the environment could cause cancer, like lung cancer from smoking" (Teacher Edition, page 107).
- Lesson 7: "Review classroom consensus model. Display slide A. Ask students to recall the big ideas they figured out in Lesson Set 1 and included in their consensus models in the last lesson.

Ask students to recall what they decided to investigate next when they revisited their DQB during the last lesson. Call on a few students to share. Help students remember that they figured out we are still figuring out the genetic basis of cancer that is based on a single gene and still have questions about why taller and older people get cancer more than others" (Teacher Edition, page 113).

- Lesson 7: Students update their Progress Trackers. A sample is provided. "Update Progress Trackers. Celebrate with students how much progress they have made, not only on why some kinds of cancer are more common than others? but also on the unit question Who gets cancer and why? Display slide M. Ask students to turn to the Progress Trackers in the science notebooks to update them on their progress in their thinking related to our unit question: Who gets cancer and why? Ask students to take a minute and think about what questions they still need to answer to make progress and what new questions have come up for them" (Teacher Edition, page 117).
- Lesson 8: "What did we figure out in the last class? The more your cells divide the more chances you have for a mutation so older and taller people have more cancer. What questions do we still have? The mutations you accumulate in your lifetime only account for 66% of cancer, what else causes cancer?" (Teacher Edition, page 124).
- Lesson 9: "Motivate an Investigation. Display slide J. Say, We noticed some interesting patterns regarding skin color, exposure to UV radiation from sunlight, and who tends to get skin cancer. It seems like we think there may be a connection between cancer and our environment, in this case exposure to the sun. One way to answer some of our questions and to gather more information is to conduct an investigation. Read the prompt on the slide and ask some students to share their ideas. If questions or ideas about using sunscreen or sunblock to protect against skin cancer came up earlier, resurface those now. Guide students to think about how we might investigate those questions as well. Students may share some of the following ideas or possible questions to investigate: We could expose cells to sunlight, and see what happens to them? Maybe they will die or change somehow? We could put some cells out in the sun and see if they get sick, like with cancer? We could try using sunscreen with some cells and then put them in the sun to see if anything happens to them?[sic] Maybe they will be more protected than cells without sunscreen? What if we could cover some cells with clothing to protect them from the sunlight? Can we test different types of clothing? Applaud students for sharing their ideas and say, Many of your ideas involve using living cells, so let's discuss what types of cells we might be able to use in the classroom" (Teacher Edition, page 144).
- Lesson 9: "Navigate to the next lesson. Recall with students that we found out that our skin produces melanin which helps protect our cells' DNA from being damaged by UV light from the sun. Explain that from the reading we also found out that people with darker skin tend to produce more melanin. Remind students that though we might expect darker skin people to have some added protection against certain types of skin cancer because they have more melanin, what we actually see is that though there are fewer new cases of skin cancer in the Black population, Black people are 3 times more likely to die from skin cancer than White people in the United States. Ask students why they think this might occur. Accept all responses for now and tell students that we will examine this discrepancy more in Lesson 12. Display slide DD. Say, As I did more research on skin cancer, I found out that there's a different type of skin cancer, called acral lentiginous melanoma, or ALM, which is not caused by exposure to UV light. Also, it primarily affects people with darker skin and who belong to Asian and sub-Saharan African ethnic groups. If there are questions on the DQB about differences in who gets cancer, point those out now. Then ask students if they have any ideas on why this phenomenon might occur. After students share their ideas, say So, how can it be that people in different groups and from

different places get cancer at different rates? Let's look more closely at that in our next lesson!" (Teacher Edition, pages 155–156).

- Lesson 10: "Generate ideas for new investigations. Display slide N. Say, We have so many ideas to explore! How could we start to investigate the answers to some of these new and unanswered questions? Revisit your original Ideas for Investigations in your science notebook or title the next page in your science notebook 'Ideas for Investigations.' Choose one question or category of questions from our Driving Question Board and talk with a partner or partners near you to consider how we might find the answer—what investigation could we design, what data should we gather, and how could we figure this out in our classroom? Keep track of your ideas in your notebook. After you have discussed one question, move on to another. We will work for about three minutes, then we will share with the group. Accept all ideas and add them to the Ideas for Investigations chart paper. Student ideas may include the following:" (Teacher Edition, page 167).
- Lesson 12: "Introduce geographic data. Say, It sounds like we have some ideas about treatment not being equitable or fair for all people. In our last class, I shared two cases about individuals with different circumstances, and today I would like to introduce some additional data to help us think about that" (Teacher Edition, page 185).
- Lesson 12: "Motivate the need for looking at data. Say, We have done some reading exploring several social determinants of health, and we have some ideas about how they could affect cancer treatment. How can we figure out if and how these determinants affect cancer outcomes? Listen for responses related to looking at data, research or scientific studies. If students do not suggest investigating with data, ask them to consider how we have investigated these kinds of ideas in the past" (Teacher Edition, pages 187–188).

The DQB is developed in Lesson 1 and used to brainstorm questions, investigations, and sources of data that could help figure out the phenomenon. Students return to the DQB in Lessons 6, 7, 9, 10, and 11 to add questions or to determine which questions have been answered. This routine links the lessons from the perspective of the student. Related evidence includes:

- Lesson 6: "Now that we have reviewed the ideas that we have learned, it is a good time to look back at the Driving Question Board. Let's review the questions that we have answered so far" (Teacher Edition, page 107).
- Lesson 10: "Choose one question or category of questions from our Driving Question Board and talk with a partner or partners near you to consider how we might find the answer—what investigation could we design, what data should we gather, and how could we figure this out in our classroom?" (Teacher Edition, page 167).
- Lesson 11: "Review the Driving Question Board. Display slide A. Have students join a Scientists Circle with their science notebooks. Ask students to consider which group of questions they have already answered and which questions remain. Ask students to mark the questions with a check if they have been or can be and add a question mark if they are unanswered" (Teacher Edition, page 173).

The Progress Tracker allows students to express their understanding of science ideas in their own words. Related evidence includes:

- Lesson 2: "Introduce the Progress Tracker. Say, Before we move on, let's take a moment to capture what we figured out so we can track our progress over the course of the unit. Distribute Progress Tracker to each student. Display slide R. Give students a few minutes to fill in the unit questions and the rows for Lesson 1 and 2. Plan for next steps. Call on a few students to share their answers for the questions they still have. Guide students toward questions that will help the class make progress on the first unit question, Who gets cancer and why? Say, How did what we figured out from the differences between non-cancer and cancer cells and how lung cancer makes us sick help us answer our lesson question What is cancer?" (Teacher Edition, page 51).

- Lesson 3: "Update Progress Trackers. Display slide AA. Ask students to turn to their Progress Tracker to update them with the progress they have made on their thinking related to our unit question, Who gets cancer and why? One possible representation of a completed Progress Tracker is shown below" (Teacher Edition, page 72).
- Lesson 5: "Update Progress Trackers. Ask students to take out Progress Tracker. Display slide A. Say, In Lesson 4 we figured out a lot of big ideas about DNA replication, mutations, p53 and how cells can end up with differences in their chromosomes. Let's take a few minutes to track our progress. Give students a few minutes to record their thinking including the questions they still need to answer. Call on a few students to share their thinking. Use the sample Progress Tracker below as a guide" (Teacher Edition, page 91).
- Lesson 6: "Revisit the Progress Tracker. Display slide B. Say, Since we have figured out so many great ideas, let's review the Progress Tracker so that we can build our Gotta-Have-It Checklist. Let's look back at the consensus model we started in Lesson 2. We will need to make a new one since we have lots of very big ideas but it is a good place to start. What are some of the biggest ideas that we have figured out since Lesson 2?" (Teacher Edition, page 101).
- Lesson 7: "Update Progress Trackers. Celebrate with students how much progress they have made, not only on why some kinds of cancer are more common than others? But also on the unit question Who gets cancer and why? Display slide M. Ask students to turn to the Progress Trackers in the science notebooks to update them on their progress in their thinking related to our unit question: Who gets cancer and why?" (Teacher Edition, page 117).
- Lesson 10: The students use their Progress Tracker to review their previous learning. "What are some of the biggest ideas that we have figured out since we continued our consensus model in Lesson 6?" (Lesson 10 Slides, Slide B).

The unit claims the following PEs are developed throughout the unit. However, there are not adequate opportunities available for students to develop all of these throughout the unit. Related evidence includes:

- **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.*
    - Lesson 5: Students participate in a kinesthetic model and a reading and use the information to answer questions related to how DNA is used to determine the structure of proteins.
    - Lesson 6: Students work as a class to explain the genetic basis of cancer, which includes how mutations in DNA result in different forms of the p53 protein.
    - While this is claimed as a PE which is developed within the unit, there are no additional opportunities for development provided in the materials and elements related to systems of specialized cells are not developed.
- **HS-LS1-2** *Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*
    - Lesson 2: Students construct a model to explain why cancer makes individuals sick.
    - While this is claimed as a PE which is developed within the unit, there are no additional opportunities for development provided in the materials.
- **HS-LS1-4** *Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.*

- Lesson 3: Students use four models (the Cell Game, cell images, a model showing the amount of genetic material, and a card sort) to build an understanding of cell division and how cancer cells form.
- Lesson 6: Students work as a class to explain the genetic basis of cancer.
- Lesson 7: Students use an online simulation which simulates five different cell types in a growing/aging individual to help figure out why cancer is more common in older and taller individuals.
- Lesson 11: Students investigate different types of cancer treatments and add cards to the cell cycle game to illustrate how they affect the process of cellular division.
- While most of the PE is developed within the unit, the concept of differentiation is not addressed within lessons in the unit.

- **HS-LS3-1*** *Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.*
  - The following note is provided in relation to this PE: "*This performance expectation is developed across multiple units. This unit reinforces these NGSS PEs in a physics context" (Teacher Edition, page 13). While this is identified as being developed in a physics context, its development is provided in a biology context.
  - Lesson 5: Students participate in a kinesthetic model and a reading and use the information to answer questions related to how DNA is used to determine the structure of proteins.
- **HS-LS3-2** *Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.*
  - Lesson 4: Students complete an online simulation which shows the process of DNA replication and the role of p53 in correcting errors. Students also engage in a reading which discusses the role of mistakes in replications.
  - Lesson 7: Students use an online simulation which simulates five different cell types in a growing/aging individual to help figure out why cancer is more common in older and taller individuals. As part of this investigation, students keep track of the number of mutations which occur throughout the divisions.
  - Lesson 8: Students look at a pedigree representing two genes, and after reading about the process of mitosis, develop a model illustrating how the process of meiosis results in the different combinations of alleles present on the pedigree.
  - Lesson 9: Students conduct an investigation and engage in a reading to determine the effect of UV radiation on skin cancer.
  - Lesson 10: Students complete a classroom consensus model which explains why different people in different places have different cancer risks using the information they have gained about inheritance, sexual reproduction, meiosis, and mutations in previous lessons.
- **HS-LS3-3*** *Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.*
  - The following note is provided in relation to this PE: "*This performance expectation is developed across multiple units. This unit reinforces these NGSS PEs in a physics context" (Teacher Edition, page 13). While this is identified as being developed in a physics context, its development is provided in a biology context.
  - Lesson 1: Students look at cancer data, including maps which show cancer incidence and geographic location. "Share data related to cancer incidence and geographic location. Display slide G. Allow students to look at the map for a minute and stop and jot what they notice before asking them again to turn and talk with their partners. Encourage

students to keep track of their thinking in their science notebooks. Call on a few pairs to share what they notice and wonder about the map. Listen for ideas related to differences in cancer rate based on geographic location. Students should notice that the incidence of cancer is not the same in all of the states and wonder why that is the case" (Teacher Edition, page 30).

  - While this is claimed as a PE which is developed within the unit, there are no additional opportunities for development provided in the materials, and the concept of differentiation is not addressed within lessons in the unit and concepts related to probability are not fully addressed within the unit.

- **HS-ETS1-3†** *Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.*
  - The following note is provided in relation to this PE: "†This performance expectation is developed across multiple courses. This unit reinforces or works toward these NGSS PEs that students will have previously developed in the OpenSciEd chemistry and/or biology courses" (Teacher Edition, page 13).
  - Lesson 11: Students investigate different types of cancer treatments and fill in an organizer with information about its mechanism, side effects, costs, and other considerations.

Suggestions for Improvement

Consider providing increased opportunities for students to develop concepts related to **HS-LS1-1**, **HS-LS1-2** and **HS-LS3-3**.

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 because the anchoring phenomenon can be completely explained using science ideas in the life science domain. While CCCs are used to connect learning in the unit, they are not used to connect to other science domains.

The teacher materials call out points where connections to other disciplines may be relevant. However these connections are not made directly to students, or the materials discourage teachers from actively making some of these connections as they are either above grade-level or better addressed in other units. Related evidence includes:

- In the front matter, the materials make a statement about how this unit is connected to other units in the biology sequence, as well as connections to middle school units. “This unit uses and builds upon disciplinary core ideas (DCIs) and other science ideas that students should have previously developed in OpenSciEd Middle School or another middle school science program. LS1.A. Structure and Function (OpenSciEd Unit 6.6: How do living things heal? (Healing Unit), OpenSciEd Unit 8.5: Why are living things different from one another? (Muscles Unit)) LS1.B: Growth and Development of Organisms (OpenSciEd Unit 7.3: How do things inside our bodies work together to make us feel the way we do? (Inside Our Bodies Unit), Muscles Unit) LS3.A: Inheritance of Traits. (Muscles Unit) LS3.B: Heredity: Inheritance and Variation of Traits (Muscles Unit) ETS1.B: Developing Possible Solutions (OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit)) This unit begins the development of disciplinary core ideas (DCIs) and other science ideas that students will utilize and continue building in subsequent units in the OpenSciEd Biology, Chemistry and Physics course” (Teacher Edition, page 15).
- Lesson 4: *“*This lesson does not address the chemical reactions that occur as nucleotides are added during DNA replication or the hydrogen bonding that happens in double stranded DNA. In the middle school grade band of the NGSS students work with ideas related to molecular interactions such as: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms (MS PS1.A) and students use this understanding of molecules in this lesson. Chemical reactions will be explored in more depth in OpenSciEd High School Chemistry” (Teacher Edition, page 77)
- Lesson 9: “While students read about the chemical changes in DNA that happen when UV radiation rearranges chemical bonds in DNA, they are not investigating whether those chemical reactions can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules (PS1.B.1). Chemical reactions and bonding as part of HS-PS1-4 and HS-PS1-5 will be explored in OpenSciEd Chemistry Unit 5 (Fuels and Nuclear Energy) and Unit 4 (Oysters), respectively. This lesson builds on the middle school physical science ideas that when light shines on an object, energy from that light can be absorbed by some materials (MS-PS4-2) and converted into kinetic energy of particles. If students need support in understanding the relationship between light and energy, refer to OpenSciEd Middle School Unit 6.1 (Light and Matter) and Unit 6.2 (Thermal Energy). In this lesson, students find out that UV radiation can damage DNA. However, they are not developing the idea that shorter wavelength electromagnetic radiation can ionize atoms and cause damage to living cells (PS4.B.2). This will be examined in greater detail as part of HS-PS4-4 in OpenSciEd Physics Unit 5. Furthermore, this is not a time to examine the entire electromagnetic spectrum in detail as students only consider the role that UV radiation plays in skin cancer. Whether other forms of radiation cause cancer does not aid in the progression and coherence of this storyline” (Teacher Edition, page 141).

While CCCs are used to connect learning throughout the materials, connections are not made between these CCCs and other science domains. In addition, these connections are typically not made apparent to students. Related evidence includes:

- Lesson 6: “Students use the crosscutting concept cause and effect throughout the lesson as they explain mutations in DNA and the structure and function of proteins by looking at small scale changes such as substitutions in bases in DNA and how that leads to changes in amino acids, which affect the shape of the p53 protein and its role in repairing DNA. They build on initial use of examining small scale mechanisms from Lessons 1 through 3 in this unit and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit) to achieve this goal" (Teacher Edition, page 100).

- Lesson 7: "Students use the crosscutting concept cause and effect as they investigate the small scale mechanism, such as complementary base pairing, that can lead to mutations. They build on their use of this element of the crosscutting concept from Lessons 1-3 and in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit)" (Teacher Edition, page 77).
- Lesson 10: "Students use the crosscutting concept cause and effect throughout the lesson as they explain mutations in DNA and the structure and function of proteins by looking at small scale changes such as mutations in DNA and how that leads to changes in proteins, which affect the function of p53 protein and its ability to repair DNA. They build on initial use of examining small scale mechanisms from Lessons 1 through 9 in this unit and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit) to achieve this goal" (Teacher Edition, page 160).

Suggestions for Improvement

Consider providing teacher prompts which provide opportunities for students to connect the CCC of **Cause and Effect** to other science domains and learning in other units.

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. Although each lesson lists the CCSS, some of the references to the ELA standards are incomplete and inaccurate. Students use their reading skills to develop understanding and explanations of concepts as well as to gather and interpret data. Students engage in written and oral explanations of their learning.

The following mathematics CCSS are claimed within the unit:

- **CCSS.MATH.PRACTICE. MP2. Reason Abstractly and Quantitatively** *Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize — to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their* *referents — and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.*

  - Lesson 1: "When students investigate cancer data, they use quantitative representations (graphs) to identify patterns and ask questions about possible mechanisms" (Teacher Edition, page 39).
  - Lesson 12: "Students calculate the survival rates for several states in order to identify trends in national cancer data" (Teacher Edition, page 196).
  - It is not clear that either of these claimed tasks adequately address "*habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.*"

- **CCSS.MATH.PRACTICE.MP.4. Model with Mathematics** *Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.*
  - Lesson 3: "Making connections in math: Ask students to keep track of how many cancer and non-cancer cells they produce. At the end of Round 2, ask each group to add their results to a class data table. Then students determine the percentage of cancer cells produced compared to non-cancer cells. Students engage in mathematical modeling as they develop an understanding of the likelihood that cell division results in a cancer cell when p53 is functioning typically versus when p53 is functioning differently. Emphasize to students that these percentages may not reflect reality and that any percentages calculated are a result of game mechanics only. Should most students end up with cancer cells during the game, it is important that they do not come away thinking that developing cancer is inevitable in their lifetime. This mathematics extension supports CCSS.MATH.PRACTICE.MP.4, model with mathematics" (Teacher Edition, page 63).
- **CCSS.MATH.CONTENT.HSF.IFC.C.7** *Graph functions expressed symbolically show the key features of the graph, by hand in simple cases and using technology for more complicated cases.*
  - This is incorrectly cited as **HSF-IF.C.7** in the materials.
  - Lesson 7: "As students interact with the Cell Growth and Cancer computer simulation, they will graph the relationship between the number of cell divisions and the average number of mutations per cell" (Teacher Edition, page 118).

The following ELA CCSS are claimed within the unit:

- **CCSS.ELA.WHST.11-12.9** *Draw evidence from informational texts to support analysis, reflection, and research.*

  - This is incorrectly cited as **CCSS.ELA-Speaking and Listening.SL.11-12.5** in the materials.
  - Lesson 2: "Students use images and a reading as informational text to analyze and reflect on the similarities and differences between various types of non-cancer human cells and cancerous cells and on how cancer cells cause disease" (Teacher Edition, page 51).
- **CCSS.ELA-Speaking and Listening.SL.11-12.5** *Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.*
  - Lesson 3: "Teachers present a visual element, (video, images), and guide students as they engage with an interactive element (Cell Game) in order to collect evidence and develop a model to explain how non-cancer cells can sometimes form cancer cells when p53 functions differently" (Teacher Edition, page 72).
- **CCSS.ELA-Literacy.9-10.9** *Draw evidence from informational texts to support analysis, reflection and research.*
  - This is incorrectly cited as **CCSS.ELA-LITERACY.WHST.9-10.0** in the materials.
  - Lesson 8: "Students cite evidence from a scientific reading about inheritance to revise their models" (Teacher Edition, page 136).
- **RI. 3.3**. *Describe the relationship between a series of scientific ideas or concepts, and cause-effect.*
  - This is an incomplete reference to a standard and is not a standard in the high school informational reading section of CCSS.
  - Lesson 6: "The class consensus model explains how mutations in genes can lead to cancer" (Teacher Edition, page 107).
- **CCSS.ELA-Literacy.RST.11-12.9** *Synthesize information from a range of sources.*
  - This is an incomplete reference to the standard. The complete standard is *"Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible."*
  - Lesson 4: "Students synthesize information from a range of sources (computer simulation, reading, game) in order to construct their explanations" (Teacher Edition, page 86). This statement does not reflect the tasks the students are doing within the lesson.
- *Key Ideas and Details*
  - This is a reference to three separate standards, **CCSS.ELA-Literacy.RST.11-12.1, CCSS.ELA-Literacy.RST.11-12.2,** and **CCSS.ELA-Literacy.RST.11-12.3.**
  - Lesson 12: "Students use information from many sources to develop an interview protocol to assess the potential needs of a family member before creating their role as navigator to support their community in co-constructing an effective treatment plan" (Teacher Edition, page 195).
- **CCSS.ELA-Literacy.WHST.11-12.9** *Draw evidence from informational texts to support analysis, reflection, and research*.
  - This is incorrectly cited as **WHST.9-12.9** in the materials.
  - Lesson 5: "When students answer questions, they will use evidence from informational texts to support their answers" (Teacher Edition, page 95).
- **CCSS.ELA-Literacy WHST.11-12.1** *Write arguments focused on discipline-specific content.*
  - This is incorrectly cited as **WHST.9-12.9** in the materials.
  - Lesson 9: "Students write claims based on evidence related to their investigative question and the data they generate during their investigations" (Teacher Edition, page 156).
- **CCSS.ELA-Literacy.WHST.9-10.9** *Draw evidence from informational texts to support analysis, reflection, and research.*

- Lesson 10: "Students use evidence from unit materials and the Transfer Task to support their claims and ideas" (Teacher Edition, page 167).
- **CCSS.ELA-Literacy.WHST.9-10.7** *Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.*
    - Lesson 11: "Students use a reading to research cancer treatments to answer questions about how they work" (Teacher Edition, page 177).

Throughout the unit, students have opportunities to engage in reading, writing, speaking, and listening to further their understanding of the phenomenon. Students have many opportunities to read adapted peer-reviewed publications, but other types of reading materials are missing. While students are provided writing opportunities throughout the unit, only one formal writing task is included, and most writing tasks are in the format of answering questions. Related evidence includes:

- Lesson 1: "Turn and Talk. Display slide D. Ask students to turn and talk to a neighbor about what they know about cancer. Remind them that they may have written about personal stories and feelings in their science notebooks and it is up to them to decide if what they share includes this. Let students know they will participate in a whole-class discussion where they share a summary of their conversation with their partner and they should make sure not to share anything their partner would prefer to keep private. Facilitate an Initial Ideas Discussion.✱ Call on a few student pairs and ask them to share their ideas. Record these ideas on the whiteboard. Encourage students to build on each others' ideas using prompts such as, Did any pair discuss similar ideas? or Who can build on this idea?" (Teacher Edition, page 29).
- Lesson 1: "Distribute cancer reading. Display slide O. Distribute Incidence of Cancer to each student and ask them to individually read the article and to mark it up using whatever literacy strategy is in place in your classroom. Encourage them to jot down notes in their science notebooks related to anything they notice and wonder. Students answer questions individually then turn and talk. Display slide P and ask students to record their answers to the Making Sense questions on the slide in their science notebooks. Next, ask them to turn and talk to a partner to compare answers. After they have had a few minutes to discuss their responses, call on a few pairs to share their thoughts" (Teacher Edition, page 35).
- Lesson 2: "Turn and Talk. Organize students into pairs to share what they noticed and wondered about the cell images. Display slide I and ask students to discuss the questions on the slide. Call on a few pairs to share their ideas. Encourage volunteers to build on their classmates' ideas" (Teacher Edition, page 47).
- Lesson 2: "Investigate cancer with a reading. Display slide N. Pass out Cancer. Say, I have a reading that I think will help you answer many of the questions on your models. Instruct students to read the article and mark it up using whatever strategy is in place in your classroom. Small-group sensemaking[sic] about the reading. Organize students into small groups of 3-4. Display slide O and ask students to answer the questions on the slide in their science notebooks as they discuss them with their small groups. Call on a few groups to share their responses" (Teacher Edition, pages 49–50).
- Lesson 3: "Review what we figured out in our last lesson. Display slide A. Ask students to turn and talk to a partner and then ask a few pairs to share their answers" (Teacher Edition, page 58).
- Lesson 3: "Stop and jot about how cancer cells form. Display slide B and ask students to stop and jot in their science notebooks about how non-cancer cells can turn into cancer cells. Then ask

students to turn and talk to a partner about their ideas. Call on a few pairs to share their responses" (Teacher Edition, page 58).

- Lesson 4: "Stop and jot. Display slide B. Ask students to take out their science notebooks and say, We want to explore more about those chromosomes and the differences we saw between the chromosomes of cancer and non-cancer cells. What do you already know about chromosomes? Turn and talk. Display slide C. Ask students to share their answers with a partner and to record new ideas they hear in their science notebooks. Listen for students to identify chromosomes as genetic material or DNA. Facilitate an Initial Ideas Discussion. Display slide D. Use the prompts below to facilitate an Initial Ideas Discussion" (Teacher Edition, page 79).
- Lesson 4: "Introduce the reading. Say, We have a lot of great evidence from our simulation and other activities from the unit. I heard you identify places where you need additional information and I have a reading that I think will help you fill in some of the gaps in evidence that you identified on the checklist. Display slide O and distribute DNA and Chromosomes to each student. Give students time to read individually using whatever reading strategy is in place in your classroom. Add evidence from the reading to the Gotta-Have-It Checklist. Display slide P. Organize students into small groups of 3-4. Challenge each student to choose a piece of evidence from the reading that they think will address the needs they identified on the checklist. They should discuss that evidence with the group, get feedback and revise what they include in the checklist based on the small group discussion" (Teacher Edition, page 84).
- Lesson 5: "Turn and Talk. Say, You all had some questions about p53, where it comes from and why there are different versions. Display slide C and ask students to turn and talk to an elbow partner about their ideas. Then, call on a few pairs to share their ideas. Listen for responses such as: we make p53 we get p53 from our food the differences are from mutations the differences are from the environment" (Teacher Edition, page 92).
- Lesson 5: "Introduce a reading. Display slide L. Pass out DNA and p53. Say, I have a reading that can help you answer some of your questions. Give students several minutes to read and annotate individually using whatever reading strategy is in place in your classroom. Small group sensemaking about the reading. Say, Based on the reading, what would you like to add to our mapping tool? Organize students into small groups of 3-4 and give them time to fill in the last two columns of the mapping tool in Kinesthetic Model using the heading from slide M as a guide" (Teacher Edition, page 93).
- Lesson 7: "Turn and Talk. Display slide B. Ask students to turn and talk about how what we figured out in our consensus model can help us think about higher rates of cancer in older and taller people. Ask students to record their ideas in their science notebook. Refer students to Age and Height to help them recall the data they investigated in Lesson 1" (Teacher Edition, page 113).
- Lesson 8: "Examine chromosome 17. Display slide J. Celebrate the class' ability to develop a model using inheritance to explain Lakita's Li-Fraumeni Syndrome. Say, p53 is on chromosome 17. I have an image of chromosome 17 that I would like to share with you. Ask students to discuss with a partner and then the class what they notice about chromosome 1" (Teacher Edition, page 128).
- Lesson 8: Students engage in a reading about sexual reproduction. "Introduce the reading. Display slide O. Let students know that the reading and images were gathered from several published scientific texts. Distribute Inheritance to each student. Give students time to complete the reading on their own. Ask them to jot down what they notice and wonder about the reading in their science notebooks" (Teacher Edition, page 132).
- Lesson 9: "Introduce reading. Say, You all noticed some patterns when we explored how environmental factors impacted cell growth in our yeast investigation. Some of you may even

have more questions when comparing your data to the graphs about skin cancer and UV exposure on day 1. Tell students that you did some research and found additional information about UV radiation and skin cancer that you want to share with them. Explain that the reading may help them with their claims for question #3. Distribute Skin Cancer Background Reading. Students read individually. Display slide X. Ask students to make a Notice and Wonder chart in their science notebooks. Give students 4-5 minutes to read the article individually and tell them to record what they notice and wonder while they read. For students who may struggle reading informational texts, consider allowing them to collaborate with a partner to read, discuss, and annotate one paragraph at a time. Small-group sensemaking[sic]. Organize students into small groups to answer the questions on slide Y. Circulate around the room and prompt students to use evidence from the reading to explain both the mechanisms of mutation and protection. Remind students to be prepared to share their ideas with the class" (Teacher Edition, page 152).

- Lesson 10: "Turn and Talk. Display slide A. Say, We have done a lot of sensemaking[sic] over the last several lessons. Let's pause to take stock of our progress. Review the ideas that we figured out in Lessons 7-9 with your partner. Facilitate a discussion about what we have figured out so far. Display the class consensus model from Lesson 6. Display slide B. Call on a few students to remind the class of the progress the class made in Lesson Set 1. Say, We are going to get new chart paper so that we can add to our consensus model because we have so much new information. Then call on a few students to share the progress we made in Lesson Set 2" (Teacher Edition, page 161).
- Lesson 11: "Turn and Talk. Display slide B. Say, We have talked about who gets cancer and why, but we have not explored how cancer is treated. It sounds like we still have some questions. Ask students to turn and talk to a partner about what they know about cancer treatments. After they have had a few moments to discuss, call on a few pairs to share their thinking" (Teacher Edition, page 173).
- Lesson 12: "Engage with Social Determinants of Health readings. Display slide M. Pass out Social Determinants Table. Assign each student a determinant and distribute the precut strips you prepared from Social Determinants Health. Say, You will read about your determinant in your row of the Social Determinants Table Social Determinants Table. Consider how your determinant could be a constraint in cancer treatment or survival" (Teacher Edition, page 187).
- Most of the reading selections are text, pictures, and graphs. There are no reading selections in different formats, such as news articles or websites.
- Some of the reading selections (e.g., DNA and Chromosomes, DNA and p53, and Inheritance) are far below grade level when analyzed using Lexile.

Suggestions for Improvement

- Consider ensuring that references to CCSS are correct and that the tasks cited show students are using the standard to promote understanding.
- Consider evaluating whether lesson tasks really show engagement in a high school level of the mathematics practices.
- Consider making some of the reading selections more rigorous or explain to teachers why the reading selections are at an elementary reading level.
- Consider incorporating more formal writing tasks, in addition to answering questions on a worksheet or a transfer task.
- Consider providing additional opportunities for students to engage with a variety of reading materials such as news articles, journal articles, and websites of scientific organizations/entities

to allow students to develop robust reading skills to better understand and explain scientific concepts.

OVERALL CATEGORY I SCORE: **2** (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

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because the phenomenon is experienced as directly as possible, and students have multiple opportunities to connect their personal experiences to their sense-making in the unit.

The phenomena and activities are likely to be relevant and meaningful to students, and students experience them as directly as possible. They also have opportunities to connect learning to their lives. Related evidence includes:

- The front matter of the materials contains a section titled “What is the anchoring phenomenon and why was it chosen?” The section contains the following information: “In the anchoring phenomenon, students explore cancer statistics including rates of new cases by cancer and state. They notice some differences that are hard to explain. Then, they investigate factors such as age and height and figure out the people in different demographics groups have higher and lower risk of cancer. They hear from a scientist who has studied cancer and are introduced to animal models. They read about incidence of cancer and discover that there is something called p53 that might prevent cancer in other organisms. They develop initial models and generate questions that need to be answered to fully explain it. This phenomenon was chosen as the anchor because it generated high student interest across racial and gender identities in a national survey” (Teacher Edition, page 13).
- Lesson 1: “Introduce the phenomenon. Display slide A. Say, If we have not already, each of us will likely have an experience with cancer in our lifetime. We have an opportunity to use our time in our science classes to talk about issues that affect us, like cancer, so we can better understand this human phenomenon” (Teacher Edition, page 28).
- Lesson 1: “Stop and Jot. Display slide C. Ask students to take a few minutes to write about what they know about cancer in their science notebooks. This may include their personal experiences, events, and/or feelings. Let them know that while you are asking them to reflect on these experiences and feelings in writing, they will not be required to make those experiences and feelings public” (Teacher Edition, page 28).
- Lesson 1: “Ask students to take a few minutes to write about what they know about cancer in their science notebooks. This may include their personal experiences, events, and/or feelings.

Let them know that while you are asking them to reflect on these experiences and feelings in writing, they will not be required to make those experiences and feelings public" (Teacher Edition, page 28).

- Lesson 1: Students look at data related to cancer. "Share data related to cancer incidence and death. Display slide E and then slide F. Distribute US Cancer Data to each student. Ask students to take a minute to look at the graphs and stop and jot what they notice and wonder in their science notebooks. Then they should turn and talk to their neighbors about what they noticed and wondered. Call on a few students to share their thinking. Listen for ideas related to the difference between the types of cancers that are most frequently diagnosed and lead to death. Share data related to cancer incidence and geographic location. Display slide G. Allow students to look at the map for a minute and stop and jot what they notice before asking them again to turn and talk with their partners. Encourage students to keep track of their thinking in their science notebooks. Call on a few pairs to share what they notice and wonder about the map. Listen for ideas related to differences in cancer rate based on geographic location. Students should notice that the incidence of cancer is not the same in all of the states and wonder why that is the case" (Teacher Edition, page 30).
- Lesson 1: "Share a video interview with Dr. Stephanie Battle. Display slide M. Introduce students to Dr. Stephanie Battle, a cancer researcher to students. Distribute Transcript Dr. Battle to each student and ask them to follow along as you play https://youtu.be/Dmmju1Ju1Pk" (Teacher Edition, page 34).
- Lesson 8: "Introduce the cases of Lakita and Lauren, cancer survivors. Display slide B. Say, I have an interview with two cancer survivors that I want to share with you. I think it will help us answer some of our questions. Let's revisit our Community Agreements and think about how they can help us as we listen to these young women describe their experiences with cancer" (Teacher Edition, page 124).
- Lesson 8: "Introduce Lakita's family pedigree. Say, We heard that Lakita and Lauren's family had something called Li-Fraumeni Syndrome, and Lauren told us it has something to do with the p53 gene. Since Lakita shared more about her family, let's take a look at a model of her family and see if we can figure out what is going on. Distribute Lakita's Family Pedigree to each student. Display slide G. Explain that scientists that study genetics in families use family trees called pedigrees. Remind students that pedigrees show matings that result in offspring. Review how pedigrees are organized and give students time to add a definition to their personal glossaries" (Teacher Edition, page 126).
- Lesson 8: The following question is on the Electronic Exit Ticket: "How has the day's lesson helped you make progress toward a question that you contributed to the Driving Question Board (or to a related phenomenon on the DQB)?" (B.3 Lesson 8 Answer Key Electronic Exit Ticket, page 3).
- Lesson 9: "Introduce cancer statistics. Say, It sounds like you have some ideas about environmental conditions that might affect cancer. Display slide B and then slide C and read students the quotes about lung and skin cancer. Stop and Jot. Display slide D. Ask students to think about how smoking or sunlight might cause those cancers. Display the class consensus model from Lesson 7 and prompt students to review the mechanisms they figured out about mutations resulting in changes in DNA and protein. Give students a minute or two to write their ideas down in their science notebooks. Turn and Talk. Ask students to talk to their neighbors and share the ideas they have written down. Make sure each student has time to share. To help ensure equity, tell students to be prepared to share their partner's ideas with the class. Once partners have had time to share, call on a few pairs to share with the class. Listen for ideas such as the environment: could cause the mutations due to changes in the DNA sequence

(bases). could change the shape of the protein. could make the DNA or proteins work differently. Consider adding sticky notes to the class consensus model to represent the ideas students have about what the mechanism could be" (Teacher Edition, page 142).

- Lesson 9: "To help build student motivation, consider allowing students to bring items from home, like sunscreen or clothing made from different fabrics. Deciding on materials on Day 1 gives students time to plan and locate materials from home to use on Day 2" (Teacher Edition, page 147).
- Lesson 11: "Introduce new cancer data. Display slide C. Let students know that while cancer is a concern a lot of progress has been made in their lifetimes to reduce the number of deaths that result from cancer. Treatment is one part of the cause for that reduction. Revisit Lakita and Lauren's cancer story. Display slide D. Remind students that they were introduced to Lakita and Lauren and their families in Lesson 8. Ask students to turn and talk to a neighbor and share what they remember. Then, call on a few pairs to share with the class. Refer back to the videos from Lesson 8 if students have trouble remembering. Share interviews with Lakita and Lauren describing their cancer treatments. Let students know that you will share additional pieces of the interviews with Lakita and Lauren. Say, As we watch the video, complete the Notice and Wonder chart, paying particular attention to personal accounts of costs, access to treatment, treatment process, decisions that have to be made, and any recommendations. Remind students that in Lesson 8 we added a column to capture feelings that the video brings up. Encourage students to capture their feelings in this space. Display slide E and play the video. After watching the video, call on a few students to share with the class. See sample student responses in the table below" (Teacher Edition, page 174).
- Lesson 11: "Ask students to turn and talk to a partner about what they know about cancer treatments" (Teacher Edition, page 173).
- Lesson 11: "Students with a connection to a particular type of cancer treatment may wish to research a treatment that is not on the list. Encourage them to do so, with your guidance and to add it to their organizer" (Teacher Edition, page 175).
- Lesson 12: "We will be working to create an interview protocol to understand our family or friend's cancer and needs in our preparation to support them as an effective health care navigator for a loved one who is visiting a doctor about a disease with a genetic component" (Teacher Edition, page 194).

The teacher is guided to provide support for students when sensitive topics arise. Related evidence includes:

- The following guidance related to the phenomenon is provided in a section titled "How do I support students' emotional needs?: "In this unit, students explore the challenges associated with talking about cancer. This may bring emotions to the surface for many students especially if a loved one has been sick from or died of cancer. Before the start of the unit, consider letting students know that the class will be discussing cancer to give them time to process and raise any concerns they have. If a school counselor is available, consider reaching out for support and resources regarding trauma related to cancer or illness. Be aware that students who are struggling may demonstrate a variety of behaviors including but not limited to: fidgeting, withdrawal, disruption or distraction, rapid breathing, holding their breath, and change in body language or tonation. If you notice a student might be struggling, share what you are observing and ask if they need some help. Often in science classrooms, we are focused on evidence and data. When addressing a phenomenon or design solution that straddles the nature-cultural divide, like this one, supporting students in using an empathy or socio-emotional lens will also be important. Make space for students to process, and validate their feelings and reactions. These opportunities were built in throughout the unit" (Teacher Edition, page 20).

- Lesson 1: "Revisit and add to our norms. Display slide B. Say, Let's take a look at the classroom agreements we established earlier in the school year. Ask students to think about which of the agreements we might want to focus on as we discuss a potentially emotionally sensitive topic like cancer. Students may share ideas about how focusing on the respectful and committed to our community agreements might help us when discussing difficult topics. Ask students to suggest specific ways they might draw on these agreements to support difficult conversations. Let students know that when the class discusses topics that feel emotionally challenging, they should feel comfortable asking to step out of the room" (Teacher Edition, page 28).
- Lesson 1: "Before the start of the unit, consider letting students know that the class will be discussing cancer to give them time to process and raise any concerns they have. If a school counselor is available, consider reaching out for support and resources regarding trauma related to cancer or illness" (Teacher Edition, page 28).
- Lesson 2: "The reading introduces the terms benign, malignant, and metastasize. These terms are not essential to understanding or explaining the science ideas in the unit, but they are terms that students may have heard or will hear in the future. Encourage students to add these terms to their personal glossaries and words we encounter as needed. The reading also briefly addresses how people get sick and can sometimes die from cancer. Be aware that this could be upsetting to students who have experience with cancer and be ready to refer students to the appropriate resource in your school" (Teacher Edition, page 50).
- Lesson 3: "The NGSS refers to the cell at the beginning of the cell cycle as the parent cell and the two cells at the end as daughter cells. This language could reinforce gender binary thinking and you may want to consider how to best represent these relationships. For more resources see: https://www.genderinclusivebiology.com/ White, Peter, et al. 'Ditch gendered terminology for cell division.' Nature, vol. 599, no. 7886, 25 Nov. 2021, p. 556. Gale In Context: Environmental Studies, link.gale.com/apps/doc/A683612168/GRNR?u=coloboulder&sid=ebsco&xid=d3ec1cf3" (Teacher Edition, page 69).
- Lesson 7: "Biological sex is usually considered to be genetically determined, typically by the X and Y chromosomes. While the XX and XY combinations are the most common, other combinations exist and should be recognized. Gender is a social construct that refers to how individuals position themselves and are positioned by others. Gender definitions, identities, expectations, and roles vary in different cultures, with some cultures embracing multiple gender definitions. In this unit, it is more scientifically accurate to refer to biological sex rather than gender. For that reason, we recommend the terms egg parent and sperm parent when discussing meiosis and fertilization instead of mother and father. In addition, families may be made up of individuals who do not conform to gender binaries. Lakita's family tree uses terms such as mother and father because that is how her family chose to be represented" (Teacher Edition, page 126).
- Lesson 8: "Supporting empathy and emotions: Consider revisiting class Community Agreements before viewing this video, as it may surface some strong emotions among students. In the video, Lakita describes losing multiple family members to cancer and describes her experience having had multiple rounds of screening, cancer diagnosis, and treatment from age 10. Be aware that students may be thinking of loved ones who have experienced cancer in their families and communities. In addition, students may be thinking about how cancer can be inherited and may start worrying about the risk of their loved ones or themselves developing cancer. Please be mindful of these and provide safety and support by sharing awareness. Consider saying: As we work through this lesson, be mindful of any impact that you are noticing within yourself based

on your own personal experiences. If you need to talk, process, or regain some grounding in the here and now, please let me or the school counselor know. Be aware that students who are struggling may demonstrate a variety of behaviors including but not limited to: fidgeting, withdrawal, disruption or distraction, rapid breathing, holding their breath, change in body language or tonation. If you notice a student might be struggling, share what you are observing and ask if they need some help" (Teacher Edition, page 124).

- Lesson 9: "Promoting empathy and supporting emotions: Some students will know someone or be related to someone who smokes, and perhaps even someone who has been diagnosed with cancer related to smoking. It is important that you explain to students that they should not feel pressured to share anything about their family during this unit. If a student decides to share something with the class about their family as it relates to cancer, it is important that they do not feel stigmatized by this. Instead, you might applaud their bravery for sharing, and explain to the class that diseases like cancer can occur, and it can be upsetting to hear or receive such news. Although cancer often impacts students in ways they cannot always control, the aim of this lesson (and unit) is to help students consider how and why cancer occurs, and to empower them to use what they learn to respond in ways that can help them and their loved ones" (Teacher Edition, page 143).
- Lesson 11; "Students may have personal experiences with cancer treatments that could evoke an emotional response. Be prepared to offer resources to students who need them by reaching out to the counselor and/or other support staff in your school prior to the lesson" (Teacher Edition, page 174).

Suggestions for Improvement

- Consider ways to address connections beyond students' homes and their families.
- Consider referencing the stories of Lakita and Lauren earlier in the unit and providing opportunities for students to return to them more frequently throughout the materials in order to make the phenomenon more compelling for students.

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 because students are provided with numerous opportunities to share their ideas and use feedback to revise their thinking.

Students are supported to express, clarify, justify, and represent their ideas. Related evidence includes:

- Teacher Handbook: "OpenSciEd units use specific types of discussions to help draw out student ideas, negotiate and refine them, and support students in communicating with one another in scientific ways:

  - Initial Ideas Discussions
  - Building Understandings Discussions
  - Consensus Discussions

  Each type of discussion serves a different complementary purpose and is useful in different phases of a lesson or unit. Regardless of the type of discussion, it is always important to consider how to make it possible for all students to contribute and work with one another's ideas. Teachers are encouraged to set aside time for students to think individually and in small groups as part of a discussion plan" (Teacher Handbook, page 39). Each of these types of discussions are used frequently in this unit.
- Students set up their notebook in Lesson 1 and use it in every lesson. This serves as a place to collect and reflect upon their learning.
- The DQB is set up to represent student questions. After initially starting the DQB in Lesson 1, students are asked to go back to the DQB in five subsequent lessons to identify questions answered and add more questions.
- Teacher Handbook: "Throughout the unit, students add their model ideas to a Progress Tracker. The Progress Tracker provides the space for students to document what they've figured out over time and consider what is needed to revise their models. At the same time, the class might use a Gotta-Have-It Checklist. This is a list of ideas that must be included in the final model" (Teacher Handbook, page 26).
- Throughout the unit, students record the questions, "What I figured out in pictures and/or words?", and "Questions I Have" in their Progress Tracker. They use the Progress Tracker in seven lessons.
- Lesson 1: "Turn and Talk. Display slide D. Ask students to turn and talk to a neighbor about what they know about cancer. Remind them that they may have written about personal stories and feelings in their science notebooks and it is up to them to decide if what they share includes this. Let students know they will participate in a whole-class discussion where they share a summary of their conversation with their partner and they should make sure not to share anything their partner would prefer to keep private. Facilitate an Initial Ideas Discussion. Call on a few student pairs and ask them to share their ideas. Record these ideas on the whiteboard. Encourage students to build on each others' ideas using prompts such as, Did any pair discuss similar ideas? or Who can build on this idea?" (Teacher Edition, page 29).
- Lesson 1: "Develop individual models. Say, We have figured out a lot about who gets cancer based on the data we investigated and in the article we just read. How can we begin to make sense of our developing ideas? Listen for students to share ideas related to developing models. Prompt them to think about the practices they used in previous units if they do not suggest modeling. Display slide Q. Ask students to take a few minutes to stop and jot their initial models in their science notebooks" (Teacher Edition, page 36).
- Lesson 2: "Initial model revision. Display slide P. While they are in their small groups, ask students to turn to their initial models and determine what revisions they can make based on the reading. They should pay close attention to the places where they added question marks to identify which questions they can answer and which questions they still have. While each student is revising their own individual model, they should draw on resources from the group to help move everyone's thinking forward" (Teacher Edition, page 50).
- Lesson 3: "Stop and jot about how cancer cells form. Display slide B and ask students to stop and jot in their science notebooks about how non-cancer cells can turn into cancer cells. Then ask students to turn and talk to a partner about their ideas. Call on a few pairs to share their responses" (Teacher Edition, page 58).

- Lesson 4: "Whole class discussion. Call on a few pairs to share their ideas. Ask students to share the ideas they identified as places where they need additional evidence. Use Checklist and Explanation Key to guide the discussion" (Teacher Edition, page 83).
- Lesson 9: "Turn and Talk. Ask students to talk to their neighbors and share the ideas they have written down. Make sure each student has time to share. To help ensure equity, tell students to be prepared to share their partner's ideas with the class. Once partners have had time to share, call on a few pairs to share with the class. Listen for ideas such as the environment: could cause the mutations due to changes in the DNA sequence (bases). could change the shape of the protein. could make the DNA or proteins work differently. Consider adding sticky notes to the class consensus model to represent the ideas students have about what the mechanism could be" (Teacher Edition, page 142).

The unit provides opportunities for students to receive peer and teacher feedback, and students often use feedback for revision purposes. Related evidence includes:

- Lesson 1: "Collect student exit tickets and look for questions related to the data as a formative assessment opportunity. Keep student questions until students are ready to develop the DQB. Provide written feedback to support question revision for DQB. Use Supporting Questioning to support students with question development" (Teacher Edition, page 31).
- Lesson 2: Students are asked to individually develop models to explain how cancer causes illness. "Develop individual models. Display slide J and ask students to develop an initial model in their science notebooks to explain how cancer makes us sick. Encourage them to choose a single cell type from the images previously investigated and to consider how the cancer cells will interact with the non-cancer cells in the system" (Teacher Edition, page 48). While no handout is provided for scaffolding, the following guidance is provided on the accompanying slide: "Use pictures, symbols, and words in your model to help explain your ideas. Pick one cell type and think about how the cells are organized as tissues -> organs -> systems -> organisms. How do the cancer cells interact in those levels? What effects do the interactions have on the whole system? What mechanisms explain those interactions?" (B.3 Lesson 2 Slides, Slide J). Students are then provided with an opportunity to share their model and receive peer feedback. "Turn and talk about initial models. Display slide K. Ask students to turn and talk to a partner to share their models and give and receive feedback. Consider setting a timer so that each student can give and receive feedback. Distribute Peer Feedback Protocol to any student that would benefit from a paper copy" (Teacher Edition, page 48). Students are then provided with an opportunity to revise their model. "Revise initial models and identify questions. Display slide L. Ask students to consider the feedback they received from their peers and make revisions to their models. Then ask them to look for places they still have questions about how components interact or what mechanisms explain the interactions. Ask them to add a question mark anywhere they still have a question. Collect and review initial models before the next class" (Teacher Edition, page 49).
- Lesson 4: Students complete an online simulation which demonstrates DNA replication and the role of p53. Students are then asked to construct an explanation to answer the question "How do cancer cells end up with differences in their chromosomes and what is the role of p53 preventing the differences?" using information they have gained from the simulation and throughout the entire unit. Students begin by creating a Gotta-Have-It Checklist. "Check in on progress toward answering the lesson question. Display slide K. Say, We have figured out a lot about DNA replication and mutations. Let's check in to see what kind of progress we have made in answering our lesson question: How do cancer cells end up with differences in their chromosomes and what is the role of p53 preventing the differences? Turn and Talk. Display slide L. Ask students to turn and talk to a partner about what evidence they have so far that

could help them answer the lesson question and what additional evidence they need. Generate ideas for Gotta-Have-It Checklists. Display slide M. Ask students to turn to a clean sheet of loose leaf paper in their science notebook and generate ideas for what to include on a checklist that will help them construct an explanation that answers the lesson question. Students should turn this in before they leave class" (Teacher Edition, page 83). Students then discuss their evidence in small groups for feedback. "Organize students into small groups of 3-4. Challenge each student to choose a piece of evidence from the reading that they think will address the needs they identified on the checklist. They should discuss that evidence with the group, get feedback and revise what they include in the checklist based on the small group discussion" (Teacher Edition, page 84). Students then construct individual explanations using the checklist. "Construct individual explanations. Say, Now that you have completed your checklists, you have all the evidence you need to explain our lesson question. Display slide Q. Ask students to take out a blank sheet of loose-leaf paper. They should use Checklist Explanation Template and additional materials in their science notebooks to explain the lesson question" (Teacher Edition, page 84).

- Lesson 4: "What to do: Collect student explanations and provide feedback using Student Explanation. Provide students an opportunity to revise their explanations based on your feedback" (Teacher Edition, page 85).
- Lesson 4: "Distribute Peer Feedback Rubric to each student. Say, Now that you have constructed explanations, you will have a chance to give and receive peer feedback that will help you revise your explanations. Organize students to exchange explanations with a peer. Give them time to read the explanation and record their feedback" (Teacher Edition, page 85).
- Lesson 5: Students complete a kinesthetic modeling activity to simulate protein synthesis and complete questions related to the activity which include identifying what each complement of the model represents as well as answering the following questions: "How does the model help you answer the question: How do we make p53, and why is it different sometimes?" "Find a classmate that worked with the same DNA strand as you. Compare your sequence of amino acids and your sequence of words. How did they compare? If they are different, why do you think they are different?", and "Find classmates that had different strands of DNA than you. How did they compare? If they are different, why do you think they are different?" Students first work with a partner to answer the questions and then work with another group before revising their answers. "Complete Part 2: Making Sense. Display slide G. As students complete the activity, ask them to return to their seats to complete Part 2 of Kinesthetic Model with their partner. Compare results. Display slide H. Have students share their response with another pair. They should discuss similarities and differences they see and mark up their own ideas to indicate where they heard new ideas they might want to add. Display slide I when students are ready to see the key to the sentences. Revise responses. Display slide J. Give students a few moments to revise their ideas in the table and to the lesson question in Kinesthetic Model. Collect student responses before the end of class" (Teacher Edition, page 92–93).
- Lesson 6: "Revise initial models. Display slide L. Ask students to update the initial models they developed in their science notebooks. They should update their models based on what they figured out by interacting with the Cell Growth and Cancer computer simulation and the feedback they received on Unknown material with identifier: bi.l7.ho2. Say, Our model was supposed to help us progress toward our lesson question Why are some kinds of cancer more common than others in older and taller people? Which questions were answered by the simulation? Are there mechanisms we now understand? Are there new questions to add?" (Teacher Edition, page 116).

- Lesson 7: Students create an initial model that explains “Why are some kinds of cancer more common than others in older and taller people?” Students begin by brainstorming some ideas with a partner and then create an individual model. “Initial model construction. Display slide C. Have students individually develop initial models in their science notebooks that explain our lesson question: Why are some kinds of cancer more common than others in older and taller people? Remind students that models include components, interactions, and mechanisms. Let students know that since these are initial models, we are still determining all components and how they are related. Suggest adding question marks where they know something is happening but do not know what. Encourage them to refer back to their science notebook for ideas” (Teacher Edition, page 113). Students then share their model with a partner and look for similarities and differences. During this discussion, the following prompt is on the accompanying slide: “Make notes on your model about what you might want to add or revise” (B.3 Lesson 7 Slides, Slide D) Students are then introduced to a cell growth and cancer simulation which uses different cell types. The following teacher guidance is provided: “Turn and talk. Ask students to turn and talk to their partner about how what we figured out about the cell cycle and mitosis is related to these different cell types. Display slide F. Once students have had a chance to share their ideas, ask them to update their initial models and add anything new that they discussed” (Teacher Edition, page 114). Students then use an online simulation to further investigate why cancer might occur more frequently in older and taller individuals. After using this model to engage in a building understanding discussion, students give and receive peer feedback on their initial models and revise them. “Engage in peer feedback. Display slide K. Share Unknown material with identifier: bi.l7.ho2 with them and give them time to review another classmate’s initial model. Revise initial models. Display slide L. Ask students to update the initial models they developed in their science notebooks. They should update their models based on what they figured out by interacting with the Cell Growth and Cancer computer simulation and the feedback they received on Unknown material with identifier: bi.l7.ho2. Say, Our model was supposed to help us progress toward our lesson question Why are some kinds of cancer more common than others in older and taller people? Which questions were answered by the simulation? Are there mechanisms we now understand? Are there new questions to add?” (Teacher Edition, pages 115–116).
- Lesson 11: “Peer review of small group game cards. Display slide L. Let students know that they will have a chance to give feedback to and receive feedback from another group. Distribute Peer Feedback Rubric to each group. Walk them through the rubric and give them time to complete it. When they are finished, ask them to return the cards and feedback to the authors. Each group should review their feedback and ask and answer questions with their peer reviewers” (Teacher Edition, page 176).

Suggestions for Improvement

Consider adding a metacognitive place in the science notebook for students to reflect on how their thinking has changed throughout the unit.

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions because prior learning is indicated in the materials and information about learning progressions are specified within lessons. However, information about prior learning and learning progressions for SEP and CCC elements is less clear.

Information is found throughout the unit which specifies expected prior learning for each dimension and how learning progresses throughout the material. Related evidence includes:

- The following information is provided regarding the development of DCIs, CCCs, and SEPs in the materials throughout the unit: "This unit is designed to introduce students to inheritance and variation of traits. Developing and using models is intentionally developed across this unit, beginning in Lesson 1, where students develop initial models to explain differences they notice in the incidence of cancer across various factors. In Lessons 2, 3, 5, 6, 7, 10 and 11, develop and revise models to explain and/or predict the growing understanding of inheritance and the variation of traits in the context of cancer. In Lessons 3 and 8 they use multiple models to explain their ideas about the cell cycle and inheritance. Student models use cause and effect and structure and function to explain interactions in the system and these concepts are intentionally developed throughout the unit. The use of asking questions and defining problems is intentionally developed in this unit. In Lessons 1, 2 and 9 students ask questions from careful observation to clarify or seek additional information. In Lesson 9 they ask questions that can be answered in the high school laboratory" (Teacher Edition, page 13).
- The Teacher Edition contains a section titled "What are some common ideas that students might have." This section contains the following information regarding potential student prior knowledge and potential ideas students may enter the unit with. For example: "Students will come into the unit with many ideas about inheritance and variation of traits derived from previous classroom experiences, intuitive understandings of the way the world works, everyday experiences with nature, and the conversations they have had with parents, friends, and family members. Nature makes offspring look like their parents. Genes control only an individual's visible traits (like hair color, skin color, and fur color), not the traits that aren't visible (like blood type, personality traits, and whether an individual will get cancer or other diseases)… I Additionally, in Lesson 8, students may have the idea that a disturbance to the ecosystem will affect all of the components equally and this is needed to motivate looking at the effect of different disturbances. However, when manipulating the computational model for the Serengeti students are able to deduce for themselves that certain components are affected differently" (Teacher Edition, page 17). While prior knowledge provided appears to be related to the unit presented, the paragraph which follows appears to be aligned to a different unit dealing with ecosystems and does not align to the unit reviewed. In addition, no information regarding ideas students may have with SEPs or CCCs is provided.

- In the "How does the unit build three-dimensional progressions across the course and the program?" section of the Teacher Edition, a table is provided which outlines in which specific OpenSciEd units SEPs and CCCs are developed. However, this information is only provided at the broad SEP and CCC category level and element-level information is not provided. In addition, familiarity with other OpenSciEd units would be required in order to fully understand student prior proficiency with these SEPs and CCCs.
- Each lesson has a section called "Where we are going and NOT going" which outlines information regarding development of elements. However, these sections do not always include clear teacher guidance for the progression of the targeted elements in all three dimensions. For example:
    - Lesson 1. "Student questions build on middle school level understanding of cells from MS LS1.A: Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. 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. As well as genetics from MS LA 1.B Genetic factors, as well as local conditions affect the growth of the adult plant. In the middle school grade band, students use the crosscutting concept cause and effect to distinguish between causal and correlational relationships. Students build on this use as they note correlational relationships and ask questions that could produce empirical evidence to use in mechanistic explanations to support casual relationships. Students encounter correlation and causation in this lesson and may add these definitions to their personal glossaries" (Teacher Edition, page 27). While information about how students will use the SEP of **Asking Questions** in relation to the CCC is provided, specific guidance related to the development of a SEP element is not provided.
    - Lesson 2: "In this lesson, students build toward understanding DCI related to the structure and function of organisms: HS LS1.A.1 Systems of specialized cells within organisms help them perform the essential functions of life. HS LS 1.A.3 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. These ideas build on middle school understanding of the structure and function of organisms including MS LS1.A: Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. 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. Students develop their use of the science practice asking questions: Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Students developed a similar element of the practice in middle school" (Teacher Edition, page 44). While some information is provided which could be related to the CCCs of **Structure and Function** and **Systems and System Models** in relationship to the DCI elements, specific information regarding development or prior knowledge of a specific CCC element is not provided, specifically in relation to **Patterns** or **Cause and Effect** which are the claimed CCCs in this lesson.
    - Lesson 3: The "Where We Are Going" section provides the following information regarding prior student learning of DCIs: "In this lesson, students investigate how non-cancer cells become cancer cells. Specifically, they look at how cells grow and then

divide via mitosis (LS1.B.1), In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. This builds upon the middle school understanding that organisms reproduce and transfer their genetic information to their offspring (MS LS1.B). The portion of the DCI crossed out will be addressed in Lessons 7 and 8" (Teacher Edition, page 57). Information regarding CCC and SEP development is not provided.

- Lesson 4: The "Where We Are Going" section provides the following information regarding prior student learning of DCIs, SEPs and CCCs: "This lesson builds on an understanding of HS LS1.B.1 from Lesson 3 and MS LS3.A which identifies mutations as changes to genes. Here students investigate the role of DNA replication in generating mutations in the form of substitutions. Students build new ideas related to the following disciplinary core idea: LS3.B.1: In sexual reproduction, ~~chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation~~. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2) and result in mutations, which are also a source of genetic variation. ~~Environmental factors can also cause mutations in genes, and viable mutations are inherited.~~ (HS-LS3-2) Students use the crosscutting concept cause and effect as they investigate the small scale mechanism, such as complementary base pairing, that can lead to mutations. They build on their use of this element of the crosscutting concept from Lessons 1-3 and in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit). Students use the science practice constructing explanations to construct and revise an explanation of the lesson question. They build on the use of this practice from Fires Unit. In this lesson, students will co-construct definitions for the following words, which they should add to their personal glossaries: DNA replication and mutation. Students will also encounter definitions including helicase and complementary base pairs. Words should be defined and recorded AFTER your class has developed a shared understanding of their meaning" (Teacher Edition, page 77).
- Lesson 6: The "Where We Are Going" section provides the following information regarding prior student learning of CCCs: "Students use the crosscutting concept cause and effect throughout the lesson as they explain mutations in DNA and the structure and function of proteins by looking at small scale changes such as substitutions in bases in DNA and how that leads to changes in amino acids, which affect the shape of the p53 protein and its role in repairing DNA. They build on initial use of examining small scale mechanisms from Lessons 1 through 3 in this unit and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit) to achieve this goal" (Teacher Edition, page 100). While information related to the development of the **LS1.A** DCI is provided in relation to development of the claimed CCC element, specific Information regarding prior knowledge or development of the claimed DCI

element is not provided. In addition, information regarding prior knowledge or development of SEPs is not provided for this lesson.

- Lesson 7: The "Where We Are Going" section provides the following information regarding prior student learning of DCIs, CCCs, and SEPs. "This lesson continues to develop an understanding of HS-LS3.B.1 from previous lessons and MS-LS3.B2, which names mutations as a source for genetic variation but whose effects will be varied. Students will see that mutation rates differ depending on cell type, and the accumulation of mutations is a cause of cancer. Students build on ideas related to the following disciplinary core idea: LS3.B.1: In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2) This lesson also begins to develop an understanding of HS-LS1.B.1 from previous lessons and MS-LS1.A which supports students in understanding the hierarchy of organization of complex organisms from cells to body systems. Students develop initial ideas of how cells differentiate from the generic cells they had been engaging with in previous lessons to the different cell types in the computer simulation. Students build on ideas related to the following disciplinary core idea: LS.1.B.1: In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4) Students use the crosscutting concept systems and system models to investigate the unequal results caused by cell division in the computer simulation. Different cell types divided at different rates which caused the variability of mutation rates. They saw that incidence of cancer resulted from the accumulation of mutations in the different cells[sic] types. They build on their use of this element of the crosscutting concept from Lessons 3 and in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit) and OpenSciEd Unit B.2: What causes fires in ecosystems to burn and how should we manage them? (Fires Unit). Students use the science practice developing and using models to explore the relationship between being older and taller by developing models to visualize their initial ideas about how differences in cell types could cause different results in rates of cancer. Students then use a computer simulation to investigate these ideas. They build on the use of this practice throughout the unit and from Fires Unit" (Teacher Edition, page 112).
- Lesson 11: The "Where We Are Going" section provides the following information regarding prior student learning of DCIs, CCCs, and SEPs: "In this lesson, students continue to build an understanding developed in Lesson 3 and 4 of LS1.B.1 In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the

needs of the whole organism. The also develop understanding of ETS.1.B.1 When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. which they began to develop in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit). While students have been using developing and using models in OpenSciEd Biology and throughout this unit they use this practice in a new way as they revise their models to predict what the effects of cancer treatments on the cell cycle. They also use cause and effect with more independence as they figure out different cancer treatments cause different outcomes for cancer and non-cancer cells in the context of the Cell Game model" (Teacher Edition, page 172).

- Lesson 1: The following guidance is provided outlining how students might build upon the 6–8 CCC elements for **Cause and Effect**: "SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT: Probe students to consider the difference between correlational and causal claims and to think about the evidence they need to support each type. If they want to make claims about how height and age cause cancer, they will need to identify mechanisms that could help them explain how height and age cause cancer. While these terms are used in the middle school grade band, students may need to build familiarity with and distinguish between them. Students can add these terms to their personal glossaries as definitions we encounter" (Teacher Edition, page 32).
- Lesson 3: "Students should be familiar with nutrients (MS LS2.B), the idea of organelles as specialized structures within cells (MS LS1.A), proteins (MS LS 1.A and 3.B) and chromosomes (MS LS3.A and 3.B) from their prior experiences in and out of school. While these terms are part of the middle school grade band of the NGSS, it is a good idea to pause and provide students an opportunity to define these terms as they are encountered in the lesson to make sure the class has a common understanding. If students need additional support developing middle school grade band ideas related to cells, see OpenSciEd Unit 6.6: How do living things heal? (Healing Unit). Lessons 10 and 11 focus on how cells get what they need to grow and make more cells" (Teacher Edition, page 59).
- Lesson 4: "This initial ideas discussion will leverage vocabulary from NGSS MS LS3.A which identifies mutations as changes to genes. If students bring up mutations during this discussion, pause to give them an opportunity to add it to their personal glossaries. They will revise this definition later in the lesson. The NGSS middle school grade band focuses on genetic material. Some students will be familiar with DNA and will bring it up here. When this happens, pause and give students an opportunity to add a definition for DNA to their personal glossaries. At this point, the definition may be general, such as genetic material. Students will revise this definition later in the lesson" (Teacher Edition, page 80).
- Lesson 9: "This lesson builds on the middle school physical science ideas that when light shines on an object, energy from that light can be absorbed by some materials (MS-PS4-2) and converted into kinetic energy of particles. If students need support in understanding the relationship between light and energy, refer to OpenSciEd Middle School Unit 6.1 (Light and Matter) and Unit 6.2 (Thermal Energy)" (Teacher Edition, page 141).

Suggestions for Improvement

- Consider providing expected prior proficiency in the front matter materials for SEP and CCC elements in a manner similar to what is done for the DCIs (in addition to the "Where We Are Going" sections of individual lessons).

- Consider extending the use of the numerical coding into the statements in the section "Where We Are Going and NOT Going". As an example: "In the middle school grade band, students use the crosscutting concept cause and effect to distinguish between causal and correlational relationships. Students build on this use as they note correlational relationships and ask questions that could produce empirical evidence to use in mechanistic explanations to support casual relationships. (CCC 2.2)"
- Consider adding a "Where we Were" section (in addition to "Where We are Going" and "Where we are not going" sections) that could include prior elements of all three dimensions for each lesson.

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials use scientifically accurate and grade-appropriate scientific information because the science ideas presented in the materials are accurate and teacher guidance is provided to help ensure accuracy.

Teacher support is provided to ensure accuracy of scientific information presented. Related evidence includes:

- The Teacher Edition, contains a section titled "What are recommended adult-level learning resources for the science concepts in this unit?" The following information is provided: "The OpenSciEd instructional model focuses on the teacher being a member of the classroom community, supporting students to figure out scientific ideas motivated by their questions about phenomena. Students iteratively build their understanding of phenomena as the unit unfolds. To match the incremental build of a full scientific explanation across the unit, the science content background necessary for you to teach individual lessons incrementally builds too. Throughout the unit, we provide just-in-time science content background for you that is specific to the Disciplinary Core Ideas (DCIs) that will be figured out in a lesson. Places to look for this guidance include the 'Where we are going' and 'Where we are not going' sections for each lesson. Also, the expected student responses, keys, and rubrics illustrate important science ideas that should be developed in each lesson. The K-12 Science Framework is another great resource to learn more about the DCIs in this unit, including what students have learned previously and where they are headed in high school. In addition to the science content background information embedded in the lesson resources, below we provide recommended resources that can help build your understanding of phenomena and Performance Expectations bundle for this unit: Fred Hutchinson Cancer Research Center. (2021, August 28) Frontiers: Intro to Cancer Unit. https://www.fredhutch.org/en/about/education-outreach/science-education-partnership/sep-curriculum/frontiers-intro-to-cancer-unit.html Walter Flemming

(1882) was the first scientist to observe and describe the movement of chromosomes during mitosis in salamanders. Later, other scientists contributed new understandings to the process of mitosis. For more information see https://www. ncbi.nlm.nih.gov/pmc/articles/PMC4142965/#:~:text=The%20first%20person%20to%20observe,3)%20(Paweletz%202001). . Davis, T. H. (2004). Meselson and Stahl: The art of DNA replication. Proceedings of the National Academy of Sciences, 101(52), 17895-17896. https://doi.org/10.1073/pnas.0407540101 https://www.scientificamerican.com/article/sex-redefined-the-idea-of-2-sexes-is-overly-simplistic1/ https://journals.sagepub.com/doi/10.1177/1948550620937188 https://wanjashealthdiary.com/focused-resilient-confident-lakita-still-standing-strong/ https://www.nytimes.com/2023/01/23/science/what-do-we-owe-lab-animals.html?campaign_id=34&emc=edit_sc_20230124&instance_id=83497&nl=science-times®i_id=7456 1015&segment_id=123362&te=1&user_id=092246db1b24a3a32c812e34285290b8 https://www.cancer.gov/about-cancer/causes-prevention/risk/myths" (Teacher Edition, page 19).

- Lesson 1: The following additional guidance is provided regarding the cancer data which is looked at by students: "The data on slides E-G were generated from https://gis.cdc.gov/Cancer/USCS/#/AtAGlance/. Newer data may be available. The rates were of new cancers and cancer deaths were calculated per 100,000 people. Prompt students to think about whether or not the population of a state is a factor in the differences they see across states in the map" (Teacher Edition, page 29).
- Lesson 3: "If students have questions and/or ideas about how cancer gets into our bodies that are not related to cancer cells arising from non-cancer cells, consider pausing to allow students to work through these ideas. Students may have ideas that cancer is contagious, particularly since many middle and high school students are vaccinated against HPV and may have heard that HPV can cause cancer. While HPV can be contagious, the cancer that can sometimes result is not. Additional resources related to common ideas about what causes cancer can be found at https://www.cancer.gov/about-cancer/causes-prevention/risk/myths" (Teacher Edition, page 59).
- Lesson 3: "Only certain cell structures are visible in the cell images. The chromosomes (DNA) are blue, spindle fibers (microtubules) are green, and centromeres are red. Students will not see a cell membrane or nuclear envelope even though they are in the scientific model. The drawings show chromatin condensing into chromosomes; both are labeled as chromosomes. DNA organization is further discussed in Lessons 4 and 5)" (Teacher Edition, page 70).
- Lesson 8: "While the p53 mutation inheritance pattern shown in the pedigrees can be described as dominant. The lesson does not use the term in an effort to help students understand the relationship between gene and protein without oversimplifying" (Teacher Edition, page 126).
- Lesson 8: "The pedigree in slide K is not trying to show that you need both p53B and BRCA1D to get a specific type of cancer. This pedigree is trying to show that p53B and BRCA1D, on their own, have a chance of causing cancer. If an individual has more genes with an allele that increases susceptibility to developing cancer, then the probability of not having any cancer decreases. There is a lot of information in this pedigree. As needed, provide scaffolding like asking volunteers to talk about different parts of the image. For example: In this pedigree, what does the shading represent? Does darker green mean you are more likely to get cancer or less likely? Who is most likely to get cancer in this pedigree? How many different alleles does this individual have for p53, for BRCA1" (Teacher Edition, page 129).

- Lesson 8: "BRCA1 was chosen because students might already be familiar with it. The crossing over frequency is not known; however, a linkage map of chromosome 17 suggests there could be some crossing over between BRCA1 and p53 (Haines et al. 1990). Haines, J. L., Ozelius, L. J., McFarlane, H. E., Menon, A. G., Tzall, S., Martiniuk, F., Hirschhorn, R., & Gusella, J. F. (1990). A genetic linkage map of chromosome 17. Genomics, 8(1), 1–6. https://doi.org/10.1016/0888-7543(90)90218-j" (Teacher Edition, page 129).
- Lesson 9: "Questions may arise about different types of sunscreens. The two most common types of sunscreen commercially available are mineral and chemical sunscreens. Mineral sunscreens contain small particles, often zinc oxide and titanium dioxide, which remain on the skin's surface and physically block UV rays from penetrating the skin. Chemical sunscreens allow UV rays to be absorbed by the skin where they react with chemicals in the sunscreen. As a result of this reaction, the energy from the UV light is converted into heat which dissipates away from the skin" (Teacher Edition, page 147).

Throughout the unit, students read scientific texts. These articles are written at a grade-appropriate level and sources are provided from reputable science publications. Selected examples include:

- Lesson 4: "National Human Genome Research Institute. (n.d.). Introduction to genomics. Genome.gov. Retrieved May 2, 2023, from https://www.genome.gov/About-Genomics/Introduction-to-Genomics Toledo , C., & Saltsman, K. (2012, June 12). Genetics by the numbers. National Institute of General Medical Sciences. Retrieved April 12, 2023, from https://nigms.nih.gov/education/Inside-Life-Science/Pages/Genetics-by-theNumbers.aspx#:~:text=3.2%20billion&text=That's%20how%20many%20base%20pairs,day%2C%20for%20about%2050%20years! (References from DNA and Chromosomes Reading)."
- Lesson 8: "Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M. C., Roberts, K., Walter, P., Wilson, J. H., & Hunt, T. (2015). Molecular biology of the cell (6th ed.). Garland Science, Taylor and Francis Group. Gilchrist, D. A. (2023, February 3). Meiosis. Genome.gov. Retrieved February 6, 2023, from https://www.genome.gov/genetics-glossary/Meiosis Marcon E, Moens PB. The evolution of meiosis: recruitment and modification of somatic DNA-repair proteins. Bioessays. 2005 Aug;27(8):795-808. doi: 10.1002/bies.20264. PMID: 16015600. Saponaro M, Callahan D, Zheng X, Krejci L, Haber JE, Klein HL, Liberi G. Cdk1 targets Srs2 to complete synthesis-dependent strand annealing and to promote recombinational repair. PLoS Genet. 2010 Feb26;6(2):e1000858. doi: 10.1371/journal.pgen.1000858. PMID: 20195513; PMCID: PMC2829061 (References from Inheritance Reading)."

Suggestions for Improvement

N/A

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 because differentiation strategies are provided for a variety of learners. However, differentiation strategies are not provided for students with disabilities and strategies for multilingual learners are limited.

A general statement about the philosophy of equitable learning is found in the introductory materials.

- "OpenSciEd units are designed to promote equitable access to high-quality science learning experiences for all students. Each unit includes strategies which are integrated throughout the OpenSciEd routines and are intended to increase relevance and provide access to science learning for all students. OpenSciEd units support these equity goals through several specific strategies such as: 1) integrating Universal Design for Learning (UDL) Principles during the unit design process to reduce potential barriers and increase accessibility for students to engage in learning experiences; 2) developing and supporting classroom agreements that encourage a safe learning culture; 3) supporting classroom discourse to promote students in developing, sharing, and revising their ideas; and 4) specific strategies for supporting emerging multilingual students in science classrooms. Many of these strategies are highlighted in the teacher guides in sidebar callout boxes with the headings of: Attending to Equity Supporting Emerging Multilingual Learners Supporting Universal Design for Learning Additional Guidance Alternate Activity Key Ideas Discussion callouts" (Teacher Edition, page 19).

Limited strategies are provided to support multilingual learners. Related evidence includes:

- "How does OpenSciEd support EMLs? There are two primary ways that OpenSciEd supports EMLs: 1) through the curricular design and pedagogical routines that are at the heart of its instructional model, and 2) through educative boxes embedded in the teacher materials. The curricular design and routines of OpenSciEd grounds students' learning experiences in real-world phenomena. For instance, a 6th grade unit on thermal energy is anchored in students figuring out - how can containers keep stuff from warming up or cooling down? In this approach to science learning, students are not just memorizing science ideas or 'facts' about energy transfer, but instead are working with peers to figure out their own understanding of - and even designing their own solutions for - real problems that occur in our natural world. When the phenomena being explored are relevant and accessible, EMLs are better able to contribute and build from their previous understandings about the phenomena. As mentioned earlier, engaging in phenomena-driven science instruction also simultaneously supports EMLs' science learning and language development. Furthermore, the various pedagogical routines embedded in the OpenSciEd instructional model - including, the Anchoring Phenomena Routine, Investigation Routine, Problematizing Routine, and Putting the Pieces Together Routine - encourage EMLs to use their multiple meaning-making resources, and provide students with numerous opportunities to make their ideas public through both linguistic and non-linguistic modes of communication. OpenSciEd teacher materials also include educative boxes focused on EMLs, often appearing as supplemental text on the margins of lesson plans. These educative boxes support teachers in considering whether particular learning moments might be spaces where they can leverage their EMLs' assets and/or address potential challenges their students might encounter. These educative boxes help teachers provide additional in-time support and explain why these instructional moves are important for EMLs. They also range greatly, from suggesting particular ways to group students to unpacking the meaning of certain words in the context of science" (Teacher Handbook pages 49–50). While this additional guidance is provided in a separate material, explicit links are not made directly within the unit materials.

- Lesson 2: The following guidance is provided when students make their models: "ATTENDING TO EQUITY: Students should be encouraged to record their ideas using linguistic (e.g., written words) and nonlinguistic modes (e.g., photographs, drawings, tables, graphs, mathematical equations, measurements), especially as we develop these new ideas. This is particularly important for emerging multilingual students because making connections between written words and nonlinguistic representations helps students generate richer explanations of scientific phenomena" (Teacher Edition, page 48).
- Lesson 4: "ATTENDING TO EQUITY: Support students with learning differences and/or emerging multilingual students by providing opportunities for students to complete the explanations in multiple modalities. You may consider allowing some students to present their answers verbally with you or with another student acting as a scribe to record their thinking on paper or through a voice recording. Some students may benefit from using gestures, images, or manipulatives to support their explanations as opposed to written text. In each case, encouraging students to use multiple modalities to show their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency" (Teacher Edition, page 85).
- No additional explicit guidance related to differentiation for multilingual learners is provided.

Strategies are provided for students who read below grade-level or who may need additional support with reading. Related evidence includes:

- Lesson 2: "For students who need additional support with reading comprehension, consider having them read and annotate the article in pairs. Have them circle any unknown words, highlight important takeaways, and write questions in the margins so that they have articulated their ideas before the whole- group discussion" (Teacher Edition, page 50).
- Lesson 4: "DNA and Chromosomes contains challenging concepts and vocabulary. Many students, including students who read below grade level, will benefit from additional reading support. The Coherent Reading Protocol is well-suited for this text. When using this protocol,

students pause after each chunk of text to monitor their understanding and identify the main ideas. This will prepare them directly for the next part of the lesson in which they use evidence from DNA and Chromosomes to construct explanations. Another strategy that can be used instead of (or in conjunction with) the Coherent Reading Protocol is a teacher read-aloud. In a read-aloud, the teacher models critical thinking strategies, including visualizing, asking questions, and synthesizing information. The Coherent Reading Protocol and more information about teacher read-alouds can be found in the OpenSciEd Teacher Handbook: High School Science" (Teacher Edition, page 84).

- Lesson 8: "Universal Design for Learning: Struggling readers may have more success engaging with the readings by implementing strategies such as these: reading with a partner, reading aloud, chunking the text, highlighting unknown words, or looking for key ideas" (Teacher Edition, page 131).
- Lesson 12: "Activity set-up: Make copies of the reading so that there are enough for each student to get one, and cut the readings into strips. Some readings are longer and more technical, and you can differentiate by literacy skill and language development by selecting which students will do each reading" (Teacher Edition, page 187).

Strategies are provided for students who are struggling with the material. However, some of this guidance is related to previous OpenSiEd units and may not be useful to teachers or students who did not experience the other units. Related evidence includes:

- Lesson 2: "If students are not ready to ask questions about cancer and non-cancer cells because they need more support building middle school ideas, see Lesson 6 from OpenSciEd Unit 6.6: How do living things heal? (Healing Unit) and https://www.openscied.org/general/microscope-body/, where students can view skin, bone, and muscle cells to look for patterns within and between these cell types" (Teacher Edition, page 47).
- Lesson 3: The "Where Are We NOT Going" section of the lesson provides guidance for students who may struggle with the material. "Although the game represents the processes of the cell cycle, including cell growth and division, students will not memorize the names of the phases of the cell cycle or mitosis. Knowing these names does not help them explain the anchoring phenomenon or support them in building conceptual understanding of how cells grow and divide (LS1.B). If students need more support in visualizing what cell division looks like, please see Lesson 9 in OpenSciEd Unit 6.6: How do living things heal? (Healing Unit)" (Teacher Edition, page 57).
- Lesson 3: "If students struggle to connect what happened in the game to what happens in a cell, they may need more time to discuss what each part of the game represents. Remix the student groups and give them additional time to discuss the Making Sense portion of Round 1 GamePlay Provide students with an opportunity to revise the Making Sense chart following the discussion. Collect from each student and provide feedback using Making Sense Key" (Teacher Edition, page 61).
- Lesson 3: Students use the Cell Game, cell images, a model showing the amount of genetic material in the cell and a M phase card sort to further develop their explanation for why cancer cells form. Students use a T-chart in their notebook to compare the three models and how they relate to the Cell Game. The following additional teacher guidance is provided: "ATTENDING TO EQUITY: Consider adding or removing scaffolding for your students to support them as they use the data to provide evidence of mechanistic accounts. Some examples of scaffolding may include metacognitive techniques to think about how we interpret figures and/or discussing as a class different parts of the figures like legends, keys, axes, and labels before students interpret figures. Some examples of less scaffolding may include removing visual cues like arrows from

the slides for Figure 1 or the cell diagrams from Figure 2, or separating images like the microscope images from the model images in the M Phase Card Sort" (Teacher Edition, pages 66–67).

- Lesson 3: "If students struggle getting started with the activity, ask them what happened on day 1 and emphasize answers about there being only non-cancerous cells. If students struggle with identifying the cancer cell on the day 2 model, ask students to compare the cells to the other non-cancerous cells they have already identified" (Teacher Edition, page 70).
- Lesson 4: "SUPPORTING STUDENTS IN ENGAGING IN CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS: If your students need more support in constructing their explanations, distribute Explanation Writing Support to each student. You can use the Student Explanation as a rubric as support for feedback. Make sure to tell students that you will be collecting this and providing feedback using the rubric" (Teacher Edition, page 84).
- Lesson 7: "The 'Adult-Height' slider in the simulation provides height measurements in centimeters. If students struggle to equate a person's height to this unit of measurement, choose a few heights from the simulation and convert them to a more familiar unit, like feet and inches. Then ask students to visualize two people of those heights, standing beside each other. For example, visualizing 180 cm as a person who is 5'11" and 220 cm as a person who is 7'2" may help students conceptualize the changes made when moving the 'Adult-Height' slider up and down" (Teacher Edition, page 114).
- Lesson 8: "If students struggle on where to start, consider working through a few individuals together. For example, ask whether Lakita's grandfather or mother has Li-Fraumeni Syndrome and figure out what his or her chromosomes would look like. Then explore the genotypes of one of their offspring with LiFraumeni Syndrome. If students struggle with the aunts who are unknown, explain that it's ok for models to show uncertainties and help students figure out how to show this. If students struggle with the grandmother, ask students to consider a case where at least one of the unknowns did not have Li-Fraumeni Syndrome and a case where both unknowns had Li-Fraumeni Syndrome" (Teacher Edition, page 127).
- Lesson 8: "The middle school grade band of NGSS exposes students to ideas about inheritance including MS LS3.B In Sexually reproducing organisms each parent contributes half of the genes acquired at random by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. If students experienced OpenSciEd middle school, they may recall OpenSciEd Unit 8.5: Why are living things different from one another? (Muscles Unit), where in Lesson 5, they used pedigrees to figure out where babies with extra-big muscles get that trait variation. If students need additional support with middle school grade band ideas, use this lesson as a resource" (Teacher Edition, page 127).
- Lesson 8: "The pedigree in slide K is not trying to show that you need both p53B and BRCA1D to get a specific type of cancer. This pedigree is trying to show that p53B and BRCA1D, on their own, have a chance of causing cancer. If an individual has more genes with an allele that increases susceptibility to developing cancer, then the probability of not having any cancer decreases. There is a lot of information in this pedigree. As needed, provide scaffolding like asking volunteers to talk about different parts of the image. For example: In this pedigree, what does the shading represent? Does darker green mean you are more likely to get cancer or less likely? Who is most likely to get cancer in this pedigree? How many different alleles does this individual have for p53, for BRCA1" (Teacher Edition, page 129).
- Lesson 8: "If students need additional support with middle school grade band ideas such as MS-LS3.B In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of

each gene, one acquired from each parent. These versions may be identical or may differ from each other. Provide them with Inheritance Extra Practice prior to working through the next set of pedigrees" (Teacher Edition, page 132).

- Lesson 9: "This lesson builds on the middle school physical science ideas that when light shines on an object, energy from that light can be absorbed by some materials (MS-PS4-2) and converted into kinetic energy of particles. If students need support in understanding the relationship between light and energy, refer to OpenSciEd Middle School Unit 6.1 (Light and Matter) and Unit 6.2 (Thermal Energy)" (Teacher Edition, page 141).
- Lesson 9: "If students do not use the term 'direct' to describe the relationship seen in the first graph, explain to them that scientists say a relationship is direct when both values on the graph increase simultaneously. For example, on slide J, as the average yearly UV index (average amount of UV a location receives over the course of one year) increases, the incidence of melanoma (occurrence of skin cancer) also increases. Refer to OpenSciEd Biology Unit 1 (Serengeti) to review how these relationships are discussed with students" (Teacher Edition, page 144).
- Lesson 10: "If you identify gaps in their understanding, encourage a peer to build on the ideas they have shared to explain what is happening to the random, inherited, and environmentally caused mutations. Focus on a single lesson and return to the components, interactions, and mechanisms, asking them to help identify ways to use pictures and/or words to make the invisible mechanisms visible" (Teacher Edition, page 163).

Extensions are provided for students who have mastered the material or who have high interest in the material. Related evidence includes:

- Lesson 2: The following suggestion for an extension is provided in the "Where We Are NOT Going" section of the lesson: "While students examine different cell types (lung, breast, skin, etc.), they will not investigate the functions of those cells and those body systems in depth. This exploration is beyond the scope of the unit. However, an extension for motivated students could include an in-depth exploration of a particular body system, how it functions, and how cancer disrupts that function. This exploration would support the development of HS LS 1.A.1" (Teacher Edition, page 44).
- Lesson 3: "Some examples of less scaffolding may include removing visual cues like arrows from the slides for Figure 1 or the cell diagrams from Figure 2, or separating images like the microscope images from the model images in the M Phase Card Sort" (Teacher Edition, page 66).
- Lesson 3: "For students who quickly grasp the ideas in the card sort, consider showing a still from the mitosis video (from slide J). Ask students to identify a cell in M phase and to explain their thinking. Replay video to give students a chance to apply their knowledge" (Teacher Edition, page 69).
- Lesson 4: The "Where Are We NOT Going" section of the lesson provides guidance for a possible extension for students. "While this lesson does not explore the discovery of the structure and function of DNA, some students may benefit from an investigation that extends their learning to include topics such as the discovery of the structure of DNA in the 1950s by scientists including James Watson, Francis Crick and Rosalind Franklin. Today, historians wonder about the cancer that ended Rosalind Franklin's short life and the repeated exposure to the x-rays she used to determine the structure of DNA" (Teacher Edition, page 77).
- Lesson 5: An extension activity is provided for students who have already demonstrated mastery. "ATTENDING TO EQUITY: For students who demonstrated mastery of the standard at an earlier stage, consider an extension activity that requires them to consider the structure and

function of the protein based on the charge of the amino acids. For more information see Optional Extension" (Teacher Edition, page 94).

- Lesson 9: "Questions may arise about different types of sunscreens. The two most common types of sunscreen commercially available are mineral and chemical sunscreens. Mineral sunscreens contain small particles, often zinc oxide and titanium dioxide, which remain on the skin's surface and physically block UV rays from penetrating the skin. Chemical sunscreens allow UV rays to be absorbed by the skin where they react with chemicals in the sunscreen. As a result of this reaction, the energy from the UV light is converted into heat which dissipates away from the skin. As an extension, students could investigate how these different sunscreens affect the yeast cell growth. Then, students could be asked to use the ideas around Structure and Function to explain how the two sunscreens work differently to protect against UV damage" (Teacher Edition, page 147).
- Lesson 11: "Students with a connection to a particular type of cancer treatment may wish to research a treatment that is not on the list. Encourage them to do so, with your guidance and to add it to their organizer. Students who demonstrate mastery of the LLPE early in the lesson, may benefit from an extension that introduces them to new areas of cancer treatment research using CRISPR. See CRISPR-based Therapy" (Teacher Edition, page 175). This is only a reading selection and there is no task associated with the reading that may provide a challenge to students who have mastered the standard.

Suggestions for Improvement

- Consider providing increased targeted support for multilingual learners. If this information is included in the Teacher Handbook, provide teachers with a link or page number for reference.
- Consider modifying graphs and diagrams so that students who are color blind can understand the images. Use textures as well as colors. For example, this could help students better access pictures on the following slides: Lesson 8 Slides K, L, M.

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in facilitating coherent student learning experiences over time because teachers are supported to connect lessons across the unit using both SEP and DCI elements, however connections to specific CCC elements are not included.

Teacher guidance is provided to support linking student engagement across lessons in a way that ensures students see learning in SEPs and DCIs is linked to their progress toward explaining the phenomenon. However, explicit support is not provided to ensure students see learning in CCCs is connected. Related elements include:

- "What is it, and what is its purpose? The Navigation routine enables students to experience the unit as a coherent storyline in which each activity has a purpose and is connected to what has gone before and what is coming. It also provides a valuable opportunity for students to reflect on their learning over time. When is it conducted? The Navigation routine is conducted throughout the unit at transition points. How do students typically represent their thinking as part of the routine? The Navigation routine is all about linking learning across lessons and activities. Students might represent their thinking in the following ways: ●Revisiting their initial ideas and focus questions in their science notebooks ● Revisiting their individual models in their notebooks to add to or revise their thinking ● Recording a "consensus" model, using a Progress Tracker, in their notebooks and publicly in the classroom ● Returning to the Driving Question Board to answer questions, add new questions, or refine their questions" (Teacher Handbook, page 16).
- The DQB is developed in Lesson 1 and used to brainstorm questions, investigations, and sources of data that could help figure out the phenomenon. Students return to the DQB in Lessons 6, 7, 9, 10, and 11 to add questions or to determine which questions have been answered.
- The unit uses a Progress Tracker where students periodically add updates to their learning and understanding of the unit phenomenon. Students do not use the Progress Tracker to think about their learning in all three dimensions.
- At the beginning of each lesson in the Teacher Edition, there is a "Where We Are Going and NOT Going" statement that explains the summary of what the key points of the lesson are for teachers as well as areas they shouldn't go to in that specific lesson.
- Lesson 1: "Share exit ticket data with students. Say, I had a chance to look through your exit tickets from our last class. It seems like many of you noticed that people who live in different places have different rates of cancer and we do not really know why. Adjust what you share with students based on the actual exit ticket data you collected and give students an opportunity to share any additional thoughts or questions with the class" (Teacher Edition, page 31).
- Lesson 1: "Prioritize next steps. Ask students to tear a half sheet of notebook paper and write down which questions make sense to investigate first. Remind them that the unit questions are Who gets cancer and why? and Where should we focus efforts on treatment and prevention? Collect their exit tickets" (Teacher Edition, page 39).
- Lesson 2: "Lead a discussion about what we figured out in the last class. Say, Yesterday, you all generated a lot of questions about who gets cancer and why. In your exit tickets, I noticed that some of you suggested we start our unit by figuring out what cancer is. Display slide A and use the prompts below as a guide" (Teacher Edition, page 45). The following teacher prompt is provided: "What ideas do you have about how we can figure out what cancer is?" (Teacher Edition, page 45). This is used to motivate the next step in the lesson. "Initial ideas discussion about cells. Say, Some of you suggested that we look at cells to figure out what cancer is. I was able to find some images of cancer and non-cancer cells for us to look at. Before we do, let's take a minute to talk about what we already know about cells. Display slide B and use the prompts below as a guide" (Teacher Edition, page 45).
- Lesson 2: "Motivate modeling as a way to make progress on the class's ideas. Say, It sounds like you all have figured out a lot about what cancer looks like at the level of the cells, but we need

to know more about how cancer interacts with other levels of organization like the organs, systems, or body. So far, we have investigated images and asked questions. What other science practices can we use to make sense of this? Listen for students to suggest developing a model. If students do not suggest modeling, ask them to think about how we have made sense of ideas in the past" (Teacher Edition, page 48).

- Lesson 2: "Review teacher feedback on initial models. Return student initial models. Display slide M and give students a few moments to review their feedback. Say, You all made a lot of progress on figuring out what cancer is in your models, first on the level of the cells and then at the level of tissues, organs, and systems. I noticed that you have a lot of questions. What do you think we should do to make progress on the unanswered questions from your models? Listen for students to suggest additional investigations into cancer, including looking at more cells, watching videos, or doing some reading" (Teacher Edition, page 49). This is a missed opportunity for students to relate learning related to the CCC of **Cause and Effect** to sense-making.
- Lesson 2: "Plan for next steps. Call on a few students to share their answers for the questions they still have. Guide students toward questions that will help the class make progress on the first unit question, Who gets cancer and why? Say, How did what we figured out from the differences between non-cancer and cancer cells and how lung cancer makes us sick help us answer our lesson question What is cancer?" (Teacher Edition, page 51). This is a missed opportunity for students to relate learning related to the CCC of **Cause and Effect** to sense-making.
- Lesson 3: "Review what we figured out in our last lesson. Display slide A. Ask students to turn and talk to a partner and then ask a few pairs to share their answers. Prioritize next steps. Ask students to recall what questions they still had in Unknown material with identifier: bi.l1.ho2 and what questions will help the class make progress on figuring out Who gets cancer and why? Listen for students to identify that although they figured out what cancer cells are and how they can make people sick, we still need to know how non-cancer cells become cancer cells or where cancer cells come from" (Teacher Edition, page 58).
- Lesson 4: The lesson begins with the following: "Review what we figured out and what new questions we have. Display slide A. Use the following prompts to guide the discussion" (Teacher Edition, page 78). The following prompts are provided to guide the discussion: "What did we figure out in our last class?", and "What question do we still need to answer?" (Teacher Edition, page 78).
- Lesson 4: "Generate ideas for next steps. Display slide T. Ask students to record their ideas for what questions the class should pursue next" (Teacher Edition, page 86).
- Lesson 5: "Introduce the kinesthetic model. Say, You all have a lot of great ideas about where p53 comes from and why there are different versions. I have a way we can investigate and figure out the answers to these questions. Let students know that you have a kinesthetic model, where they will get up and move around just like they did with the wildebeest and grass in OpenSciEd Unit B.1: How do ecosystems work, and how can understanding them help us protect them? (Serengeti Unit), that can help us figure it out" (Teacher Edition, page 92).
- Lesson 5: "Review our progress with the kinesthetic model. Display slide K. Return Kinesthetic Model to each student. Give students a few moments to individually review the feedback. Then, ask them to turn and talk to a partner and talk about what questions they still have. Call on a few students to share their thinking. Listen for students to point out places where they need more information to answer their questions" (Teacher Edition, page 93).
- Lesson 6: "Lead a discussion about what we have figured out so far. Display slide A. Say, We have figured out a lot of big science ideas over the past week or two! What are some of the

ways that we make sense of a lot of ideas? How do we make connections between ideas that we have? Pause to give students an opportunity to share their ideas about what practices they might engage in. Listen for ideas such as: We develop written explanations. We create models to explain relationships between components and ideas. We communicate our ideas with others. Say, Today we are going to take what we have learned to develop a class model that tells the story of what we have figured out" (Teacher Edition, page 101).

- Lesson 6: "Say, It sounds like we understand the genetic basis of cancer. What are the questions that we have left to answer? Can any of those questions help us make progress on filling in what our model does not explain? Give students a moment to identify key questions and share in their small groups. In addition, challenge students to add new questions that have come up for them. Consider asking students to nominate questions we could investigate next to continue making progress on the question Who gets cancer and why? Call on volunteers to share their questions and ideas for investigation with the class. Listen for ideas such as: We saw data about being older and taller giving you cancer too. Our model does not show us how that happens. Our model does not show anything about how cancer gets passed on in families. Our model also does not show how the environment could cause cancer, like lung cancer from smoking" (Teacher Edition, page 107).
- Lesson 9: "Review what we have figured out. Display slide A. Ask students to recall the progress that we have made in figuring out who gets cancer and why. Tell students to refer to their Unknown material with identifier: bi.l1.ho2 if needed. Listen for responses such as: We know some people get cancer due to random mutations during cell division. This usually happens to people who are older. Some people get cancer due to a germline mutation, which means it is in the eggs or sperm and is passed on. This increases risk for cancer and diagnosis at a younger age. Elicit ideas about next steps. Remind students that the mechanism we figured out so far only accounts for some of the cancer that occurs in the United States, but not the majority of cancers. Ask them to consider what we might investigate to figure out what factors might be responsible for other types of cancer that occur more frequently. Refer to the Driving Question Board and focus on students' questions connected to the environment, and its possible link to cancer. Listen for responses such as: We need to look at things in the environment. We should look at things like smoking, the sun, or pollution" (Teacher Edition, page 142).
- Lesson 9: "Navigate to the next lesson. Recall with students that we found out that our skin produces melanin which helps protect our cells' DNA from being damaged by UV light from the sun. Explain that from the reading we also found out that people with darker skin tend to produce more melanin. Remind students that though we might expect darker skin people to have some added protection against certain types of skin cancer because they have more melanin, what we actually see is that though there are fewer new cases of skin cancer in the Black population, Black people are 3 times more likely to die from skin cancer than White people in the United States. Ask students why they think this might occur. Accept all responses for now and tell students that we will examine this discrepancy more in Lesson 12. Display slide DD. Say, As I did more research on skin cancer, I found out that there's a different type of skin cancer, called acral lentiginous melanoma, or ALM, which is not caused by exposure to UV light. Also, it primarily affects people with darker skin and who belong to Asian and sub-Saharan African ethnic groups. If there are questions on the DQB about differences in who gets cancer, point those out now. Then ask students if they have any ideas on why this phenomenon might occur. After students share their ideas, say So, how can it be that people in different groups and from different places get cancer at different rates? Let's look more closely at that in our next lesson!" (Teacher Edition, pages 155–156)

Suggestions for Improvement

- Consider providing support for teachers to relate the CCC of **Cause and Effect** to unit coherence by providing specific prompts and questions related to the focus CCC elements.
- Consider using the Progress Tracker as a way for students to update their learning in all three dimensions.

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 adjust supports over time because support is provided to help all students build toward use of SEPs, however there is not clear evidence that scaffolding is reduced over time for all targeted SEP elements.

Some supports are provided throughout the unit to support students use of SEPs. Related evidence includes:

- Lesson 1: The following teacher prompt is provided to support students in the SEP of **Developing and Using Models**: *"*Support individual students by asking probing questions about how the components of the models are related…Probe them to think about and represent the smaller-scale mechanisms that they cannot see in their models" (Teacher Edition, page 36).
- Lesson 4: "SUPPORTING STUDENTS IN ENGAGING IN CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS If your students need more support in constructing their explanations, distribute Explanation Writing Support to each student. You can use the Student Explanation as a rubric as support for feedback. Make sure to tell students that you will be collecting this and providing feedback using the rubric" (Teacher Edition, page 84). However, this is not indicated as a targeted SEP for the unit.
- Lesson 6: *"*SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS Students will participate in the development of the class consensus model based on evidence they have collected in Lesson Set 1 to illustrate the genetic basis of cancer. The evidence they have collected is from multiple types of models including computer simulations, kinesthetic simulations, and a game model. Ask students to consider the merits and limitations of each of these types of models" (Teacher Edition, page 103).

Students are provided with multiple opportunities to develop proficiency in elements of the **Developing and Using Models** SEP, however it is not always clear that scaffolding is removed throughout the unit. Opportunities for students to develop and use elements of **Asking Questions and Defining Problems** are limited and therefore evidence of reduced scaffolding for these elements is limited. Related evidence includes:

- **Asking Questions and Defining Problems** *Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.*
    - Lesson 1: Students look at cancer data and fill out a notice wonder chart before engaging in a large group discussion. The following teacher guidance is provided: "Whole-group discussion. Display slide H. Facilitate a whole-group discussion to capture what students noticed and wondered about the data. Make a three-column chart on the board and ask small groups to share what they notice and wonder. Head each column with the following: Ideas We Agree On, Ideas We Disagree On, and New Ideas to Consider" (Teacher Edition, page 30). Students then complete the following Exit Ticket. "Exit Ticket. Display slide I. Ask students to turn to a new piece of loose-leaf paper in their science notebooks and answer the questions on the slide: What is one question that you have whose answer will help us make progress on our lesson question: Who gets cancer?" (Teacher Edition, page 31).
    - Lesson 1: "Identify gaps that the model cannot yet explain. Say, We have made great progress on our initial model to explain who gets cancer and why? We also have questions that we need to answer to make progress. Display slide V. Ask students to brainstorm in small groups a list of as many questions as they can think of that they would need to answer to make additional progress on the question Who gets cancer and why? Pass back the questions students identified on day 1 to remind students of the questions they had after investigating the data. Encourage them to include any of their original questions that remain unanswered" (Teacher Edition, page 37).
    - Lesson 8: Students engage in a discussion to elicit further questions. "What did we figure out in the last class? The more your cells divide the more chances you have for a mutation so older and taller people have more cancer. What questions do we still have? The mutations you accumulate in your lifetime only account for 66% of cancer, what else causes cancer?" (Teacher Edition, page 124). While this SEP element is not explicitly claimed for this lesson, this is a missed opportunity for students to further develop and use this element.
    - While this is identified as a targeted SEP element for development, this element is only claimed in Lesson 1, and because its use only occurs briefly in Lesson 8, it is not clear that students use the SEP element with increased independence.
- **Asking Questions and Defining Problems** *Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.*
    - Lesson 2: Students engage in a discussion about cells. Within the discussion the following teacher prompt is provided: "To figure out what cancer is, what questions do we need to answer about cells?" (Teacher Edition, page 46). However, no specific guidance is provided to ensure questions can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources.
    - Lesson 9: Teacher guidance is provided to motivate students to ask questions which can be investigated. Later in the lesson the following teacher guidance is provided: "Consider possible relationships to investigate. Display slide M. Tell students that we have access to UV sensitive yeast, as well as wild-type yeast in order to explore the relationship between the environment and cell growth, and what this tells us about skin cancer. Review the ideas for investigation discussed earlier by students on slide J. Let students know that based on their ideas for investigations, and the materials available in the classroom, the class can investigate two possible relationships: (1) how

environmental factors (such as UV radiation) affect cell growth in yeast, OR (2) how environmental factors (like sunscreen) can protect yeast cells from UV damage. Should other ideas for investigation come up that you are comfortable exploring as a class, adjust this text on this slide as needed" (Teacher Edition, page 145). Students are then introduced to yeast cells as a type of cell which can be used in the classroom. While students are guided to ask questions, the decision to use a question and organism which can be used in the classroom is teacher directed. Students are then guided to develop an investigative question with a partner based on the class question. A handout is provided which guides students in designing an investigative question. While there is an increase in independence from forming a question in a very teacher-directed way to developing a question with a partner, this is the only lesson in which this focus SEP element is developed.

- **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.*
  - Lesson 2: Students develop an individual model and then talk with a partner about their model. Using feedback from peers, students revise their models. All students are asked to contribute their ideas to a class consensus model.
  - Lesson 3: Students use a different type of model as they interact with the Cell Game in which they consider the relationship of the different parts of mitosis.
  - Lesson 5: In the Kinesthetic model, students consider the relationship between the code in the DNA and the protein produced. While this opportunity provides students with a chance to use a different type of model, it is not clear how scaffolding is removed.
  - Lesson 6: Students create a class consensus model to explain the genetic basis of cancer based on the information they have gathered in the first five lessons. While students work with a partner to create the Gotta-Have-It Checklist, they do not create an individual model and it is not clear how scaffolding is removed from previous opportunities to construct models.
  - Lesson 10: Students individually and in small groups develop a checklist of important components of a model. While students work independently to create the checklist initially, which shows increased independence, students finish creating the checklist with a partner and in small groups and the final model is created as a class.
- **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.*
  - Lesson 3: Students use the Cell Game, cell images, a model showing the amount genetic material in the cell and an M phase card sort to further develop their explanation for why cancer cells form. The following scaffolding guidance is provided; however, this scaffolding guidance is not directly related to the targeted SEP element: "ATTENDING TO EQUITY Consider adding or removing scaffolding for your students to support them as they use the data to provide evidence of mechanistic accounts. Some examples of scaffolding may include metacognitive techniques to think about how we interpret figures and/or discussing as a class different parts of the figures like legends, keys, axes, and labels before students interpret figures. Some examples of less scaffolding may include removing visual cues like arrows from the slides for Figure 1 or the cell diagrams from Figure 2, or separating images like the microscope images from the model images in the M Phase Card Sort" (Teacher Edition, pages 66–67).
  - Lesson 6: While this specific SEP element is not claimed in the materials, the following additional teacher guidance is provided while students brainstorm components for their

classroom consensus model: "SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS Students will participate in the development of the class consensus model based on evidence they have collected in Lesson Set 1 to illustrate the genetic basis of cancer. The evidence they have collected is from multiple types of models including computer simulations, kinesthetic simulations, and a game model. Ask students to consider the merits and limitations of each of these types of models" (Teacher Edition, page 103).

- Lesson 8: Students use multiple model types (e.g., pedigrees, pipe cleaners as physical model, and simulation based upon limitation of each of the models). However, the limitations found by the models and the movement between models is teacher driven.
- While this is identified as a targeted SEP element, these are the only instances in which this SEP is developed or used in the materials and students do not have an opportunity to use the SEP element individually.

Suggestions for Improvement

Considering providing students with multiple exposures to all focal SEP elements and supporting students to become more independent and proficient in the use of those focal elements. Consider using the "Supporting Students In..." sidebars to explain how students should be progressing in the elements of the SEPs and how teachers could adjust scaffolding as the unit progresses in a way that makes the waning support evident to teachers.

OVERALL CATEGORY II SCORE: 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

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 and/or design solutions. Key assessments do not always fully assess elements of SEPs that are claimed as focus elements in the unit and monitoring individual student progress is minimal as most activities are group work or class discussions without guidance for the teacher to monitor individual student progress.

Materials routinely elicit evidence that students are integrating the three dimensions in service of making sense of phenomena and solving problems. However, there is some mismatch between elements assessed in formal assessments and those claimed as focused on in the unit. Related evidence includes:

- The Assessment System Overview includes a section called the Lesson-by-Lesson Assessment Opportunities, which list the three-dimensional Lesson-Level Performance Expectations (LLPEs), the targeted SEP(s) and CCC(s), and the DCI understanding students should be able to demonstrate. For example:
  - Lesson 4: “Construct an explanation based on evidence about how mutations can occur during DNA replication resulting in differences in chromosomes and the role of p53 in their repair. (SEP: 6.2; DCI: LS3.B.1; CCC: 2.2)” (Teacher Edition, page 203).
  - Lesson 8: “Develop and use multiple models to explain how the inheritance of p53 alleles and other gene alleles can cause cancer in multiple generations of a family through new combinations of alleles” (Teacher Edition, page 205).
  - Lesson 9: “Make and defend a claim using evidence about how environmental factors cause mutations in genes. (SEP 7.5; DCI LS3.B.2; CCC 2.1)” (Teacher Edition, page 206). The labeled assessment opportunities in this lesson involve student discussions, without individual student artifacts to assess.
- The unit contains 21 claims about student performances, including a statement about the DCI, SEP, and CCC elements used in the assessments (Teacher Edition, pages 201–207). Of those, 17 tasks require students to use the complete element at a high school level. The remaining four tasks are incomplete as one or more of the high school level elements of either the CCCs or SEPs are not addressed.
- Lesson 1: “Develop individual models. Say, We have figured out a lot about who gets cancer based on the data we investigated and in the article we just read. How can we begin to make sense of our developing ideas? Listen for students to share ideas related to developing models. Prompt them to think about the practices they used in previous units if they do not suggest modeling. Display slide Q. Ask students to take a few minutes to stop and jot their initial models in their science notebooks” (Teacher Edition, page 36). Students work independently to create models without scaffolding. While there is no specific guidance provided to ensure the

model is used to predict or illustrate the relationship between systems, teacher guidance is provided to look for these interactions. In this task, students use the following elements of the three dimensions:

- DCI: **LS3.B: Genetic Variation** *Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.*
- 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: **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 2: Students are asked to individually develop models to explain how cancer causes illness. "Develop individual models. Display slide J and ask students to develop an initial model in their science notebooks to explain how cancer makes us sick. Encourage them to choose a single cell type from the images previously investigated and to consider how the cancer cells will interact with the non-cancer cells in the system" (Teacher Edition, page 48). While no handout is provided for scaffolding, the following guidance is provided on the accompanying slide: "Use pictures, symbols, and words in your model to help explain your ideas. ● Pick one cell type and think about how the cells are organized as tissues -> organs -> systems -> organisms. ● How do the cancer cells interact in those levels? ● What effects do the interactions have on the whole system? ● What mechanisms explain those interactions?" (B.3 Lesson 2 Slides, Slide J). Students are then provided with an opportunity to share their model and receive peer feedback. "Turn and talk about initial models. Display slide K. Ask students to turn and talk to a partner to share their models and give and receive feedback. Consider setting a timer so that each student can give and receive feedback. Distribute Peer Feedback Protocol to any student that would benefit from a paper copy" (Teacher Edition, page 48). Students are then provided with an opportunity to revise their model. "Revise initial models and identify questions. Display slide L. Ask students to consider the feedback they received from their peers and make revisions to their models. Then ask them to look for places they still have questions about how components interact or what mechanisms explain the interactions. Ask them to add a question mark anywhere they still have a question. Collect and review initial models before the next class" (Teacher Edition, page 49). In this task, students use the following elements of the three dimensions:
  - DCI:
    - **LS1.A: Structure and Function** *Systems of specialized cells within organisms help them perform the essential functions of life.*
    - **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: **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 4: Students write a formal explanation to answer the question "How do cancer cells end up with differences in their chromosomes and what is the role of p53 preventing the differences?" While this task requires the use of focus DCI and CCC elements, the specific SEP element assessed is not claimed as a focus SEP element for development in the unit. In this task, students use the following elements of the three dimensions:
    - DCI: **LS3.B: Genetic Variation** *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.*
    - 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 5: At the end of the lesson, students complete an online Exit Ticket. A key is provided which contains correct student responses, as well as a rationale for correct responses and what to do if students do not get the correct answer. Specific questions related to SEPs and CCCs are provided to help with student thinking about their development. For example: "How can you use structure and function to explain or ask questions about something you have seen or experienced in your everyday life?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 5), "How did obtaining and communicating information from multiple sources such as a kinesthetic simulation, reading and images help you make sense of how we make p53 and why it is different sometimes?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 7), and "How did the crosscutting concept structure and function help you explain the lesson question: How do we make p53, and why is it different sometimes?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 7). While these do allow direct assessment of CCC and SEPs, they are not assessed at the element level, and do not represent SEPs and CCCs which were identified as a focus in the materials.
- Lesson 7: Students create an initial model that explains "Why are some kinds of cancer more common than others in older and taller people?" In this task, students use the following elements of the three dimensions:
    - DCI:
        - **LS3.B: Genetic Variation** *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.*
        - **LS1.B: Growth and Development of Organisms** *In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain*

a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.
    - 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: **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 10: The transfer task provided indicates the focus SEP element as "**Engaging in Argument from Evidence**. *Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence*", however this is not indicated as a focus SEP element for development in the materials. In addition, while the CCC and SEP elements cited are focus elements for the unit, they only represent two DCI elements and one CCC element and most SEP and CCC elements claimed are not formally assessed. In this task, students use the following elements of the three dimensions:
    - DCI:
        - **LS3.B: Genetic Variation** *In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell divis ion), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.*
        - **LS3.B: Genetic Variation** *Environmental factors also affect expression of traits , and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of trait factors.*
    - SEP: **Engaging in Argument from Evidence**. *Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.*
    - CCC: **Cause and Effect** *Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.*

Suggestions for Improvement

- Consider modifying the key assessments in Lessons 4 and 10 to assess SEP elements explicitly claimed for development in the unit.
- Consider adding more opportunities for individual assessment such as the Exit Tickets found in a few lessons.

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 because the materials include frequent and varied supports to the teacher to monitor formative assessments. The assessments are part of instruction and are found in various formats. Teachers are provided with support to modify instruction based on the results of formative assessments. Formative assessments occur in all lessons in the unit. The formative assessment opportunities allow students to show their thinking across all three dimensions.

The materials include opportunities for formative assessment of all three dimensions that are called out explicitly throughout the lessons. Related evidence includes:

- Lesson 1: Students develop individual models to explain who gets cancer and why.
- Lesson 2: Students are asked to individually develop models to explain how cancer causes illness.
- Lesson 3: Students complete an M phase card sort. “Introduce M phase card sort. Display slide V. Say, I have some data about the M phase that I think will help answer your questions. The data consists of actual cell photos and drawings from a scientific model of a cell during the M phase. Ask students to work with a partner to 1) use the scientific model to identify the blue and green colored structures in the photos, 2) sequence the photos from start to end, and 3) describe what they think is happening during the M phase. Distribute one set of M phase cards to each pair. Display slide W and ask them to record their thinking in their T-chart in their science notebooks” (Teacher Edition, page 69).
- Lesson 5: Students complete a kinesthetic modeling activity to simulate protein synthesis and complete questions related to the activity which include identifying what each component of the model represents as well as answering the following questions: “How does the model help you answer the question: How do we make p53, and why is it different sometimes?”, “Find a classmate that worked with the same DNA strand as you. Compare your sequence of amino acids and your sequence of words. How did they compare? If they are different, why do you think they are different?”, and “Find classmates that had different strands of DNA than you. How did they compare? If they are different, why do you think they are different?” Students first work with a partner to answer the questions and then work with another group before revising their answers. “Complete Part 2: Making Sense. Display slide G. As students complete the activity, ask them to return to their seats to complete Part 2 of Kinesthetic Model with their partner. Compare results. Display slide H. Have students share their response with another pair. They should discuss similarities and differences they see and mark up their own ideas to indicate where they heard new ideas they might want to add. Display slide I when students are ready to see the key to the sentences. Revise responses. Display slide J. Give students a few moments to revise their ideas in the table and to the lesson question in Kinesthetic Model. Collect student responses before the end of class” (Teacher Edition, page 92–93).
- Lesson 5: At the end of the lesson, students complete an online Exit Ticket. A key is provided which contains correct student responses, as well as a rationale for correct responses and what to do if students do not get the correct answer. For example: “Correct response: All of the above. The structure of p53a has 9 amino acids. The structure of p53b has 8 amino acids and one is different. The difference in the amino acids results in a different shape in the protein.

Rationale: All of the responses help explain the structure of the p53 protein and why it is different. What to do: Ask students to return to the shapes of the p53 protein and the associated amino acid sequences. They can identify and explain the differences" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 6).

- Lesson 7: Students create an initial model that explains "Why are some kinds of cancer more common than others in older and taller people?"
- Lesson 8: After students complete interpreting the pedigree to create their model, students are provided with "Making Sense" questions on the provided handout.
- Lesson 8: At the end of the lesson students complete an online Exit Ticket. A key is provided which aligns each question to elements of SEPs, CCCs and DCIs. Each question contains a sample response which includes the correct response, rationale for correct response, and what to do. For example: "Correct response: Population B Rationale for correct response: The model shows the potential of gametes to have different combinations of alleles with crossing over. Population B has four different gametes, while A has two different gametes. What to do: Ask students to compare the number of different gametes for the two populations in the model" (B.3 Lesson 8 Answer Key Electronic Exit Ticket, page 2).

Formative assessment opportunities are aligned to three-dimensional learning outcomes derived from grade-appropriate elements from all three dimensions. In addition, sample student responses are provided throughout the materials.

- Assessment callout boxes are found throughout the unit. Each of these contains a section titled "What to look/listen for" and "What to Do." Some samples are below:
  - Lesson 2: "What to look for/listen for in the moment: Models that explain: (SEP: 2.3)
    - Cancer and non-cancer cells interact at the level of the cell, tissue, organ, body system, and organism. (DCI: LS1.A.3; CCC: 2.2)
    - Those interactions may disrupt the typical function of the cells. (DCI: LS1.A.1; CCC: 2.2)
    - If the typical function is disrupted, the person might feel sick because they do not get what they need from that organ or system. (DCI: LS1.A.1 & LS1.A.3; CCC: 2.2)

    What to do: Provide written feedback on student models.

    - If the student is missing the levels of organization, ask them what organ and organ system the cells are a part of.
    - If the student is missing the idea that cancer cells disrupt non-cancer cells, ask them how they think the cancer cells interact with the non-cancer cells.
    - If the student is missing the effect that the disruption might lead to illness, ask them to consider what those cells do and how a disruption might affect their function.

    Building toward 2.B.1 Develop and revise a model to illustrate the relationship between systems of specialized cells and cancer cells at the scales of the cells, the tissue, the organ, and the body. (SEP: 2.3; DCI: LS1.A.1 & LS1.A.3; CCC: 2.2)" (Teacher Edition, page 49).
  - Lesson 8: "What to look for/listen for in the moment: See Lakita's Pedigree Key for guidance.
    - Using pipe cleaners and beads to illustrate genotypes for Lakita's family pedigree. (SEP: 2.4)

- Correctly identifying genotypes based on phenotypes and inheritance for different individuals over multiple generations. (DCI: LS3.B.1; CCC: 2.2)
- Lakita's grandfather and mother will be homozygous for the p53 allele that corrects mutation.
- Lakita's father and aunts and uncles and Lakita will be heterozygous for the p53 allele that does not correct mutation.
- Lakita's aunts that have not been tested could be homozygous for the p53 allele that corrects mutation or heterozygous for the p53 allele that does not correct mutations.
- Lakita's grandmother could be homozygous or heterozygous for the p53 allele that does not correct for mutations.

What to do:

- If students struggle on where to start, consider working through a few individuals together. For example, ask whether Lakita's grandfather or mother has Li-Fraumeni Syndrome and figure out what his or her chromosomes would look like. Then explore the genotypes of one of their offspring with LiFraumeni Syndrome.
- If students struggle with the aunts who are unknown, explain that it's ok for models to show uncertainties and help students figure out how to show this.
- If students struggle with the grandmother, ask students to consider a case where at least one of the unknowns did not have Li-Fraumeni Syndrome and a case where both unknowns had Li-Fraumeni Syndrome.
- For further informal assessment, consider collecting and reviewing their answers on Lakita's Family Pedigree.

Building toward 8.A.1 Develop and use multiple models to explain how the inheritance of p53 alleles and other gene alleles can cause cancer in multiple generations of a family through new combinations of alleles. (SEP: 2.4; DCI: LS3.B.1; CCC: 2.2)" (Teacher Edition, page 127).

- Lesson 9: "What to look for/listen for in the moment: As students complete the Unknown material with identifier: bi.l9.ho1 with their partner, listen and look for the following:
  - Selection of an investigative question.(SEP: 1.6)
  - Identification of an independent variable and dependent variables which will be observed during their investigation and provide empirical evidence that environmental factors can cause mutations. (DCI: LS3.B.2; CCC: 2.1)

  What to do: Support students in choosing investigative variables that are supported by the available materials and that will help them generate evidence to answer their questions. For example, if they are interested in the protective mechanism, guide them toward variables such as different types of sunscreen or different types of fabric. If they are interested in the effect of latitude and exposure to sunlight, guide them toward varying the time the yeast cells are exposed to the light source" (Teacher Edition, page 146).

Results of formative assessment are routinely used to guide instructional decisions, but this guidance is often based on the class as a whole and do not always attend to individual student needs.

- Lesson 1: “Support individual students by asking probing questions about how the components of the models are related. Focus on the language of cause and effect, such as What do you think the cause of cancer is for taller or older people? or What effect might where you live have on incidence of cancer? Probe them to think about and represent the smaller-scale mechanisms that they cannot see in their models” (Teacher Edition, page 36).
- Lesson 2: The following guidance is provided as a “What to Do” in an assessment opportunity box: “If students are not ready to ask questions about cancer and non-cancer cells because they need more support building middle school ideas, see Lesson 6 from OpenSciEd Unit 6.6: How do living things heal? (Healing Unit) and https://www.openscied.org/general/microscope-body/ , where students can view skin, bone, and muscle cells to look for patterns within and between these cell types” (Teacher Edition, page 47). While this is a useful guidance for guiding instructional decisions for the class as a whole, there is a missed opportunity for providing guidance to support individual students in building these ideas rather than only providing guidance for addressing the whole class.
- Lesson 3: “If students have trouble relating what happened in the game to what happens in a real cell, provide them with a paper copy of Game Board. Ask them to mark up the gameboard by using pictures and/or words to explain what is happening at each step of the game” (Teacher Edition, page 65).
- Lesson 3: “If students struggle to connect what happened in the game to what happens in a cell, they may need more time to discuss what each part of the game represents. Remix the student groups and give them additional time to discuss the Making Sense portion of Round 1” (Teacher Edition, page 61). While this is useful guidance for guiding instructional decisions for the class as a whole there is a missed opportunity for providing guidance to support individual students in building these ideas rather than only providing guidance for addressing the whole class.
- Lesson 3: “For students who quickly grasp the ideas in the card sort, consider showing a still from the mitosis video (from slide J). Ask students to identify a cell in M phase and to explain their thinking. Replay video to give students a chance to apply their knowledge” (Teacher Edition, page 69).
- Lesson 8: “If students end up with different combinations of alleles than expected, review their images prior to the first cell division and check for swapping of material. For further informal assessment, consider having students submit their photos online in a shared slide deck or flip book or collect their drawings in class. As students complete their models, choose an offspring from the pedigree and ask students to identify which sperm fertilized the egg that produced this person” (Teacher Edition, page 134).
- Lesson 10: “If you identify gaps in their understanding, encourage a peer to build on the ideas they have shared to explain what is happening to the random, inherited, and environmentally caused mutations. Focus on a single lesson and return to the components, interactions, and mechanisms, asking them to help identify ways to use pictures and/or words to make the invisible mechanisms visible” (Teacher Edition, page 163).

Suggestions for Improvement

N/A

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 materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions because sample student responses, and "look-fors" are provided for key assessments throughout the materials along with guidance to interpret scores. However, explicit guidance to support students in interpreting their own progress toward targeted standards (specifically related to SEPs and CCCs) is not provided.

Assessment targets for grade-appropriate elements of all dimensions being assessed together are clearly stated in the scoring guidance along with information that can be used to interpret responses. Related evidence includes:

- Assessment callout boxes are found throughout the unit. Each of these contains a section titled "What to look/listen for" and "What to Do" as well as what specific three-dimensional learning target the assessment is aligned to. For example:
  - Lesson 4: "What to look for/listen for: Explanations based on evidence including: (SEP: 6.2)
    - DNA must be unzipped and unwound for DNA replication to begin. (DCI LS3.B.1)
    - When non-cancer cells divide, the new cells, including chromosomes, are identical to the parent cell; cancer cells have differences in their chromosomes. (DCI LS3.B.1)
    - Mutations occur during cell division and cause the differences in the chromosomes. (DCI:LS3.B.1; CCC: 2.2)
    - One version of p53 was able to attach to the DNA strand to break the bonds of the mutation to repair it. (DCI:LS3.B.1; CCC: 2.2)
    - There were versions of p53 that did not help correct mutations.

    What to do: Collect student explanations and provide feedback using Student Explanation. Provide students an opportunity to revise their explanations based on your feedback. This is also an opportunity to support student growth in providing and acting on peer feedback. Review the peer feedback and provide written feedback. Use the prompts on slide S. Consider how the receiving student acted on the feedback. Look for examples of places where students acted on or missed an opportunity to act on peer feedback in their revisions. Building toward: 4.A Construct an explanation based on evidence collected from a simulation about how mutations can occur during DNA replication and the role of p53 in repairing mutations. (SEP 6.2; DCI LS3.B.1; CCC 2.2)" (Teacher Edition, page 85).
  - Lesson 7: "What to look for/listen for in the moment: Revised initial models (SEP 2.3) explaining how getting older and taller affects mutation rates and its relationship to cancer.
    - Different cell types form after mitosis. (DCI LS1.B.1)

        - Different cell types divide at different rates. (DCI LS1.B.1 & LS3.A.1; CCC 4.4)
        - The more cells divide, the more chances for mutations to happen. (DCI: LS3.B.1; CCC: 4.4)
        - The more mutations a person has, the higher their likelihood of getting cancer. (DCI: LS3.B.1; CCC: 4.4)
        - Cells divide as you grow, so an older person has more cell divisions than a younger person. Because of this, the older person will likely have more mutations than the younger person. (DCI: LS3.B.1; CCC: 4.4)
        - Taller people have more cells than shorter people, so there are more divisions happening in the same amount of time for the taller person. Because of this, taller people will accumulate mutations more frequently than shorter people. (DCI: LS3.B.1; CCC: 4.4)
    - What to do: As students revise their models, prompt them to use evidence from the computer simulation, discussion, notes, and peer feedback to inform their revisions. Remind students they observed different types of cells, manipulated conditions like height and age, and collected data about the relationships between cell division rate, number of mutations per cell, and cancer diagnoses. Encourage students to revisit the simulation if needed.
    - 7.A Use a computer simulation as evidence to develop and revise a model that predicts how the rate of cell division affects the likelihood of cancer. (SEP: 2.3; DCI: LS3.B.1 & LS1.B.1; CCC: 4.4)" (Teacher Edition, page 117).
- Lesson 5: At the end of the lesson, students complete an online Exit Ticket. A key is provided which contains correct student responses, as well as a rationale for correct responses and what to do if students do not get the correct answer. For example: "Correct response: All of the above. The structure of p53a has 9 amino acids. The structure of p53b has 8 amino acids and one is different. The difference in the amino acids results in a different shape in the protein. Rationale: All of the responses help explain the structure of the p53 protein and why it is different. What to do: Ask students to return to the shapes of the p53 protein and the associated amino acid sequences. They can identify and explain the differences" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 6). In addition, a chart is provided which outlines where specific SEP, CCC, and DCI elements are used on the assessment.
- Lesson 8: At the end of the lesson students complete an online Exit Ticket. A key is provided which aligns each question to elements of SEPs, CCCs and DCIs. Each question contains a sample response which includes the correct response, rationale for correct response and what to do if students do not get the correct answer. For example: "Correct response: Population B Rationale for correct response: The model shows the potential of gametes to have different combinations of alleles with crossing over. Population B has four different gametes, while A has two different gametes. What to do: Ask students to compare the number of different gametes for the two populations in the model" (B.3 Lesson 8 Answer Key Electronic Exit Ticket, page 2).
- Lesson 9: A handout is provided which guides students in designing an investigative question. A key is provided that includes a single exemplary sample student response.
- Lesson 10: Students investigate cancer treatments through readings and record their notes in an organizer. A treatment organizer answer key is provided containing a single sample student response.
- Lesson 10: A key is provided for the Genetics Transfer Task which outlines how specific SEP, CCC, and DCI elements are aligned to each question. A single sample student response is provided for part 1 of the assessment. A rubric is provided for part 2 which contains a "what to look for"

section aligned to all three dimensions for "Foundational Pieces", "Linked Understanding", and "Organized Understanding" levels. Each level also contains an example claim as well as feedback which could be provided for each level. A correct answer is provided for part 3, along with ideas for instruction aligned to Foundational Understanding, Linked Understanding, and Organized Understanding levels. However, it is not clear how a teacher would know which level to choose to guide instruction.

- Answer keys or rubrics are also provided for the following assessments:
    - Lesson 3: Mitosis Card Sort Key
    - Lesson 3: Making Sense Key. Feedback guidance is provided for the teacher.
    - Lesson 4: Student Explanation Rubric. This rubric provides scoring guidance in all three dimensions. A variety of student responses are provided labeled as foundational, linked, and organized understanding. Teachers are provided with "Ideas for Instruction" if students are struggling.
    - Lesson 4: Checklist and Explanation Key
    - Lesson 6: Gene Expression Simulation Answer Key
    - Lesson 8: Lakita's Pedigree Key
    - Lesson 9: Sample Progress Tracker Answer Key
    - Lesson 11: Treatment Organizer Answer Key
    - Lesson 12: Sample Transfer Task

Exemplar student responses are provided for all classroom discourse/teacher oral questioning. Related evidence includes:

- Lesson 3: The suggested prompt, "What were some of the differences that we discovered between non- cancer and cancer cells?" is paired with the sample student responses, "They get mutations" and "There is something wrong with them somehow" (Teacher Edition, page 58).
- Lesson 5: The suggested prompt, "Why were there different versions of the DNA? What did each different version code for?" is paired with the sample student response, "There were mutations in the original sequences of the p53 gene that gave us the other versions of p53" with a teacher follow up question, "What were the differences between the three different strips of paper that represented DNA?" (Teacher Edition, page 94).
- Lesson 8: The suggested prompt, "What did you notice in the reading?" is paired with a range and variety of sample student responses. These include, "Sperm and eggs are produced by a process called meiosis", "Meiosis was similar to the cell division we saw in an earlier lesson, but there were some differences", "Meiosis has two divisions", "The first division divides chromosome pairs", "The second division divides duplicated chromosomes", "We ended up with 4 cells, each with half the chromosomes as the starting cell", and "There was another step that involved exchanging parts of chromosomes, crossing over" (Teacher Edition, page 132).

Students are provided with limited ways of tracking their own progress. Related evidence includes:

- Students use a Progress Tracker throughout the unit to track their learning toward making sense of the phenomenon, however, this is only used to track learning directly related to DCI elements.
- Lesson 6: "Lead students in a self-assessment opportunity. Display slide E. Students will explain what evidence they have for the genetic basis for cancer. They will also explain why they included some ideas and not others on their Gotta-Have-It Checklist. Remind students that they are to annotate their Gotta-Have-It Checklist with their colored pen so that they can see the results of their self-assessment and the additional ideas that they believe that need to be added" (Teacher Edition, page 103).

- Lesson 10: "For an optional assessment, have students do the self-assessment that they did on their Gotta-Have-It Checklists in Lesson 6. To complete the self-assessment: Circle evidence Underline the evidence that answers the question Why do people in different groups and places get cancers at different rates? Could the model be improved by adding more science ideas? Challenge them to add an idea that was not already included in the initial draft of the checklist" (Teacher Edition, page 163).

Suggestions for Improvement

- Consider adding ideas related to CCCs and SEPs to the Progress Tracker as well as the Gotta-Have-It Checklist self-assessments.
- Consider adding opportunities for students to assess their own three-dimensional learning, such as by using the provided rubrics to score themselves or providing general rubrics for key learning objectives so that students can assess and track their progress over time.
- Consider providing teachers with scoring guidance that provides information about student progress toward specific elements of each dimension. This is provided for the major summative assessments but could be included for other assessments as well.

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 because the unit offers opportunities that measure student learning in a variety of ways. Over the course of the unit students write, draw, discuss, and verbally present. Although multiple modalities are used for student responses, there is little student choice of modality.

Vocabulary and text volume in student assessments are grade-level appropriate. Support is provided for students to access tasks when needed. Related evidence includes:

- Vocabulary is developed throughout the unit through use of students creating a glossary in their notebooks. Guidance is provided to teachers throughout the unit to assist with vocabulary development. The following guidance is provided for developing vocabulary throughout the unit: "This unit refers to two categories of academic language (i.e., vocabulary). Most often in this unit, students will have experiences with and discussions about science ideas before they know the specific vocabulary word that names that idea. After students have developed a deep understanding of a science idea through these experiences, and sometimes because they are looking for a more efficient way to express that idea, they have co-developed that definition and can add the specific term to a personal glossary at the back of their notebooks. These 'definitions we codevelop' should be recorded using the students' own words whenever possible. On the other hand, 'definitions we encounter' are 'given' to students in the course of a reading, video, or other activity, often with a definition clearly stated in the text. Sometimes, definitions we encounter are helpful just in that lesson and need not be recorded in students' personal glossaries. However, if a word we encounter will be frequently referred to throughout the unit, it should be added. It is best for students if you create consensus definitions in the moment, using phrases and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the meaning of the word, students 'own' the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary, which includes an accessible definition and visual support. Sometimes defining a word is a challenge. The Teacher Guide provides a suggested definition for each term to support you in helping your class develop a student-friendly definition that is also scientifically accurate" (Teacher Edition, page 20).

- Guidance for Developing Your Personal Glossary (Teacher Edition, page 20) includes teacher support for introducing new and technical terms during the instruction. Students have a way to learn and access vocabulary in a grade-appropriate manner with extra supports with visual aids.
- Readings, supplemental materials, and assessments have visual aids and other cues to help student understanding.
- Lesson 10: Support is provided to ensure students can access materials on the transfer task by allowing them to first ask questions and use materials they have created throughout the unit. "Orient students to the Transfer Task. Display slide L. Distribute Genetics Transfer Task and give students a few minutes to read over the task and ask clarifying questions. Allow students to use their Progress Trackers, Gotta-Have-It Checklists, and science notebooks as resources as they complete the task" (Teacher Edition, page 166).

Representations are made accessible by the use of pictures, graphs, computer simulations, and video.

- Lesson 1: Student directions are presented orally and frequently on the lesson slide set (B.3 Lesson 1 Slides, Slide P).
- Lesson 4: Directions for computer simulations are contained in a handout for easy student reference (Lesson 4 Handout Simulation Guidance).
- Lesson 5: Students are provided with a graphic organizer to collect their ideas about DNA replication (Lesson 5 Slides, Slide M).
- Lesson 8: Students view videos that introduce two case studies (Lesson 8 Slides, Slide E).
- Lesson 10: The transfer task begins with a scenario which is represented both with graphs and text. "There has been a dramatic increase in the number of people getting genetic tests in the past few years. Figure 1 and 2 above report how many requests and payments have been made to and by Medicare, the government healthcare system. In this task you will investigate the following question: What are these genetic tests for and what information can they provide us?" (B.3 Lesson 10 Assessment Genetics Transfer Task, page 1). The accompanying graphs visually show the Medicare payments for genetic tests from 2018–2019 and the number of genetic testing procedure codes covered by Medicare from 2016–2019.

Students are provided with the ability to demonstrate their learning in multiple ways including through writing, drawing, and speaking. However, student choice in modality is limited. Related evidence includes:

- Lesson 1: "Turn and Talk. Display slide D. Ask students to turn and talk to a neighbor about what they know about cancer. Remind them that they may have written about personal stories and feelings in their science notebooks and it is up to them to decide if what they share includes this. Let students know they will participate in a whole-class discussion where they share a summary of their conversation with their partner and they should make sure not to share anything their partner would prefer to keep private. Facilitate an Initial Ideas Discussion. Call on a few student pairs and ask them to share their ideas. Record these ideas on the whiteboard. Encourage students to build on each others' ideas using prompts such as, Did any pair discuss similar ideas? or Who can build on this idea?" (Teacher Edition, page 29).
- Lesson 1: "Develop individual models. Say, We have figured out a lot about who gets cancer based on the data we investigated and in the article we just read. How can we begin to make sense of our developing ideas? Listen for students to share ideas related to developing models. Prompt them to think about the practices they used in previous units if they do not suggest modeling. Display slide Q. Ask students to take a few minutes to stop and jot their initial models in their science notebooks" (Teacher Edition, page 36).
- Lesson 3: Students complete a M phase card sort. "Introduce M phase card sort. Display slide V. Say, I have some data about the M phase that I think will help answer your questions. The data consists of actual cell photos and drawings from a scientific model of a cell during the M phase. Ask students to work with a partner to 1) use the scientific model to identify the blue and green colored structures in the photos, 2) sequence the photos from start to end, and 3) describe what they think is happening during the M phase. Distribute one set of M phase cards to each pair. Display slide W and ask them to record their thinking in their T-chart in their science notebooks" (Teacher Edition, page 69).
- Lesson 4: "Stop and jot. Display slide B. Ask students to take out their science notebooks and say, We want to explore more about those chromosomes and the differences we saw between the chromosomes of cancer and non-cancer cells. What do you already know about chromosomes? Turn and talk. Display slide C. Ask students to share their answers with a partner and to record new ideas they hear in their science notebooks. Listen for students to identify chromosomes as genetic material or DNA. Facilitate an Initial Ideas Discussion. Display slide D. Use the prompts below to facilitate an Initial Ideas Discussion" (Teacher Edition, page 79).
- Lesson 4: Students write an explanation to answer the question "How do cancer cells end up with differences in their chromosomes and what is the role of P53 preventing the differences?". The following teacher guidance is provided: "Lesson 4: "ATTENDING TO EQUITY Support students with learning differences and/or emerging multilingual students by providing opportunities for students to complete the explanations in multiple modalities. You may consider allowing some students to present their answers verbally with you or with another student acting as a scribe to record their thinking on paper or through a voice recording. Some students may benefit from using gestures, images, or manipulatives to support their explanations as opposed to written text. In each case, encouraging students to use multiple modalities to show their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency" (Teacher Edition, page 85). However, this is the only significant task in which a choice of modality is suggested.
- Lesson 9: "Ask students to complete the table in Part 3 of Investigation Plan by making predictions about what they think will happen in each condition and what evidence they are basing their predictions on. Encourage students to use words and/or drawings when making their predictions" (Teacher Edition, pages 150–151).
- Lesson 9: "Students should fill out the data collection table by recording both a drawing of their petri dishes and written observations" (Teacher Edition, page 151).

Suggestions for Improvement

Consider providing specific guidance which indicates that a choice of modality is suggested for key assessments throughout the materials.

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 because all assessment types are present, and the materials connect to stated learning goals from all three dimensions.

Guidance is provided for teachers to see how the provided assessments work together to form a coherent assessment system. Related evidence includes:

- The “Assessment System Overview” in the “Unit B.3 Teacher Reference Materials” section of the Teacher Edition, includes a table with lesson-by-lesson assessment opportunities categorized by the type of assessment (pre-, formative, summative, self-), and a description of the purpose of each listed assessment (Teacher Edition, pages 198–200).
- Lesson-by-Lesson Assessment Opportunities: This document includes what LLPEs are in each lesson as well as assessment guidance (Teacher Edition, pages 200–207).

The materials contain a pre-assessment. Related evidence includes:

- Lesson 1: “Develop individual models. Say, We have figured out a lot about who gets cancer based on the data we investigated and in the article we just read. How can we begin to make sense of our developing ideas? Listen for students to share ideas related to developing models. Prompt them to think about the practices they used in previous units if they do not suggest modeling. Display slide Q. Ask students to take a few minutes to stop and jot their initial models in their science notebooks” (Teacher Edition, page 36).

The materials contain formative assessments that measure three-dimensional learning. Related evidence includes:

- Multiple key assessment tasks are found in every lesson and are called out in the “Assessment Opportunity” boxes. All of these “Assessment Opportunity” tasks formatively assess student learning in three dimensions.
- In the “Lesson-by-Lesson Assessment Opportunities,” the teacher is told, “The table below summarizes opportunities in each lesson for assessing every lesson-level performance

expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion" (Teacher Edition, page 200).

- Lesson 1: "Collect student exit tickets and look for questions related to the data as a formative assessment opportunity. Keep student questions until students are ready to develop the DQB. Provide written feedback to support question revision for DQB" (Teacher Edition, page 31).
- Lesson 2: Students are asked to individually develop models to explain how cancer causes illness.
- Lesson 3: Students show their understanding of mitosis by sequencing a set of cards and describing what is happening in each phase of mitosis.
- Lessons 5 and 8: Electronic Exit Tickets can be used to evaluate understanding of individual students.
- Lessons 6 and 10: Class consensus models give information about the understanding of the class as a whole.

The materials contain summative assessments that measure three-dimensional learning. Related evidence includes:

- Lesson 4: Students write a formal explanation of DNA replication, mutations, and the role of p53 in repairing mutations in a DNA strand.
- Lesson 10: Students use three dimensions to make sense of a new phenomenon.
- Lesson 12: Students complete a transfer task. "Students develop an interview protocol for the role of health navigator. They use their understanding of the genetics basis of cancer as well as the social determinants of health to develop their questions" (Teacher Edition, page 200).

The materials contain self-assessment opportunities. Related evidence includes:

- Lesson 5: Students fill out an Electronic Exit Ticket. Specific questions related to SEPs and CCCs are provided to help with student thinking about their development. For example: "How can you use structure and function to explain or ask questions about something you have seen or experienced in your everyday life?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 5), "How did obtaining and communicating information from multiple sources such as a kinesthetic simulation, reading and images help you make sense of how we make p53 and why it is different sometimes?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 7), and "How did the crosscutting concept structure and function help you explain the lesson question: How do we make p53, and why is it different sometimes?" (B.3 Lesson 5 Answer Key Electronic Exit Ticket, page 7).
- Lesson 6: "Lead students in a self-assessment opportunity. Display slide E. Students will explain what evidence they have for the genetic basis for cancer. They will also explain why they included some ideas and not others on their Gotta-Have-It-Checklist. Remind students that they are to annotate their Gotta-Have-It-Checklist with their colored pen so that they can see the results of their self-assessment and the additional ideas that they believe that need to be added" (Teacher Edition, page 103).
- Lesson 10: "For an optional assessment, have students do the self-assessment that they did on their Gotta-Have-It Checklists in Lesson 6. To complete the self-assessment: Circle evidence Underline the evidence that answers the question Why do people in different groups and places get cancers at different rates? Could the model be improved by adding more science ideas?

Challenge them to add an idea that was not already included in the initial draft of the checklist" (Teacher Edition, page 163).

Suggestions for Improvement
N/A

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 because students are provided with many opportunities to demonstrate their learning and receive feedback in all three dimensions in the unit for most of the claimed learning. However, opportunities are limited for elements of targeted SEPs and CCCs related to **Structure and Function** and **Asking Questions and Defining Problems**.

Students are provided with multiple opportunities to receive and respond to feedback throughout the unit related to some key claimed learning. Related evidence includes:

- For key claimed learning related to elements of **Developing and Using Models, Cause and Effect, LS1.A Structure and Function, LS1.B Growth and Development of Organisms, LS3.A Inheritance of Traits,** and **LS3.B Genetic Variation:**
  - Lesson 1: Students make individual initial models and are then asked to identify gaps in their models. One of the ideas they are asked to consider is the mechanism that causes cancer. Students then review models to identify gaps and mark places where more information is needed before sharing their models with classmates. "Turn and talk about initial models. Display slide S. Ask students to take out their initial models and turn and talk to a partner about what their model explains and what additional information they still need to answer the question Who gets cancer and why? Let students know when half the allotted time has passed so that they each have time to share" (Teacher Edition, page 36). Students then develop small group models. "Develop small group models. Display slide T. Organize students into small groups of 3-4. Distribute whiteboards or chart paper and markers to each group and ask them to share their individual models one at a time. Students should look for the components and interaction that all or most of the models share as well as the unique features of the modes. They should come to consensus on what to include and develop a single group model. Revisit your classroom agreements and ask students to recall what equitable participation looks like in small groups" (Teacher Edition, page 37). Finally, students work as a class to develop an initial consensus model. Throughout the unit,

students have a chance to receive feedback on their initial model through sharing in small groups and use the feedback to decide what should be included on the final whole class model.

- Lesson 2: Students develop an individual model to explain how cancer makes a person sick. Then they share their model with a partner and use a peer feedback protocol to give and receive feedback on their model. Students are provided with an opportunity to revise their initial models based on this feedback. "Ask students to consider the feedback they received from their peers and make revisions to their models. Then ask them to look for places they still have questions about how components interact or what mechanisms explain the interactions. Ask them to add a question mark anywhere they still have a question. Collect and review initial models before the next class" (Teacher Edition, page 49). The class gathers more information using a reading selection. Information from the reading and feedback received from teachers and peers are used to revise models. While students update their original individual model, they do so while working with a small group. "Initial model revision. Display slide P. While they are in their small groups, ask students to turn to their initial models and determine what revisions they can make based on the reading. They should pay close attention to the places where they added question marks to identify which questions they can answer and which questions they still have. While each student is revising their own individual model, they should draw on resources from the group to help move everyone's thinking forward" (Teacher Edition, page 50).
- Lesson 4: Students complete an online simulation which demonstrates DNA replication and the role of p53. Students are then asked to construct an explanation to answer the question "How do cancer cells end up with differences in their chromosomes and what is the role of p53 preventing the differences?" using information they have gained from the simulation and throughout the entire unit. Students are provided with an opportunity to receive peer and teacher feedback and then revise their explanations.
- Lesson 6: The class combines information and models from the first five lessons in the unit to build a model showing all components and interactions to explain the genetic basis of cancer.
- Lesson 7: Students create an initial model that explains "Why are some kinds of cancer more common than others in older and taller people?"; "Initial model construction. Display slide C. Have students individually develop initial models in their science notebooks that explain our lesson question: Why are some kinds of cancer more common than others in older and taller people? Remind students that models include components, interactions, and mechanisms. Let students know that since these are initial models, we are still determining all components and how they are related. Suggest adding question marks where they know something is happening but do not know what. Encourage them to refer back to their science notebook for ideas" (Teacher Edition, page 113). Students then share their model with a partner and look for similarities and differences. During this discussion, the following prompt is on the accompanying slide: "Make notes on your model about what you might want to add or revise" (B.3 Lesson 7 Slides, Slide D). Students are then introduced to a cell growth and cancer simulation which uses different cell types. Students then use an online simulation to further investigate why cancer might occur more frequently in older and taller individuals. After using this model to engage in a building understanding discussion, students give and receive peer feedback on their initial models and revise them. "Engage in peer feedback. Display slide K. Share Unknown material with identifier: bi.l7.ho2 with them and give them time to review another classmate's initial

model. Revise initial models. Display slide L. Ask students to update the initial models they developed in their science notebooks. They should update their models based on what they figured out by interacting with the Cell Growth and Cancer computer simulation and the feedback they received on Unknown material with identifier: bi.l7.ho2" (Teacher Edition, pages 115–116).
  - Lesson 8: Pairs of students use pipe cleaners and beads to model how meiosis can explain how offspring with certain characteristics can be produced. In the Electronic Exit Ticket, they respond to a question about how two types of models can help provide a mechanistic account of inheritance.
  - Lesson 10: A transfer task is provided. The transfer task consists of two parts. Part 1 provides information about a 15-year-old who is having problems with feeling sick after he eats. The following text is provided which outlines the scenario: "José is a 15 year old biological male who has been having problems with feeling sick after he eats. He visited the doctor several times. José's father has both lactose intolerance which keeps him from digesting dairy products and celiac disease which keeps him from digesting wheat. His doctor sent him to get a genetic test to find out if he inherited either of these conditions from his father. This information can help him adjust his diet so he can feel better. There are two genes on chromosome 2 that code for proteins that are associated with digesting milk" (B.3 Lesson 10 Assessment Genetic Transfer Task, page 1).
- Opportunities for students to demonstrate learning and respond to feedback are not present for claimed learning related to **Asking Questions and Defining Problems** and **Structure and Function.**

Suggestions for Improvement

Provide additional opportunities for students to demonstrate learning and respond to feedback in relation to key claimed learning for **Asking Questions and Defining Problems** and **Structure and Function.** Include tasks where students receive feedback from peers and the teacher and then have subsequent tasks where they can demonstrate their proficiency.

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 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

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)